

3330B

FA 000 547

Programmable Constant Volt./ Constant Current Calibrator

Instruction Manual

P/N 313460
January 1971
Rev. 2 4/75



WARRANTY

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In the event of failure of a product covered by this warranty, John Fluke Mfg. Co., Inc., will repair and calibrate an instrument returned to an authorized Service Facility within 1 year of the original purchase; provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within 1 year of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident, or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

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2. On receipt of the shipping instructions, forward the instrument, transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

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CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon original delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

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CHANGE/ERRATA INFORMATION

ISSUE NO: 11 8/86

This change/errata contains information necessary to ensure the accuracy of the following manual. Enter the corrections in the manual if either one of the following conditions exist:

1. The revision letter stamped on the indicated PCB is equal to or higher than that given with each change.
2. No revision letter is indicated at the beginning of the change/errata.

MANUAL

Title: 3330B
Print Date: January 1971
Rev.- Date: 2-4/75

C/E PAGE EFFECTIVITY

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CHANGE #1 - 10077, 10796

On page 5-3:

CHANGE: A3|Front Mother Board Assembly (3330-4006)|286310|1
 TO: A3|Front Mother Board Assembly (3330-4008)|448654|1

CHANGE: A4A4|Series Pass Driver Assembly (333A-4024)|275388|1
 (See Figure 5-11)
 TO: A4A4|Series Pass Driver Assembly (333A-4030)|446813|1
 (See Figure 5-11)

On page 5-5, change the stock numbers for A3 and A4A4:

FROM: 286310, 275388
 TO: 448654, 446813

On page 5-6, change the stock number on Figure 5-1 (sheet 2 of 2) A3:

FROM: 286310
 TO: 448654

On page 5-9:

CHANGE: DS1 thru DS10 |Lamp, incadescent, 28v|246686|10|10
 TO: CR21 thru CR30|LED Assy |429555|10|10

DELETE: XDS1 thru XDS10|Lampholder|278986|10
 Lens, decimal lamp, clear|271643|8
 Lens, decimal lamp, red|282475|2

On page 5-10, change the reference designators:

FROM: DS1 through DS10
 TO: CR21 through CR30

On page 5-13:

ADD: R52, R53, R54|Res, comp, 1.5k +/-10%, 1w |109413|3
 R55, R56 |Res, comp, 3.3k +/-10%, 1/2w|108373|2

On page 5-32:

CHANGE: R26|Res, comp, 330Q +/-5%, 2w |219063|1
 TO: R26|Res, comp, 2.2k +/-10%, 1w|109843|1

On page 5-38:

Delete the entire listing for R3.

Delete R9 and R25 from the R8,R9,R25,R26 listing and change the TOT

QTY: FROM: 4 TO: 2.

On page 5-39, delete R3, R9 and R25 in the lower right quadrant of Figure 5-14.

On page 8-6:

Change the reference designators DS1 through DS10 to CR21 through DR30 in the existing sequence. The cathode of the diode goes to the left in all ten cases.

Insert R52 (1.5k) between the cathode junction of CR21 through CR24 and the -25V supply.

Insert R53 (1.5k) between the cathode junction of CR27 and CR28 and the

-25V supply.

Insert R54 (1.5k) between the cathode of CR30 and the -25V supply.

Insert R55 (3.3k) between the cathode of CR26 and the tie-point to the right of R3 and the emitter of Q3.

Insert R56 (3.3k) between the anode of CR25 and pin 36.

On page 8-13, Figure 8-11, change the value of R26:

FROM: 330
TO: 2.2k

On page 8-16, Figure 8-14:

DELETE: R3 (150Q)
R9 (120Q)
R25 (120Q)

CHANGE #2 - 10784

On page 5-3, reference designator A4A10, change the drawing number and the stock number:

FROM: (333A-4029) 275420
TO: (333A-4009) 463398

On page 5-48, change the title of Figure 5-17:

FROM: Figure 5-17. LADDER DRIVER NO. 1 ASSEMBLY
TO: Figure 5-17. LADDER DRIVER NO. 1 AND 2 ASSEMBLY

On page 5-49:

Change the reference of Figure 5-18, to Figure 5-17.

Change the stock number for A4A11:

FROM: 275420
TO: 463398

Change the entire A4A11 parts list to match the A4A10 parts list located on page 5-47 with the following exception:

R6|Res, var, cermet, 20Q +/-30%, 3/4w|186197|1

On page 5-51, change the title of Figure 5-18:

FROM: Figure 5-18. LADDER DRIVER NO. 2 AND 3 ASSEMBLY
TO: Figure 5-18. LADDER DRIVER NO. 3 ASSEMBLY

On page 8-20, Figure 8-18:

Change the figure to match Figure 8-17 (page 8-19), then change R6 from a 10 ohm fixed resistor to a 20 ohm variable resistor with the wiper tied to the leftside.

ERRATA #1

On page 1-2, under "COMPLIANCE VOLTAGE":

CHANGE: (see voltage limit)
TO: (see voltage trip)

On page 1-3, Table 1-1:

Under the CODING column for CURRENT LIMIT:

CHANGE: 1.0 TO: *

Under the CODING column for REMOTE TRIP LEVEL:

CHANGE: <1% TO: *

At the end of the table, place the following footnote: * Not usable

ERRATA #2

On page 1-4, under RESPONSE TIME:

CHANGE: -300 milliseconds typical

TO: -300 milliseconds typical above 100 uA.

On page 1-5/1-6:

Under SHOCK and VIBRATION:

CHANGE: (MIL-T-21200)

TO: (MIL-T-28800 class 5)

Under SIZE:

CHANGE: 7" high X 17" wide X 18" deep

TO: 7" (178 mm) high X 17" (432 mm) wide X 18" (458 mm) deep

Under WEIGHT:

CHANGE: 58 lbs

TO: 58 lbs (26.3 kg)

On page 5-27, change the description and the stock number:

FROM: Tstr, silicon, NPN 177105

TO: tstr, selected 437723

On page 5-33, change the stock no. for C2:

FROM: 190468

TO: 194068

Add the following new listings to MANUFACTURERS CROSS REFERENCE LIST on the pages indicated:

On page 5-67: 109413;00121;GB1521
109843;01121;GB2221

On page 5-69: 170274;73445;ET 151X063A01

On page 5-73: 429555;12040;NSL 5053/NSC003
437723;89536;437723
448613;89536;448613
448654;89536;448654
463398;89536;463398

ERRATA #3

On page 4-1, Table 4-1, under the RECOMMENDED EQUIPMENT column:

CHANGE: Tektronix Model 545B

TO: Tektronix Model 545B with 1A1 or differential plug-in module

On page 4-19, para. 4-75, delete the warning preceeding step e, and add the following warning prior to step a:

WARNING

TO AVOID ELECTRICAL SHOCK USE A SCOPE CAPABLE OF MAKING DIFFERENTIAL MEASUREMENTS, I.E., MEASURING A FLOATING INPUT SIGNAL. DO NOT GROUND ANY OF THE MEASUREMENT POINTS SPECIFIED TO SCOPE CHASSIS (VIA THE LOW INPUT LEADS). INTERPRET SCOPE HIGH INPUT AS CHANNEL A, AND SCOPE LOW INPUT AS CHANNEL B. IF A 1A1 PLUG-IN IS USED, SELECT THE "ADD" MODE AND USE THE A/B INPUTS FOR HIGH/LOW SIGNAL CONNECTIONS.

ERRATA #4

On page 4-11, para. 4-49, step d:

CHANGE: A7R1

TO: A7R2

On page 4-16, Table 4-16:

Change A7R1 located under PROCEDURE for STEP 4 to A7R2.

On pages 8-4, Figure 8-2 and 8-5, Figure 8-3:

CHANGE: R1

TO: R2 and indicate 5k

CHANGE #3

On page 5-4, change the stock number for the line cord:

FROM: 226100

TO: 284174

On page 5-7, change the description and stock number for J7:

FROM: Connector, male, 3 contact 159012

TO: Connector, Line-power, 3-contact 284166

ERRATA #5

On page 3-15, Figure 3-8, and page 8-6, Figure 8-4, make the changes shown in Figure 1.

ERRATA #6

On page 1-2, add (DC to 10 kHz) to both the RIPPLE AND NOISE spec's.

ERRATA #7

On page 4-2, para. 4-12:

CHANGE: F1, 1/8, Fast-Blo (115/230V ac)

TO: F1, 1/4, Fast-Blo (115/230V ac)

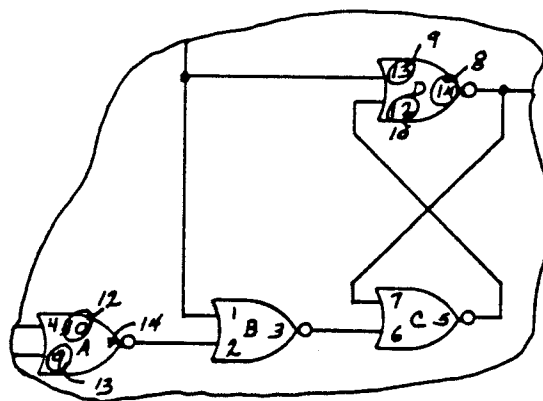


Figure 1.

On page 5-7:

CHANGE: F1|Fuse, fast acting, 1/8 amp, 250v|196790|1|10
 TO: F1|Fuse, fast acting, 1/4 amp, 250V|109314|1|10

On page 5-67:

ADD: 109314/71400/AGC1-4

ERRATA #8

On page 1-2, under GENERAL SPECIFICATIONS, add the following information:

Protection Class #1 (Relates solely to insulation or grounding properties further defined in IEC 348.)

CHANGE #4 - 12822

Rev.- K, Final Assembly (3330B-5001)

On page 5-8:

CHANGE: C4,C5|Cap, cer, 0.01 uf, 500v|105684|2
 (mounted on J7)

TO: C4,C5|Cap, cer 0.005 uf, 25V rms|485839|2
 (mounted on J7)

On page 8-4, change the value of C4 and C5, mounted on J7:

FROM: 0.1

TO: 0.005

CHANGE #5 - 12938

Rev.- D, A4A1 +10 Volt Reference Supply Assy (333A-4005)

On page 5-3:

CHANGE: A4A1|+10 Volt Reference Supply Assembly (333A-4005) |251926|1
 (See Figure 5-8)

TO: A4A1|+10 Volt Reference Supply Assembly (3330A-4013T)|577080|1
 (See Figure 5-8)

On page 5-22:

Delete entire entries: C5, CR1, CR2, IC1, R5, R6, R7, R8, R9, R23,

R16,R17,R18.

CHANGE: A4A1|+10 VOLT REFERENCE SUPPLY ASSEMBLY|251926|REF
Figure 5-8

TO: A4A1|+10 VOLT REFERENCE SUPPLY ASSEMBLY|577080|REF
Figure 5-8

ADD: C1|Cap, mica, 100 pf +/-5%, 500v|148494|1

CHANGE: C2|Cap, elect, 400 uf +10/-50%, 25v|168153|1
TO: C2|Cap, TA, 10 uf +/-20%, 20v |330662|1

CHANGE: C3|Cap, plstc, 1 uf +/-10%, 250v|190330|2
TO: C3|Cap, mylar, 1 uf +/-20%, 200v|106450|1

CHANGE: C4|Cap, plstc, 0.047 uf +/-10%, 40v|162008|1
TO: C4|Cap, film, 4 uf +/-20%, 50 dev |340281|1

ADD: CR1,CR2|Diode, silicon, LO-CAP, LO-LEAK|348177|2
CR3 |Diode, zener, 5.6v |277236|1
CR4 |Diode, field effect |334839|1

CHANGE: Q1|Tstr, silicon, NPN|168708|1
TO: Q1|Tstr, silicon, NPN|203489|1

CHANGE: R1|Res, comp, 39k +/-5%, 1/2w|186049|1
TO: R1|Res, comp 330 +/-5%, 1w |163394|1

CHANGE: R3|Res, met film, 16.5k +/-1%, 1/2w|162529|1
TO: R3|Res, met film, 16.5k +/-1%, 1/8w|349159|1

CHANGE: R4|Res, met film, 2.32k +/-1%, 1/2w|262014|1
TO: R4|Res, met film, 2.32k +/-1%, 1/8w|347062|1

CHANGE: R14|Res, met film, 1.15k +/-1%, 1/2w|155010|1
TO: R14|Res, met film, 886 +/-1%, 1/8w |248641|1

CHANGE: R19,R20,R21|Res, var, ww, 10k +/-10%, 1-1/4w |195164|3
TO: R19,R20,R21|Res, var, cermet, 10k +/-20%, 1/2w|267880|3

CHANGE: IC2,R2,R11,R15|Reference Amplifier matched Set|224824|1
TO: U2,R2,R11,R15 |Reference Amplifier mathced Set|224824|1

ADD: U1|IC,LIN,OP AMP|284960|1
SPACER, TRANSIPAD|152207|1

On page 5-23, Figure 5-8:
Replace Figure 5-8 with Figure 2.

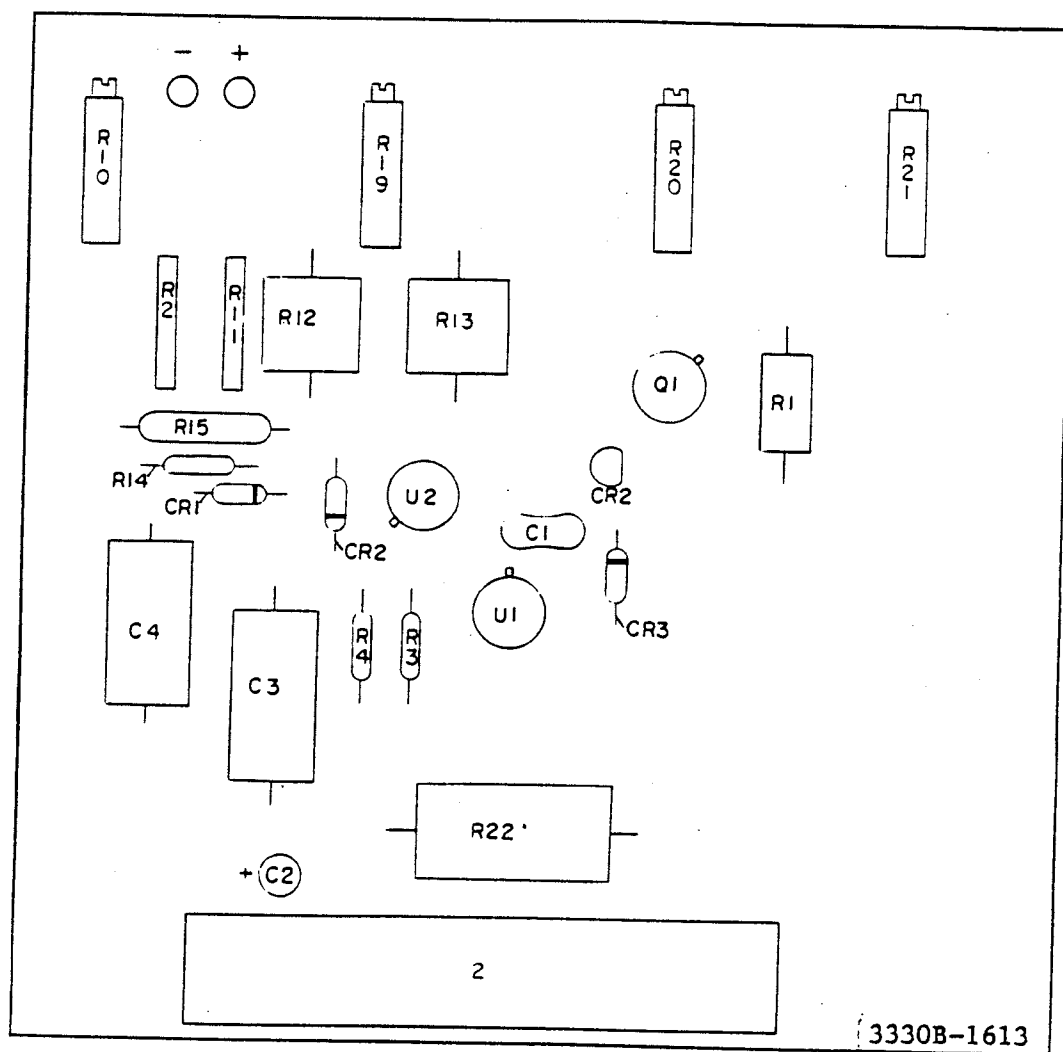
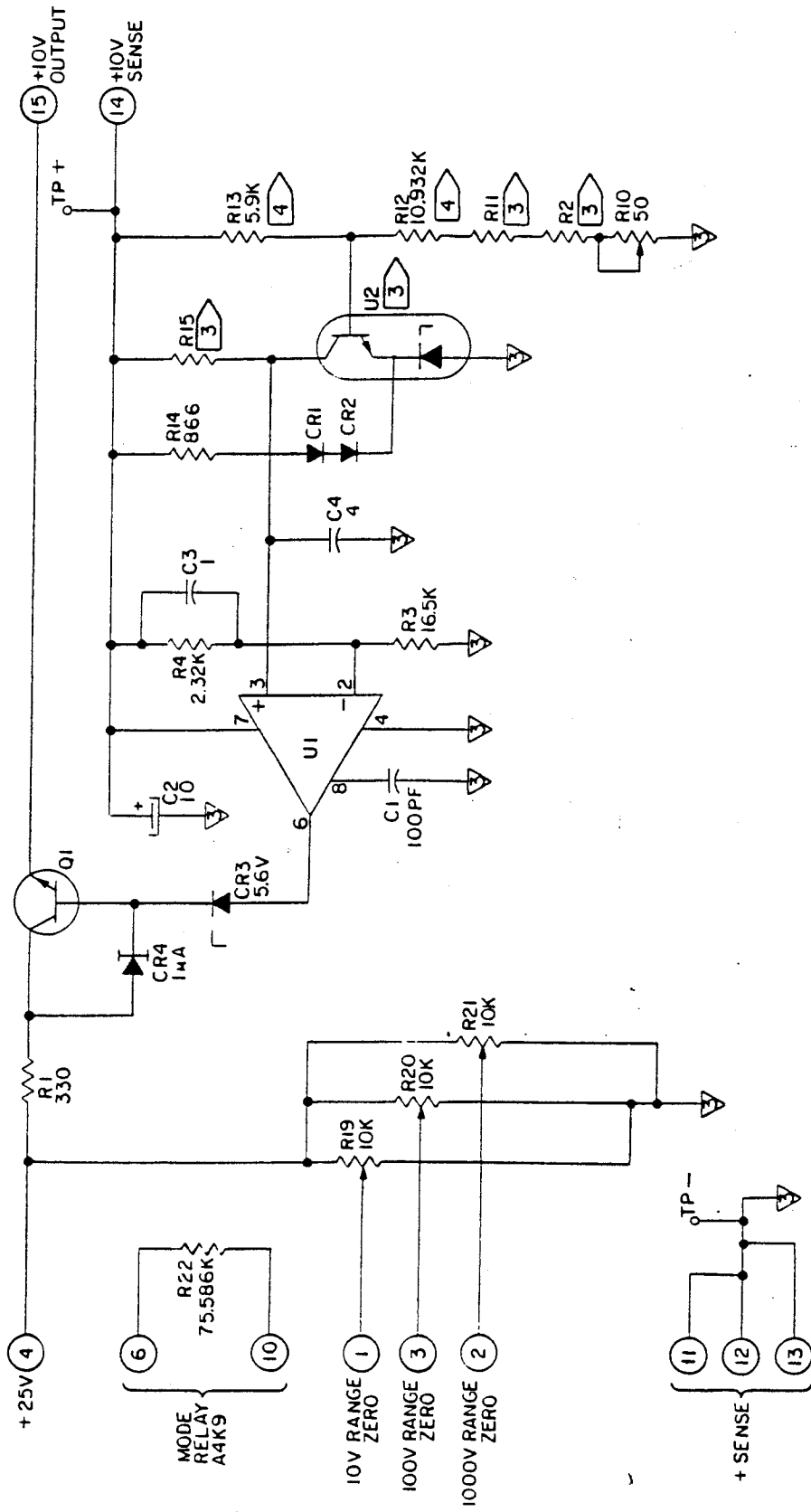


Figure 2.

On page 8-10, Figure 8-8:
Replace Figure 8-8 with Figure 3.



3330B-1013

Figure 3.

CHANGE #6 - 12941

Rev.-D, Switch Board Assembly (3330-4007)

On page 5-16:

ADD: Pushbutton, Red|268870|2
 Pushbutton, Black|28888|2

On pages 5-16 and 5-17:

Change the STOCK NO.'s for S1 thru S5, S6 thru S10, and S11 thru S1 respectively:

FROM:	257063	257071	257089
TO:	380980	380998	381004

CHANGE #7 - 13023

Rev.-B, Front Mother Assy (3330B-4088)

On page 5-11:

CHANGE: CR2 thru CR10,
 CR13 thru CR24 |Diode, silicon 150 ma|203323|21|2
 TO: CR2 thru CR10,
 CR13 thru CR24, CR32|Diode, silicon 150 ma|203323|22|5

On page 8-6:

Change the schematic as shown in Figure 4.

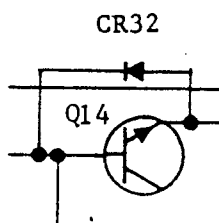


Figure 4.

CHANGE #8 - 13558

Rev.-A, Relay Assembly (3330B-4004)

On page 5-4:

CHANGE: A6|Relay Board Assembly (3330B-4004)|286195|1
 (See Figure 5-25)TO: A6|Relay Board Assembly (3330B-4004)|576488|1
 (See Figure 5-25)

On page 5-66:

Change the STOCK NO. for A6 on the parts list and Figure 5-25:

FROM:	286195
TO:	576488

CHANGE #9 - 13625

Rev.-N, Rear Panel Final Assy (3330B-5001)

On page 5-7:

CHANGE: XF1,XF2|Fuseholder |160846|2
 TO: XF1,XF2|Fuseholder -body|375188|2
 -cap |460238|2

CHANGE #10 - 13690

Rev.-F, Main Mother Board Assembly (3330-4001)

On page 5-21, change the STOCK NO. for K1 thru K5:

FROM: 281170
 TO: 543827

CHANGE #11 - 14113

Rev.-C, Power Supply Assembly (333A-4003)

On pages 5-4 and 5-60, change the STOCK NO. for A5A1:

FROM: 251900
 TO: 362327

On page 5-60:

ADD: E1,E2|Ferrite, choke core|219535|2

On page 8-26, add E1 and E2 as shown in Figure 5.

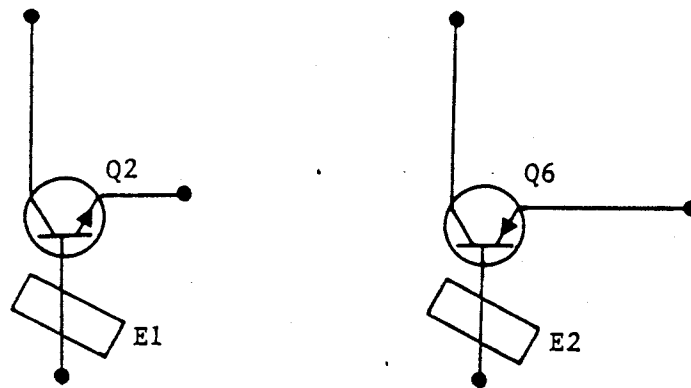


Figure 5.

CHANGE #12 - 14337

Rev.-G, Chopper Amplifier Assy (333A-4004)

On page 5-24:

Delete entire entries for CR2 thru CR5 and CR6, CR7.

ADD: CR2 thru CR9|Diode, SI, Hi-speed switching|203323|8

CHANGE: Q2|Tstr, FET, N-channel |166223|1

TO: Q2|Tstr, J-FET, P-channel|271924|1

CHANGE: Q4|Tstr, silicon, PNP |261032|1
 TO: Q4|IC, PNP, silicon, small signal|288761|1

On page 5-26:

CHANGE: R30|Res, comp, 8.2k +/-5%, 1/4w|160796|1
 TO: R30|Res, comp, 3.3k +/-5%, 1/4w|348813|1

CHANGE: R35|Res, met flm, 24.3k +/-1%, 1/2w|217430|1
 TO: R35|Res, met flm, 12k +/-1%, 1/4w |348847|1

On page 8-11, Figure 8-9, change the values of R30 and R35:
 FROM: 8.2K and 24.3
 TO: 3.3K and 12K

CHANGE #13 - 14460

Rev.-E, Preregulator Assembly (332B/AF-4082)

On pages 3-12 and 3-13, delete paragraphs 3-101 thru 3-107 and replace with the following:

3-101. Pre-Regulation Circuitry

3-102. OSCILLATOR. A unijunction oscillator, consisting of Q9 and associated circuitry, is located on the A4A5 Series Pass Element P/C Assembly (333A-1034). Applied to base two of Q9 is 6.8v clipped, full-wave rectified, 60 Hz sine wave. The potential at the emitter of Q9 depends upon the charge of C4 and C5. The charge of C5 depends upon the voltage across the main series pass element, Q8. At the trailing edge of each pulse at the base two of Q9, the oscillator provides a series of positive pulses until the leading edge of the next +6.8 volt pulse occurs. With an increased charge across C4 and C5, the initial output pulse of the oscillator will occur earlier in each half cycle. The preregulator from the oscillator during each half cycle will switch the preregulator off to control the amount of line power supplied to the high voltage transformer. If the series pass element voltage of Q8 increases, the pre-regulator is switched off earlier in each half cycle. This in turn reduces the series pass element voltage of Q8 to its equilibrium value.

3-103. The +6.8 volt operating voltage for the oscillator circuit is taken from the +150 volt supply for the series pass element. A portion of the +150 volt supply is applied to the voltage divider consisting of R1 through R3. The divided-down voltage is regulated by zener diode CR6 to approximately +6.8 volts.

3-104. PRE-REGULATOR. The A5A2 Preregulator (332B/AF-1081) controls the ac power supplied to the instrument by passing only enough power to the A4A6 H. V. Power Supply to meet the output load requirement. It consists of a +/-V supply, a relay power supply, preregulator control drivers, a preregulator bridge, and a current limiter.

3-105. +/-V and +10V dc operating voltages are produced for the A5A2 Preregulator by the rectifier CR1 through CR4 and associated components. A 10V ac input is applied to CR1 through CR4. The dc output at the junction of CR2 and CR4 is filtered by C3 to provide a -V operating voltage. The dc voltage at the junction of CR3 and CR1 is heavily loaded

by R1 to provide an unfiltered +V operating voltage. This voltage is also isolated through CR5 and filtered by C4 to provide a +10V dc operating voltage.

3-106. Operating voltage for relay K1, which supplies ac voltage to the preregulator bridge, is produced by bridge rectifier CR6 through CR9 and K2. AC return for the bridge rectifier is provided through the contacts of K2. This relay is energized only in the OPR mode by a control voltage from the A4A4 Series Pass Driver. The A4A4 Series Pass Driver automatically removes the control voltage from K2 should a VOLTAGE TRIP occur, thus removing ac power to the preregulator bridge and establishing a STDBY condition.

3-107. The circuitry consisting of Q2 through A9 controls the condition of the preregulator bridge attenuator, Q1. Input pulses from the VCO in the A4A5 Series Pass are supplied to the base of Q7 via terminal 14. The first pulse turns on Q7 and Q6, which through regenerative action, saturate. This condition turns off Q5 and causes Q4 and Q8 to also turn off. Q9 is subsequently turned on by the -V collector voltage of Q8 and provides a negative voltage at the base of Q2. This condition turns off Q2 and also Q1, thus causing the preregulator bridge of CR10 through CR13 and Q1 to provide maximum attenuation to the ac voltage applied to the A4A6 H.V. Power Supply. When the ac line passes through zero, the 0V, +V condition at the emitter of Q6 causes it to turn off and also turns off Q7. This condition reverses the previously described state of each transistor and the preregulator bridge again passes the ac line voltage to the A4A6 H.V. Power Supply.

3-107a. AC line voltage applied to T2 and subsequently the A4A6 H.V. Power Supply is controlled through the preregulator bridge consisting of CR10 through CR13 and Q1. The previously described circuitry of Q2 through A9 controls condition of Q1. Diodes CR10 through CR13 provide a unidirectional current through Q1. Positive alternations are passed by CR10 and CR13. CR12 and CR11 pass negative alternations. Should Q1 be cut off, C6 and R5 provide a dynamic load for the bridge. Overload current protection for Q1 is provided through divider R2, R8, and R9 and Q3. Should the current through Q1 exceed 17 amperes, the voltage at the base of Q3 turns it on and causes Q6 to saturate. This condition causes Q1 to be cut off, thus limiting the current through the preregulator bridge.

On page 5-4:

CHANGE: A5A2|Preregulator Assembly (332B/AF-4082) |222000|1

T0: A5A2|Preregulator Assembly (332B/AF-4081T)|610543|1

On page 5-58, change the STOCK NO. for A5A2:

FROM: 222000

T0: 610543

On pages 5-63 and 5-65:

Replace the entire A5A2 parts list for Table 1.

Table 1.

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
A5A2	PREREGULATOR PCB ASSEMBLY FIGURE 5-24	610543	89536	610543	REF		
C1	CAP, CER, 0.05 UF +80/-10%, 500V	105676	56289	33C58B	4		
C2	CAP, CER, 0.05 UF +80/-10%, 500V	105676	56289	33C58B	REF		
C3	CAP, ELECT, 330 UF, -10/+50%, 16V	187765	73445	C437ARE250	2		
C4	CAP, ELECT, 330 UF, -10/+50%, 16V	187765	73445	C437ARE250	REF		
C5	CAP, PLSTC, 1 UF +/-20%, 200V	106450	72928	364	1		
C6	CAP, CER, 0.05 UF +80/-10%, 500V	105676	56289	33C58B	REF		
C7	CAP, MYLAR, 0.001 UF +/-10%, 200V	159582	56289	192P10292	1		
C8	CAP, CER, 0.05 UF +80/-10%, 500V	105676	56289	33C58B	REF		
C10	CAP, PLSTC, 0.47 UF +/-10%, 250V	184366	73445	C280AE/47 OK	1		
CR1	DIODE, SILICON, 1 AMP, 100 PIV	116111	05277	1N4817	8	2	
CR2	DIODE, SILICON, 1 AMP, 100 PIV	116111	05277	1N4817	REF		
CR3	DIODE, SILICON, 1 AMP, 100 PIV	116111	05277	1N4817	REF		
CR4	DIODE, SILICON, 1 AMP, 100 PIV	116111	05277	1N4817	REF		
CR5	DIODE, SILICON, 1 AMP, 100 PIV	116111	05277	1N4817	REF		
CR6	DIODE, SILICON, 1 AMP, 600 PIV	112383	05277	1N4822	4	1	
CR7	DIODE, SILICON, 1 AMP, 600 PIV	112383	05277	1N4822	REF		
CR8	DIODE, SILICON, 1 AMP, 600 PIV	112383	05277	1N4822	REF		
CR9	DIODE, SILICON, 1 AMP, 600 PIV	112383	05277	1N4822	REF		
CR10	DIODE, SILICON, 3 AMP, 200PIV	187716	04713	MR1032B	4	1	
CR11	DIODE, SILICON, 3 AMP, 200PIV	187716	04713	MR1032B	REF		
CR12	DIODE, SILICON, 3 AMP, 200PIV	187716	04713	MR1032B	REF		
CR13	DIODE, SILICON, 3 AMP, 200PIV	187716	04713	MR1032B	REF		
CR14	DIODE, ZENER, 200V	187617	04713	1N3350RA	1	1	
CR15	DIODE, SILICON, 1 AMP, 100 PIV	116111	05277	1N4817	REF		
CR16	DIODE, SILICON, 1 AMP, 100 PIV	116111	05277	1N4817	REF		
CR17	DIODE, SILICON, 1 AMP, 100 PIV	116111	05277	1N4817	REF		
K1	RELAY, ARMATURE, 115 VAC, DPDT	106864	16332	100-5ADPDT	1		
K2	RELAY, REED, 500V	136630	12617	TYPE DRG-1	1		
	COIL, REED RELAY, 24V	186155	71707	SP-24-P	1		
MP1	COMPONENT HOLDER	104794	98159	2829-115-3	1		
MP2	TRANSIPAD SPACER	152207	07047	10123-DAP	1		
P1	CONNECTOR, MALE, 16 CONTACT	187724	91662	02-016-013-5-200	1		
Q1	TSTR, SILICON, NPN	586552	03508	064VS5	1	1	
Q2	TSTR, SILICON, PNP	261347	16758	TYPE DTS410	1	1	
Q3	TSTR, SILICON, NPN	203489	07910	CDQ10656	3	1	
Q4	TSTR, SILICON, PNP	159491	89536	4805-159491	4	1	
Q5	TSTR, SILICON, NPN	203489	07910	CDQ10656	REF		
Q6	TSTR, SILICON, PNP	159491	89536	4805-159491	REF		
Q7	TSTR, SILICON, NPN	203489	07910	CDQ10656	REF		
Q8	TSTR, SILICON, PNP	159491	89536	4805-159491	REF		
Q9	TSTR, SILICON, PNP	159491	89536	4805-159491	REF		
R1	RES, COMP, 68 +/-10%, 2W	110205	01121	HB6 801	1		
R2	RES, WW, 0.192 +/-1%, 3W	238741	89536	238741	1		
R4	RES, WW, 2K +/-5%, 5W	113506	44655	1538	1		
R5	RES, COMP, 22K +/-5%, 1/2W	186064	01121	EB2235	1		
R6	RES, WW 1 +/-10%, 5W	112425	44655	1K48F	1		
R7	RES, COMP 220 +/-10%, 1/2W	108191	01121	EB2211	1		

Table 1. (continued)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
R8	RES, COMP 430 +/-5%, 1/2W	109058	01121	EB4315	1		
R9	RES, COMP 100 +/-10%, 1/2W	188508	01121	EB1015	1		
R10	RES, COMP 2.2K +/-5%, 1/2W	108506	01121	EB2035	1		
R11	RES, COMP 100 +/-5%, 1W	190652	01121	EB1015	1		
R12	RES, COMP 1K +/-5%, 1/2W	108597	01121	EB1025	4		
R13	RES, COMP 1K +/-5%, 1/2W	108597	01121	EB1025		REF	
R14	RES, COMP 1K +/-5%, 1/2W	108597	01121	EB1025		REF	
R15	RES, COMP 4.7K +/-5%, 1/2W	108886	01121	EB4725	1		
R16	RES, COMP 3.3K +/-5%, 1/2W	165761	01121	EB3325	1		
R17	RES, COMP 1K +/-5%, 1/2W	108597	01121	EB1025		REF	
R18	RES, COMP 560 +/-5%, 1/2W	109124	01121	EB5615	1		
R19	RES, COMP 68 +/-5%, 1/2W	178384	01121	EB6805	1		
R20	RES, COMP 30 +/-5%, 1/2W	218792	01121	EB3005	1		

On page 5-64, Figure 5-24, replace entire figure with Figure 6.

On page 8-27/8-28, Figure 8-25, replace the entire figure for Figure 7.

ERRATA #9

On page 8-9, Figure 8-7, change polarity of CR38 to be in series with CR39 rather than back to back.

ERRATA #10

On page 4-6, para. 4-32, step d:

CHANGE: d. Advance the Decade Dials to 10x.xx000. When this new setting is reached, the I LIMIT/V TRIP lamp should illuminate and the OPR lamp should go out.

TO: d. Advance the Decade Dials to 10X.XX. The I LIMIT/VTRIP lamp should not illuminate. Verify that trip will occur if the voltage trip vernier is adjusted less than approximately 1/4 inch from maximum setting.

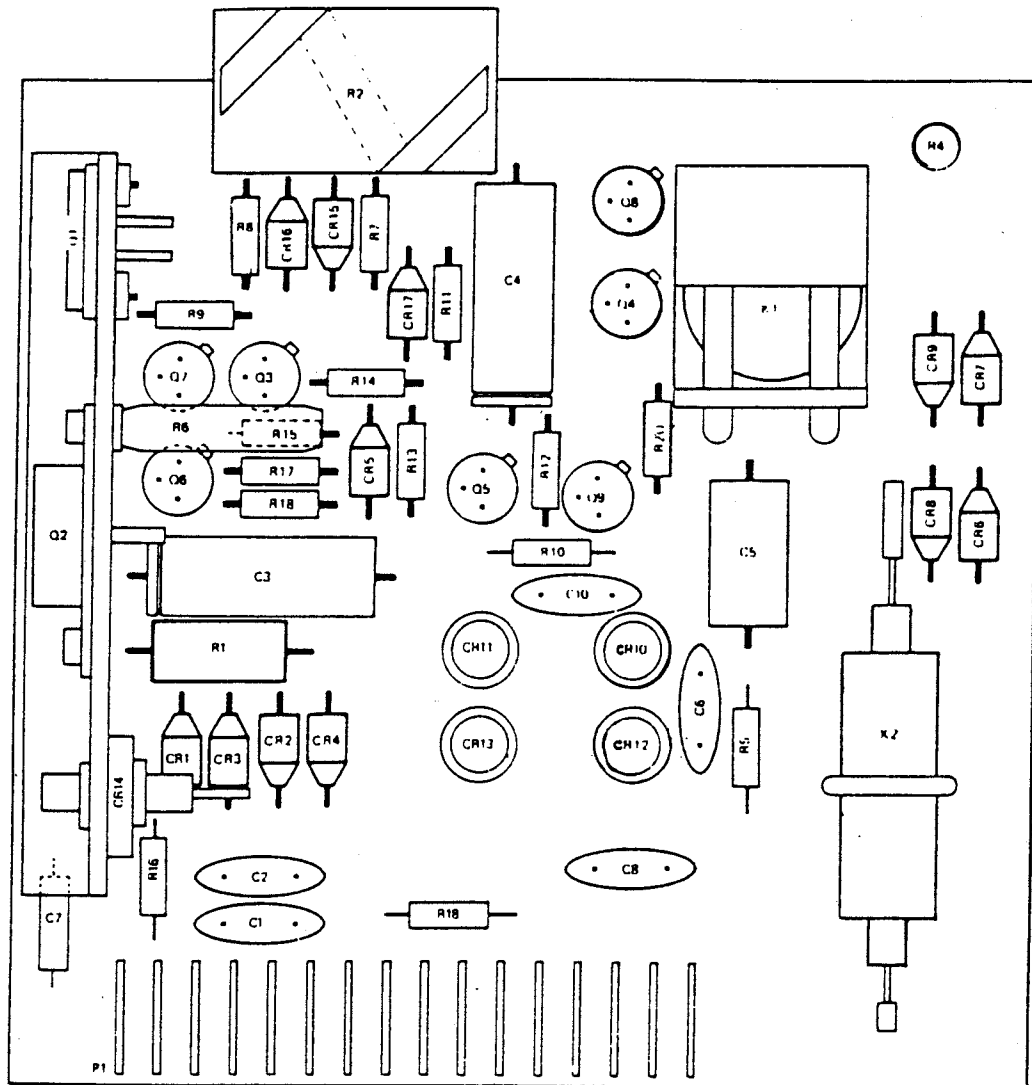


Figure 6.

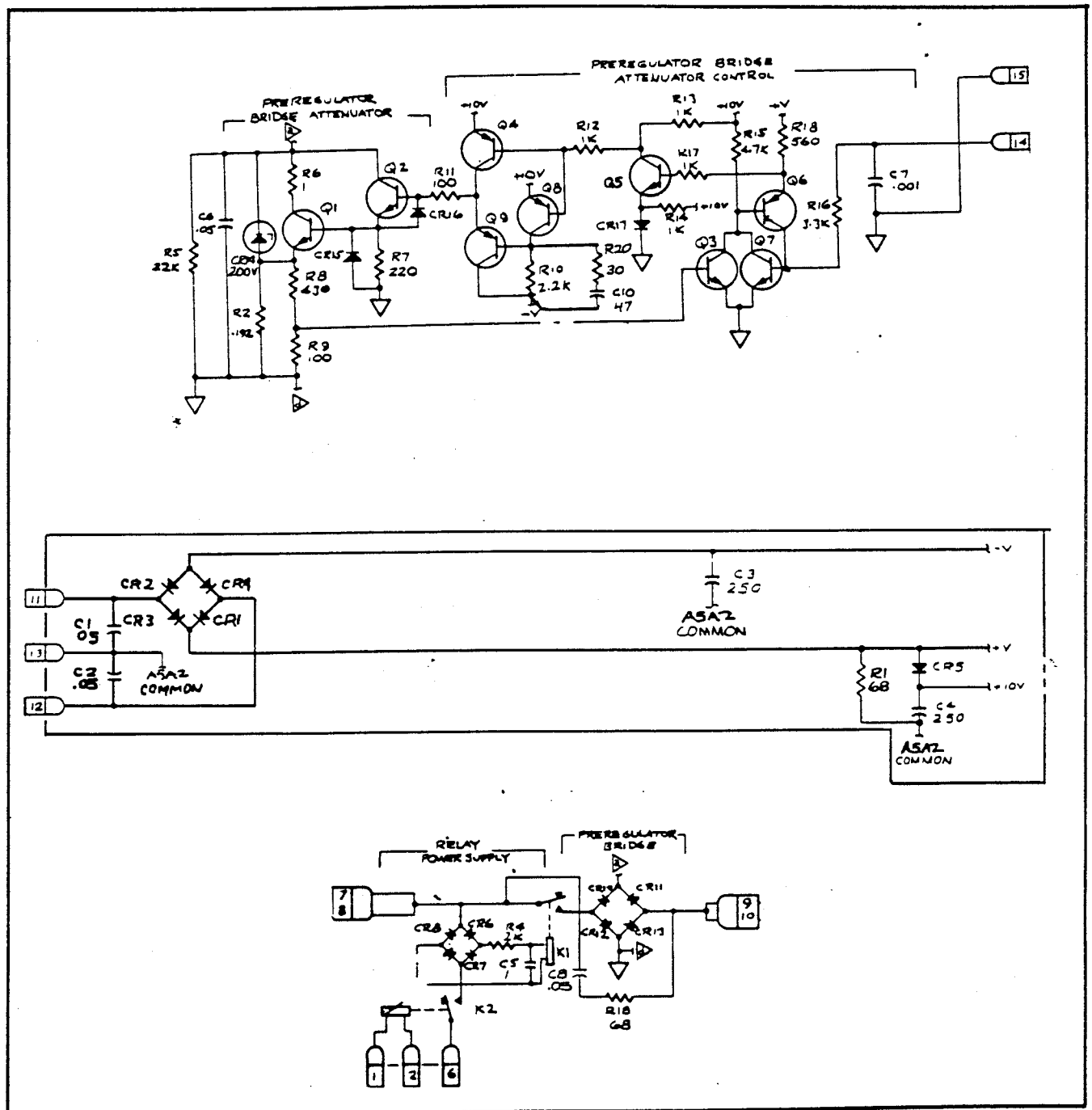


Figure 7.

CHANGE #14 - 15173

Rev.-H, Chopper Amplifier, Assy (333A-4004)

On page 5-24:

CHANGE: Q1|Tstr, MOS FET, P-channel|226043|1
 TO: Q1|Tstr, MOS FET, P-channel |306142|1

CHANGE #15 - 16081

Rev.-F, Current Limiter Assembly (333A-4032)

On page 5-38:

CHANGE: Q2|Tstr, germanium, PNP|152868|1|1
 TO: Q2|Tstr, silicon, PNP |483222|1|1

CHANGE #16 - 16475

Rev.-G, Main Motherboard Assembly (3330B-4001)

On page 5-21:

CHANGE: R5|Res, comp, 333 +/-5%, 1w|163394|1
 TO: R5|Res, comp, 1k +/-10%, 1w|109371|1

On page 8-9, change the value of R5:

FROM: 330
 TO: 1K

ERRATA #11

On page 4-20, para. 4-81:

CHANGE: step b to d
 step c to b
 step d to c

Add the following to the new step c:
 STDBY/OPR OPR

Delete the last sentence in the new step d and add the following:

Use current limiting in the general purpose supply of approximately 20 to 50 mA. After the 3330B is in OPERATE, set the general purpose supply output for 5.5V dc.

ERRATA #12

On page 5-4:

ADD: Guide, PCB card|241455|38

CHANGE #17 - 15821

Rev.-S, Final Assembly (3330B-5001)

On pages 5-19 and 5-50, change the STOCK NO for A4A12,

FROM: 275412
 TO: 612531

On pages 5-19 and 5-52, change the STOCK NO for A4A13,

FROM: 252031
 TO: 612549

On pages 5-19 and 5-54, change the STOCK NO for A4A14, A4A15 and A4A16,
 FROM: 251892
 TO: 612556

On pages 5-50, 5-52 and 5-54,
 CHANGE: K1 thru K4|Reed relay, |267708|4|2
 |Coil, reed relay |186155|4|1
 TO: K1 thru K4|Reed relay, encapsulated|603563|4|1

ERRATA #13

On page 4-1, para 4-2, replace the last sentence with:
 Equipment having equivalent specifications may be used.

ERRATA #14

On page 4-4, para. 4-24, make the following changes.

Step d, replace the first sentence with:
 "Connect a X1000, 10 kHz Bandwidth preamplifier to the OUTPUT terminals."

Step e:
 CHANGE: 200 uv
 TO: 200 mV

Step f:
 CHANGE: 1.0 mv
 TO: 1V

Replace step g with:

- g. "Select the 100 mA range, and then connect the rms voltmeter directly to the Model 3330B OUTPUT terminals. The rms voltmeter indication should be less than 100 mV.

In Table 4-3, add an * to the S1 POSITION column heading, and add the following note to the bottom of the table.

* Go to standby and reduce decade to 6 before opening switch then return to OPERATE and increase decade back to 10.

On page 4-7, para 4-34, replace steps d, e and f with:

- d. Advance the Decade Dials to 10X.XX. The I LIMIT/VTRIP lamp should not illuminate. Verify illumination at a current limit control setting less than approximately 1/4 inch from max.
- e. Set the Decade Dials to 03.00000. The I LIMIT/VTRIP lamp should be off.
- f. Slide the current limit control towards the LO setting. The I LIMIT/VTRIP lamp should illuminate at approximately 1/4 inch or less from the minimum setting.

ERRATA #15

On page 4-5, para. 4-26, step C, change to read:

- c. Connect a power supply calibrator (Fluke model 7105A System as pictured on page 2-4, Figure 2-4 of the 7100 manual) to the 3330B output terminals.

In Table 4-5A, add a column labeled NULL DETECTOR INDICATION, and an entry of 0 ± 30 uV for each step 1 thru 8.

In Table 4-5B, change the RSTD and the OUTPUT CURRENT (RSTD VDC) columns for steps 1, 4 and 7:

FROM:	1	1k	0.1 ± 6 uV
	4	100Q	0.1 ± 6 uV
	7	10Q	0.1 ± 6 uV
TO:	1	10k	1 ± 60 uV
	4	1k	1 ± 60 uV
	7	100Q	1 ± 60 uV

ERRATA #16

On page 4-1, Table 4-1:

Under EQUIPMENT NOMENCLATURE, in the STANDARD RESISTORS block,

ADD: 10 KQ, 0.002W

Under RECOMMENDED EQUIPMENT, in the LEEDS & NORTHRUP STDS block,

ADD: 4040-B

On page 4-2, para. 4-14, add the following to the end of the paragraph.

(Fluke part number 429555 for LEDS.)

On page 4-5, para. 4-27, step c,

CHANGE: 1K, 0.001W

TO: 10K, 0.002W

ERRATA #17

On page 4-13:

Following paragraph 4-55, add,

NOTE

Prior to this test, verify that the meter is resting at zero with the power off. If not, adjust the mechanical zero adjustment on the meter face for zero indication.

On step c,

CHANGE: ... +/-10vdc ...

TO: ... +/-20vdc ...

On page 4-14, replace Table 4-10, with Table 2.

Table 2.

NOMINAL CURRENT	CURRENT LIMIT	LIMIT TOLERANCE (MA)
80.00000	80% (8)	80 +/-18 mA
40.00000	40% (4)	40 +/-10 mA
20.00000	20% (2)	20 +/-6 mA
10.00000	10% (1)	10 +/-4 mA

Errata #18

On page 4-14, change paragraph 4-60 to read:

4-60. Manual Voltage Trip Alignment

Preceding paragraph 4-61, add the following:

4-60a. Remote Voltage Trip Alignment

If the 3330B is to be operated remotely, perform the following voltage trip-out adjustments:

a. Rotate A4A4R13, V TRIPOUT ADJ, fully counter-clockwise.

b. Set the Model 3330B controls as follows:

POWER	OPR
MODE	VOLTS, 100
VOLTAGE TRIP	100
VOLTAGE TRIP LEVEL	110% (8+2+1)
CROWBAR	OFF
POLARITY	POSITIVE
Decade Dials	10X.XX000

- c. Slowly adjust A4A4R13 clockwise until the model 3330B trips to the STDBY/RESET mode. The I LIMIT/V TRIP lamp should illuminate, and the OPR lamp should go out.
- d. Program the conditions in Table 4-10A, observing that the I LIMIT/V TRIP lamp illuminates within the specified tolerance.

Table 4-10A. Remote Voltage Trip Checks

NOMINAL VOLTAGE	VOLTAGE TRIP	TOLERANCE (VOLTS)
80.00000	80% (8)	80 +/-8V
40.00000	40% (4)	40 +/-4V
20.00000	20% (2)	20 +/-4V
10.00000	10% (1)	10 +/-2V

ERRATA #19

On page 8-10, Figure 8-8, make the following changes:

Change R20,
FROM: 1 kV RANGE
TO: 100V RANGE

Change R21,
FROM: 100V RANGE
TO: 1 kV RANGE

CHANGE #18 - 17513

Rev.-B, A4A3 Differential Amplifier PCB (3330B-4003)

On page 5-29, add:

R37|RES, MF, 1/2W, 1%, 2.15K|144733|1

On page 8-12, Figure 8-10, add R37 as shown in Figure 8.

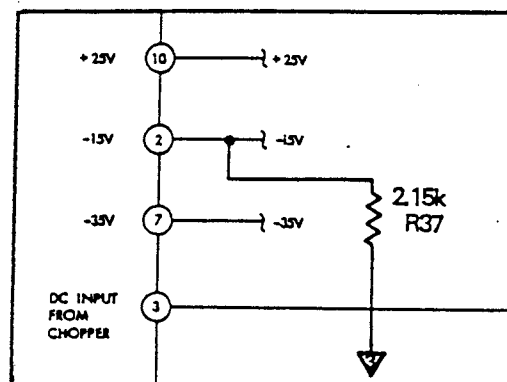


Figure 8.

On page 8-26 Figure 8-24, add L1 and L2 as shown in Figure 10.

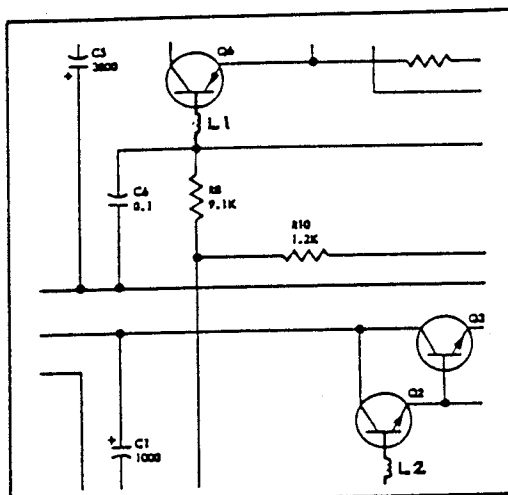


Figure 10.

CHANGE #23 - 19534

Rev.-C, A4A10 Ladder Driver No.1 Assembly (3330B-4031)

On page 5-47, make the following change:

CHANGE: K1-K4|RELAY|277186|4
TO: K1-K4|RELAY|714097|4

CHANGE #24 - 19535

Rev.-B, A4A11 Ladder Driver No.2 Assembly (3330B-4009)

On page 5-49, make the following change:

CHANGE: K1-K4|RELAY|277186|4
TO: K1-K4|RELAY|714097|4

CHANGE #19 - 17850

Rev.-D, A5A1 -25 & -5 Volt Power Supply Assembly (333B-4003)

On page 5-60, make the following changes:

DELETE: E1,E2|Ferrite, choke core|219535|2

ADD: C8|CAP, CER, .22 UF, 50V|190314|1

On page 8-26, Figure 8-24, delete E1 and E2 and add C8 as shown in Figure 9.

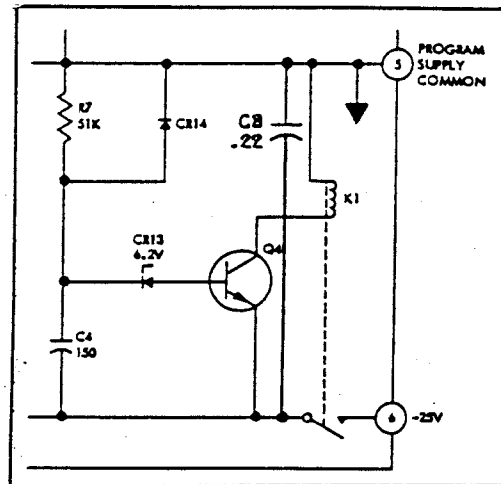


Figure 9.

CHANGE #20 - 12871,13558

On page 5-3, make the following change:

CHANGE: A4|Main Mother Board Assembly (3330B-4001)|285460|1

TO: A4|Main Mother Board Assembly (3330B-4010)|528067|1

CHANGE #21 - 18652

Rev.-C, A3 Front Mother Board Assembly (3330B-4008)

On page 5-11, make the following change:

CHANGE: Q4 thru Q13,Q16,Q17,Q18|Tstr,silicon,PNP|266015|13|2

TO: Q4 thru Q13,Q16,Q17,Q18|Tstr,silicon,PHP|266619|13|2

CHANGE #22 - 18923

Rev.-E, A5A1 -25 & -5 Volt Power Supply Assembly (333A-4003)

On page 5-60, add the following:

L1,L2|Ferrite tube|219535|2

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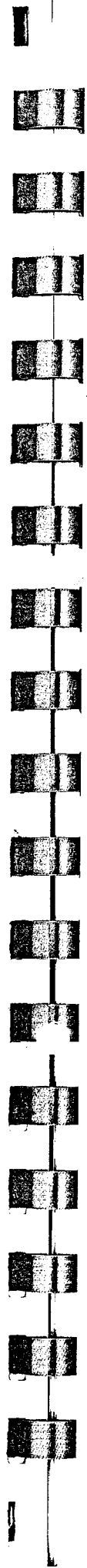
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Section 1

Introduction & Specifications

1-1. INTRODUCTION

1-2. The Model 3330B Programmable Constant Current-Constant Voltage Calibrator is a dc calibration instrument which produces output currents from 0 to 111.11110 milliamperes and output voltages from 0 to 1111.1110 volts dc. Output current selection is provided in three ranges and is accurate to within 0.006% of the selected range. Output voltage selection is also available in three ranges with accuracies as stated in paragraph 1-6. Over current and voltage protection features are also provided, thus preventing harm from occurring to devices being tested with this instrument.

1-3. Front panel indicators provide visual indication of the output current or voltage and the operating modes of the instrument. In-line decade dials and a panel meter indicate the magnitude of the selected output. Indicator lamps provide visual indication of the various operating modes.

1-4. Systems capability is enhanced by remote control of most operating features. Remote operation is possible through the rear panel Remote connector using either contact closures or DTL/TTL logic. Programming coding requirements are binary 8-4-2-1.

1-5. The instrument is completely solid-state in design, and module plug-in construction is used for ease in maintenance. The instrument is designed for bench-top use or installation in a 19-inch electronic equipment rack. The chassis is also drilled to accept rack mounting slides.

1-6. SPECIFICATIONS

1-7. Constant Voltage Mode

ANALOG OUTPUTS

10V Range - 0 to 11.111110 volts dc (1 uv steps)

100V Range - 0 to 111.11110 volts dc (10 uv steps)

1000V Range - 0 to 1111.1110 volts dc (100 uv steps)

ACCURACY OF OUTPUT:

(% of Programmed Level)

10V range - $\pm 0.003\%$ or ± 30 uv

100V range - $\pm 0.003\%$ or ± 300 uv

1000V range - $\pm 0.003\%$ or ± 3 mv

NOTE: Above accuracies apply for 90 days at standard reference conditions of $23^{\circ}\text{C} \pm 1^{\circ}\text{C}$ (nominal calibration temperature, constant line voltage, up to 70% relative humidity, and constant external load.) With uninterrupted operation for more than one hour at loads greater than 25 mA, the specified accuracy is $\pm 0.005\%$ over an operating temperature range of $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$.

OUTPUT CURRENT:

10V and 100V Ranges - 0 to 100 milliamperes at any programmed level.

1000V Range - 0 to 50 milliamperes at any programmed level.

TEMPERATURE COEFFICIENT OF OUTPUT:

Less than 4 ppm of programmed level or 0.4 ppm of range/ $^{\circ}\text{C}$.

STABILITY OF OUTPUT:

- 10V Range - 5 ppm of output or 10 uv/day
15 ppm of output or 30 uv/month
- 100V Range - 5 ppm of output or 100 uv/day
15 ppm of output or 300 uv/month
- 1000V Range - 5 ppm of output or 1 mv/day
15 ppm of output or 3 mv/month

NOTE

Stabilities apply at standard conditions described under accuracy of output.

RIPPLE AND NOISE:

	UP TO 50 MA LOAD	UP TO 100 MA LOAD
10V Range	60 uv rms	100 uv rms
100V Range	70 uv	100 uv
1000V Range	100 uv	Not applicable

LINE/LOAD REGULATION:

5 ppm of programmed level or 2 ppm of range for combined 10% line voltage and full-load changes.

Constant Current Mode

ANALOG OUTPUTS:

- 1 MA Range - 0 to 1.1111110 ma (0.1 na steps)
- 10 MA Range - 0 to 11.111110 ma (1 na steps)
- 100MA Range - 0 to 111.11110 ma (10 na steps)

ACCURACY OF OUTPUT:

±0.006% of programmed level, or ±0.0006% of current range.

NOTE

Accuracy applies for 90 days at standard reference conditions described under constant voltage mode.

TEMPERATURE COEFFICIENT OF OUTPUT:

Less than 6 ppm of programmed level or .4 ppm of range/°C.

STABILITY OF OUTPUT:

- 10 ppm of programmed level or 1 ppm of range/day.
- 30 ppm of programmed level or 6 ppm of range/month.

NOTE

Stabilities apply at standard conditions described under constant voltage mode.

COMPLIANCE VOLTAGE:

- 1 ma and 10 ma Ranges - up to 1000V
- 100 ma Range - up to 500V
(See voltage limit)

RIPPLE AND NOISE:

For negative ground or floating operation.

MA RANGE	RIPPLE
1 MA	20 na
10 MA	100 na
100 MA	1 ua

LOAD REGULATION:

- 1 MA Range - 2 ppm of range per 100V compliance
- 10 MA Range - 5 ppm of range
- 100 MA Range - 5 ppm of range

1-9. General Specifications

CURRENT LIMIT (voltage or current operation):

- Remote mode - Programmable in 12 steps from 1.0 to 110 ma. (see input/output table)
- Local mode - Continuously adjustable from 1 ma to 110 ma.

NOTE

Limit indication by contact closure (see input/output table), and front panel lamp.

VOLTAGE TRIP (voltage or current operation):

- Remote mode - Programmable in 10% steps from 10% to 110% of trip range (see input/output table)

Local mode - Can be calibrated to be continuously adjustable from 10% to 110% of range (see Voltage Trip-calibration procedure).

NOTE

In the constant current mode, the actual absolute trip voltage is decreased by the following:

$$10 \times \frac{\text{Output Current}}{\text{Output Current Range}} \text{ Volts}$$

NOTE

Output goes to zero and unit returns to standby if trip point is exceeded. Limit indication by contact closure (see Table 1-1) and front panel lamp.

ISOLATION:

Programming lines are isolated from output. Output is isolated and guarded from chassis. Potential between programming lines and either side of output should not exceed 1150V.

METER:

For local operation, switch selectabel to indicate 0 to 1100 VDC or 0 to 110 ma.

PROGRAMMING INPUTS/OUTPUTS:

All inputs/outputs through a 50 pin rear panel connector. Mating connector furnished with instrument. See Table 1-1 for line functions.

OUTPUT CONNECTIONS:

Separate output and sense terminals provided for four-terminal connection to the load. All front

Table 1-1. PROGRAMMING INPUTS AND OUTPUTS

INPUTS	LINES	CODING	INPUTS	LINES	CODING
		Logic "0" = +4.5 to +20V or open circuit Logic "1" = 0 to +0.5V or closed circuit			40 = 0100 50 = 0101 60 = 0110 70 = 0111 80 = 1000 90 = 1001 100 = 1010 110 = 1011
STANDBY OPERATE	1	STANDBY = "0" OPERATE = "1"			
MODE	1	VOLTAGE = "0" CURRENT = "1"	VOLTAGE TRIP:		
RANGE	2	CODE	VOLTAGE TRIP RANGE	2	CODE
10V or 1 MA		"00" (Code "11" not allowed)	10V TRIP RANGE		00
100V or 10 MA		"01"	100V TRIP RANGE		01 (Code "11" Not Allowed)
1000V or 100MA		"10"	1000V TRIP RANGE		10
OUTPUT LEVEL (7 Decades)	28	DECADE CODING	REMOTE TRIP LEVEL (10% to 110% of selected range)	4	CODING
		DIGIT 8421			RANGE % 8421
		0 = 0000			<1% = 0000
		1 = 0001			10% = 0001
		2 = 0010			20% = 0010
		3 = 0011			30% = 0011
		4 = 0100			40% = 0100
		5 = 0101			50% = 0101
		6 = 0110			60% = 0110
		7 = 0111			70% = 0111
		8 = 1000			80% = 1000
		9 = 1001			90% = 1001
		10 = 1010			100% = 1010
					110% = 1011
VOLTAGE TRIP/ CURRENT LIMIT:			POLARITY	1	(+) = "0" (-) = "1"
LOCAL/REMOTE	1	LOCAL = "0" REMOTE = "1"	CROWBAR	1	OFF = "0" ON = "1"
CURRENT LIMIT: REMOTE LIMIT LEVEL	4	CODING	OPERATE FLAG OUTPUT	1	CONTACTS CLOSED IN OPERATE MODE
		MA 8421	CURRENT LIMIT FLAG OUTPUT	1	CONTACTS OPEN IN NORMAL OPERATION
		1.0 = 0000	VOLTAGE TRIP FLAG	1	CONTACTS OPEN IN NORMAL OPERATION
		10 = 0001			
		20 = 0010			
		30 = 0011			

panel output, guard, and chassis connections are duplicated on the rear panel.

OPERATION:

Local via front panel controls or remote via program input; selectable at front panel.

RESPONSE TIME:

- 1, 10, 100 ma Ranges - 300 milliseconds typical - dependent on load resistance.
- 10V Range - 60 milliseconds.
- 100V Range - 300 milliseconds
- 1000V Range - 3 seconds.

NOTE

When on the 1000V range, maximum repetition rate of a sequentially programmed instruction should not exceed the time intervals contained in Figure 1-1.

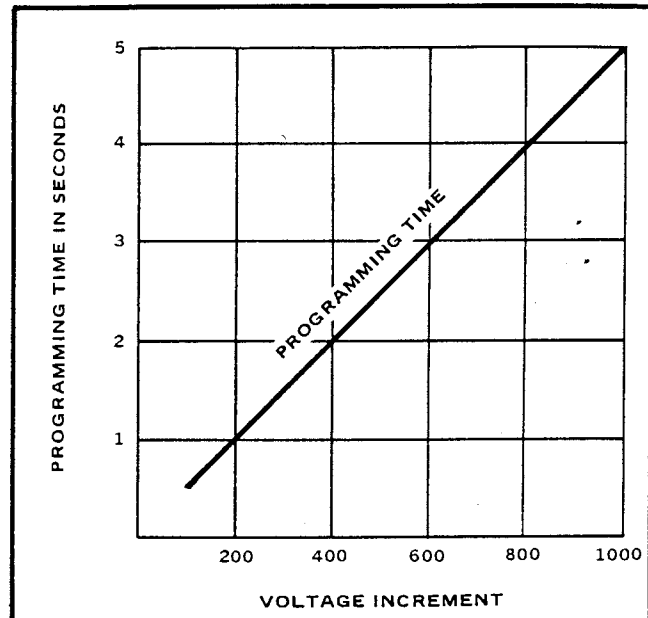


Figure 1-1. ALLOWABLE PROGRAMMING INTERVALS, 1000V RANGE AND CURRENT MODE

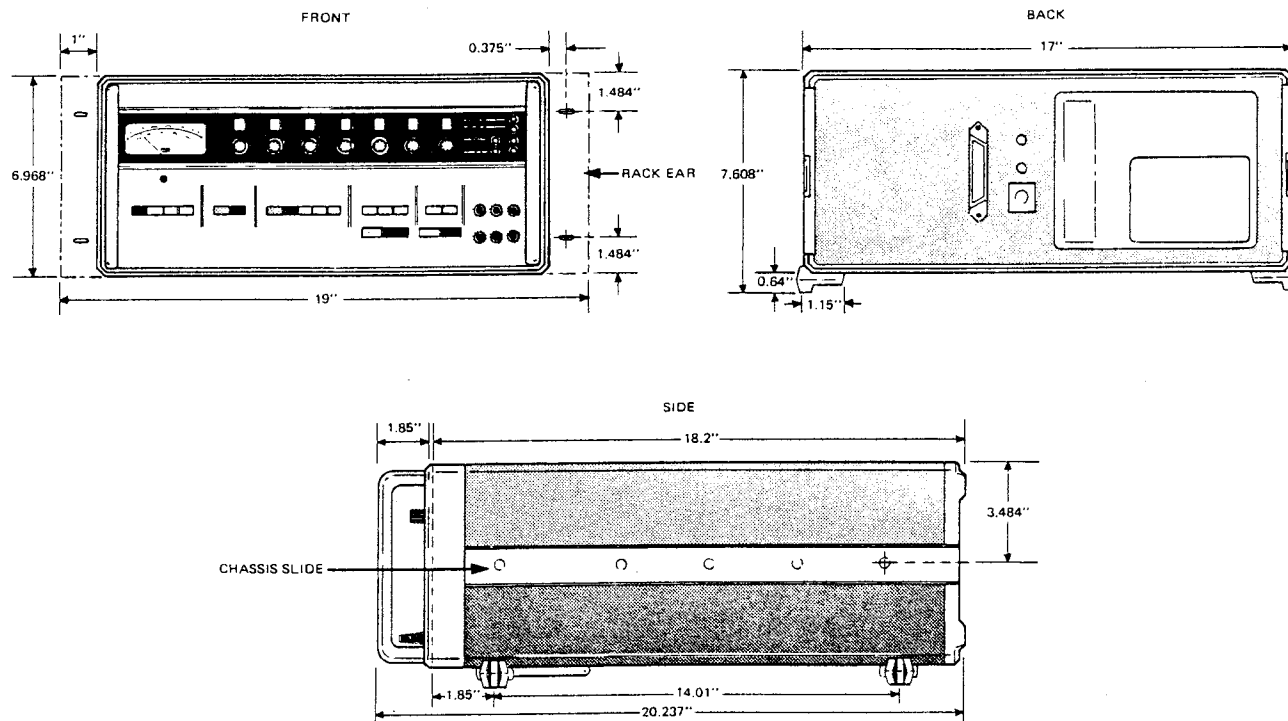


Figure 1-2. MODEL 3330B OUTLINE DRAWING

TEMPERATURE:

OPERATING - 0° to +50°C

NON-OPERATING - -40°C to +65°C

RELATIVE HUMIDITY:

0 to 70%

SHOCK:

15 g. 11 millisecond half-sine wave (MIL-T-21200)

VIBRATION

10 Hz to 55 Hz, 3g maximum (MIL-T-21200)

ALTITUDE:

OPERATING - 0 to 10,000 ft.

NON-OPERATING - 0 to 50,000 feet

INPUT POWER:

115/230 VAC $\pm 10\%$, 48 to 62 Hz single phase at approximately 130 VA fully loaded.

SIZE:

7" high x 17" wide x 18" deep

WEIGHT:

58 pounds

MOUNTING:

Bench: Self-supported or included custom-designed feet.

Rack: Accepts optional brackets MEE-7003 for 19" rack mounting and optional 18" chassis slides MEE-8078 (24" slides also available).

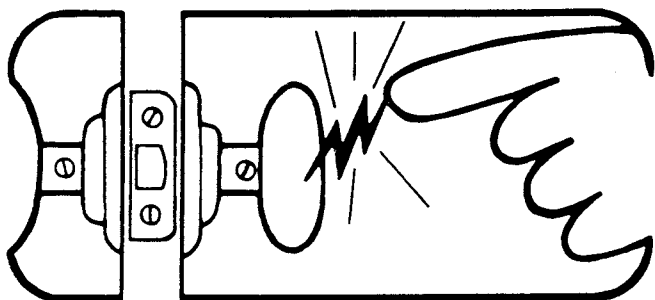




static awareness



A Message From
John Fluke Mfg. Co., Inc.

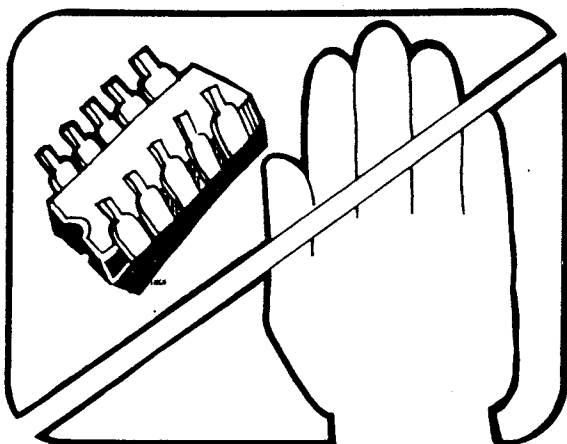


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

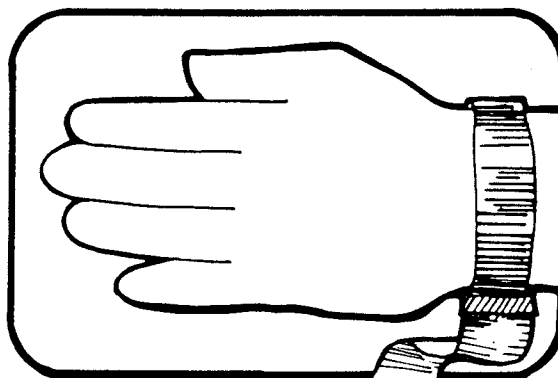
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol "ⓧ"

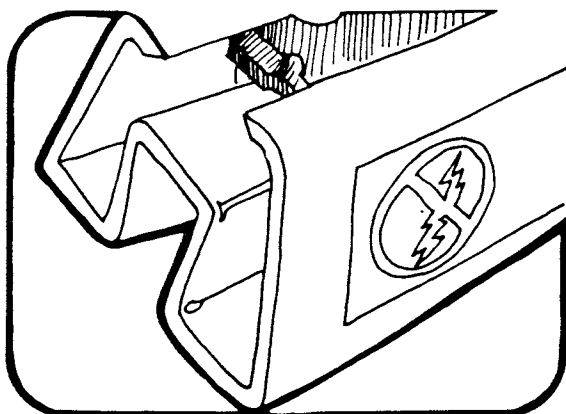
The following practices should be followed to minimize damage to S.S. devices.



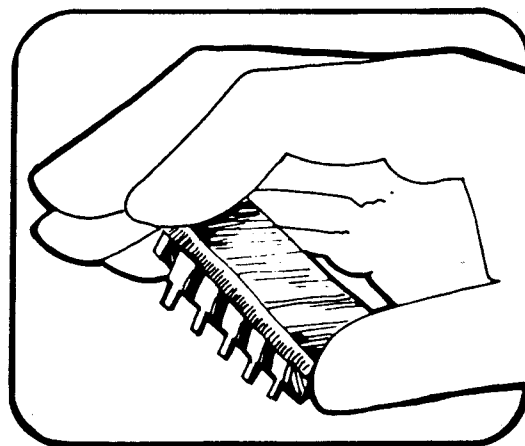
1. MINIMIZE HANDLING



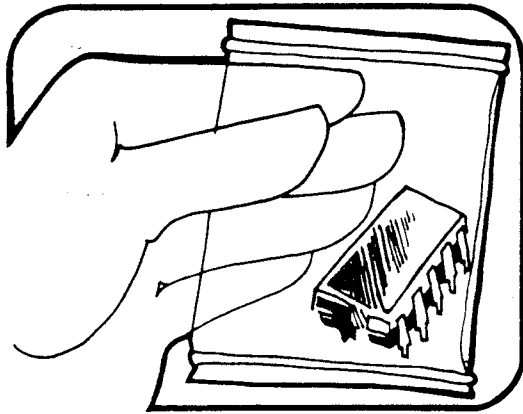
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



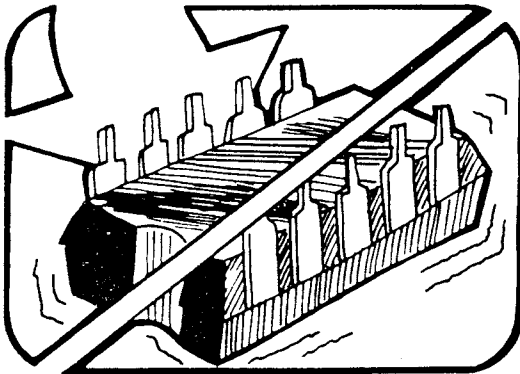
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



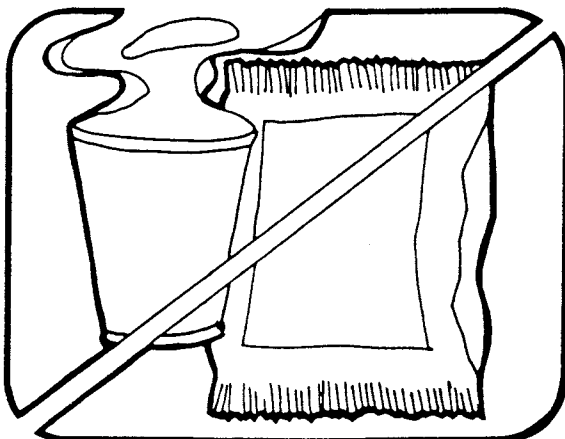
4. HANDLE S.S. DEVICES BY THE BODY



5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT

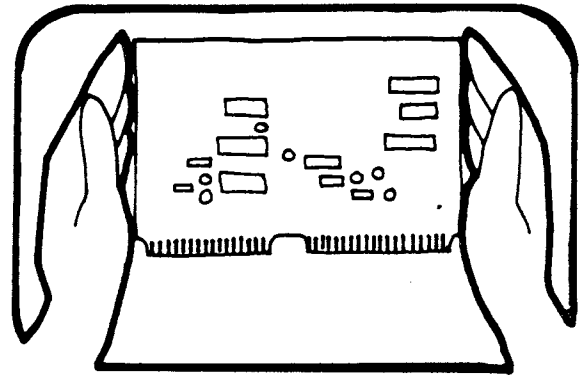


6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE

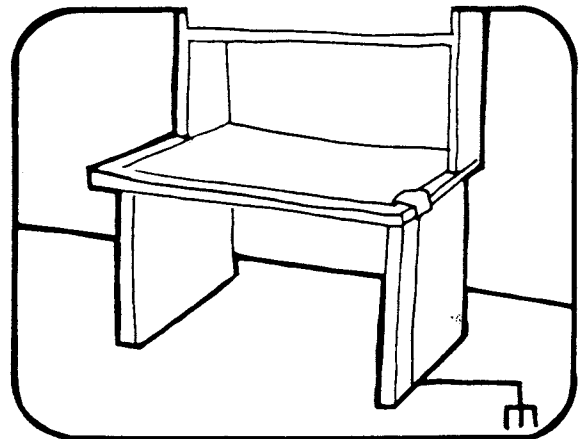


7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA

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AND GENERAL DYNAMICS, POMONA DIV.



8. WHEN REMOVING PLUG-IN ASSEMBLIES, HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR HELPS TO PROTECT INSTALLED SS DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION
10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.
11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

A complete line of static shielding bags and accessories is available from Fluke Parts Department, Telephone 800-526-4731 or write to:

JOHN FLUKE MFG. CO., INC.
PARTS DEPT. M/S 86
9028 EVERGREEN WAY
EVERETT, WA 98204

Section 2

Operating Instructions

2-1. INTRODUCTION

2-2. This section of the manual contains information essential to the correct operation and performance of the Model 3330B. It is recommended that the contents of this section be thoroughly read and understood before attempting to operate the instrument. Should any difficulties be encountered during the operation of your instrument, please feel free to contact the nearest John Fluke Sales Representative or the John Fluke Mfg. Co., Inc., Box 43210, Mountlake Terrace, WA 98043. A complete list of Sales Representatives is located in Section 7 of this manual.

2-3. Claim For Damage In Shipment

2-4. The Instrument should be thoroughly inspected immediately upon receipt. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to the John Fluke representative. Upon receipt of this report you will be advised of the disposition of the equipment for repair or replacement. Include the model number, type number, and serial number when referring to this instrument for any reason.

2-5. Shipping Instructions

2-6. All John Fluke Mfg. Co., Inc. instruments should be shipped prepaid in the original packing carton. Upon request, a new carton can be obtained from the John Fluke Mfg. Co., Please include the instrument model number when requesting a new container.

2-7. RACK MOUNTING PROCEDURES

2-8. Accessory kits are available to provide for installation of the instrument in rack or sliding mounts.

2-9. To install the rack mounting ears (MEE-7003), perform the following steps in conjunction with Figure 2-1.

- a. Remove the four molded feet and the bail from the bottom cover.
- b. Remove the nameplate decals from the corner castings.
- c. Remove the screws from the corner castings that match the hole pattern in the rack mounting ears.
- d. Attach the rack mounting ears with pan head screws.

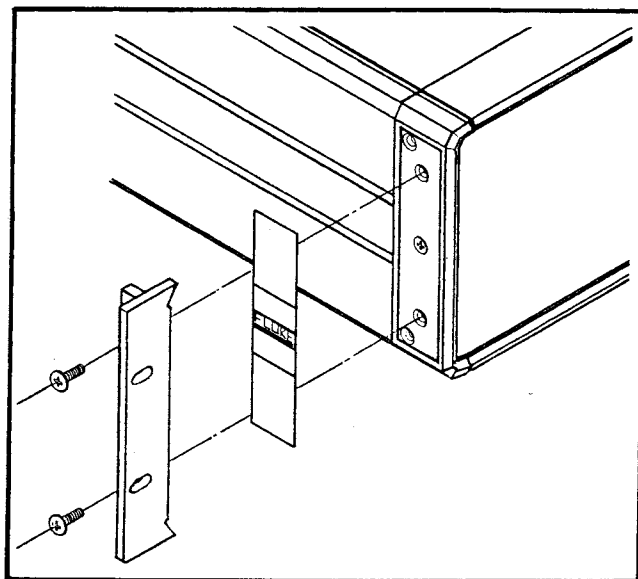


Figure 2-1. INSTALLATION OF RACK MOUNTING EARS

2-10. Perform the following steps to install the slide mounts (MEE-8078). Refer to Figure 2-2.

- a. Remove the plastic trim strips (A) from the side of the instrument by sliding it towards the rear.
- b. Attach the chassis section (B) of the slide and spacer strip (C) to the instrument using the center low mounting holes.
- c. Install cabinet section (E) and center section (D) of slide into rack. The extension angle bracket is provided.
- d. Extend center section (D) of slide towards you until it locks in the extended position.
- e. Depress the spring lock on chassis section (B) and insert the instrument between the extended slide sections.

- a. Ensure that the line cord is disconnected from line power and then remove the top and bottom dust covers.
- b. Remove the jumpers between terminals 1 and 2, 3 and 4, or 2 and 3 of the input power transformer located on the bottom of the instrument. A decal located on the top of the transformer indicates location of the terminals. Refer to the illustrated parts list for location of the input power transformer.

- c. Make the following connections between the appropriate terminals of the power transformer:

115 VOLTS AC	230 VOLTS AC
Terminals 1 and 2	Terminals 2 and 3
Terminals 3 and 4	

- d. Replace the dust covers and install the following rated fuse in the rear panel fuseholder, F2:

115 VOLTS AC	230 VOLTS AC
3A, SLO-BLO	1.5A, SLO-BLO

2-11. INPUT POWER

2-12. The Model 3330B can be operated from either a 115 or 230 volt ac input. To convert from 115 to 230 VAC or vice versa, perform the following steps:

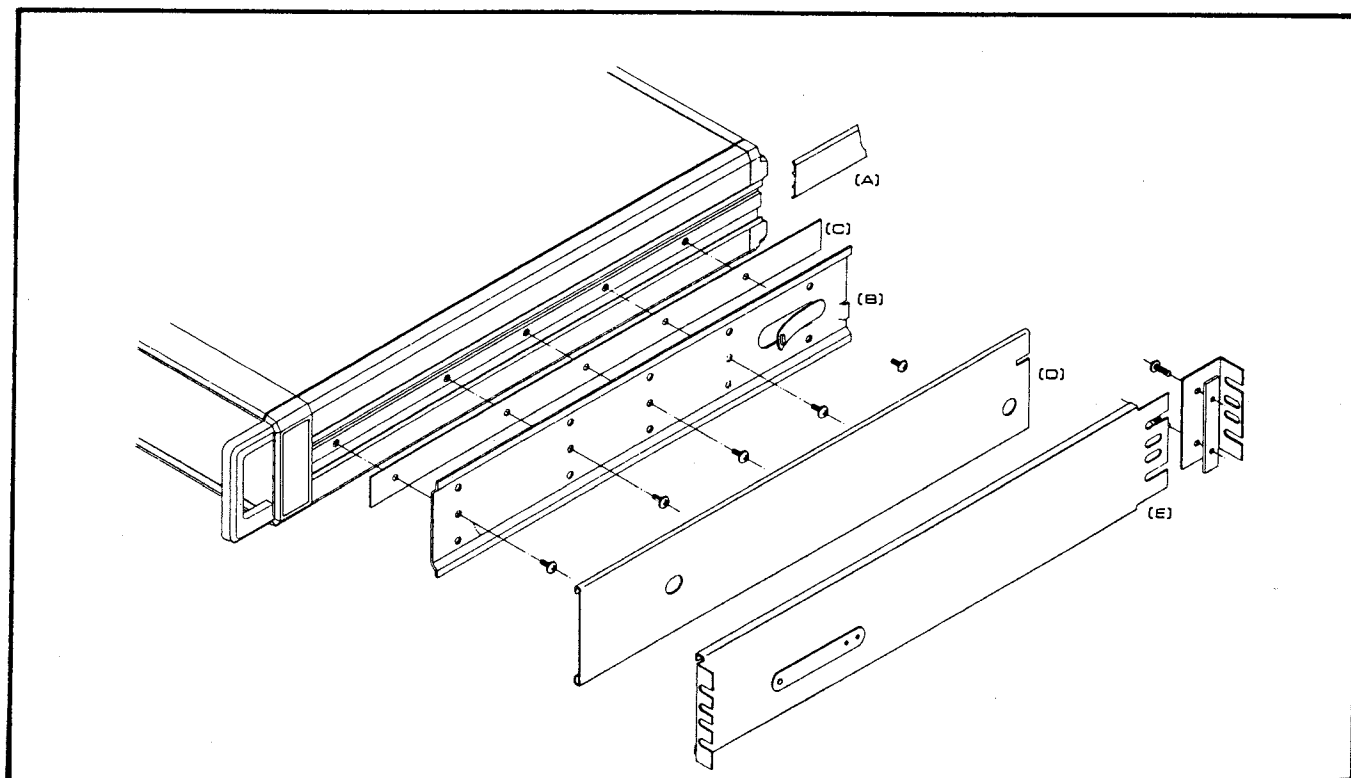


Figure 2-2. INSTALLATION OF SLIDE MOUNT

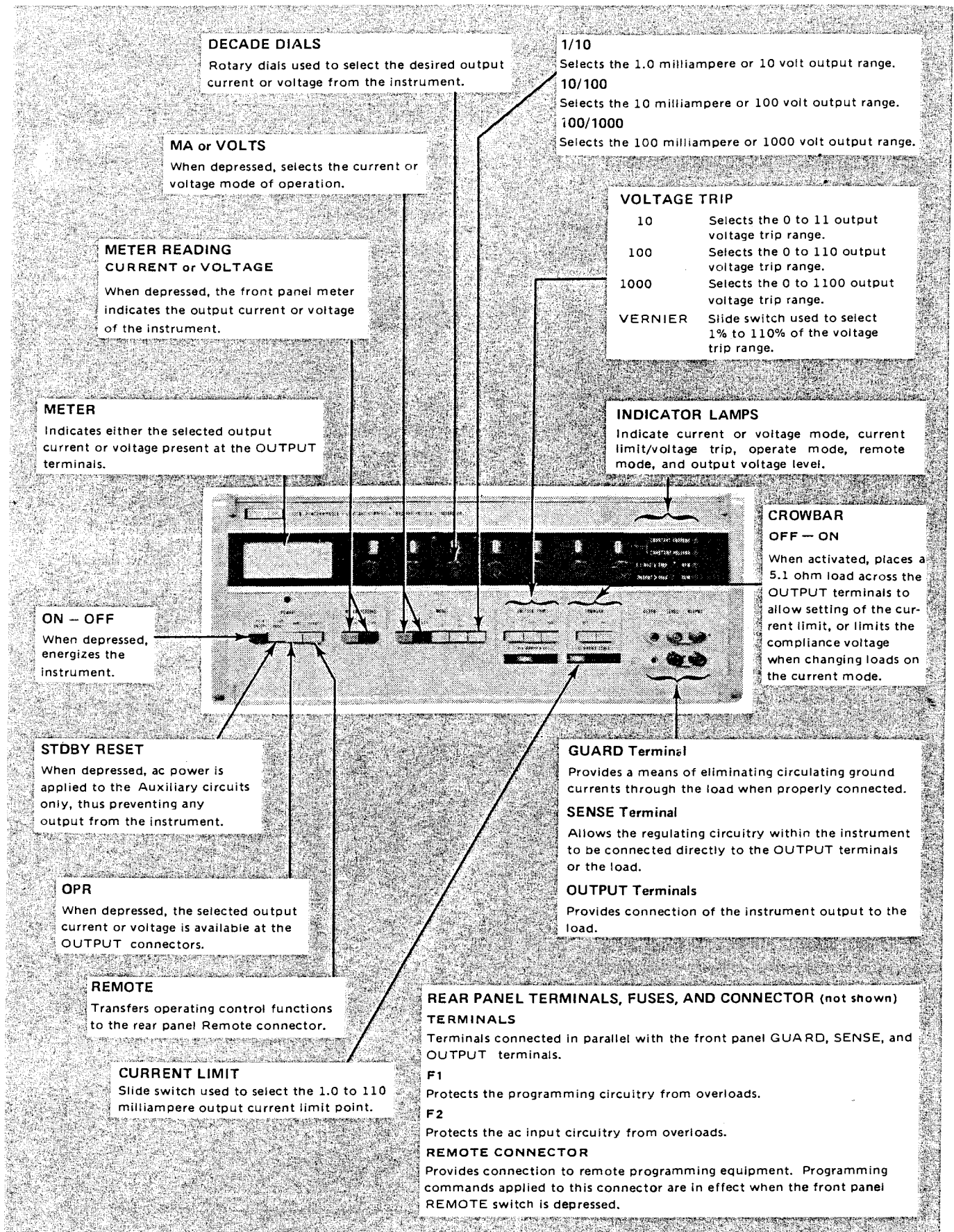


Figure 2-3. LOCATION OF CONTROLS, TERMINALS, AND INDICATORS

13. OPERATING FEATURES

14. Location and function of all controls, terminals, indicators, fuses, and connectors are contained in Figure 1-3.

2-15. PRELIMINARY PROCEDURES

2-16. The following paragraphs describe preliminary equipment connections, control settings, and safety precautions which should be taken before attempting to operate the Model 3330B.

2-17. AC Line Connection

- a. Connect the Model 3330B line cord to a 115 volt ac (230 volts ac, if so wired), 48 to 62 Hz, single phase three-wire outlet.

WARNING

Ensure that the round pin on the three-prong line cord plug is connected to a high quality earth ground.

- b. Depress the ON-OFF and STDBY RESET switches.

2-18. Sense Terminal Connections

2-19. Whenever a load is connected to the Model 3330B there may be an appreciable voltage drop between the instrument and the load due to the resistance of the connecting cable leads. The nomograph illustrated in Figure 2-4 can be used to determine the approximate voltage drop within the connecting cable. If the voltage drop is excessive for the particular application, the instrument can be connected for remote sensing using the procedure described in paragraph 2-21.

NOTE

On all voltage ranges, the remote sense leads operate at a current level which varies from 0 to 1 mA in proportion to the output voltage. Voltage drops in the sense leads are additive and appear at the output as a voltage increase.

NOTE!

The maximum allowable differential between an OUTPUT terminal and its respective SENSE terminal is ≤ 0.5 V dc.

2-20. NOMOGRAPH USE. Lay a straight edge between the point representing the output current on scale 1 and the gauge of the connecting cable on scale 2. The voltage developed across connecting cable, in millivolts per foot, is then

read on scale 3. Calculate the total voltage drop by multiplying the total connecting cable length in feet by the scale 3 value. (A 5 foot cable will have a total connection length of 10 feet).

2-21. REMOTE SENSING TERMINAL CONNECTIONS.

- a. Depress the STDBY RESET switch.
- b. Remove the shorting links between the SENSE and OUTPUT terminals.
- c. Connect the + and - SENSE terminals to the respective positive and negative sides of the load. Use a twisted pair of insulated wires between the SENSE terminals and the load.

CAUTION

Ensure that the SENSE terminals are connected in proper polarity to the load or a loss in regulation or even damage to the Model 3330B may occur. IF THIS REMOTE SENSING FEATURE IS NOT USED, THE SENSE TERMINALS MUST BE CONNECTED TO THE OUTPUT TERMINALS WITH THE SHORTING LINKS.

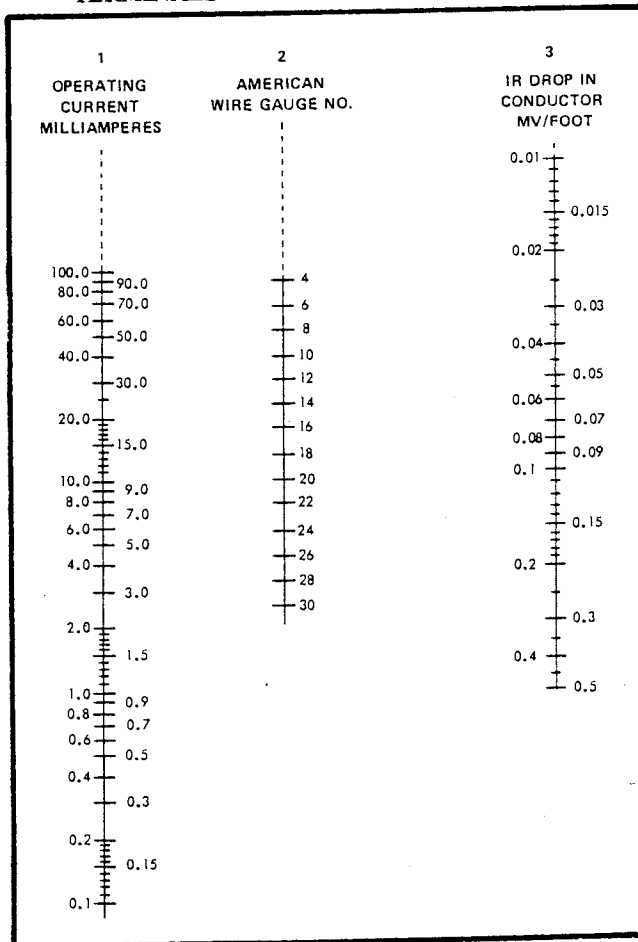


Figure 2-4. NOMOGRAPH OF VOLTAGE DROP ACROSS LOAD WIRES

2-22. Guarded Measurements

2-23. **INTRODUCTION.** When using the Model 3330B significant errors may arise out of undesired conversion of common mode signals to normal mode. This instrument has a guard shield that functions to minimize common mode-to-normal mode conversion. The following paragraphs describe errors that may arise out of common mode problems and provide a means to reduce them.

2-24. COMMON MODE REJECTION RATIO (CMRR)

In non-guarded applications, a path for undesired common mode signals is created by the stray capacitance C_1 (Figure 2-5) representing the circuitry-to-case capacitance in the instrument. This capacitance enables frequency dependent currents to appear in the connecting leads between the instrument and load, and in the instrument circuitry itself.

2-25. The guard shield provides a means of making the circuitry-to-case capacitance very small, thereby reducing common mode currents. This is done by placing a shield, or guard, between the circuitry and case. Addition of the guard results essentially in two things; it provides a separate path for common mode signals, and it effectively prevents the introduction of common mode errors in the circuitry itself. Where common mode signals previously had a path through C_1 into the circuitry and connecting leads and through R_s , insertion of the guard now provides a separate path through C_3 and into the guard lead. In addition, the circuitry-to-case capacitance is significantly reduced, and the CMRR of the instrument is greatly enhanced.

2-26. **SUGGESTIONS FOR USING THE GUARD.** Under most applications it is satisfactory to strap the front panel GUARD to the ground terminal of the load. In applications where common mode signals are of no concern, the GUARD may be connected to the \perp (ground) terminal.

2-27. Voltage Trip Settings

2-28. The VOLTAGE TRIP switch and VERNIER controls provide protection for external equipment by limiting the maximum allowable output voltage to the external load. The range of voltage limiting is selected with the VOLTAGE TRIP switches. Refinement of the value of the voltage to be limited is accomplished with the VERNIER control.

- a. Without any load connected to the OUTPUT terminals, depress the STDBY/RESET switch and set the front-panel controls to the following positions:

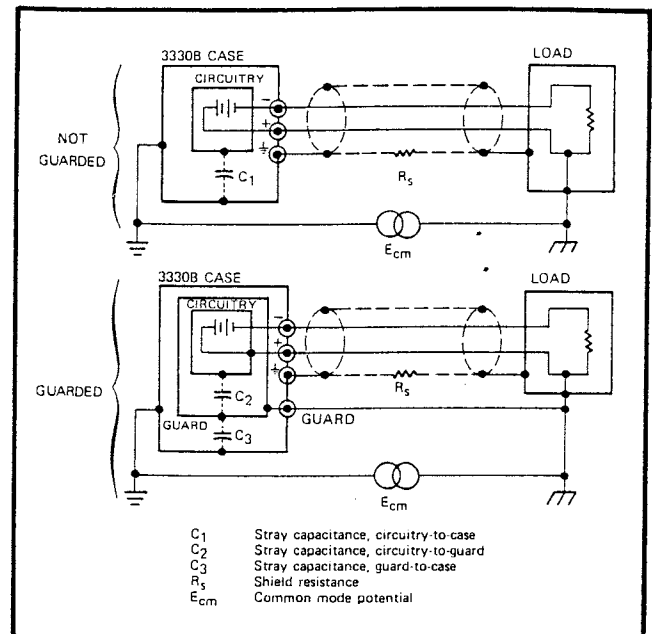


Figure 2-5. GUARDED LOAD CONNECTIONS

MODE	Desired voltage range
VOLTAGE TRIP	To the lowest voltage range that overlaps the desired trip voltage.
VERNIER	HI
CURRENT LIMIT	As desired
METER	VOLTAGE
Decade Dials	Desired trip voltage

- b. Depress the OPR switch.
- c. Slowly slide the VERNIER control to the left until the 1 LIMIT/V TRIP indicator illuminates and the OPR lamp extinguishes. The voltage trip is now set to the value indicated on the Decade Dials, and the instrument is tripped to the STDBY mode.
- d. To reset the instrument, set the Decade Dials to a value less than the trip voltage, depress the STDBY/RESET switch, and then depress the OPR switch.

2-29. Current Limit Settings

2-30. The CURRENT LIMIT control provides a means of limiting the amount of output current applied to the load. If limiting within the output current range of the instrument is not desirable, set the CURRENT LIMIT control to HI. Should some degree of current limiting be desirable, proceed as follows:

- a. Depress the STDBY RESET switch, and set the front panel controls to the following positions:

MODE	Desired current (MA) range
VOLTAGE TRIP	As desired. However, must be >10V for full scale output current. To set a precise level, use the voltage trip setting procedure, given earlier, and set the Decade Dials to:

Output Current
Output Current Range + desired voltage trip level

For example, at full scale current output, a precise 5V trip level is established by setting the Decade Dials to 15.

CURRENT LIMIT LO
METER CURRENT
Decade Dials As required

Depress the CROWBAR ON and OPR switches.

Slide the CURRENT LIMIT control to the right until the desired maximum output current is indicated on the front panel meter.

Depress the STDBY RESET switch and then depress the CROWBAR OFF switch. Current limiting is now set to the desired value for any output setting of the instrument.

1. FRONT PANEL OPERATING PROCEDURES.

2. The Model 3330B can be operated as a voltage current source by performing the following steps:

Depress the ON-OFF and STDBY RESET switches. Allow the instrument circuitry to stabilize for at least 10 minutes if it has not been previously energized.

Connect the SENSE terminals to the OUTPUT terminals using the shorting links provided with the instrument.

Set the Current Limit and Voltage Trip to the desired values using the procedures described in paragraphs 2-27 and 2-29.

Depress the STDBY/RESET switch and select the desired current or voltage range with the MODE switches.

Set the Decade Dials to the desired output current or voltage value.

Connect the load to the OUTPUT terminals. If remote sensing is desired, connect the SENSE terminals to the load using the procedures described

in paragraph 2-21. GUARD terminal connections are described in paragraph 2-22.

WARNING

The Model 3330B has a compliance voltage capability of 1100 volts dc. Always connect the load with the instrument in STDBY/RESET.

- g. Depress the OPR switch to energize the load. The output current or voltage can be monitored at any time on the front panel meter by depressing the appropriate METER READING switch.

2-33. REMOTE OPERATION

2-34. Remote programming of the Model 3330B is possible through the rear panel Remote connector using either DTL/TTL logic and 8-4-2-1 coding or contact closures. A mating connector for the remote connector is furnished with the instrument to provide the necessary circuit interface. Table 2-1 contains a list of the Remote connector terminals and their functions. Coding information is located in Section 1, Table 1-1.

Table 2-1. REMOTE CONNECTOR TERMINALS AND FUNCTIONS (Sheet 1 of 2)

TERMINAL	FUNCTION
1	1 - Highest Order Decade
2	2 - Highest Order Decade
3	4 - Highest Order Decade
4	8 - Highest Order Decade
5	1 - Second Order Decade
6	2 - Second Order Decade
7	4 - Second Order Decade
8	8 - Second Order Decade
9	1 - Third Order Decade
10	2 - Third Order Decade
11	4 - Third Order Decade
12	8 - Third Order Decade
13	1 - Fourth Order Decade
14	2 - Fourth Order Decade
15	4 - Fourth Order Decade
16	8 - Fourth Order Decade
17	1 - Fifth Order Decade
18	2 - Fifth Order Decade
19	4 - Fifth Order Decade
20	8 - Fifth Order Decade
21	1 - Sixth Order Decade
22	2 - Sixth Order Decade
23	4 - Sixth Order Decade
24	8 - Sixth Order Decade

Table 2-1. REMOTE CONNECTOR TERMINALS AND FUNCTIONS (Sheet 2 of 2)

TERMINAL	FUNCTION
25	1 – Seventh Order Decade
26	2 – Seventh Order Decade
27	4 – Seventh Order Decade
28	8 – Seventh Order Decade
29	Logic "0" – 10V/1 MA Range Logic "1" – 100V/10 MA Range
30	Logic "0" – Voltage Mode Logic "1" – Current Mode
31	Logic "0" – 10V/1 MA or 100V/10 MA Range Logic "1" – 1000V/100MA Range
32	
33	Logic "0" – Standby Mode Logic "1" – Operate Mode
34	Logic "0" – Crowbar Mode Off Logic "1" – Crowbar Mode On
35	Logic "0" – Positive Polarity Output Logic "1" – Negative Polarity Output
36	Program Common
37	'Operate' Flag
38	Logic "0" – Front Panel Voltage Trip and Current Limiter Control Logic "1" – Remote Voltage Trip and Current Limiter Control
39	1 – 10% Voltage Trip Vernier
40	2 – 20% Voltage Trip Vernier
41	4 – 40% Voltage Trip Vernier
42	8 – 80% Voltage Trip Vernier
43	8 – 80% – Current Limit Vernier
44	4 – 40% – Current Limit Vernier
45	2 – 20% – Current Limit Vernier
46	1 – 10% – Current Limit Vernier
47	1 KV Voltage Trip Range
48	100V Voltage Trip Range
49	Current Limit Flag
50	Voltage Trip Flag

2-35. Activation of the remote control feature is accomplished by first energizing the instrument while in STDBY RESET or by selecting STDBY RESET, and then selecting the REMOTE mode of operation. Control is then transferred to the rear Panel Remote connector where either transistor logic level programming or contact closures can

be used to control the operating modes of the instrument. Logic "1" is 0 to 0.5 volts dc or a short circuit, and Logic "0" is +4.5 to 20 volts dc or an open circuit. Short circuit current to programming common is less than 4.0 milliamperes. Open circuit voltage is 4 to 6 volts dc.

2-36. Excessive output level changes will result in triggering of the Voltage Trip circuitry, especially on the 1000 volt range. In this event the 3330B must be manually reset using the STDBY RESET Switch. Safe programming rates are listed below. Figure 1-1 located in Section 1 shows recommended 1000V range programming rates below 1000 volts.

a. 1000 volt range 1 programming change every 5 seconds for 1000 volt change.

All current ranges: 1 programming change every 5 seconds for a 1000V change.

2-37. Accuracy of the Model 3330B output is also affected by the magnitude of the programming changes. Figure 2-6 shows typical output accuracies in relation to 1/10th to full-scale voltage changes.

2-38. PROGRAMMING NOTES

2-39. Introduction

2-40. Successful programming of the 3330B calibrator requires knowledge of the timing involved and an awareness of control line definitions. The following paragraphs contain notes which will be of value in programming, plus timing information for proper instrument control.

2-41. Decade Dials

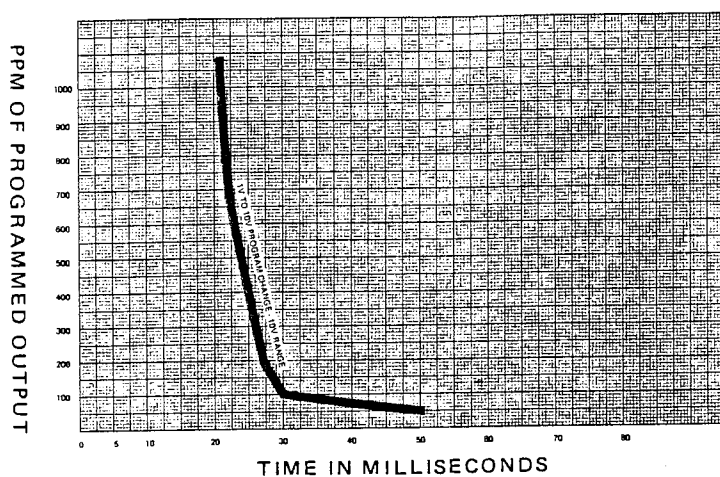
2-42. Programming of each Decade Dial is accomplished using 8-4-2-1 coding. The maximum digit that can be programmed on each decade is 10, using a "1010" code. Maximum remote controlled output is 111.11110 milliamperes and 1111.1110 volts dc.

2-43. Polarity

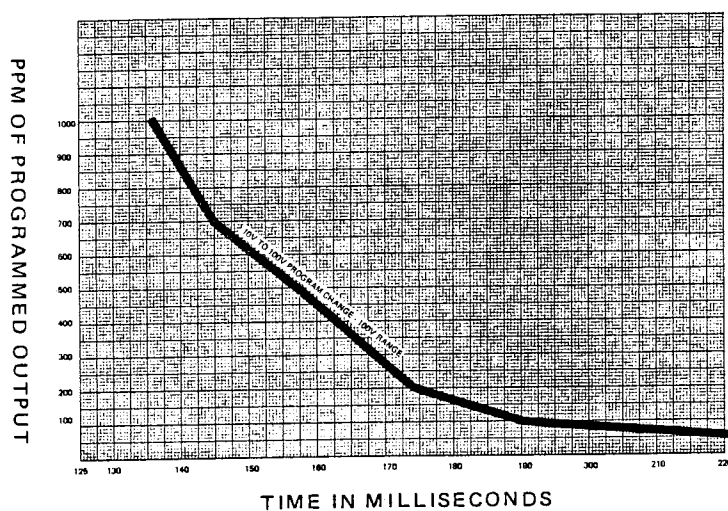
2-44. A Logic "1" applied to the proper programming terminal will reverse the output polarity at both the front and rear terminals of the instrument.

2-45. Voltage/Current Limit Vernier

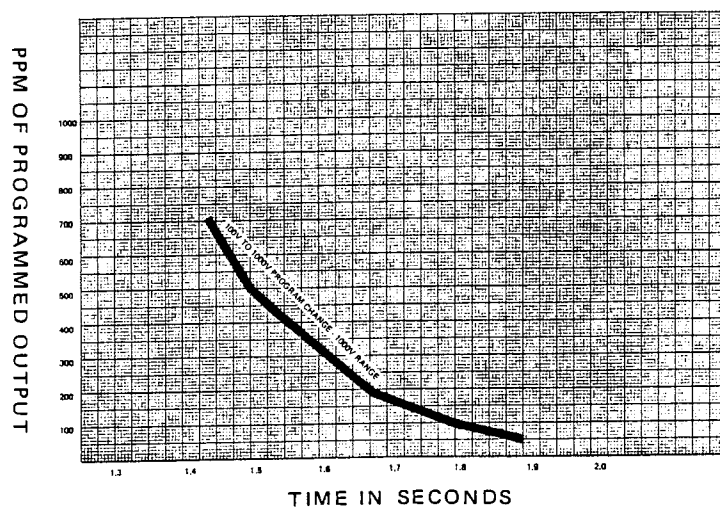
2-46. Programming of the Voltage or Current Vernier is accomplished using 8-4-2-1 coding. The minimum



OUTPUT ACCURACY FOR A 1V TO 10V PROGRAM CHANGE — 10V RANGE



OUTPUT ACCURACY FOR A 10V TO 100V PROGRAM CHANGE — 100V RANGE



OUTPUT ACCURACY FOR A 100V TO 1000V PROGRAM CHANGE — 1000V RANGE

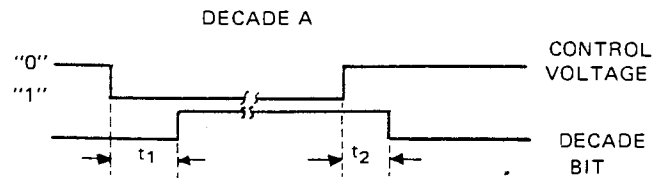
Figure 2-6. OUTPUT ACCURACY VERSUS PROGRAM CHANGE TIME

DECADE PULL-IN TIME: THE PERIOD REQUIRED TO ELECTRICALLY ADD A DECADE BIT TO THE CIRCUITRY AFTER THE PARTICULAR BIT HAS BEEN ACTIVATED BY AN EXTERNAL CONTROL VOLTAGE.

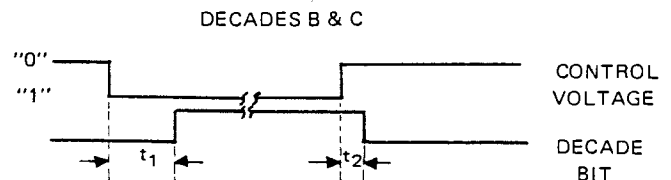
DECADE A	- 15 MS
DECADE B & C	- 10 MS
DECADE D-G	- 2 MS

DECADE DROP-OUT TIME: THE PERIOD REQUIRED TO ELECTRICALLY DROP A PARTICULAR DECADE BIT FROM THE CIRCUITRY AFTER REMOVING ITS EXTERNAL CONTROL VOLTAGE.

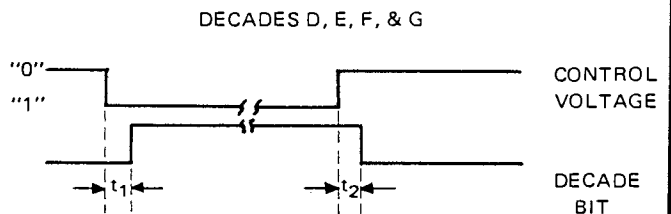
DECADE A	- 12 MS
DECADE B & C	- 3 MS
DECADE D-G	- 3 MS



PULL-IN TIME (t_1) = 15 ms TYPICALLY
DROP-OUT TIME (t_2) = 12 ms TYPICALLY



PULL-IN TIME (t_1) = 10 ms TYPICALLY
DROP-OUT TIME (t_2) = 3 ms TYPICALLY



PULL-IN TIME (t_1) = 2 ms TYPICALLY
DROP-OUT TIME (t_2) = 3 ms TYPICALLY

SETTLING TIME: THE TOTAL TIME REQUIRED FOR THE INSTRUMENT TO SETTLE TO ITS RATED ACCURACY WITHIN A PARTICULAR RANGE AND MODE OF OPERATION.

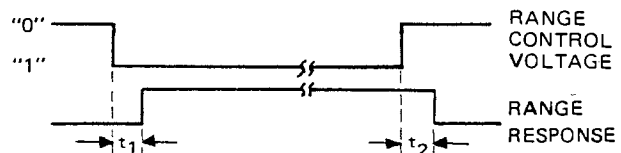
VOLTAGE MODE:

10V RANGE	- 60 MS
100V RANGE	- 300 MS
1000V RANGE	- 3 SEC.

CURRENT MODE:

1 MA RANGE	- 300 MS
10 MA RANGE	- 300 MS
100 MA RANGE	- 300 MS

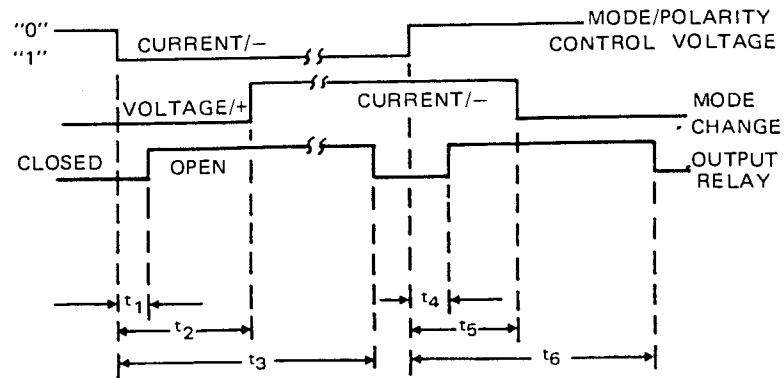
RANGE CHANGE TIME: THE PERIOD OF TIME BETWEEN APPLICATION OF AN EXTERNAL RANGE CONTROL VOLTAGE AND WHEN THE PARTICULAR RANGE IS ADDED ELECTRICALLY TO THE CIRCUIT (10ms).



PULL-IN TIME (t_1) = 15 ms TYPICALLY
DROP-OUT TIME (t_2) = 5 ms TYPICALLY

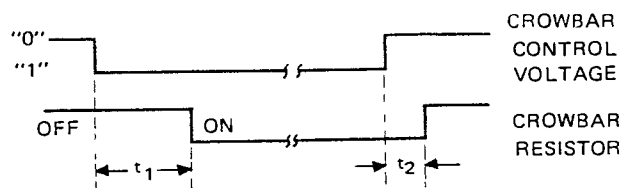
Figure 2-7. TIMING INFORMATION (Sheet 1 of 3)

POLARITY AND MODE CHANGE TIME: THE PERIOD OF TIME BETWEEN APPLICATION OF AN EXTERNAL CONTROL VOLTAGE AND WHEN THE OUTPUT RELAY CONTACTS REMOVE THE SHORT ACROSS THE OUTPUT TERMINALS. (See Crowbar Time) (130 ms).



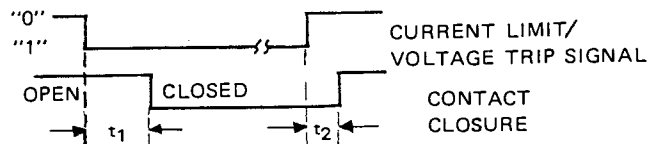
PULL-IN TIME (t_2) = 45 ms TYPICALLY
 PULL-IN TIME (t_3) = 100 ms TYPICALLY
 PULL-IN TIME (t_6) = 80 ms TYPICALLY
 DROP-OUT TIME (t_1) = 10 ms TYPICALLY
 DROP-OUT TIME (t_4) = 10 ms TYPICALLY
 DROP-OUT TIME (t_5) = 50 ms TYPICALLY

CROWBAR TIME: THE PERIOD BETWEEN APPLICATION OF AN EXTERNAL CONTROL VOLTAGE AND WHEN THE CROWBAR RESISTOR APPEARS ELECTRICALLY ACROSS THE OUTPUT TERMINALS (15 ms).



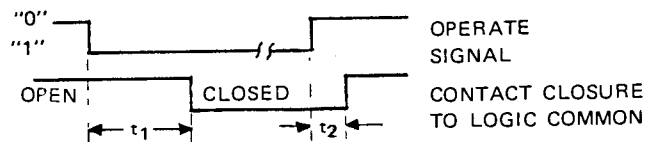
PULL-IN TIME (t_1) = 15 ms TYPICALLY
 DROP-OUT TIME (t_2) = 5 ms TYPICALLY

CURRENT LIMIT AND VOLTAGE TRIP FLAG TIME: THE PERIOD BETWEEN THE OVER-CURRENT OR OVER-VOLTAGE CONDITION AND A CONTACT CLOSURE TO LOGIC COMMON AT THE PROGRAMMING CONNECTOR. (2 ms).



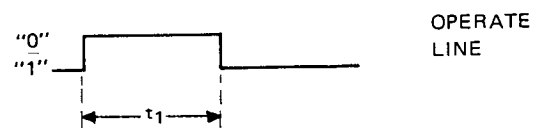
PULL-IN TIME (t_1) = 2 ms TYPICALLY
 DROP-OUT TIME (t_2) = 1 ms TYPICALLY

OPERATE FLAG TIME: THE PERIOD OF TIME BETWEEN DEPRESSION OF THE OPERATE SWITCH AND A CONTACT CLOSURE TO COMMON AT THE PROGRAMMING CONNECTOR. (15 ms).



PULL-IN TIME (t_1) = 15 ms MAXIMUM
 DROP-OUT TIME (t_2) = 5 ms TYPICALLY

RESET TIME: THE PERIOD OF TIME THE "OPERATE" LINE MUST BE HELD AT LOGIC "O" IN ORDER TO ELECTRICALLY RESET THE INSTRUMENT. (10 ms). (Refer to "NOTE" of paragraph 2-54).



MINIMUM RESET TIME (t_1) = 10 ms TYPICALLY

Figure 2-7. TIMING INFORMATION (Sheet 2 of 3)

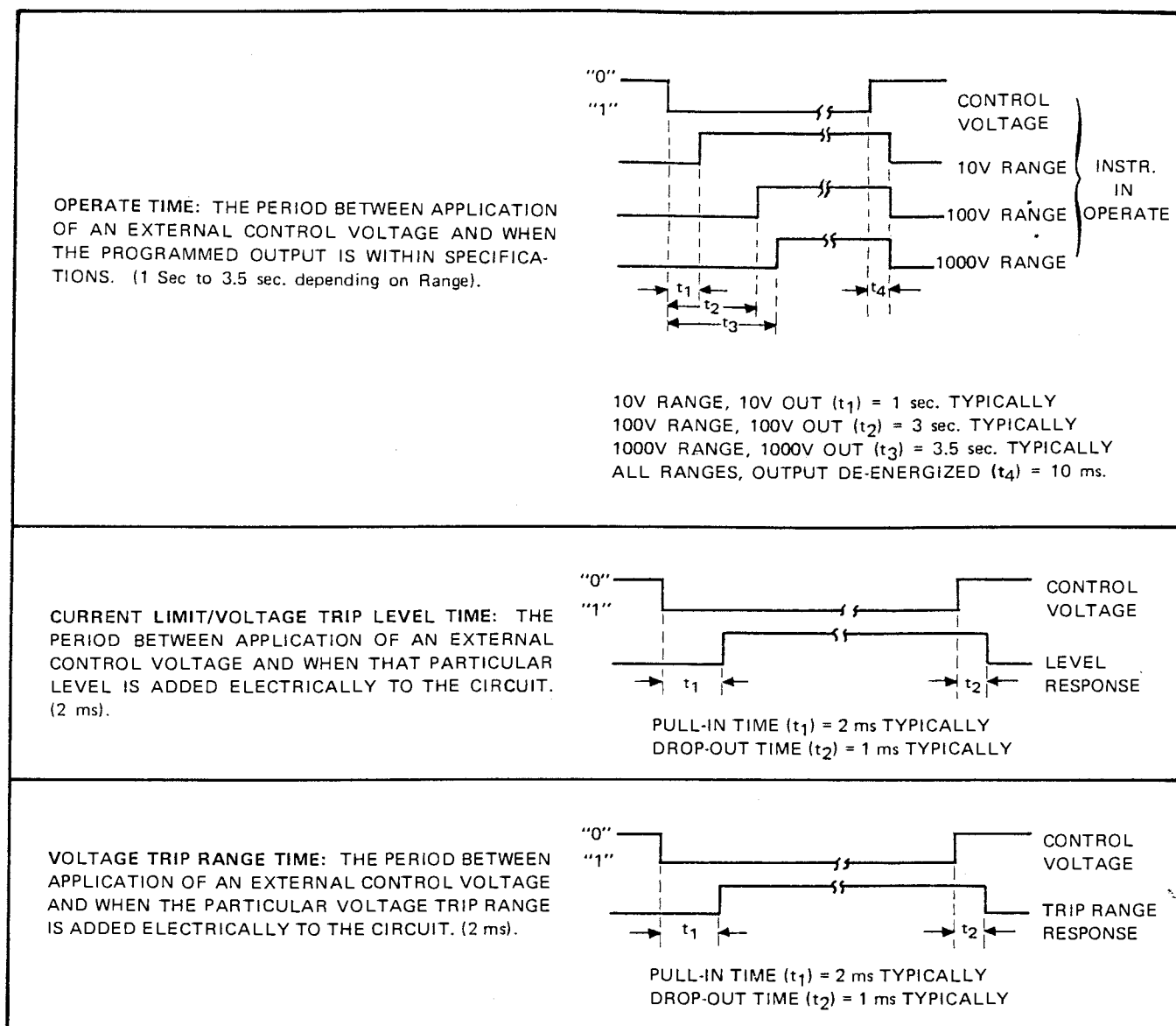


Figure 2-7. TIMING INFORMATION (Sheet 3 of 3)

vernier voltage or current limit value that can be programmed is 10% of the selected range using a "0001" code. Maximum vernier limit value is 110% of the selected range using a "1011" code.

2-47. Voltage Trip Range

2-48. Programming of the Voltage Trip Range may be accomplished by applying Logic "1" to the proper programming terminals. The Voltage Trip is normally in the 10V range with program lines at Logic "0". Whenever the Voltage Trip Feature is triggered, the instrument is automatically tripped to the STDBY/RESET mode. Logic "0" must then be applied to terminal 33, followed by Logic "1" to return the instrument to OPERATE. Refer to paragraph 2-54 for resetting information.

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2-49. Flag Indicator Outputs

2-50. Isolated flag indicator outputs are available at the Remote connector to provide an indication of the Operate/Voltage Trip, or Current Limit modes of operation. Terminal 50 is the Voltage Trip Flag, terminal 49 is the Current Limit Flag, and terminal 37 is the Operate Flag. If a polarity or mode change is programmed, a standby state will be indicated for approximately 100 milliseconds. Each flag is a contact closure to terminal 36, Program Common.

2-51. Timing Information

2-52. Figure 2-7 contains timing definitions and waveforms which will be of assistance in programming the Model

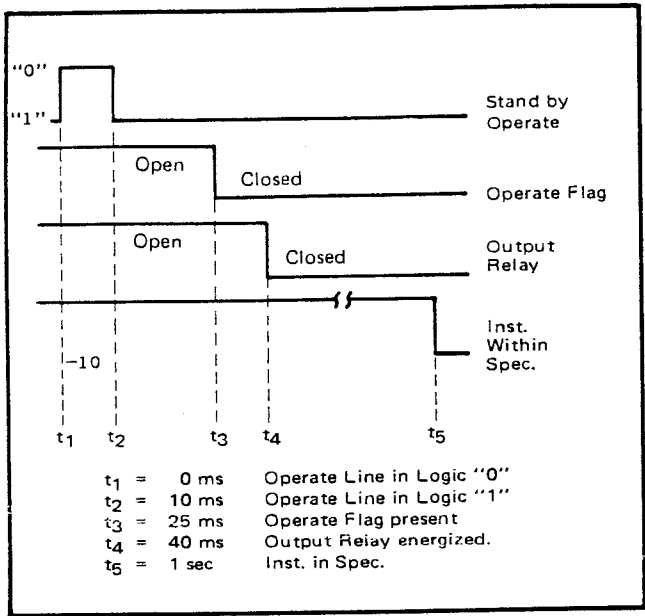


Figure 2-8. TYPICAL RESET ON 10V RANGE

3330B. Pay particular attention also to the special operating considerations outlined in paragraph 2-53.

2-53. Special Operating Conditions

2-54. RESETTING. The operate line must be held in a Logic "0" state for a minimum of 10 ms before Logic "1" may be applied. Actual resetting is accomplished as soon as the operate line is returned to Logic "0". When a Logic "1" is applied, the output becomes energized.

NOTE

Resetting is not possible for a period of five seconds if the instrument is in a voltage trip condition due to excessive application of the automatic crowbar. Refer to paragraphs 3-70 and 3-74.

2-55. CURRENT MODE. When switching from low to high compliance voltages, programming speeds must be slower. This applies when using compliance voltages in excess of 200 volts; programming rates should not exceed the times shown in Figure 1-1, Section I.

2-56. VOLTAGE MODE. Range or programming changes within the 1 kv range must be made at rates within the times shown in Figure 1-1; this applies when output voltages are greater than 200 volts.

2-57. CURRENT LIMIT/VOLTAGE TRIP FLAGS. The current and voltage flags will not be enabled and consequently cannot be present at the programming connector until approximately 40 ms after the instrument is in the operate mode. Also, there will be an absence of both flags for approximately 100 ms during either a mode or polarity change, due to the instrument being placed in standby during this time.

2-58. OPERATE FLAG. A contact closure to program common will be present approximately 15 ms after the instrument is commanded to the operate mode. The output relay does not energize for another 15 ms; see Figure 2-8. During a polarity or mode change, the output relay will open for 100 ms and then close.

2-59. VOLTAGE TRIP RANGE. When programming the Output Voltage and Voltage Trip range from some high level to a low level, it must be remembered that the Voltage Trip Range time is much less than the Output Voltage settling time. If both are programmed down simultaneously, the instrument will trip into the Voltage Trip mode. Allow sufficient time after programming the output from a high level to a low level before programming the Voltage Trip Range from a high level to a low level. In a worst-case application, with the instrument operating on the 1000 volt range, if all the decades are

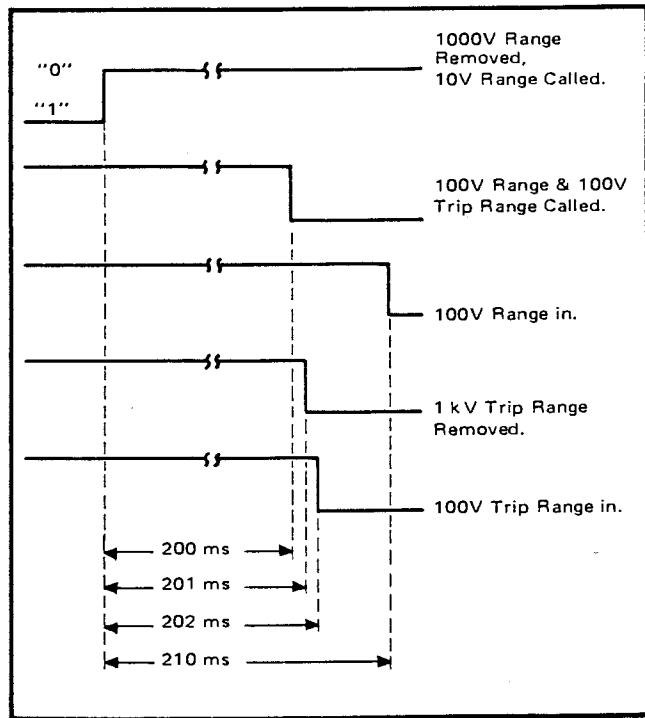


Figure 2-9. 1 KV to 100V TRIP TIMING

programmed to zero, allow 3 seconds before programming the Voltage Trip Range to a lower range.

2-60. To program the Voltage Trip Range from the 1000V range to the 100V range, first down-range the instruments' output to the 10V range. Then, 200 ms after the instrument has been down-ranged, program the 100V range and the 100V Voltage Trip Range simultaneously. Refer to Figure 2-9.

2-61. Operating Examples

2-62. The use of an output crowbar when using the current mode is normal procedure, since the crowbar is used when changing loads in the current mode. As pointed out in Figure 2-7, 15 ms is required before the crowbar actuates. Therefore, 15 ms of time is required before removing or changing loads. If this procedure is not followed, the instrument will slew up to the voltage trip point.



Section 3

Theory of Operation

3-1. INTRODUCTION

3-2. This section of the manual contains the theory of operation for the Model 3330B. The information is arranged under headings of "ASSEMBLY NUMBERING SYSTEM, FUNDAMENTAL CIRCUIT DESCRIPTION, GENERAL CIRCUIT ANALYSIS, and CIRCUIT DESCRIPTIONS". An equivalent circuit of the instrument is illustrated in Figure 3-2. A system block diagram and schematic diagrams are located in Section 8 of the manual.

3-3. ASSEMBLY NUMBERING SYSTEM.

3-4. General

3-5. The following assembly numbering system has been employed in the Model 3330B to identify specific assemblies and their electrical components.

3-6. Assembly Reference Designations.

3-7. The Model 3330B is divided into major parent assemblies designated the letter number A1 through A7. These assemblies and their respective titles are:

A1	Front Panel
A2	Rear Panel
A3	Front Mother Board
A4	Main Mother Board
A5	Rear Mother Board
A6	Relay Board
A7	Inner Chassis

3-8. Assemblies contained within major assemblies are also identified by a letter number designation. For example,

the Chopper Amplifier located on the A4 Main Mother Board has been assigned the letter number A2. Complete identification of this assembly is A4A2.

3-9. Components located on each assembly are designated the appropriate letter number Q1, C1, R1, etc. For example, the MOS FET transistor on the Chopper Amplifier is designated the letter number Q1. Complete identification of a component is then possible by preceding its reference designation by the assembly designation. In the preceding example, Q1 is completely identified by the designation A4A2Q1.

3-10. Assembly Identifiers

3-11. During the manufacturing processes, assembly identifiers have been assigned to the completed printed circuit boards. A printed circuit board may be identified by a 3000 series number that is silk-screened on the land pattern side of the assembly, or by a six-digit FLUKE part number located on the component side.

3-12. Schematic Diagram Identifiers

3-13. Figure 3-1 contains a chart which lists all of the diagrams associated with this instrument. These diagrams are located at the rear of the manual.

3-14. FUNDAMENTAL CIRCUIT DESCRIPTION.

3-15. The circuitry of the Model 3330B consists basically of a high-gain operational amplifier such as the one shown in Figure 3-2. A precision reference voltage fur-

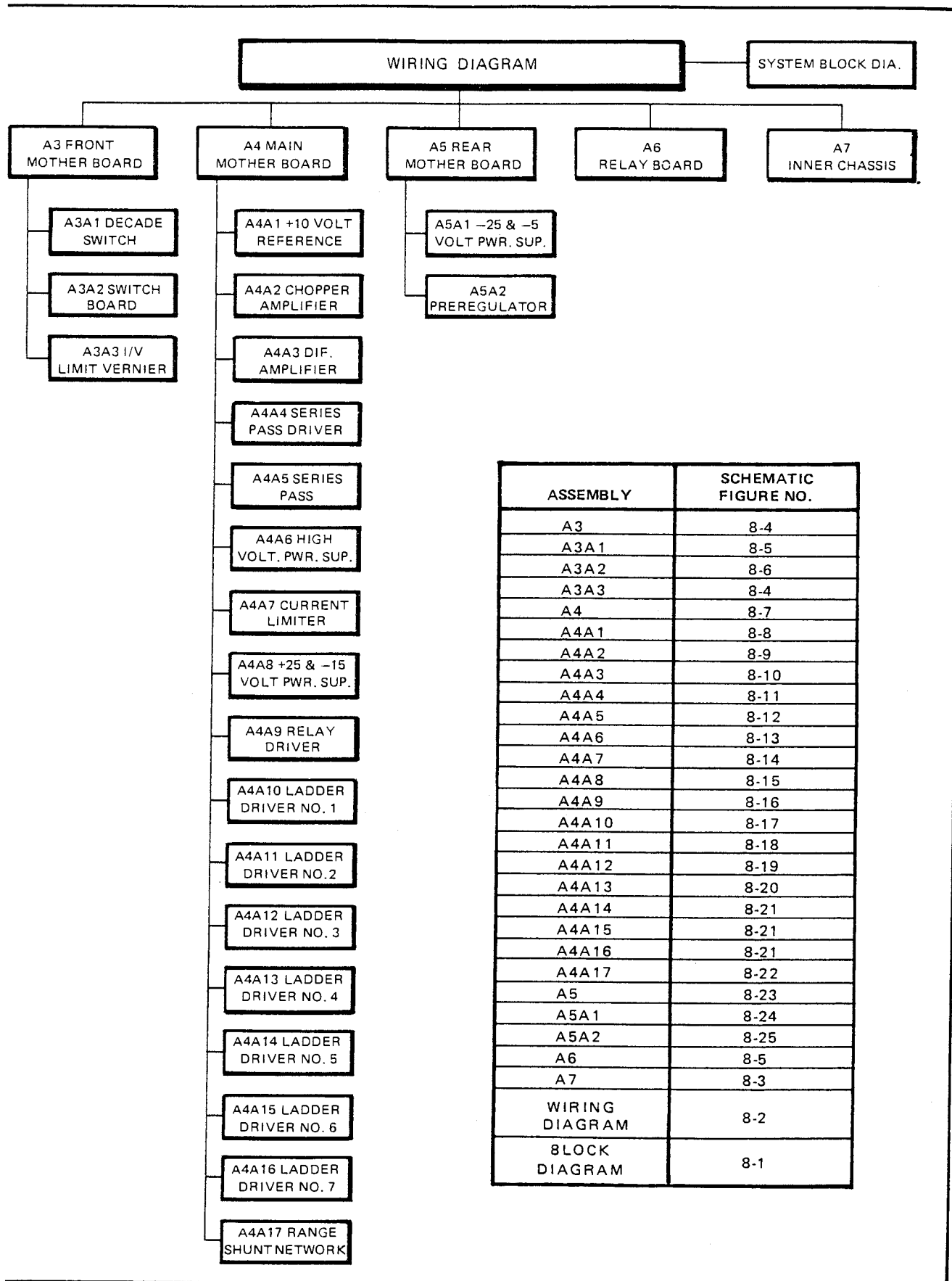


Figure 3-1. MODEL 3330B DIAGRAMS

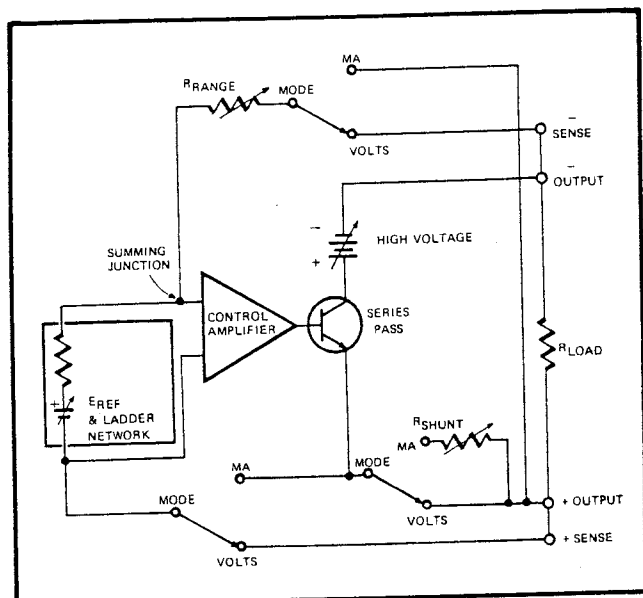


Figure 3-2. BASIC INSTRUMENT CIRCUITRY
(DRAWN WITHOUT THE PREREGULATION LOOP)

nished by the reference supply and ladder network provides a current through the range resistor equal to the dialed output. The voltage developed across the range resistor furnishes a signal to the control amplifier that determines the rate of conduction of the series pass element. The conduction level of the series pass element then establishes the appropriate output voltage or current.

3-16. Two major loops actually form the instrument circuitry. One loop consists of an ac pre-regulator and the other is the main dc regulator. Each of these loops is described separately in the following paragraphs.

3-17. Voltage Mode

3-18. **PRE-REGULATOR.** This loop consists of the Pre-regulator and the Voltage Controlled Oscillator (VCO) shown in Figure 3-3. The VCO samples the voltage present across the series pass element and supplies pulsed timing information related to the load power requirement. These pulses are synchronized to the start of the line frequency cycle and are applied to the pre-regulator. The pre-regulator then initiates line current flow to the high voltage supply in only the amount necessary to meet the actual load requirement, thereby improving the efficiency of the instrument.

3-19. **MAIN REGULATOR LOOP.** The main regulator loop consists of a Reference Supply and Ladder Network, a Control Amplifier, the Series Pass Element, and a High Voltage Power Supply. The configuration is shown in

Figure 3-3 and is redrawn in bridge form for explanation in the same illustration.

3-20. The reference supply/ladder network and RSOURCE form one side of the bridge, while the series pass element/high voltage supply and R_RANGE form the other side. What the operator is doing when he dials an output voltage is to vary the Ladder Network which effectively produces a variable EREFERENCE. The current from EREFERENCE is determined by the Ladder and the effective voltage of EREF. This current passes through R_RANGE developing a voltage across it which is equal to the dialed output voltage. When the voltage across R_SOURCE equals EREF, and the voltage across E_RANGE equals E_OUT, a state of balance exists across the bridge, and there is zero potential across the inputs to the amplifier. When a new output voltage is dialed into the instrument, a state of imbalance will momentarily exist because E_OUT will no longer be equal to the voltage across R_RANGE. If, for example, the instrument is operating at 100 volts and is subsequently dialed to 500 volts, a positive error voltage will appear at the summing junction and at the input to the amplifier. This amplified positive error voltage (the control amplifier is non-inverting) is applied to the series pass element causing it to conduct harder and resulting in a lower voltage drop across it. Through the action of the series pass and the pre-regulator (mentioned later), the output voltage will rise until it equals the voltage across R_RANGE, or until the bridge is again balanced. The gain of the control amplifier is very high and provides the bulk of the regulation.

3-21. At the same time the control amplifier is causing the series pass element to increase in conduction, or, in other words, producing a lower voltage drop across the series pass, the VCO is sampling E_SERIES PASS and affecting the rest of the pre-regulator loop to increase the output of the high voltage supply.

3-22. Current Mode

3-23. **PRE-REGULATOR LOOP.** Operation of the pre-regulator loop is essentially the same in current mode as it is in voltage mode. The voltage across the series pass element is sampled by the VCO which causes the pre-regulator to supply power to the high voltage supply in the amount necessary to meet load requirements. A simplified block diagram of this mode is shown in Figure 3-4.

3-24. **MAIN REGULATOR LOOP.** The main regulator loop, like the pre-regulator loop, operates essentially the same in the current mode as in the voltage mode. The only difference is that the loop acts to maintain a constant vol-

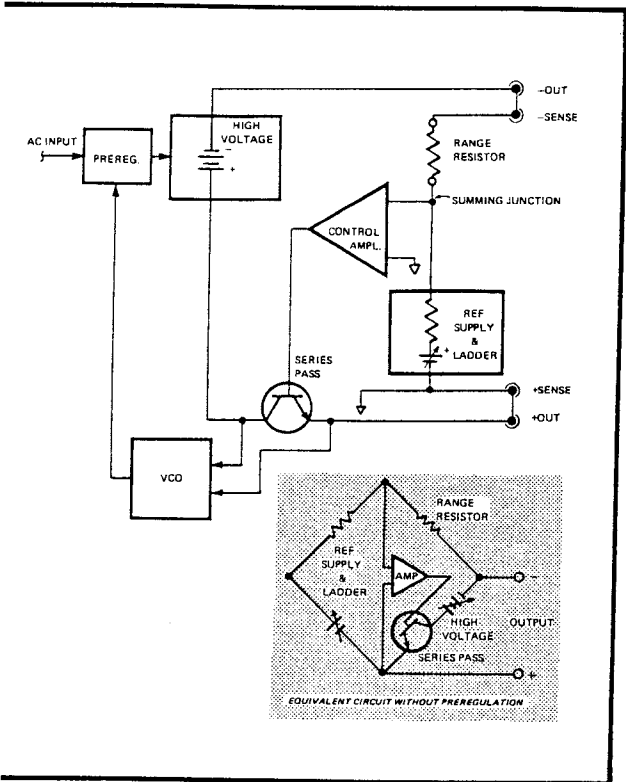


Figure 3-3. VOLTAGE MODE (SIMPLIFIED)

ge across the current shunt resistor (a precision resistor network) to ensure that a constant current is available at the output terminals. The action of the series pass element and control amplifier maintains the output current at whatever level is specified by the conditions of RANGE and the reference supply/ladder network.

3-25. GENERAL CIRCUIT ANALYSIS

3-26. This description relates primarily to the system block diagram found at the rear of the manual, Figure 8-1, and discusses the interaction of the major circuits. Some of the circuits mentioned are not represented on the block diagram, but are included to maintain continuity in the discussion.

3-27. The basic reference voltage for the instrument is the 10 volt reference supply. The supply employs a selected reference amplifier to ensure that the output reference voltage is highly stable with respect to time and temperature. The reference supply output is applied to the input of a seven deck resistive ladder network. This ladder is controlled by the seven front panel decade switches in the local mode, and by a 28 line 8-4-2-1 binary coded decimal (BCD) input in the REMOTE mode. The resulting voltage at the summing junction is applied to the input of the control amplifier, which consists of the chopper amplifier and differential amplifier. The function of the control amplifier is to control conduction of the series pass so that the resulting voltage at the summing junction approaches zero. The chopper amplifies all frequencies from dc to approximately 30 Hz; the differential amplifier is used principally for frequencies from 30 Hz to approximately 200 kHz and has a dc path for signals coming from the chopper.

3-28. The current limiter, together with the control amplifier and series pass, forms a servo loop which limits instrument output current at a present value. The current

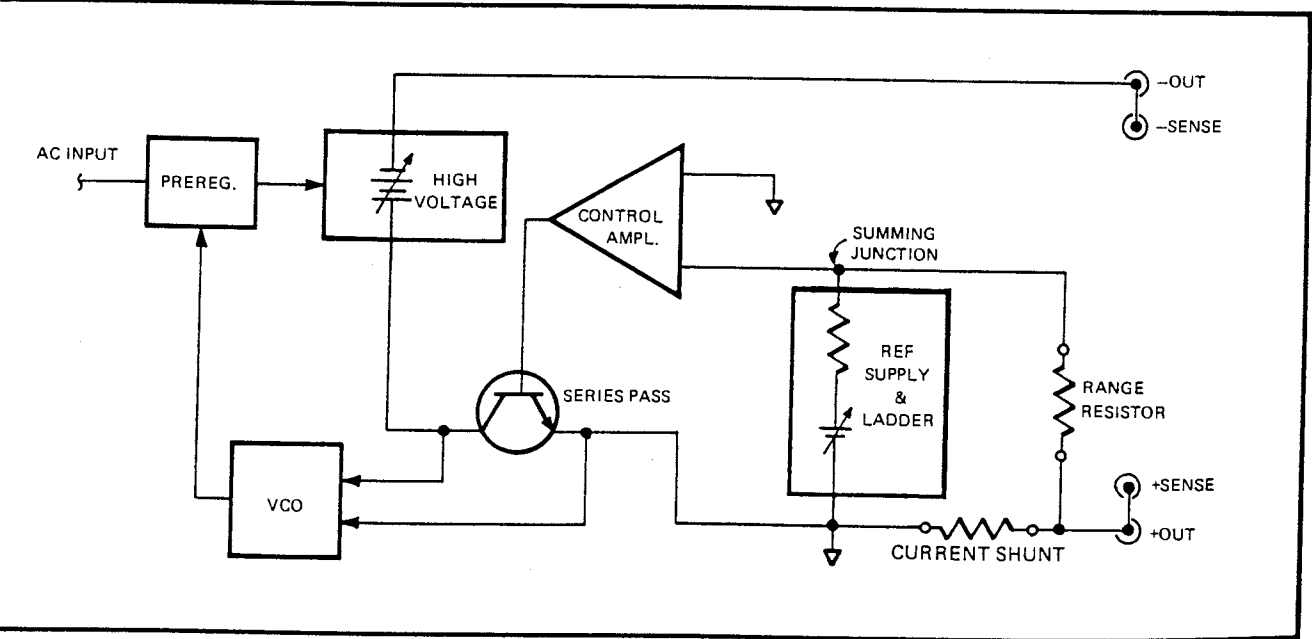


Figure 3-4. CONSTANT CURRENT MODE (SIMPLIFIED)

limiter continuously monitors output current and compares it to the setting of the CURRENT LIMIT control. When the voltage across the current sensing resistor exceeds the reference voltage set by the CURRENT LIMIT control, the limiter is activated. A portion of the current flowing from the reference supply into the summing junction is then bypassed, and the output current is limited or clamped to the preset value.

3-29. The series pass driver performs two functions: It amplifies control signals sufficiently to drive the series pass, and it disables the output in the event of an over-voltage or catastrophic over-current condition. When the voltage across the current sensing resistor exceeds a predetermined value, the trip circuitry acts to de-energize relays A5A2K1 and A5A2K2 which removes ac power from the high voltage transformer primary. The voltage trip circuit is activated whenever the output voltage exceeds the selected trip voltage set by the VOLTAGE TRIP VERNIER. Again A5A2K1 and A5A2K2 are de-energized and the instrument is tripped to standby. The instrument is reset by first pressing the STDBY/RESET switch to de-energize A4K5 and then the OPR switch.

3-30. The series pass regulates instrument output current in response to control signals from the series pass driver. The series pass is actually eight transistors connected in series, an arrangement which provides the regulated high voltage capability. The series pass assembly also contains a voltage controlled oscillator (VCO) which provides a pulsed timing signal to the pre-regulator. The pre-regulator increases the efficiency of the instrument by regulating the input to the high voltage power supply. It utilizes voltage level information from the VCO to provide full-wave phase control of the input line voltage of the high voltage transformer. Thus, the power supplied by the high voltage transformer is controlled to provide only that amount necessary for load requirements.

3-31. The high voltage power supply is connected as a full-wave bridge rectifier, obtaining its input from the pre-regulator and supplying dc voltages to the series pass regulators. Contained on the high voltage assembly is a rate limiter for the automatic crowbar which prevents excessive crowbar activation, thereby providing protection for the series pass transistors. See paragraphs 3-67, 3-70 and 3-74.

3-32. The function of the automatic crowbar circuitry is to quickly discharge the high voltage filter capacitors when down-ranging the instrument. This circuit also provides protection for the instrument during abnormal load conditions, such as short-circuited output. A second crowbar

circuit, which is manually operated, is connected across the output terminals. It is used to limit compliance voltage while changing loads.

3-33. Operating voltages for the instrument are provided by the low voltage power supplies. The +25 volt and -15 volt supplies provide operating voltages for the +10 volt reference, chopper amplifier, and differential amplifier. A separate -25 volt dc supply furnishes operating voltages for all decade control relays. Operating voltages for the series pass driver are provided by a ± 35 volt supply located on the current limiter assembly. A -5 volt supply provides the program supply voltage.

3-34. The 50 program input/output (I/O) lines provide remote control of all front panel control functions and remote indication of instrument power condition and voltage trip/current limit operation. Mode, standby/operate, polarity, manual crowbar, and voltage/current range input lines terminate in a relay driver, which supplies the driving current for the selected relay. Output voltage level is controlled by a 28-line 8-4-2-1 BCD input. The front panel controls are connected in parallel with the program I/O lines, and the same circuits are activated in either remote or local operation. The selection of remote or local operation is made only at the front panel. When the OPR switch is pressed, front panel controls are enabled; when the REMOTE switch is pressed, instrument control is switched to the programmed input at J8.

3-35. Mode input commands are applied through the relay driver to relays A4K3 and A4K6. These relays change the instrument circuitry to provide either voltage or constant current operation. Together with the range relays A4K1 and A4K2, they select the appropriate voltage range resistor, current shunt, and chopper amplifier zero adjust control.

3-36. The standby/operate input is applied through the relay driver to relay A4K5. This relay controls the operation of relay A5A2K2, which in turn, controls relay A5A2K1. When operated, A5A2K1 connects main power to the pre-regulator. The remote polarity input is applied through the relay driver to relay A4K4. Upon command, A4K4 reverses the output voltage polarity at the front and rear terminals. The manual crowbar input operates relay A6K2. When activated, this relay shorts the output terminals through a 5 ohm resistor.

3-37. The 28-line output level input is applied to the seven-deck resistive ladder network and a set of relay switches, which are used to connect the reference voltage

to the proper terminal of the network as a function of each digital input bit.

3-38. The 5-line current limit input consists of a 4-bit BCD input which is applied to the remote current limit circuit, and a single local/remote line which is applied through a relay driver to A3K1 and A3K6. Upon remote command, A3K1 closes and selects the current limit ladder. The circuit then performs the current limit adjustment in accordance with the BCD input. The voltage limit circuitry is arranged in the same way. The local/remote input operates relay A3K6 which selects the remote voltage limit ladder. Again, the BCD input controls the decoder which accomplishes the adjustment function.

3-39. CIRCUIT DESCRIPTIONS

3-40. The following paragraphs describe in detail the operation of each circuit. The information is grouped according to individual assemblies found in the Model 3330B. To find the description of a particular circuit, first determine the name of the assembly that the circuit is located on and proceed from there. For example, the VCO circuit is located on the Series Pass assembly A4A5.

3-41. Main Mother Board (A4)

3-42. Functioning as the parent assembly for assemblies A4A1 through A4A17, the Main Mother Board interconnects all the assemblies found on it and distributes signal paths to appropriate sections of the instrument. Individual circuit descriptions for A4A1 through A4A17 are provided in the following paragraphs.

3-43. Components mounted on the A4 board consist primarily of diodes and relays. Diodes CR1 through CR28 are associated with the ladder assemblies. Relays K3 and K6 form part of the mode selection circuitry. K2 is energized when the instrument is in the 1000 volt range. K1 is energized in the 100 volt range and de-energized in the 10 volt range. Relay K5 is the Standby/Operate relay, and K4 is the Polarity relay.

3-44. +10 Volt Reference Supply (A4A1)

3-45. The +10 Volt Reference Supply produces an extremely stable reference voltage upon which the instrument's stability is based. Range zero adjustments and a resistor for the current mode are also located in this assembly.

3-46. 10 VOLT REFERENCE SUPPLY. This is a voltage regulated power supply consisting of a stable reference amplifier, a differential comparator amplifier, and a series regulator. Reference amplifier IC2 contains a matched zener reference and amplifier elements to produce an extremely stable voltage with respect to time and temperature. Voltage variations at the regulator sense line (terminal 14) are developed across the voltage divider R10 through R13 and R2 and are applied to the other input of IC2. Any difference between the sense terminal voltage and the reference voltage is amplified by IC2 and IC1 and used to control the conduction of the series regulator Q1 and Q2, which establishes a +10 volt dc reference voltage at terminal 15. Variable resistor R10 provides adjustment of the regulated output voltage.

3-47. RANGE ZERO AND CURRENT SHUNT. The voltage divider of R16 through R21 allow zero adjustments in the voltage mode of operation. Resistor R22 is used in the current mode of operation.

3-48. Chopper Amplifier (A4A2)

3-49. The Chopper Amplifier compares low frequency and dc control signals from the Ladder summing junction to the +SENSE terminal voltage and amplifies any difference. The Chopper Amplifier circuitry consists of an input filter, a MOSFET chopper, an operational amplifier, a synchronous demodulator, an output filter, and a multivibrator.

3-50. Low frequency and dc control signals at terminal 6 are passed through the input filter C2, R1, and C3 to reject frequencies above 30 Hz. The MOSFET chopper Q1 modulates the signal appearing at the junction of its drain and R2. C4 couples the resultant to the gate of JFET Q2. The output signal at the drain of Q2 is then amplified by the operational amplifier IC1, which has a gain of approximately 420. The paraphase amplifier Q3 amplifies the output of IC1 and provides two equal amplitude, but 180° out-of-phase signals. The collector signal of Q3 is coupled by C16 to the shunt demodulator Q4. The resulting demodulated signal appearing at the junction of C17 and R24 is filtered by R24, R26 and C18, leaving only the amplified dc and low frequency signals. The emitter signal of Q3 is applied through C14, R21, C15, R25, R23, and C22 to C18, where it is used to cancel any chopper ripple at 215 Hz.

3-51. The 215 Hz multivibrator is formed by Q6, Q7 and associated timing networks, in addition to a driver Q5. Variable resistor R43 adjusts the level of the signal applied to the driver Q5, and subsequently the output

signal applied to the gate of Q1. The collector signal of Q5 is applied to the drain of Q1 to compensate for spikes coupled between the gate and drain. Variable resistor R34 provides adjustment of the compensation signal. An output signal at the collector of Q7 is applied to the base of Q4, which synchronously demodulates the Chopper Amplifier output.

3-52. Differential Amplifier (A4A3)

3-53. The Differential Amplifier provides a control signal to the Series Pass Driver. Part of the current limit circuitry is also located in this assembly. The differential amplifier consists of Q2 through Q11, and the current limit circuitry consists of Q1, Q12, CR10 through CR12, and R7 through R10. A restraining circuit of Q13, and Q14, and associated circuitry, prevents the chopper Amplifier from saturating in the standby mode.

3-54. DIFFERENTIAL AMPLIFIER. Input control signals from the A4A10 through A4A16 Ladder summing junction are applied to terminal 5 for amplification by the differential amplifier of Q2 through Q10. High frequency input signals are coupled through C1 to one input of the differential amplifier. Low frequency and dc control signals are applied through R21 to terminal 6, where they are amplified by the A4A2 Chopper Amplifier. Over-voltage protection for the differential amplifier and Chopper Amplifier inputs is provided by CR2 through CR9 and associated components. The amplified control signals from the Chopper Amplifier are applied to terminal 3 as the other input of the differential amplifier. The resulting output at the collector of Q9 is applied to the emitter follower Q11, which provides a low impedance drive signal required by the A4A4 Series Pass Driver at terminal 1. Transistor Q8 is a current source for one stage of the amplifier and provides common mode rejection at the input to the amplifier.

3-55. CURRENT LIMIT CIRCUITRY. The current limit circuitry consisting of Q1, Q12, CR10 through CR12, and R7 through R10 provide a means of bypassing Ladder current during a current limit condition. Transistor Q1 receives base and emitter operating voltages from the A4A7 Current Limiter and is normally cut-off. However, if the output current of the instrument exceeds a preset value established by the CURRENT LIMIT control, Q1 is driven into conduction by a corresponding drop in emitter voltage and turns on transistor diode Q12. Conduction of these transistors shunts the Ladder current through the range resistor R9, thus limiting the control signal applied to the A4A4 Series Pass Driver and the output current of the instrument.

3-56. RESTRAINING CIRCUIT. The circuitry of Q13 and Q14 ensures that the Differential Amplifier is provided with a dynamic load during a standby condition to keep the output of the amplifier relatively constant. This also maintains fast response during turn-on and range changes. The emitter voltage of Q14 is derived from the emitter of Q11, while the base voltage of Q14 is derived from the voltage divider of R33 and R34. The collector of Q14, whose conduction depends primarily on its emitter voltage, supplies base drive to Q13. The output of Q13 drives diode-connected Q12, controlling the current appearing in the summing junction. In this manner, the loop is completed and the output of the Differential amplifier will remain nearly constant, thus preventing the Chopper from going into saturation.

3-57. Series Pass Driver (A4A4)

3-58. The Series Pass Driver applies amplified control signals to the A4A5 Series Pass assembly. Additional circuits found on the assembly are the overcurrent/voltage trip circuit and the front panel meter multiplier resistors. A three-stage amplifier composed of Q5 through Q7 forms the series pass driver. The overcurrent/voltage trip circuitry consists of Q1 through Q4 and Q8. The meter multipliers are R1 through R6.

3-59. SERIES PASS DRIVER. The series pass driver of Q5 through Q7 amplifies the input regulation control signal at terminal 1 sufficiently to drive the A4A5 series-pass transistor Q8. The common-base configuration of Q7 provides isolation of the input circuitry and the required voltage gain of the control signal. The common-collector stages of Q5 and Q6 provide sufficient current gain of the drive signal applied out terminal 4.

3-60. OVERCURRENT/VOLTAGE TRIP. The over-current/voltage trip circuitry, through relay A5A2K2, removes ac power from the high voltage transformer whenever a catastrophic overcurrent or voltage trip occurs. Transistor Q3 is a current source for the solenoids of this relay and produces a -30 volt dc operating voltage at terminal 10. Transistors Q1 and Q2 activate the voltage trip feature. Transistors Q4 and Q2 activate the over-current trip feature. Resistors R22 and R29 are the sensing resistor for the overcurrent trip feature. Transistor Q8 is the driver amplifier for the OPR indicator lamp.

3-61. The voltage trip feature is activated when the output of the instrument exceeds the level established by the VOLTAGE TRIP controls, or when triggered by the rate limiter. (Paragraph 3-74). Transistor Q1 receives

base voltage from the wiper of the VOLTAGE TRIP RNIER control or Ladder. When the base voltage, which is proportional to the output voltage of the instrument, exceeds the established level at the base of Q1, transistor Q2 conducts and biases Q2 into saturation. The conduction of Q2 clamps the voltage at terminal 8 to nearly zero volts and de-energizes the associated relay. This action trips the instrument to the STANDBY mode. Transistor Q8 is also turned off by a corresponding increase in negative base voltage, and the OPR lamp is extinguished. The instrument is returned to the OPR mode by first selecting the STDBY/RESET mode, which turns off Q2 by applying a circuit common to terminal 9 through the contacts of A4K5, and then selecting the OPR mode.

3-62. The overcurrent trip feature is a protective circuit that functions in the event of a current limit malfunction. When the current through the sensing resistors of R22 and R29 exceeds 200 milliamperes, Q4 conducts and biases Q2 into saturation, which activates the trip circuit discussed in the preceding paragraph.

3-63. METER MULTIPLIERS. Resistors R1 through R6 provide a current through the front panel meter that is proportional to either the output voltage or current of the instrument. When the METER READING VOLTAGE switch is pressed, R3 through R6 and A4R1 through R3 are connected to the meter and produce a reading proportional to the output voltage of the instrument. Variable resistor R5 allows calibration of the voltage reading. When the METER READING CURRENT switch is pressed, R1 and R2 are connected to the meter and produce a reading proportional to the output current of the instrument. Variable resistor R2 allows calibration of the current reading.

3-64. Series Pass (A4A5)

3-65. The Series Pass contains the series-pass transistors used to control the output current or voltage from the instrument. Additional circuitry consists of the pre-regulator VCO used to control the amount of voltage across the series pass transistors, and an automatic "crowbar" driver used to limit the maximum voltage across the series-pass elements. A +150 volt power supply is also included to provide operating voltages for the series-pass and VCO circuitry. The +150 volt power supply consists of the bridge rectifier CR1 through CR4, and the series pass elements are Q1 through Q8. The VCO consists of the relaxation oscillator Q9 and the associated timing networks. Transistor Q10 is the automatic "crowbar" driver.

3-66. +150 VOLT POWER SUPPLY. AC voltage at terminals 8 and 9 is rectified by diodes CR1 through CR4 to produce an unfiltered positive voltage. This voltage is isolated by CR5 and filtered by C2 to provide a +150 volt dc operating voltage for the series pass transistors. The voltage divider of R1 through R3 and zener diode CR6 produces a clipped full-wave rectified six volt synchronizing signal for the VCO, Q9.

3-67. SERIES PASS TRANSISTORS AND AUTOMATIC CROWBAR. The series-pass transistor of Q1 through Q7 are normally saturated, and transistor Q8 is absorbing the total voltage required to establish the output of the instrument. However, when the output level or load is changed and the voltage across Q8 exceeds 150 volts, Q1 through Q7 absorb the additional voltage. The pre-regulator circuitry then reduces the output of the high voltage supply and the voltage across the series pass transistors. As soon as the voltage drop across Q8 decreases below 150 volts, Q1 through Q7 again saturate, and Q8 absorbs the total regulation voltage. Load or output changes that increase the voltage across the series pass transistors to above 225 volts result in the conduction of the "crowbar" driver, Q10. Conduction of Q10 energizes relay K1 in the A4A6 High Voltage assembly, which places a load across the high voltage rectifier. This action limits the voltage across the series pass transistors and provides a quick discharge path for the high voltage filter capacitors.

3-68. PREREGULATOR VCO. Unijunction transistor Q9 and associated timing elements comprise a voltage-controlled oscillator which furnishes a turn-off pulse to the pre-regulator. A clipped, six volt pulse, synchronous with the 60 Hz line, is applied to base 2 of Q9 (see Figure 3-5). The potential at the emitter of Q9 depends upon the charge on capacitors C4 and C5. The charge on C5 depends upon the voltage across the series pass control transistor Q8. When the charge on C4 and C5 equals a critical level, determined by the bias on Q9, Q9 will conduct, delivering a pulse of current through transformer T1 to the pre-regulator. The oscillator will be enabled only during interval t_1 and the point at which oscillation will occur is determined by the charge on C5. If the Charge across C5 increases, the initial output pulse of the oscillator will occur earlier in each half cycle. During each half cycle, the initial pulse from the oscillator will switch the pre-regulator off to control the amount of line power supplied to the high voltage transformer. Thus, if the voltage across Q8 increases, the pre-regulator is switched off earlier in each half cycle. This, in turn, reduces the voltage across Q8 to the proper working value.

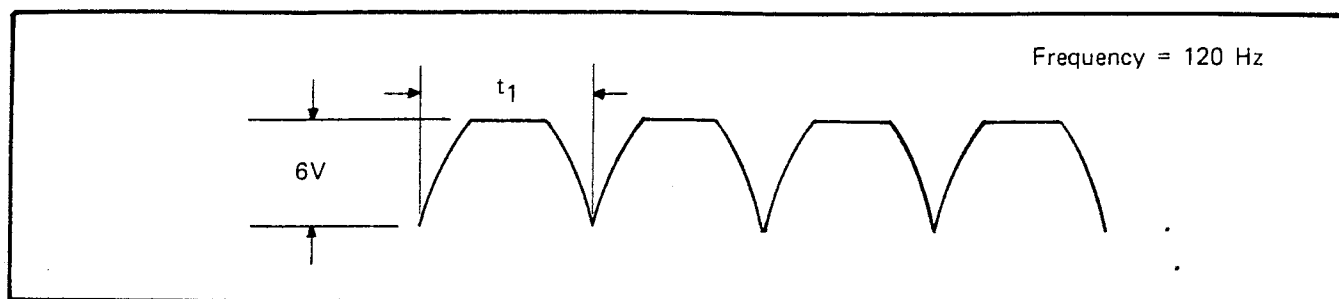


Figure 3-5. VCO OPERATING VOLTAGE

3-69. High Voltage Power Supply (A4A6)

3-70. The High Voltage Power Supply produces the required voltage necessary to obtain the pre-selected output. Additional circuitry consisting of a sink supply and a portion of the automatic "crowbar" circuitry is also included and allows rapid downranging of the instrument. The automatic "crowbar" circuit also prevents damaging of the series pass elements if the output terminals are shorted or an overload occurs. The high voltage power supply consists of the bridge rectifier CR1 through CR4. The sink supply is composed of the voltage doubler CR5 through CR8, and the automatic "crowbar" circuit consists of K1 and R7 with the rate limiter of Q1 thru Q4 acting to limit the number of times the crowbar may be activated at a given time.

3-71. HIGH VOLTAGE POWER SUPPLY. AC input voltage from the pre-regulator at terminals 15 and 16 is rectified by CR1 through CR4 to provide high level operating voltage for the instrument. Resistors A4R6 through A4R8 and capacitors A4C5 through C7 filter the resulting output appearing on terminal 5.

3-72. SINK SUPPLY. AC input voltage at terminals 1 and 2 is rectified and filtered by CR5 through CR8, C1, C2, R4, and R5. The resulting -700 volts output at terminal 12 is applied to the A4A5 Series Pass assembly and ensures a minimum current through the series-pass element when the instrument is downranged.

3-73. AUTOMATIC CROWBAR. Relay K1 and the resistor R7 are part of the automatic "crowbar" circuit used to provide a quick discharge path of the filter capacitors contained within the instrument. When an over-voltage condition across the series pass elements is detected, A4A5Q10 will conduct and energize K1. The contacts of K1 place R7 in parallel with the high voltage power supply which provides a discharge path for the filter capacitors.

3-74. RATE LIMITER. The rate limiter, in conjunction with the automatic crowbar, protects the series pass transistors. If the automatic crowbar activates more often than the times given in Figure 1-1 of Section I, the rate limiter relay K2 will supply -35 v to the voltage trip circuitry, placing the instrument in the voltage trip mode. Q1 thru Q4, CR12 thru CR19, R3, R9 thru R14, C4 thru C6, and K2 comprise the rate limiter circuitry. When the crowbar activates due to excessive voltage across the series pass, a voltage develops across R3 charging C5 directly and charging C4 through R9. If there is excessive crowbar action, C4 will charge sufficiently to turn on Q1 and Q2, energizing K2. If the crowbar rate is not excessive, the charge on C4 will not become great enough to turn on Q1 and Q2. Meanwhile, as a result of the crowbar action, C5 becomes charged; when the charge is high enough, Q4 conducts, turning off Q3. Some time later, it will discharge, turning off Q4 and allowing Q3 to conduct. When Q3 turns on, it discharges C4, and the rate limiter is reset. However, the 3330B must be manually reset.

3-75. Current Limiter (A4A7)

3-76. The Current Limiter contains two separate plus and minus 35 volt dc power supplies and part of the current limit circuitry. The ± 35 volt power supply is a bridge supply with rectifiers CR1 through CR4 and the regulators Q1 and Q2. The current limit circuitry consists of a three-stage amplifier, Q3 through Q5, and the I LIMIT/V TRIP drivers Q6 and Q7.

3-77. ± 35 VOLT DC POWER SUPPLIES. The ac input voltage applied to terminals 7 and 9 is rectified and filtered by CR1 through CR4, R1, C1, R4, and C4. Positive unregulated voltage is applied to Q1, and negative unregulated voltage is applied to Q2. Zener diodes CR5 and CR7 establish a reference voltage at the base of Q1 and Q2. The conduction of Q1 and Q2 produces ± 35 volt dc output voltages available at terminals 1 and 3. A -3.9 volt dc output at terminal 15 is developed by CR6 and R6 for use as a bias voltage in the A4A3 Differential Amplifier.

The unregulated negative output is also applied through R8 and R26 to terminal 6 for use in the A3 assembly indicator lamps.

3-78. CURRENT LIMIT CIRCUITRY. The current limit circuitry receives a dc control voltage at terminal 10 which is proportional to the output current of the instrument. Diode CR12 applies this signal to the base of Q5. The emitter of Q5 is connected through R21 to terminal 11, which receives a control voltage from the wiper of the CURRENT LIMIT VERNIER control or Ladder. Variable resistors R23 and R24 are also part of this circuit and allow calibration of the CURRENT LIMIT LO and HI settings. When the output current of the instrument attempts to exceed the value preset with the CURRENT LIMIT control, Q5 is driven into conduction by the increase in voltage at terminal 10, which drives Q4 and Q3 into conduction. This action bypasses a portion of the Ladder current through the A4A3 Differential Amplifier range resistor connected to terminal 16, and thereby limits the output current of the instrument. The regenerative pair of Q6 and Q7 are also driven into conduction at this time and supply a drive current to the A3 I Limit/V Trip lamp which is also illuminated on the STDBY/RESET or VOLTAGE TRIP mode by a zero volt control signal at terminal 5. This input also brings Q3, Q4, Q6 and Q7 into conduction.

3-79. +25 and -15 Volt Power Supply (A4A8)

3-80. The +25 and -15 Volt Power Supply consists of two separate low-ripple power supplies used to produce operating voltages for the instrument. The +25 volt power supply is composed of a bridge rectifier CR1 through CR4 and the regulator Q2 through Q6. The -15 volt power supply consists of a bridge rectifier CR7 through CR10 and the regulator Q7 through Q9. Transistor Q1 and associated components are not used in this instrument.

3-81. +25 VOLT POWER SUPPLY. AC voltage at terminals 13 and 14 is rectified and filtered by CR1 through CR4, C2, R4, and C3. Transistor Q2 is a constant current source for the regulator consisting of Q3 through Q6. The differential comparator amplifier of Q5 and Q6 provides a reference voltage at the base of Q6 derived from diode CR6. Variations at the +25 volt output (terminal 10) are developed across the voltage divider through R10 and are applied to the base of Q5. The difference between the base voltages of Q5 and Q6 is amplified and used to control the conduction of the pass driver Q3. Conduction of Q3 controls the conduction of the series-pass regulator transistor Q4, which establishes a low-ripple +25 volt dc output at terminal 10. A variable resistor R9 allows adjustment of the regulator

3-82. -15 VOLT POWER SUPPLY. AC voltage at terminals 1 and 6 is rectified and filtered by CR7 through CR10, R14, and C8 to produce a negative operating voltage for the regulator of Q7 through Q9. A voltage divider comprised of R18 and R19 references the base of Q9 to a potential dependent on the +25 and -15 volt output. Variations in the output are amplified by Q9 and used to control the conduction of Q8. The conduction of Q8 controls the series-pass regulator Q7, which establishes a low-ripple -15 volt dc output at terminals 3 and 9.

3-83. Relay Driver (A4A9)

3-84. The Relay Driver activates the various relays within the instrument on commands from the A3 assembly. The relay drivers Q1, Q3, Q5, and Q7 are identical PNP switches used to activate relays. Transistors Q4, Q10, Q11 and Q12 are used to invoke the STDBY/RESET mode whenever a mode or polarity change occurs. A Logic "1" (0 to +0.5 volts) will turn the relay drivers on, and a Logic "0" (+4.5 to +20 volts) will turn them off.

3-84. RELAY DRIVERS. Relay drivers Q1, Q3, Q5, and Q7 are identical PNP switches. Each transistor receives -25 volts at its collector derived from the associated relay. Base voltage is dependent on the input logic signal from the A3 assembly. Zener diodes located in the collector circuit protect the transistors from the induced voltages developed by the relay solenoids. The drivers consisting of Q2, Q8 and Q6, Q9 provide current for relay operation. Circuitry for these drivers is essentially the same as the other drivers, with the exception of the additional base circuitry used to invoke the STDBY/RESET mode.

3-86. STDBY/RESET MODE. When changing a program between the voltage or current mode, it is necessary to temporarily place the instrument in standby to prevent uncontrolled voltages from appearing on the output terminals. This is accomplished by circuitry located on the relay driver assembly. When the negative or low input is applied to the base of Q9 (current mode command), it is also applied to a differentiator consisting of C6 and R30. The negative differentiator output is coupled through diode CR12 to the base of Q11, turning it on. Q12 turns on at the time that Q11 does, and stays on until C7 discharges through R26 to a value below 0.6 volts, a period of approximately 100 milliseconds. In the interval that Q12 is on, the base of Q3 is effectively connected to ground, which de-energizes relay A4K5 and places the instrument in standby. When the positive or high input is applied to the base of Q9 (voltage mode command), it is also applied to the base of Q4. The signal is inverted in Q4, differentiated by C5 and R28, and applied to Q11.

Again, Q11 and Q12 together with Q3 act to place the instrument in standby for 100 milliseconds. The momentary standby function is also invoked by application of a polarity change command. A separate inverter Q10 together with associated differentiator circuits provide the negative trigger to Q11.

3-87. Ladders (A4A10 through A4A16)

3-88. There are seven Ladders contained in the instrument. Each Ladder consists essentially of the same circuitry with the only difference being the tolerance of the divider components. The Ladder circuitry consists of relay driver/decoders and a ladder network.

3-89. RELAY DRIVER/DECODERS. Relay Drivers Q1 through Q4 are PNP switches. A Logic "1" (0 to +0.5 volts) will turn the drivers on, and Logic "0" (+4.5 to 20 volts) will turn them off. Each transistor receives a -25 volt dc collector voltage through the associated relay of K1 through K4. Base bias voltage is dependent upon the input logic signal from the A3 assembly. Diodes CR5 and CR6 convert the 8-4-2-1 coded inputs to a 4-4-2-1 code. This conversion is necessary to limit the maximum digital command to a four digital word of eleven which corresponds to the maximum decade range.

3-90. LADDER. Each deck of the seven ladder decks performs an identical function. The relative position of the decks, with respect to the summing junction, determines the significance of that deck's contribution to the ladder output. For example, Ladder no. 1, which is nearest the junction, determines the most significant portion of the output, and Ladder no. 7, which is farthest from the junction, determines the least significant portion. Although the circuit arrangement of each ladder is the same, the individual assemblies are not interchangeable, because component tolerance are different.

3-91. Ladder network R1 through R10, reed relay switches K1 through K4, and switch drivers Q1 through Q4 comprise a four-bit, weighted-resistor, digital-to-analog decoder. The analog output of the decoder is weighted in terms of elevenths of the reference voltage (+10 volts) so that it can be programmed by input digital words 1 through 11. The ladder network functions as a voltage divider, where resistors R3 through R10 are, in various combinations, connected in series with R1 and R2, which are the output resistors. Assume, for example, the four-bit digital word 0101, representing 5, is present at the decoder input. The first and third bits, present at pins 16 and 14 respectively, turn on drivers Q2 and Q4 and, through them, relays K2 and K4, while the second and

fourth bits, present at pins 15 and 13, bias drivers Q3 and Q1 off. With K2 and K4 energized, +10 volts is applied to R5 and R9. The parallel combination of R5, R6 and R9, R10 in series with R1, R2 provide an output that is five-elevenths of the available decoder output. This decoder deck together with the other decoder decks produces a combined output which corresponds to the 28-word BCD input. An important characteristic of the ladder is that its output impedance is constant regardless of the reed switch positions, thereby presenting a constant load to the reference supply.

3-92. Referring to the simplified diagram of Figure 3-6, the operation of the Ladders can be more easily seen. The numerals "4", "4", "2", and "1" refer to the BCD commands, and the 1R, 2R, etc., refer to the relative weights of the associated Ladder segments. The value of 1R is 25K, so that 2R is 50K, etc. Selecting various combinations of "R" in each Ladder varies the current supplied to the Range resistors; this current is available in increments of 1/11 from each Ladder.

3-93. Range/Shunt Networks (A4A17)

3-94. The Range/Shunt Networks allow calibration of the various voltage/current ranges of the instrument. Variable resistors R21, R18, and R15 are used to calibrate the full-scale output on the corresponding 10, 100, and 1000 volt ranges. Variable resistors R1, R5, and R9 are used to calibrate the full-scale output on the corresponding 1, 10, and 100 milliampere ranges.

3-95. Rear Mother Board (A5).

3-96. The Rear Mother Board contains the A5A1 power supply assembly and the A5A2 Pre-regulator Assembly. Also located on the board are K1, the CURRENT LIMIT/VOLTAGE TRIP FLAG delay; K2, used in current limit and voltage trip conditions; and K3, the CURRENT LIMIT/VOLTAGE TRIP FLAG. AST1 on this assembly couples the VCO pulses from the A4A5 Series Pass Assembly to the A5A2 Pre-regulator assembly.

3-97. -25 and -5 Volt Power Supply (A5A1)

3-98. The -25 and -5 Volt Power Supply consists of two separate low-ripple power supplies that produce the logic power and relay operating voltages for the instrument. The -25 volt power supply consists of a bridge rectifier CR1 through CR4, positive rectifier CR5 and CR6, the regulator Q1 through Q3, and the turn-on delay circuit Q4. The -5 volt power supply consists of a bridge rectifier CR7 through CR10 and the regulator Q5 through Q8.

-99. **-25 VOLT POWER SUPPLY.** AC voltage at terminals 1 and 2 is rectified and filtered by CR1 through R4 and C1 to provide a negative operating voltage for the regulator Q1 through Q3. Diodes CR5 and CR6 produce a positive operating voltage for the regulator. The comparator amplifier Q1 receives a reference voltage at its emitter derived from zener diode CR12. Variations at the -25 volt output (terminal 6) are developed across the voltage divider of R4 through R6 and applied to the base of Q1. Any difference between the base and emitter voltage of Q1 is amplified and used to control the conduction of the series pass regulator Q2. Conduction of Q2 controls the conduction of the series-pass transistor Q3, which establishes a low-ripple -25 volts dc output. Variable resistor R5 allows adjustment of the regulator output. The turn-on delay circuit consisting of C4, R7, R13, Q4 and K1 prevents the -25 volt output from appearing at terminal 6 for approximately three seconds after initial turn-on.

-100. **-5 VOLT POWER SUPPLY.** AC voltage at terminals 14 and 15 is rectified and filtered by CR7 through R10 and C5 to produce a negative operating voltage for the regulator configuration of Q5 through Q8. Additional negative operating voltage is obtained from the -25 volt power supply through R8 and R10. The comparator amplifier Q7 receives a reference voltage at its emitter derived from zener diode CR11. Variations at the -5 volt output (terminal 16) are developed across the voltage divider of R11 and R12 and applied through R14 to the base of Q7. Any difference between the base and emitter reference voltage of Q7 is amplified and used to control the conduction of the series-pass regulator Q6. Transistor Q8 functions as a current limiter to prevent the output current from exceeding 300 ma. The conduction of Q6 controls the conduction of the series-pass transistor Q5, which establishes a low-ripple -5 volt dc output at terminal 6. Variable resistor R11 allows adjustment of the regulator output.

-101. Pre-regulator (A5A2)

-102. The Pre-regulator controls the ac power dissipated in the instrument by passing only enough power to the high voltage circuitry to meet the output load requirement. The Pre-regulator consists of the $\pm V$ power supply CR1 through CR4, a relay power supply CR6 through CR9, a pre-regulator drivers Q2 and Q4 through Q7, a pre-regulator bridge CR10 through CR13 and Q1, and current limiter Q3.

-103. **$\pm V$ POWER SUPPLY.** AC voltage at terminals 11 and 12 is rectified by CR1 through CR4 to provide unfiltered $\pm V$ operating voltages. Diode CR5 provides isolation of a +10 volt filtered output.

-104.

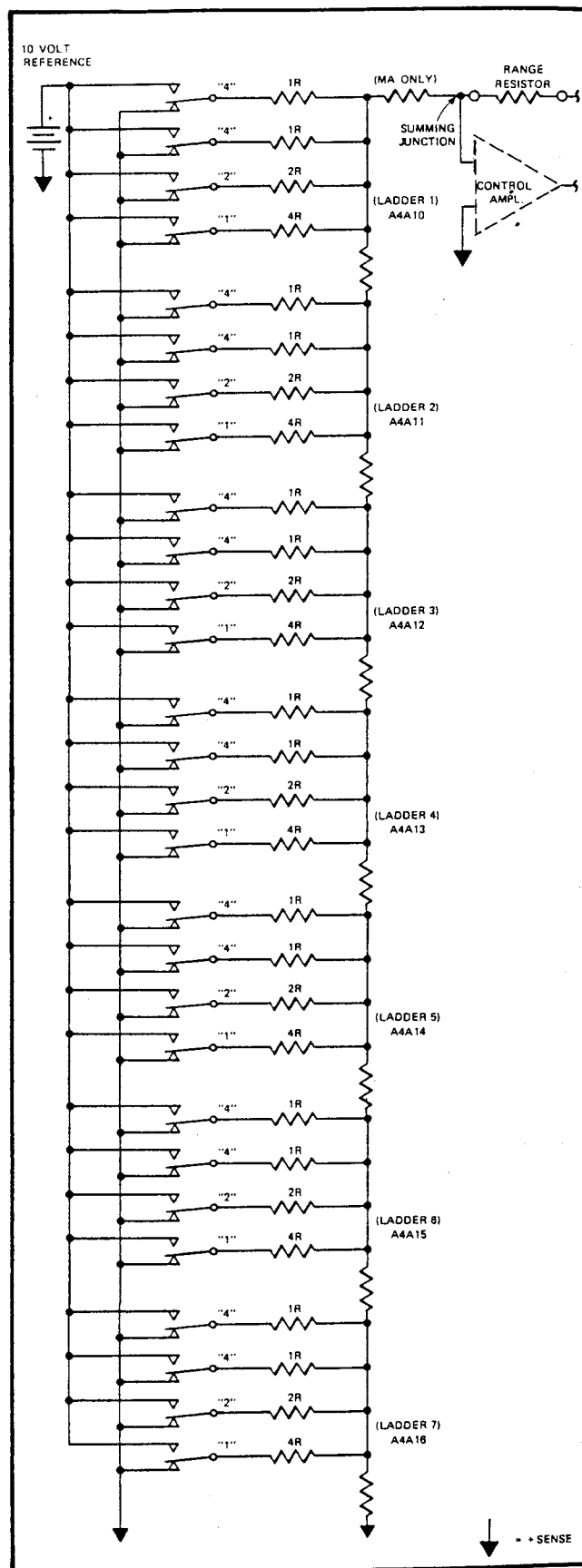


Figure 3-6. LADDER NETWORK -
SIMPLIFIED VERSION

3-104. RELAY OPERATION. Operating voltage for relay K1, which applies ac voltage to the pre-regulator bridge, is produced by the bridge rectifier CR6 through CR9. Relay K2 is energized when the instrument is in operate. During an overcurrent or voltage trip condition, both relays de-energize and remove the ac input to the pre-regulator.

3-105. PRE-REGULATOR DRIVERS. The series of VCO pulses are coupled across A5T1 from the series pass assembly to the input of the pre-regulator. At the beginning of each 60 Hz half cycle, Q5 is turned on by the positive going +V voltage through R17 and L2. Conduction of Q5 saturates Q4, Q2, and Q1. Conduction of Q1 allows current to flow in the primary of the high voltage transformer. Sometime during each half cycle, the initial pulse from the VCO will trigger the regenerative pair (Q6 and Q7) into saturation. With Q6 and Q7 conducting, transistors Q5, Q4, and Q1 turn off and remain off as long as Q6 and Q7 are conducting. Transistors Q6 and Q7 remain conducting until the end of each half cycle. At this time, the current through them automatically drops below the regenerative value, due to the zero-crossing of the full-wave rectified 60 Hz sine wave voltage ($-V$) at the emitter of Q7. Therefore, transistor Q1 is held off for the remainder of the half cycle, which corresponds to the period that the VCO is generating pulses. This limits the amount of power to the high voltage transformer and reduces the power dissipation requirements for the series pass transistors.

3-106. PRE-REGULATOR BRIDGE. The pre-regulator bridge of CR10 through CR13 and Q1 passes or attenuates the ac voltage applied to the high voltage transformer T1 in amounts determined by the Pre-regulator drivers. The bridge connected diodes of CR10 through CR13 provide an unidirectional current flow through the control element Q1. Positive alternations are passed by CR10 and CR13. Negative alternations are passed by CR11 and CR12. Whenever Q1 is turned-off, R5 and C6 provide a dynamic load for the bridge. Over-voltage protection for Q1 is provided by zener diode CR14. Overcurrent protection for Q1 is provided by R2 and the current limiter Q3. Essentially the bridge functions as a switch in the ac line. Refer to the simplified diagram and the stylized waveforms of Figure 3-7. The portion of the ac line waveform that passes to the High Voltage transformer is represented by the shaded portion of waveform 1. Waveform 2 represents the base drive to the bridge transistor. The pulses of waveform 3 are from the VCO. Note that the initial pulse turns off the base drive to the bridge transistor, and that the next zero crossing of the line waveform turns the base drive back on, resulting in current flow through the bridge. Only the first VCO pulse is used for turn-off.

3-107. CURRENT LIMITER. Maximum current through Q1 is limited to 17 amperes by the current limiter Q3. Normally, Q3 is cut-off; however, if the current through R2 in the pre-regulator bridge exceeds 17 amperes, Q3 conducts and turns on the regenerative pair of Q6 and Q7. Conduction of these transistors turns off Q2 and Q1, thus limiting the current through the pre-regulator bridge.

3-108. Protection Circuitry

3-109. Instrument protection is afforded by several circuits; the over-voltage/over-current trip circuit, discussed with the series pass driver assembly in paragraph 3-60, the automatic and manual crowbar circuits, and the rate limiter (paragraph 3-74).

3-110. CROWBAR CIRCUITS. The automatic crowbar circuit consists of transistor Q10 in the series pass assembly, relay K1 on the high voltage assembly, and associated circuitry. When the voltage across the series pass element reaches approximately 225 volts, transistor Q10 conducts. Since relay K1 is in the collector circuit of Q10, the relay is energized, closing the contacts. With the K1 contacts closed, a discharge path is provided for the filter capacitors. The manual crowbar circuit consists of relay driver Q1 on

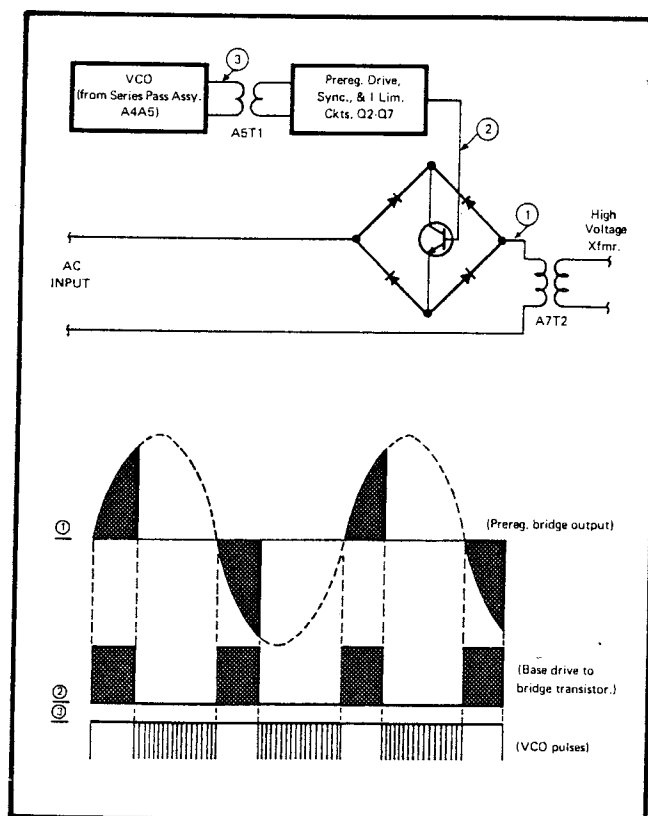


Figure 3-7. PREREGULATOR SIMPLIFIED DIAGRAM AND STYLIZED WAVEFORMS

he Relay Driver Assembly A4A9 and relay A6K2. The instrument output is connected to the normally open contacts of A6K2. When the front panel CROWBAR-OFF switch is depressed, the relay is de-energized and, consequently, has no effect. When the CROWBAR-ON switch is depressed, A6K2 is energized, through the relay driver, and resistor A6R1 is placed across the output terminals to quickly discharge the output capacitors.

3-111. Control Circuitry and Front Mother Board

3-112. The Control Circuitry for the instrument consists of four assemblies. The parent assembly is the (A3) Front Mother Board, which interconnects the (A3A1) Decade Switch assembly, the (A3A2) Switch Board, and the (A3A3) I Limit/V Trip assembly, and distributes the resulting control signals to the appropriate sections of the instrument. Programming inputs from the rear panel Remote connector, except for the operate, voltage trip range and vernier and current limit are parallel connected with the limit circuitry in the instrument. The Voltage Trip range is determined by the relay switching circuitry. The operate line is routed through the Front Mother Board in order for both local and remote modes of operation to be controlled by the inhibit circuitry which prevents the instrument from being turned on before being placed in standby.

3-113. FRONT MOTHER BOARD (A3). The Front Mother Board contains the ladder networks for the remote current limit and voltage trip vernier control features, a greater than 100 volt output detector, the status indicator lamps, and an inhibit circuit. The current limit ladder consists of Q5 through Q8, K2 through K5, and the remote selection circuit Q4 and K1. The voltage trip ladder consists of Q10 through Q13, K7 through K10, and the remote selection circuit Q9 and K6. Transistors Q1 through Q3 form the greater than 100 volt output detector, and the status indicator lamps consist of DS1 through DS10. The circuitry of K11 thru K13, Q17, and Q18 form the Voltage Trip range. Elements of the inhibit circuitry are IC1, Q15, and Q16.

3-114. The remote current limit ladder consists of relay drivers Q5 through Q8 and relays K2 through K5, a resistive ladder network of R17, R19, R21, and R23, and the remote selection circuit of Q4 and K1. The relay drivers are identical PNP switches which are turned on by a Logic "1" (+0.5 volts) and turned off by a Logic "0" (+3.8 to 20 volts). Each transistor receives a -25 volt dc collector voltage through the associated relay which is connected to terminal 22. Base voltages are dependent on the input logic signals from the Remote connector. Diodes CR7

and CR8 convert the 8-4-2-1 coded input to 4-4-2-1 code, which limits the maximum digital command to a four digit word of eleven or 110 milliamperes. The resistive ladder network is selected in various combinations by relays K2 through K5 and divides the I limit resistance at terminal 19 into weighted terms of elevenths. The remote selection circuit of Q1 and K1 is activated upon the presence of a Logic "1" remote current limit command at terminal 21 and applies the ladder output to terminal 19. The current limit circuitry in the instrument receives this ladder output and limits the maximum output current to the level established by the coded inputs at terminals 43 through 46 of the Remote connector.

3-115. The remote voltage limit ladder employs relay drivers Q10 through Q13, relays K7 through K10, and the resistive ladder network of R26, R28, R30, and R32. The remote selection circuit for this network is Q9 and K6. Operation of the voltage limit ladder is essentially the same as that of the current limit ladder. Collector voltage for the relay drivers is obtained from the -25 volt source in the same manner described for the current limit ladder. CR9 and CR10 perform the 8-4-2-1 to 4-4-2-1 decoding. The ladder output appears at the remote contact of K6 and is coupled through R40 to the base of emitter follower Q14. The output is developed across R41 and appears on terminal 92.

3-116. The Voltage Trip Range circuitry is composed of K11 thru K13 and associated elements. Relay K13 is a "Local-Remote" relay for this circuit and is energized by Q9. With pins 3 and 4 held at Logic "0", the 10 volt trip range is activated. When a Logic "1" is applied to Q17, the 100 volt trip range is called; with the base of Q17 held at a Logic "0" and a Logic "1" applied to Q18, the 1000 volt trip range is in effect. Both relay drivers are PNP switches that are identical to the current limit and voltage trip switches.

3-117. The greater than 100 volt output detector of Q1, Q2 and Q3 samples the output and illuminates DS6 when the output voltage exceeds 100 volts. This provides a visual indication that the instrument has output voltages present that require caution in their application.

3-118. The configuration of Q15, Q16, and quad NOR gate IC1 forms an inhibit circuit which prevents the instrument from going into operate before passing through standby. Refer to Figure 3-8 for a simplified diagram of this circuit. The flip-flop is set initially to the proper state by the Logic "1" coming from S2 on the Switch Board (A3A2), when the standby position is selected. Should the instrument be in the operate mode when the power is turned on,

the flip-flop will be in the wrong state due to the Logic "0" from A3A2S2. A Logic "0" must be present at the output of the flip-flop (pin IC1 14) when the operate-mode is selected; otherwise it is impossible to energize the instrument output's. If a Logic "1" (zero volts) is present at pin 14 when the operate mode is selected, Q15 and Q16 will turn on, holding the operate line down to nearly zero volts. The instrument must then be placed in the standby mode to set the flip-flop before the operate mode can be selected.

3-119. The indicator lamps provide visual indications of the instruments status while in local mode. The lamps and their function are:

DS1	Provide decimal point indication in association with the front panel Decade Dials.
DS2	
DS3	
DS4	
DS5	I LIMIT/V TRIP indicates limit or trip mode
DS6	OUTPUT > 100v
DS7	CONSTANT CURRENT
DS8	CONSTANT VOLTAGE
DS9	OPR operate mode
DS10	REM remote mode

3-120. DECADE SWITCH ASSEMBLY (A3A1). This assembly contains the seven decade switches used to select the desired output current or voltage while in local mode. Each switch is an eleven position switch; the highest order, S1, has positions ranging from 0 to 10, while the remaining switches S2 through S7 have a range of 0 to X. The "X" indicates a "carry one" function, so that an output voltage of, for example, 1100,0000 volts would be dialed as 10X0.0000.

3-121. On the schematic diagram the switches are shown for representation as 5 position switches, the positions being 8, 4, 2, 1, and 0 with numbers in parenthesis by the positions. The 8-4-2-1 corresponds to the BCD coding applied to the ladders. On S2 position 1, for example, the numbers 1, 3, 5, 7, 9, in parenthesis indicate that CR5 is connected to the wiper arm in the decade settings 1, 3, 5, 7, and 9.

3-122. The wiper arm of each switch is connected to -5 volts. The four outputs of each switch are connected to the appropriate relay driver in the ladder drive assembly.

3-123. SWITCH BOARD (A3A2) This assembly contains the front panel push button switches used to activate the various conditions in the instrument. The groups of

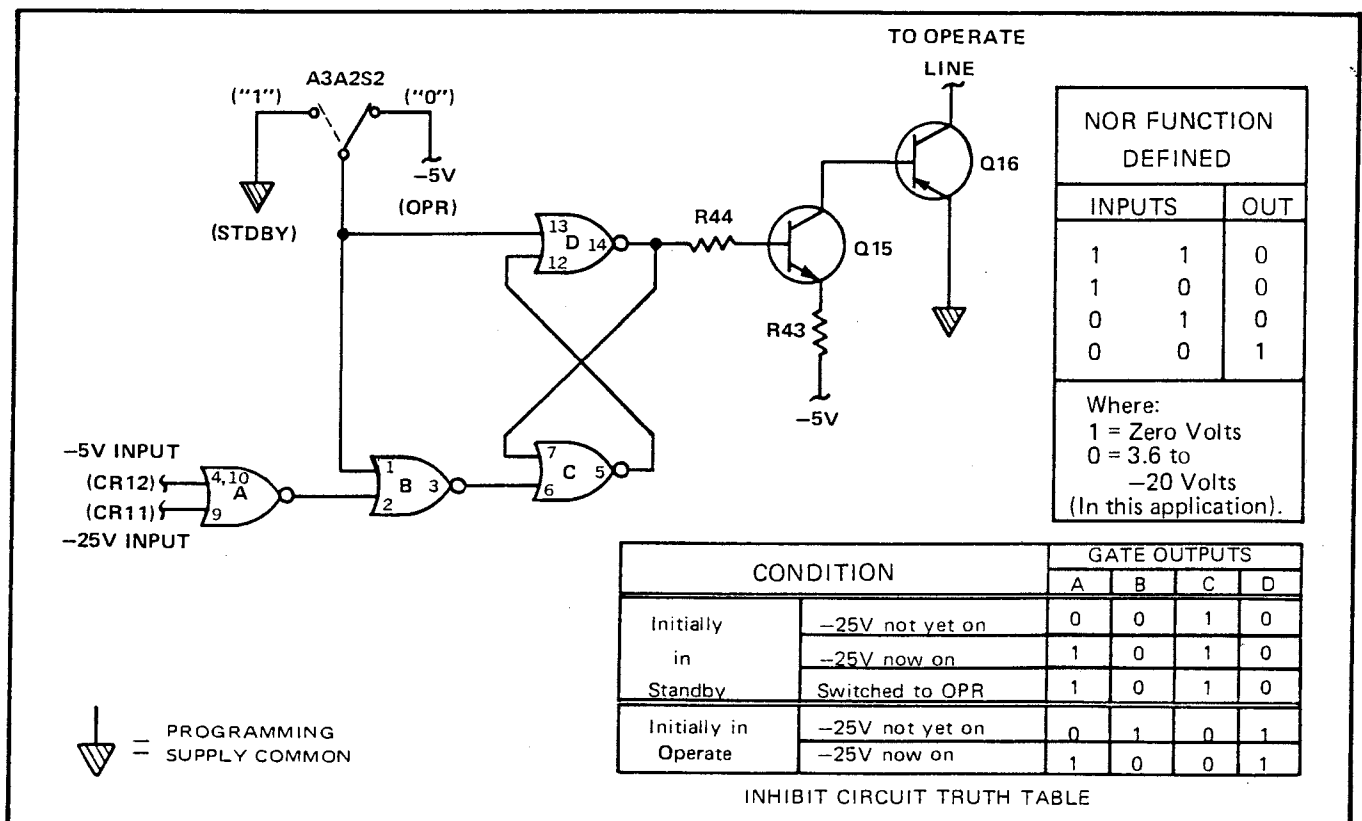


Figure 3-8. INHIBIT CIRCUIT

switches are mechanically linked so that if one switch in the group is depressed, the remaining non-appropriate switches are pushed into the non-depressed positions.

3-124. I LIMIT/V TRIP VERNIER (A3A3). Two variable resistors (R1 and R2) form this assembly. Both are front panel adjustments; R1 is the voltage limit trip, and R2 is the current limit vernier. Mechanically, the wiper arms form a sliding arrangement to allow selection of settings from LO to HI on the front panel.

3-125. Relay Board (A6)

3-126. Two relays are found on this assembly. K1, the operate relay, and K2, the Manual Crowbar relay.

3-127. Inner Chassis (A7)

3-128. Contained within the Inner Chassis assembly are three transformers arranged in a bracket. T1 is the primary power distribution transformer. T2 supplies ac power to the High Voltage Supply (A4A6) and obtains its input from the Pre-regulator (A5A2). T3 supplies power to the -25 and -5 volt Power Supply (A5A1).

3-129. Relay Summary

3-130. Figure 3-9 is provided to summarize the relays found in the 3330B. The decade ladder relays, current limit and voltage trip range ladder relays, and the time delay relay A5A1K1 are not included in the illustration.

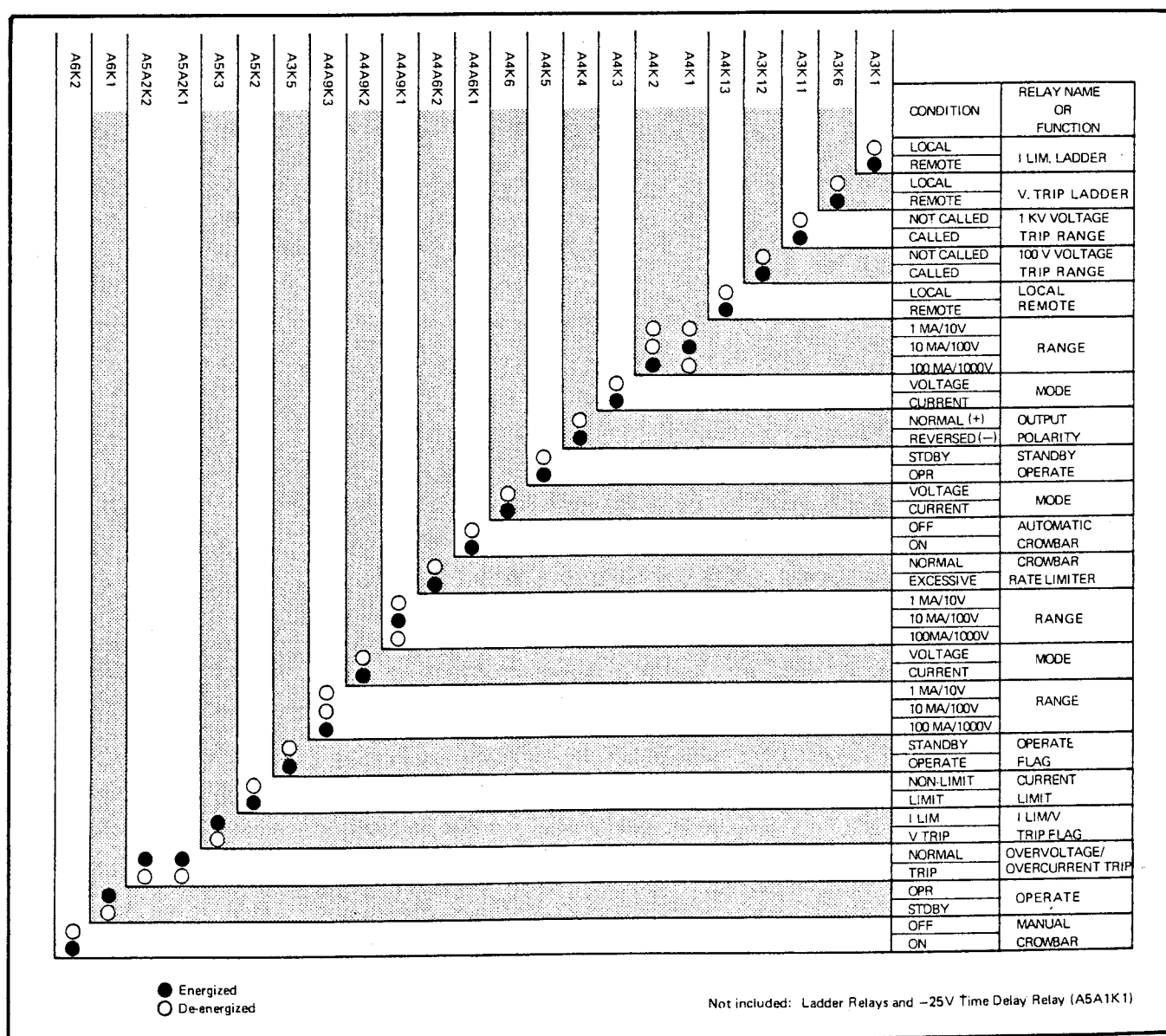


Figure 3-9. RELAY SUMMARY

Section 4

Maintenance

4-1. INTRODUCTION

4-2. This section of the manual contains servicing and maintenance information for the Model 3330B. The information is arranged under headings of "SERVICE

INFORMATION, GENERAL MAINTENANCE, PERFORMANCE CHECKS, CALIBRATION, and TROUBLESHOOTING". Table 4-1 lists the recommended test equipment. If the recommended items are not available, substitute equipment having equivalent specifications can be used.

Table 4-1. REQUIRED TEST EQUIPMENT

EQUIPMENT NOMENCLATURE	RECOMMENDED EQUIPMENT	TEST FUNCTION
Autotransformer	Variac	Performance Checks Calibration Troubleshooting
DC Voltmeter	Fluke Model 895A	Performance Checks Calibration Troubleshooting
DC Voltage/Ratio Calibration System	Fluke Model 7105A Differential Voltmeter Power Supply Calibration Stability Measurement	Performance Checks Calibration
Oscilloscope	Tektronix Model 545B	Calibration Troubleshooting
Preamplifier	Gain X1000	Performance Checks
RMS Voltmeter	Fluke Model 931B	Performance Checks Calibration
STANDARD RESISTORS: 10 Ω , 0.2W 100 Ω , 0.02W 1K, 0.002W	LEEDS & NORTHRUP STDS. 4025-B 4030-B 4035-B	Performance Checks Calibration
RESISTIVE LOADS	100, $\pm 5\%$, 2W 10K $\pm 10\%$, $\frac{1}{4}$ W 1K, $\pm 5\%$, 20W 20K $\pm 5\%$, 50W 2K, $\pm 5\%$, 5W 100K $\pm 10\%$, 20W 5K, $\pm 10\%$, 50W 1M $\pm 10\%$, 2W	Performance Checks Calibration Troubleshooting

4-3. SERVICE INFORMATION

4-4. All products manufactured by the John Fluke Mfg. Co., Inc. are warranted for a period of one year. Complete warranty information is located in the WARRANTY at the front of the manual.

4-5. Factory authorized calibration and service for all Fluke products is available at various world-wide locations. A complete list of Factory Authorized Service Centers is located at the rear of the manual. If requested, an estimate will be provided before repair work is done on an instrument that is beyond the warranty period.

4-6. GENERAL MAINTENANCE

4-7. Cleaning

4-8. The Model 3330B should be cleaned periodically to remove dust, grease, or other contaminants. Care has been taken in design to prevent leakage through the use of high quality insulation materials on all switches. Special attention has also been given to component locations. All circuit boards, with the exception of the A4A6 H. V. Power Supply, have been coated with a moisture sealant to inhibit fungus growth.

4-9. EXTERIOR CLEANING. To clean the exterior, use a cloth moistened with anhydrous ethyl alcohol or Freon T.F. Degreaser (MS180 Miller Stephensen Chemical Co., Inc.). If either of these cleaning agents are not readily available, soap and water applied sparingly to a cloth can be used.

4-10. INTERIOR CLEANING. Use clean, dry air at low pressure to remove loose contamination from the interior sections of the Model 3330B.

4-11. Fuse Replacement

4-12. Two fuses are located on the rear panel. Fuse F1 protects the programming circuitry, and F2 protects the input power circuitry. If replacement is necessary, use the following types of fuses:

F1 1/8 FAST-BLO (115/230 vac)

F2 3A SLO-BLO (115 vac)
1.5A SLO-BLO (230 vac)

4-13. Lamp Replacement

4-14. Status indicator lamps are located on the front panel. These lamps are accessible from the top of the in-

strument after removal of the top dust cover and front trim strip. The lamps are easily removed and replaced with no special tools. If replacement is necessary, use GE 7387 lamps (or equivalent), FLUKE PART NO. 246686.

4-15. PERFORMANCE CHECKS

4-16. Introduction

4-17. The following checks can be used to verify the electrical characteristics of the Model 3330B. These checks can also be used for receiving inspection, periodic inspection, and precalibration checks.

4-18. When performing these checks, it is not necessary to remove the covers from the instrument. All test equipment is connected to the OUTPUT terminals. Table 4-1 lists the required test equipment for these checks.

NOTE!

If a malfunction is discovered during the performance checks, complete as many tests as possible and record the abnormal indications. This information can then be used to more efficiently troubleshoot the instrument.

4-19. Line/Load Regulations Checks

4-20. VOLTAGE MODE. This check will determine if the output voltage remains constant for a combined $\pm 10\%$ line voltage and full-load change.

a. Connect the Model 3330B power cord to an auto-transformer set for an output of 115 vac.

b. Set the Model 3330B controls as follows:

POWER	PUSH ON, STDBY/RESET
METER READING	VOLTAGE
MODE	VOLTS, 10
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	1.000000

c. Connect a dc voltmeter to the OUTPUT terminals, observing proper polarity.

d. Select the OPR mode and perform the checks given in Table 4-2. The output voltage must be within the specified limits. Output loads are listed in Table 4-1.

Table 4-2. VOLTAGE MODE REGULATION CHECKS

STEP	MODEL 3330B CONTROL SETTINGS		OUTPUT LOAD	INPUT POWER (VAC)	OUTPUT VOLTAGE
	RANGE	DECADE DIALS			
1	10	1.000000	NONE	115	RECORD
2	10	1.000000	NONE	103 thru 127	$\pm 20 \mu\text{V}$ of step 1
3	10	1.000000	10Ω , 0.2W	115	$\pm 20 \mu\text{V}$ of step 1
4	10	1.000000	10Ω , 0.2W	103 thru 127	$\pm 20 \mu\text{V}$ of step 1
5	1000	1000.0000	NONE	115	RECORD
6	1000	1000.0000	NONE	103 thru 127	$\pm 5 \text{ mV}$ of step 5
7	1000	1000.0000	20K, 50W	115	$\pm 5 \text{ mV}$ of step 5
8	1000	1000.0000	20K, 50W	103 thru 127	$\pm 5 \text{ mV}$ of step 5

NOTE!

If desired, each range can be checked at 1/10 and full-scale outputs using the procedure given in Table 4-2. Loads are listed in Table 4-1.

- e. Select the STDBY/RESET mode.

4-21. MA MODE. This check will determine if the output current remains constant for a combined $\pm 10\%$ line voltage and full load change.

- a. Connect the Model 3330B power cord to an autotransformer set for an output of 115 vac.

- b. Set the Model 3330B controls as follows:
- | | |
|---------------|---------------------|
| POWER | PUSH ON, STBY/RESET |
| METER READING | CURRENT |
| MODE | MA, 1 |
| VOLTAGE TRIP | 1000, VERNIER HI |
| CURRENT LIMIT | HI |
| CROWBAR | OFF |
| Decade Dials | 1.0000000 |

- c. Make the equipment connections shown in Figure 4-1. R_L is 1M, 2W and R_S is a 1K, 0.002W

Standard. All connecting leads must be pure copper with spade lugs.

- d. Select the OPR mode and perform the checks given in Table 4-3. The output current (R_S voltage) should be within the specified limits.

- e. Select the STDBY/RESET mode.

4-22. Ripple Checks

4-23. VOLTAGE MODE. This check provides a means of verifying that ac components superimposed on the constant voltage output are within the specified limits.

- a. Connect the Model 3330B power cord to 115 vac.

- b. Set the Model 3330B controls as follows:

POWER	PUSH ON, STBY/RESET
METER READING	VOLTAGE
MODE	VOLTS, 10
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	10.000000

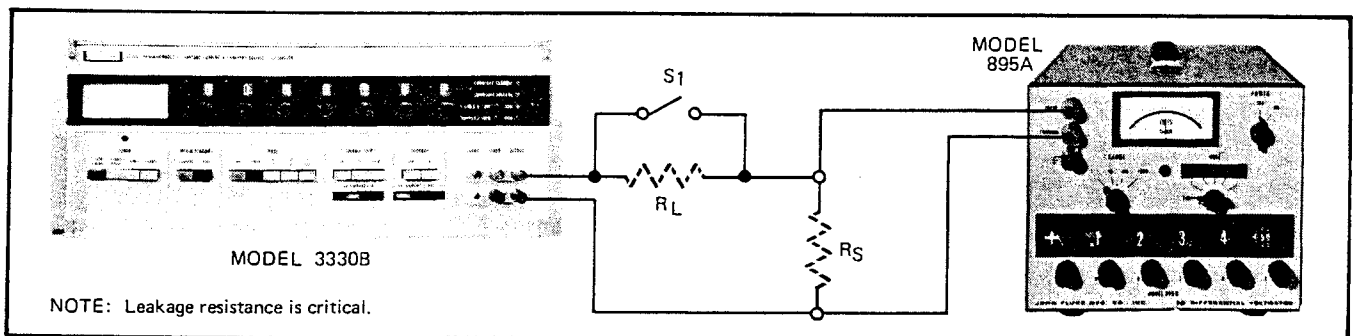


Figure 4-1. MA MODE REGULATION CHECK-EQUIPMENT CONNECTIONS

- c. Connect a x1000 Preamplifier to the Model 3330B OUTPUT terminals. Also connect an rms voltmeter to the Preamplifier output.
- d. Select the OPR mode and perform the checks given in Table 4-4. Specified ripple indications in Table 4-4 include the gain of the Preamplifier.
- e. Select the STDBY/RESET mode.

4-24. MA MODE. This check provides a means of verifying that ac components on the constant current output are within specified limits.

- a. Connect the Model 3330B power cord to 115 vac.
- b. Set the Model 3330B controls as follows:

POWER	PUSH ON, STBY/RESET
METER READING	CURRENT
MODE	MA, 1
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	.0000000

- c. Connect a 10K $\pm 10\%$, 1 watt load to the OUTPUT terminals. Also connect the GUARD terminal to the common side of the load.
- d. Connect a X1000 Preamplifier to the OUTPUT terminals. Connect an rms voltmeter to the Preamplifier output.
- e. Select the OPR mode, observing that the rms voltmeter indication is less than 200 uv.
- f. Select the 10MA range, observing that the rms voltmeter indication is less than 1.0 mv.
- g. Disconnect the Preamplifier, and then connect the rms voltmeter directly to the Model 3330B OUTPUT terminals. The rms voltmeter indication should be less than 10 mv.
- h. Select the STDBY/RESET mode.

4-25. Accuracy Checks

4-26. VOLTAGE MODE. The accuracy of the output voltage can be verified in the following manner:

Table 4-3. MA MODE REGULATION CHECKS

STEP	MODEL 3330B CONTROL SETTINGS		OUTPUT LOAD		INPUT POWER (VAC)	S1 POSITION	OUTPUT CURRENT (R_s VOLTAGE)
	RANGE	DECADE DIALS	RL	R_s (Std)			
1	1	.10000000	1M, 2W	1K	115	Closed	RECORD
2	1	.10000000	1M, 2W	1K	103 thru 127	Open	± 20 uv of step 1
3	10	10.000000	100K, 20W	100 Ω	115	Closed	RECORD
4	10	10.000000	100K, 20W	100 Ω	103 thru 127	Open	± 5 uv of step 3
5	100	100.000000	5K, 50W	10 Ω	115	Closed	RECORD
6	100	100.000000	5K, 50W	10 Ω	103 thru 127	Open	± 5 uv of step 5

Table 4-4. VOLTAGE MODE RIPPLE CHECKS

STEP	MODEL 3330B CONTROL SETTINGS		OUTPUT LOAD	MAXIMUM RIPPLE RMS (X1000)
	RANGE	DECADE DIALS		
1	10	10.000000	NONE	60 mv
2	10	10.000000	100 Ω , 2W	0.1v
3	100	100.000000	NONE	70 mv
4	100	100.000000	1K, 20W	0.1v
5	1000	1000.0000	NONE	0.1v
6	1000	1000.0000	20K, 50W	0.1v

- a. Connect the Model 3330B power cord to 115 vac.
- b. Set the Model 3330B controls as follows:
- | | | | |
|---------------|---------------------|---------------|---------------------|
| POWER | PUSH ON, STBY/RESET | POWER | PUSH ON, STBY/RESET |
| METER READING | VOLTAGE | METER READING | CURRENT |
| MODE | VOLTS, 10 | MODE | MA, 1 |
| VOLTAGE TRIP | 1000, VERNIER HI | VOLTAGE TRIP | 1000, VERNIER HI |
| CURRENT LIMIT | HI | CURRENT LIMIT | HI |
| CROWBAR | OFF | CROWBAR | OFF |
| Decade Dials | 5.000000 | Decade Dials | .1000000 |
- c. Connect a power supply calibrator (Fluke Model 7105A System) to the Model 3330B OUTPUT terminals.
- d. Select the OPR mode and perform the checks given in Table 4-5A. The output voltage should be within the specified limits.
- e. Select the STDBY/RESET mode.

4-27. MA MODE. The accuracy of the output current can be verified in the following manner:

- a. Connect the Model 3330B power cord to 115 vac.

4-28. Stability Checks

4-29. VOLTAGE MODE. This check will determine if the output voltage remains constant over a given period of time.

- a. Connect the Model 3330B power cord to 115 vac.

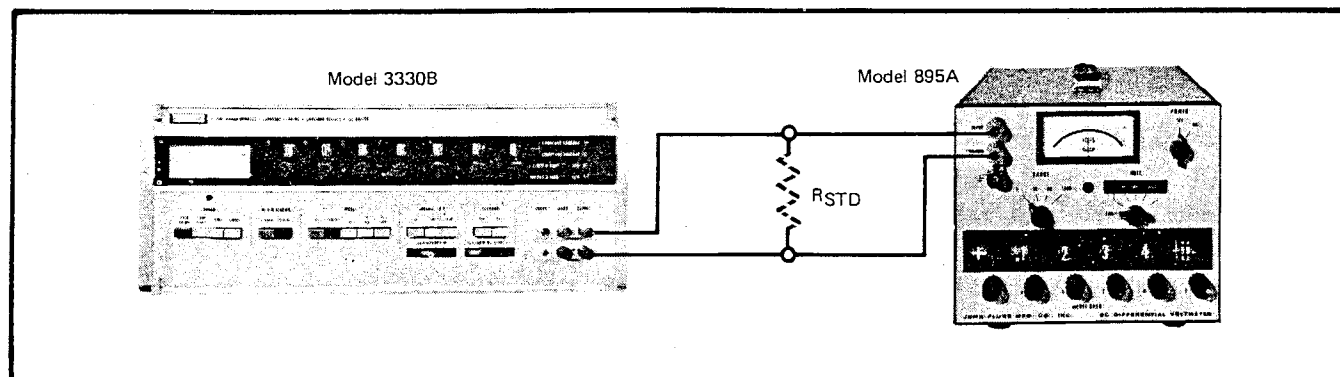


Figure 4-2. MA MODE ACCURACY CHECK – EQUIPMENT CONNECTIONS

Table 4-5A. VOLTAGE MODE ACCURACY CHECKS

STEP	MODEL 3330B CONTROL SETTINGS		OUTPUT VOLTAGE (VDC)
	RANGE	DECADE DIALS	
1	10	5.000000	5 ± 0.15 mv
2	10	10.000000	10 ± 0.3 mv
3	100	10.000000	10 ± 0.3 mv
4	100	50.000000	50 ± 1.5 mv
5	100	100.000000	100 ± 3 mv
6	1000	100.000000	100 ± 3 mv
7	1000	500.000000	500 ± 15 mv
8	1000	1000.000000	1000 ± 30 mv

Table 4-5B. MA MODE ACCURACY CHECKS

STEP	MODEL 3330B CONTROL SETTINGS		R _{STD}	OUTPUT CURRENT (R _{STD} VDC)
	RANGE	DECADE DIALS		
1	1	.10000000	1K	0.1 ± 6 μ v
2	1	.50000000	1K	0.5 ± 30 μ v
3	1	1.00000000	1K	1.0 ± 60 μ v
4	10	1.00000000	100 Ω	0.1 ± 6 μ v
5	10	5.00000000	100 Ω	0.5 ± 30 μ v
6	10	10.00000000	100 Ω	1.0 ± 60 μ v
7	100	10.00000000	10 Ω	0.1 ± 6 μ v
8	100	50.00000000	10 Ω	0.5 ± 30 μ v
9	100	100.00000000	10 Ω	1.0 ± 60 μ v

- b. Set the Model 3330B controls as follows:

POWER	PUSH ON, STBY/RESET
METER READING	VOLTAGE
MODE	VOLTS, 1000
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	<u>1000.0000</u>

- c. Select the OPR mode and allow the Model 3330B to operate for at least one hour. The ambient room temperature must be 23°C , $\pm 1^{\circ}\text{C}$.
- d. Select the STDBY/RESET mode and connect a DC Voltage Stability Measurement System (FLUKE Model 7105A) to the OUTPUT terminals.
- e. Select the OPR mode. After 24 hours the output voltage should not change more than ± 5 mv.
- f. Select the STDBY/RESET mode.

4-30. MA MODE. This check will determine if the output current remains constant over a given period of time.

- a. Connect the Model 3330B power cord to 115 vac.

- b. Set the Model 3330B controls as follows:

POWER	PUSH ON, STBY/RESET
METER READING	CURRENT
MODE	MA, 10
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	<u>10.000000</u>

- c. Make the equipment connections shown in Figure 4-1. R_L is 100K, 20W, and R_S is a 100 Ω Standard

NOTE!

SI must be open

- d. Select the OPR mode and allow the Model 3330B to operate for at least one hour. The ambient room temperature must be 23°C , $\pm 1^{\circ}\text{C}$.
- e. Connect a chart recorder to the dc voltmeter RECORDER OUTPUT terminals and establish a reference which is the voltage across R_S .
- f. Operate the equipment for 24 hours. The output current should not change more than ± 0.1 ua during this period. This is equal to a voltage change of less than ± 10 uv across R_S .

4-31. Voltage Trip Checks

4-32. This check provides a means of verifying that the VOLTAGE TRIP is functioning properly.

- a. Connect the Model 3330B power cord to 115 vac.
- b. Set the Model 3330B controls as follows:

POWER	PUSH ON, STBY/RESET
METER READING	VOLTAGE
MODE	VOLTS, 100
VOLTAGE TRIP	100, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	<u>100.00000</u>

- c. Select the OPR mode. The OPR lamp should be illuminated.
- d. Advance the Decade Dials to 10X.XX000. When this new setting is reached, the I LIMIT/V TRIP lamp should illuminate and the OPR lamp should go out.
- e. Select the STDBY/RESET mode and set the Decade Dials to 10X.00000.
- f. Select the OPR mode. The OPR lamp should be illuminated.
- g. Select the STDBY/RESET mode.

4-33. Current Limit Checks

4-34. This check provides a means of verifying that the CURRENT LIMIT is functioning properly.

- a. Connect the Model 3330B power cord to 115 vac.
- b. Set the Model 3330B controls as follows:

POWER	PUSH ON, STBY/RESET
METER READING	CURRENT
MODE	MA, 100
VOLTAGE TRIP	100, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	ON
Decade Dials	<u>100.00000</u>

- c. Select the OPR mode.
- d. Advance the Decade Dials to 10X.X0000. When this new setting is reached, the I LIMIT/V TRIP lamp should just illuminate.
- e. Set the Decade Dials to 01.00000. The I LIMIT/V TRIP lamp should be off.
- f. Slide the CURRENT LIMIT control towards the LO setting. The I LIMIT/V TRIP lamp should just illuminate when the LO position is reached.
- g. Select the STDBY/RESET and CROWBAR OFF modes.

4-35. Rate Limiter Checks

4-36. This check provides a means of verifying that the programming rate limiter is functioning properly.

- a. Connect the Model 3330B power cord to 115 vac.
- b. Set the Model 3330B controls as follows:

POWER	PUSH ON, STBY/RESET
METER READING	VOLTAGE
MODE	VOLTS, 1000
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	<u>1000.0000</u>

- c. Select the OPR mode.
- d. Alternately select the 10 and 1000 volt ranges at a rate greater than once every 5 seconds. The I LIMIT/V TRIP lamp should illuminate, and the OPR lamp should go out.
- e. Select the STDBY/RESET mode and then the OPR mode. The OPR lamp should be illuminated.
- f. Select the STDBY/RESET mode.

4-37. Remote Programming Checks

4-38. Complete verification of all remote programming functions should be done before the Model 3330B is considered fully operational. Information located in the Section II, Operating Instructions, can be used to check these functions.

4-39. CALIBRATION

4-40. Introduction

4-41. The Model 3330B should be calibrated every 90 days or whenever repairs have been made. Calibration should be done at an ambient room temperature of 23°C, $\pm 1^\circ\text{C}$. Table 4-1 lists the required test equipment.

4-42. Maintenance Access

4-43. To gain access to the calibration adjustments, proceed as follows:

- a. Turn off the Model 3330B.
- b. Remove the top dust cover and inner cover. Access is now provided to the calibration adjustments and test points shown in Figure 4-3.

NOTE!

The interlock switch shown in Figure 4-3 must be closed before the instrument can be energized with the covers removed.

4-44. Servicing Tools

4-45. Special tools are provided for servicing of the plug-in assemblies. These tools consist of a card puller ring and an extender card. The card puller ring is located in a container shipped with the instrument. The extender card is mounted in a plastic holder on the rear panel. To service a plug-in assembly, proceed as follows:

- a. Perform the Maintenance Access procedures in paragraph 4-42.
- b. Locate the assembly to be removed and insert the card puller ring in the hole at the top of the board. Refer to Figure 4-3 for assembly locations.
- c. Insert your index finger in the card puller ring and remove the plug-in assembly using a gentle rocking and even pulling force.
- d. Install the extender card in the assembly position. Ensure that the mating connectors are correctly aligned.
- e. Install the plug-in assembly on the extender card. The mating connectors must be correctly aligned with the same configuration as that in the instrument.

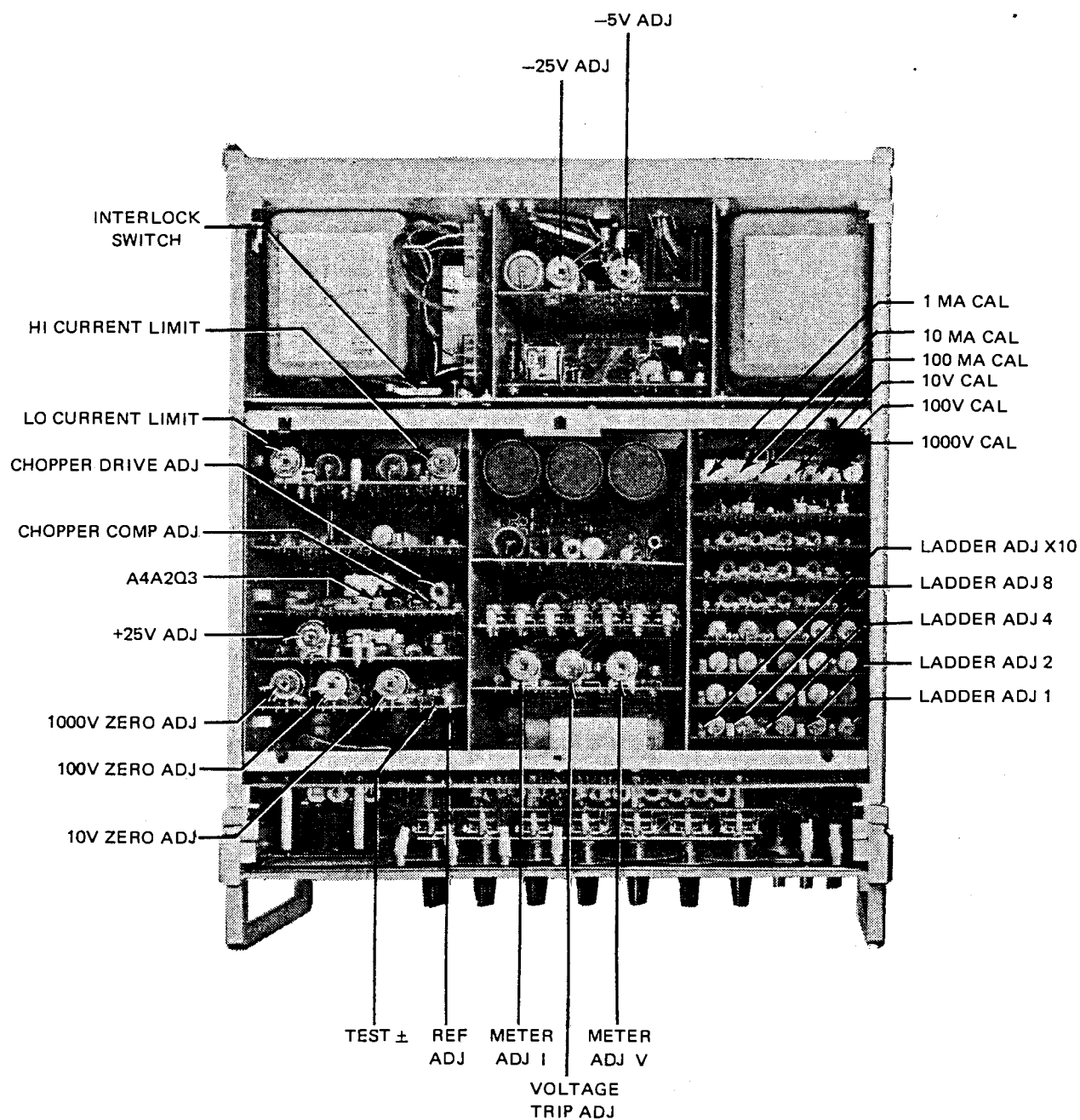


Figure 4-3. ADJUSTMENT, TEST POINT AND ASSEMBLY LOCATIONS (Sheet 1 of 2)

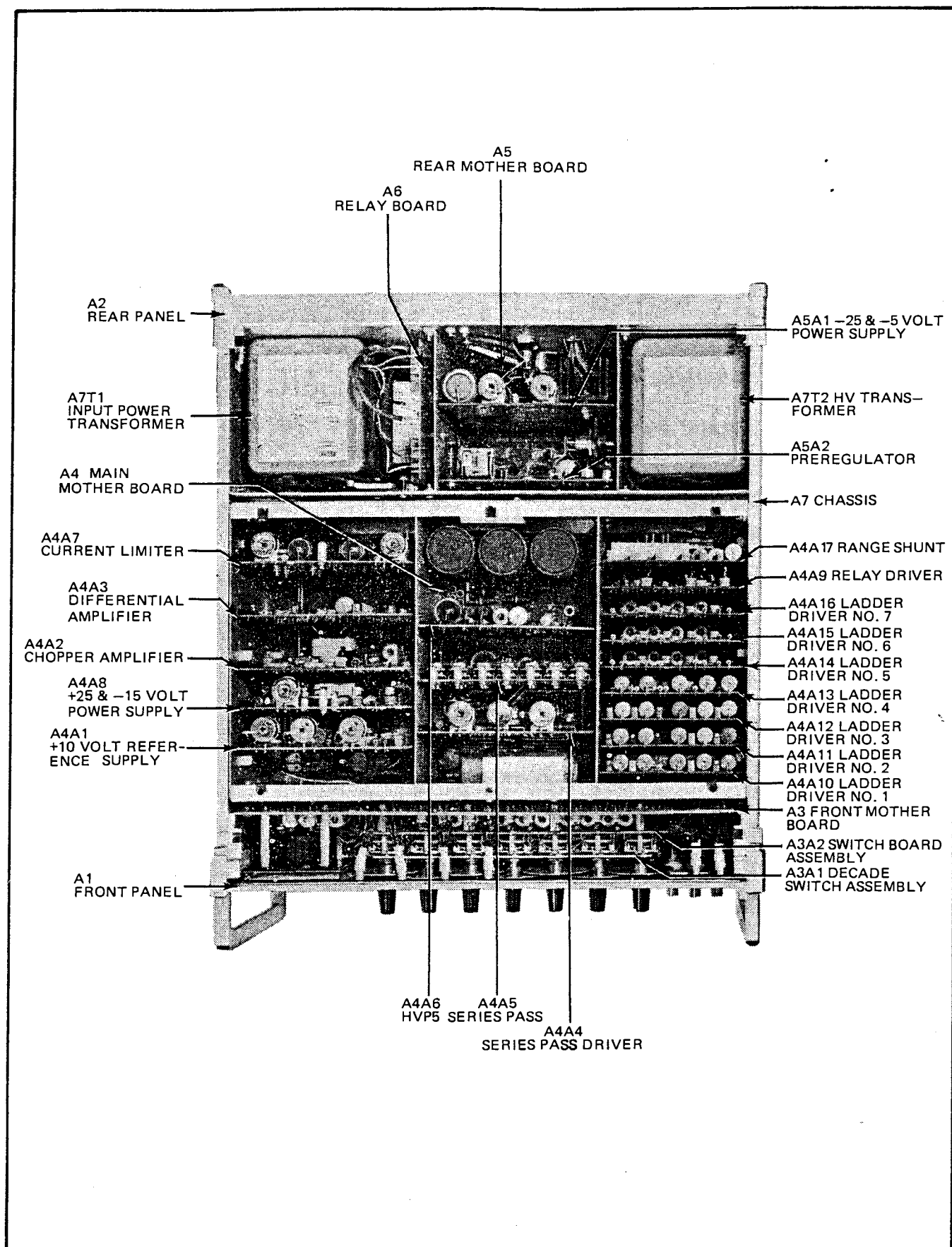


Figure 4-3. ADJUSTMENT, TEST POINT AND ASSEMBLY LOCATIONS (Sheet 2 of 2)

4-46. Preliminary Calibration Procedures

- a. Perform the Maintenance Access procedures given in paragraph 4-42.
- b. Connect the Model 3330B power cord to 115 vac.
- c. Set the Model 3330B controls as follows:

POWER	PUSH ON, STBY/RESET
METER READING	VOLTAGE
MODE	VOLTS, 10
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	0.000000
- d. Select the OPR mode and allow the Model 3330B to operate for at least one hour.

4-47. +25 and -5 VDC Alignment

- a. Install the A4A8 assembly on the extender card.
- b. Connect the input of a dc voltmeter to A4A8 terminal 10 and its common to the +SENSE terminal.
- c. Turn on the Model 3330B and select the STDBY/RESET mode.
- d. Adjust A4A8R9, +25V ADJ, for a 25 ± 0.01 vdc indication on the voltmeter.
- e. Turn off the Model 3330B and install the A4A8 assembly.
- f. Install the A5A1 assembly on the extender card.
- g. Connect the input of a dc voltmeter to A5A1 terminal 6 and its common to terminal 5.
- h. Turn on the Model 3330B and select the STDBY/RESET mode.
- i. Adjust A5A1R5, -25V ADJ, for a -25 ± 0.025 vdc indication on the voltmeter.
- j. Connect the dc voltmeter input to A5A1 terminal 16.
- k. Adjust A5A1R11, -5V ADJ, for -5 ± 0.01 vdc indication on the voltmeter.
- l. Turn off the Model 3330B and install the A5A1 assembly.

4-48. Chopper Amplifier Alignment

- a. Remove the A4A2 Chopper Amplifier PCB Assembly from its slot and install a jumper wire between pins 6 and 12 on the pcb.
- b. Install the extender pcb in the Chopper Amplifier slot, and install the Chopper Amplifier PCB on the extender.
- c. On the front panel of the 3330B connect the positive output terminal (red) to the chassis ground terminal.
- d. Refer to Figure 4-4 and connect a X1 scope probe to the negative side of C13 on the Chopper Amplifier PCB. Connect the probe's ground lead to the main chassis (not the guard chassis).
- e. Connect the 3330B to line power and sequentially depress the ON-OFF and STDBY RESET switches.

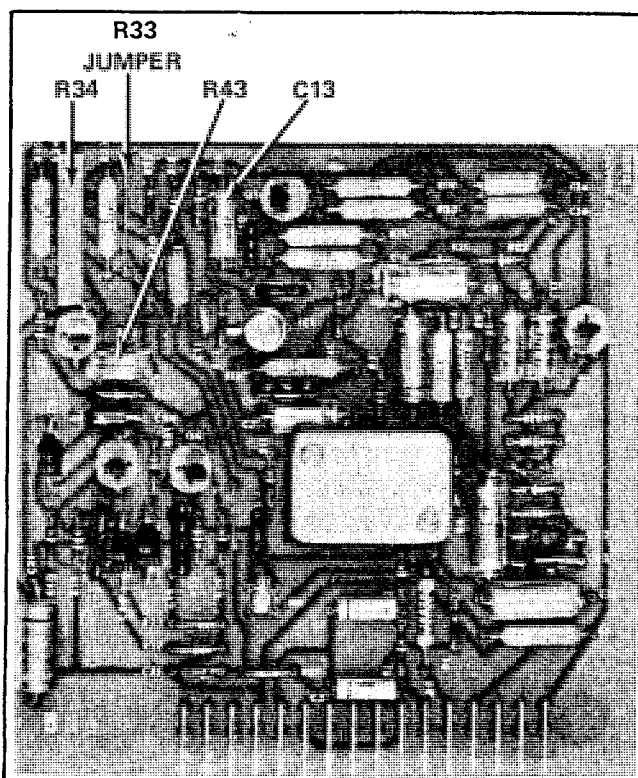


Figure 4-4. CHOPPER AMPLIFIER ADJUSTMENTS AND TEST POINTS

- f. Set the scopes vertical sensitivity to 1V per division and its horizontal time base to 500 us per division. Use dc coupling and adjust the trace so that zero volts is at the center of the display.
- g. Refer to Figure 4-4 and adjust R43 (chopper drive) to its maximum CW position.
- h. On the scope, observe a low level signal which is interrupted approximately every 2 ms by a spike.

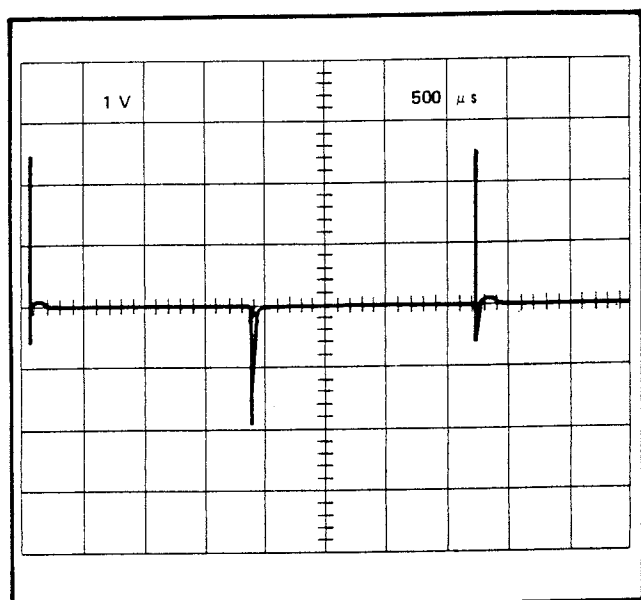


Figure 4-5. CHOPPER WAVEFORM – INITIAL ADJUSTMENT

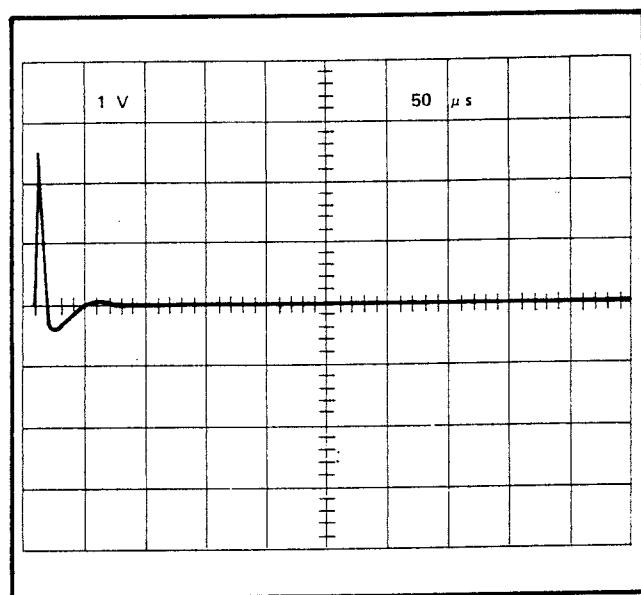


Figure 4-6. CHOPPER WAVEFORM – FINAL ADJUSTMENT

- i. Adjust R43 in a CCW direction until the noise on the alternate 2 ms segments appears to be equal. From this point, adjust R43 one-quarter of a turn in the CW direction. One segment should appear noisy and the other quiet.
- j. Adjust R34 so that the noisy segment is preceded by a positive-going spike similar to that shown in Figure 4-5. If the adjustment cannot be made, either install or remove the jumper across R33 (See Figure 4-4) and readjust R34 to obtain the specified display.

- k. Decrease the scope's time base to 50 μ s per division, and fine tune R34 so that the area under the spike preceding the noisy region is equal to the area under the negative overshoot as shown in Figure 4-6.
- l. Remove the jumper wire from pins 6 and 12.
- m. Set the front panel dials to 0.00000 and select the 10V range.
- n. Depress the OPR (operate) switch.
- o. Set the scope's time base to 1 sec per division. There should be no evidence of low frequency oscillations (1 to 5 Hz) on the display. If oscillations do occur, turn R43 CW until the oscillations have stopped. Then continue to advance R43 for another one-quarter of a turn in the CW direction. Readjust R34 in accordance with steps j and k of this procedure.
- p. Turn the 3330B off, remove the probe and re-install the Chopper Amplifier PCB in its slot.

4-49. Current Ripple Compensation

- a. Connect the input of an rms voltmeter to the -OUTPUT terminal and its common to the +OUTPUT terminal.
- b. Connect a 10K \pm 10%, 1/4W resistor between the \pm OUTPUT terminals.
- c. Set the Model 3330B controls as follows:

POWER	PUSH ON, STBY/RESET
METER READING	CURRENT
MODE	MA, 1
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	.0000000

- d. Select the OPR mode and adjust A7R1 for minimum rms voltage at the OUTPUT terminals.
- e. Select the STDBY/RESET mode and disconnect the test equipment.

4-50. Range Zero Alignment.

- a. Connect the input of a dc voltmeter to the OUTPUT terminals, observing proper polarity.
- b. Set the Model 3330B controls as follows:

POWER	PUSH ON, OPR
METER READING	VOLTAGE
MODE	VOLTS, 10
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	0.000000

- c. Adjust A4A1R19, 10V ZERO ADJ, for a 0 ± 2 uv indication on the voltmeter.
- d. Select the 100 volt range and adjust A4A1R21, 100V ZERO ADJ, for a 0 ± 20 uv indication on the voltmeter.
- e. Select the 1000 volt range and adjust A4A1R20, 1000V ZERO ADJ, for a 0 ± 0.2 mv indication on the voltmeter.

4-51. 10 Volt Reference Alignment

- a. Select the 10 volt range.
- b. Connect the input of a dc voltmeter to the TEST \pm points on the A4A1 assembly.
- c. Adjust A4A1R10, REF ADJ, for a $10V \pm 10$ uv indication on the voltmeter.
- d. Disconnect the voltmeter.

4-52. Ladder Alignment

- a. Select the 100 volt range.
- b. Connect the input of a dc voltmeter to the OUTPUT terminals, observing proper polarity.
- c. Perform the adjustments in Table 4-6.

Table 4-6. LADDER ADJUSTMENT ①

DECADE DIALS	ADJUSTMENT (A4A10)	VOLTMETER INDICATION (VDC)
40.00000	A4A17R18 100V CAL	$40V \pm 40$ uv
80.00000	R4 LADDER ADJ 8	$80V \pm 80$ uv
20.00000	R8 LADDER ADJ 2	$20V \pm 20$ uv
10.00000	R10 LADDER ADJ 1	$10V \pm 10$ uv
0X.00000	R2 LADDER ADJ X10	$10V \pm 10$ uv

- d. Select the STDBY/RESET mode and then exchange the positions of Ladder Driver No. 1 and No. 2 (A4A10 and A4A11).
- e. Select the OPR mode and perform the adjustments in Table 4-7.
- f. Select the STDBY/RESET mode.
- g. Install Ladder Driver No. 2 in its correct A4A11 position.
- h. Exchange the positions of Ladder Driver No. 1 and No. 3 (A4A10 and A4A12).
- i. Select the OPR mode and perform the adjustments in Table 4-7.

Table 4-7. LADDER ADJUSTMENT ②

DECADE DIALS	ADJUSTMENT (A4A10)	VOLTMETER INDICATION (VDC)
40.00000	R6 LADDER ADJ 4	$40V \pm 40$ uv
80.00000	R4 LADDER ADJ 8	$80V \pm 80$ uv
20.00000	R8 LADDER ADJ 2	$20V \pm 20$ uv
10.00000	R10 LADDER ADJ 1	$10V \pm 10$ uv
0X.00000	R2 LADDER ADJ X10	$10V \pm 10$ uv

- j. Select the STDBY/RESET mode and install the Ladder Driver No. 1 and No. 3 in their correct A4A10 and A4A12 positions.
- k. Select the OPR mode.
- l. Set the Decade Dials to 10.00000 and record the output voltage to within ± 2 uv.
- m. Set the Decade Dials to 0X.00000 and adjust A4A10R2, LADDER ADJ, X10, for the same voltage recorded in step 1.

4-53. Voltage Range Alignment

- a. Set the Decade Dials to 10.00000.
- b. Perform the adjustments in Table 4-8.
- c. Select the STDBY/RESET mode and disconnect the voltmeter.

Table 4-8. VOLTAGE RANGE ADJUSTMENTS

MODE (Range)	ADJUSTMENT (A4A17)	VOLTMETER INDICATION (VDC)
10V	R15, 10V CAL	10V \pm 10 μ v
100V	R18, 100V CAL	100V \pm 0.1 mv
1000V	R21, 1000V CAL	1000V \pm 1 mv

4-54. MA Range Alignment

- a. Set the Model 3330B controls as follows:

POWER	PUSH ON, STBY/RESET
METER READING	CURRENT
MODE	MA, 1
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	.10000000

- b. With the instrument in the OPR mode perform the adjustments in Table 4-9. Loads and voltmeter connections are made at the OUTPUT terminals using a four terminal shunt circuit connection.
- c. Select the STDBY/RESET mode and disconnect the load and voltmeter.

4-55. Meter Alignment

- a. Set the Model 3330B controls as follows:

POWER	PUSH ON, OPR
METER READING	VOLTAGE
MODE	VOLTS, 1000
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	1000.0000

- b. Adjust A4A4R5, METER ADJ. V, for a meter reading of 1000 \pm 10 vdc.
- c. Check the meter reading at Decade Dial settings of 600.0000 and 200.0000. The meter reading should be within \pm 10 vdc of the selected output. If necessary, adjust A4A4R5, METER ADJ. V, for the best possible meter reading linearity.
- d. Set the Model 3330B controls as follows:
- | | |
|---------------|------------------|
| POWER | PUSH ON, OPR |
| METER READING | CURRENT |
| MODE | MA, 100 |
| VOLTAGE TRIP | 1000, VERNIER HI |
| CURRENT LIMIT | HI |
| CROWBAR | ON |
| Decade Dials | 100.00000 |
- e. Adjust A4A4R2, METER ADJ. I, for a meter reading of 100 \pm 1 ma.
- f. Select the STDBY/RESET and CROWBAR OFF modes.

4-56. Current Limit Alignment

4-57. Two methods can be used to align the CURRENT LIMIT feature; one is for manual front panel operation, and the other is for remote operation. Choice of either method depends on the particular instrument applications.

4-58. MANUAL CURRENT LIMIT ADJUSTMENTS. If the Model 3330B is to be operated manually, perform the following CURRENT LIMIT adjustments:

- a. Set the Model 3330B controls as follows:

POWER	PUSH ON, OPR
METER READING	CURRENT
MODE	MA, 100
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	ON
Decade Dials	10X.X0000

Table 4-9. MA RANGE ADJUSTMENTS

MODEL 3330B CONTROLS		OUTPUT LOAD	VOLTMETER INDICATION (VDC)	ADJUSTMENT (A4A17)
MA RANGE	DECADE DIALS			
1	.10000000	1K, Std.	1V \pm 2 μ v	R1, 1MA CAL
10	10.000000	100 Ω , Std.	1V \pm 2 μ v	R5, 10 MA CAL
100	100.00000	10 Ω , Std.	1V \pm 2 μ v	R9, 100MA CAL

- b. Adjust A4A7R23, HI CURRENT LIMIT ADJ, until the I LIMIT/V TRIP lamp just illuminates.
- c. Set the Decade Dials to 01.00000.
- d. Slide the CURRENT LIMIT vernier to LO and adjust A4A7R24, LO CURRENT LIMIT ADJ., until the I LIMIT/V TRIP lamp just illuminates.
- e. Repeat steps a through d until the specified results are obtained.
- f. Select the STDBY/RESET and CROWBAR OFF modes.

4-59. REMOTE CURRENT LIMIT ADJUSTMENT. If the Model 3330B is to be operated remotely, perform the following CURRENT LIMIT adjustments:

- a. Program the following operating conditions:

POWER	OPR
MODE	MA, 100
V TRIP/I LIMIT	REMOTE
V TRIP/ RANGE	100V
V TRIP VERNIER	110% (8 + 2 + 1)
CURRENT LIMIT	110% (8 + 2 + 1)
CROWBAR	ON
POLARITY	POSITIVE
Decades	<u>10</u> X.XX000

- b. Adjust A4A7R23, HIGH CURRENT LIMIT ADJ., until the I LIMIT/V TRIP lamp just illuminates.
- c. Program the Decades to 01.00000 and the CURRENT LIMIT to LO (0-0-0-0).
- d. Adjust A4A7R24, LO CURRENT LIMIT ADJ, until the I LIMIT/V TRIP lamp just illuminates.
- e. Repeat steps a through d until the specified results are obtained.
- f. Program the conditions in Table 4-10, observing that the I LIMIT/V TRIP lamp illuminates within the specified limit tolerance.
- g. Program the STDBY/RESET and CROWBAR OFF conditions.

4-60. Voltage Trip Alignment

- a. Rotate A4A4R13, V TRIPOUT ADJ, fully counter-clockwise.

Table 4-10. REMOTE CURRENT LIMIT CHECKS

DECADES	CURRENT LIMIT	LIMIT TOLERANCE (MA)
80.00000	80% (8)	80 ± 10%
40.00000	40% (4)	40 ± 10%
20.00000	20% (2)	20 ± 20%
10.00000	10% (1)	10 ± 20%

- b. Set the Model 3330B controls as follows:

POWER	PUSH ON, STBY/RESET
METER READING	VOLTAGE
MODE	VOLTS, 100
VOLTAGE TRIP	100, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	<u>10</u> X.XX000

- c. Select the OPR mode and adjust A4A4R13 clockwise until the Model 3330B trips to the STDBY/ reset mode. The I LIMIT/V TRIP lamp should illuminate, and the OPR lamp should go out.

- d. Select the STDBY/RESET mode.

4-61. Final Calibration

4-62. The following calibration procedures should be done only after the Model 3330B has been operated for at least 24 hours at an ambient room temperature of 23°C ± 1°C, with the output set to 100 volts on the 100 volt range. The inner cover must be installed and the top dust cover set in place during the operating period. All output measurements are done using a FLUKE model 7105A System or equivalent.

4-63. FINAL RANGE ZERO

- a. Set the Model 3330B controls as follows:

POWER	PUSH ON, STBY/RESET
METER READING	VOLTAGE
MODE	VOLTS, 10
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	0.000000

- b. Connect a null detector (FLUKE 7105A System) to the OUTPUT terminals.

- c. Select the OPR mode and perform the adjustments in Table 4-11

Table 4-11. FINAL RANGE ZERO ADJUSTMENTS

VOLTAGE RANGE	ADJUSTMENT (A4A1)	NULL DETECTOR INDICATION
10	10V ZERO ADJ	$0 \pm 2 \text{ } \mu\text{V}$
100	100V ZERO ADJ	$0 \pm 20 \text{ } \mu\text{V}$
1000	1 KV ZERO ADJ	$0 \pm 200 \text{ } \mu\text{V}$

- d. Select the STDBY/RESET mode and disconnect the null detector.

4-64. FINAL LADDER AND VOLTAGE RANGE.

- a. Connect a dc differential voltmeter (FLUKE 7105A System) to the OUTPUT terminals, observing proper polarity.
- b. Select the 100 volt range and OPR mode.
- c. Perform the adjustments in Table 4-12.

Table 4-12. FINAL LADDER ADJUSTMENTS

DECADE DIALS	ADJUSTMENT (A4A10)	DVM INDICATION (VDC)
40.00000	100V CAL (A4A17)	$40\text{V} \pm 40 \text{ } \mu\text{V}$
80.00000	LADDER ADJ 8	$80\text{V} \pm 80 \text{ } \mu\text{V}$
20.00000	LADDER ADJ 2	$20\text{V} \pm 20 \text{ } \mu\text{V}$
10.00000	LADDER ADJ 1	$10\text{V} \pm 10 \text{ } \mu\text{V}$
0X.00000	LADDER ADJ X10	$10\text{V} \pm 10 \text{ } \mu\text{V}$

- d. Select the STDBY/RESET mode and then connect a power supply calibrator (FLUKE 7105A System) to the OUTPUT terminals.
- e. Select the OPR mode and then perform the adjustments in Table 4-13.

- f. Perform the checks in Table 4-14.

- g. Select the STDBY/RESET mode and disconnect the test equipment.

4-65. FINAL MA RANGE

- a. Set the Model 3330B controls as follows:

POWER	PUSH ON, STBY/RESET
METER READING	CURRENT
MODE	MA, 1
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	.10000000

- b. Connect a dc differential voltmeter (FLUKE 7105A System) to the OUTPUT terminals.

Table 4-14. FINAL VOLTAGE RANGE CHECKS

MODEL 3330B CONTROL SETTINGS		POWER SUPPLY CALIB. INDICATION
RANGE	DECADE DIALS	(VDC)
10	5.000000	$5\text{V} \pm 15 \text{ } \mu\text{V}$
100	50.00000	$50\text{V} \pm 15 \text{ } \mu\text{V}$
1000	500.0000	$500\text{V} \pm 15 \text{ } \mu\text{V}$

- c. With the Model 3330B in the OPR mode, perform the adjustments in Table 4-15. The specified load must be connected between the OUTPUT terminals and voltmeter using a four terminal shunt connection.
- d. Select the STDBY/RESET mode and disconnect the test equipment. Calibration of the Model 3330B is completed. Table 4-16 contains a summary of all calibration steps.

Table 4-13. FINAL VOLTAGE RANGE ADJUSTMENTS

MODEL 3330B CONTROL SETTINGS		ADJUSTMENT (A4A17)	PWR. SUPPLY CALIB. INDICATION (VDC)
RANGE	DECADE DIALS		
10	10.000000	10V CAL	$10\text{V} \pm 4 \text{ } \mu\text{V}$
100	100.00000	100V CAL	$100\text{V} \pm 4 \text{ } \mu\text{V}$
1000	1000.0000	1000V CAL	$1000\text{V} \pm 4 \text{ } \mu\text{V}$

Table 4-15. FINAL MA RANGE ADJUSTMENTS

MODEL 3330B CONTROL SETTINGS		LOAD (Rstd)	ADJUSTMENT (A4A17)	DVM INDICATION (VDC)
MA RANGE	DECADE DIALS			
1	.10000000	1K	1 MA CAL	1V \pm 1 μ v
10	10.000000	100 Ω	10 MA CAL	1V \pm 1 μ v
100	100.00000	10 Ω	100 MA CAL	1V \pm 1 μ v

Table 4-16. CALIBRATION PROCEDURE SUMMARY (Sheet 1 of 2)

STEP	PARA	PROCEDURE	RESULT
1	4-46	Preliminary Calibration	(1 hr. warm-up, 10V Range- 0.000000 OUTPUT)
2	4-47	± 25 and -5 VDC Alignment + 25V ADJ - 25V ADJ - 5V ADJ	+25 \pm 0.01 vdc (A4A8-10, + SENSE) -25 \pm 0.025 vdc (A5A1-6, 5) - 5 \pm 0.01 vdc (A5A1 - 16, 5)
3	4-48	Chopper Alignment CHOPPER DRIVE ADJ CHOPPER COMP ADJ CHOPPER DRIVE ADJ CHOPPER COMP ADJ	(Scope to A4A2Q3 base, + SENSE) Fully cw Minimum pulse amplitude ccw for noise. cw for clean signal +1/8 turn cw. Equal pulse amplitude
4	4-49	Current Ripple Compensation A7R1	(RMS Voltmeter at OUTPUT with 10K load) Minimum rms voltage at OUTPUT
5	4-50	Range Zero Alignment 10V ZERO ADJ 100V ZERO ADJ 1000V ZERO ADJ	(DVM at OUTPUT) 0 \pm 2 μ v 0 \pm 20 μ v 0 \pm 0.2.mv
6	4-51	10 Volt Reference Alignment REF ADJ	(DVM at TEST \pm) 10V \pm 10 μ v
7	4-52	Ladder Alignment (Decade Dials) (1) Ladder 1 100V CAL (40.00000) LADDER ADJ 8 (80.00000) LADDER ADJ 2 (20.00000) LADDER ADJ 1 (10.00000) LADDER ADJ X10 (0X.00000) (2) Swap Ladder 1 & 2 (3) Ladder 2 LADDER ADJ 4 (40.00000) LADDER ADJ 8 (80.00000) LADDER ADJ 2 (20.00000) LADDER ADJ 1 (20.00000) LADDER ADJ X10 (0X.00000)	(DVM at OUTPUT) 40v \pm 40 μ v 80v \pm 80 μ v 20v \pm 20 μ v 10v \pm 10 μ v 10v \pm 10 μ v 40v \pm 40 μ v 80v \pm 80 μ v 20v \pm 20 μ v 20v \pm 10 μ v 10v \pm 10 μ v

Table 4-16. CALIBRATION PROCEDURE SUMMARY (Sheet 2 of 2)

STEP	PARA	PROCEDURE	RESULT
7	4-52 Cont.	(4) Return Ladder 2 (5) Swap Ladder 1 & 3 (6) Repeat step (3) (7) Return Ladder 1 & 3 (8) Decade Dials to 10.00000 (9) Decade Dials to 0X.00000 (10) LADDER ADJ X10	Record Output ($\pm 2 \mu\text{v}$) Step (8) Voltage Level
8	4-53	Voltage Range Alignment 10V CAL (<u>10.000000</u>) 100V CAL (<u>100.00000</u>) 1000V CAL (<u>1000.0000</u>)	(DVM at OUTPUT) 10V $\pm 10 \mu\text{v}$ (10V Range) 100V $\pm 0.1 \text{ mv}$ (100V Range) 1000V $\pm 1 \text{ mv}$ (1000V Range)
9	4-54	MA Range Alignment 1 MA CAL (1.000000) 10 MA CAL (10.00000) 100 MA CAL (100.0000)	(DVM and Load at OUTPUT) 1v $\pm 2 \mu\text{v}$, 1k Std. (1 MA Range) 1v $\pm 2 \mu\text{v}$, 100 Ω Std. (10 MA Range) 1v $\pm 2 \mu\text{v}$, 10 Ω Std. (100 MA Range)
10	4-55	Meter Alignment METER ADJ V METER ADJ I (<u>100.0000</u>)	(Panel Meter Reading) 1000 $\pm 10 \text{ vdc}$ (1000v Range) 100 $\pm 1 \text{ ma}$ (100 MA Range)
11	4-56 4-58 4-59	Current Limit Alignment MANUAL CURRENT LIMIT HI CURRENT LIMIT (<u>10X.X0000</u>) LO CURRENT LIMIT (<u>01.00000</u>) REMOTE CURRENT LIMIT HI CURRENT LIMIT (<u>10X.X0000</u>) LO CURRENT LIMIT (<u>01.00000</u>)	(100 MA Range, CROWBAR ON) I LIMIT/V TRIP Indication (CURRENT LIMIT HI) I LIMIT/V TRIP Indication (CURRENT LIMIT LO) I LIMIT/V TRIP Indication (CURRENT LIMIT 110%) I LIMIT/V TRIP Indication (CURRENT LIMIT $<1\%$)
12	4-60	Voltage Trip Alignment VOLTAGE TRIP ADJ (<u>10X.XX000</u>)	(100V Range) I LIMIT/V TRIP Indication (VOLTAGE TRIP - 100, VERNIER HI)
13	4-61	Final Calibration	(24 hour Operation at 100V OUTPUT)
14	4-63	FINAL RANGE ZERO 10V ZERO ADJ (0.000000) 100V ZERO ADJ (00.00000) 1 kV ZERO ADJ (000.0000)	(Null Detector at OUTPUT) 0 $\pm 2 \mu\text{v}$ (10V Range) 0 $\pm 20 \mu\text{v}$ (100V Range) 0 $\pm 200 \mu\text{v}$ (1000V Range)
15	4-64	FINAL LADDER AND VOLTAGE RANGE 100V CAL (40.00000) LADDER ADJ 8 (80.00000) LADDER ADJ 2 (20.00000) LADDER ADJ 1 (10.00000) LADDER ADJ X10 (0X.00000) 10V CAL (<u>10.000000</u>) 100V CAL (<u>100.00000</u>) 1000V CAL (<u>1000.0000</u>)	(DVM at OUTPUT — FLUKE 7105A) 40v $\pm 40 \mu\text{v}$ 80v $\pm 80 \mu\text{v}$ 20v $\pm 20 \mu\text{v}$ 10v $\pm 10 \mu\text{v}$ 10v $\pm 10 \mu\text{v}$ 10v $\pm 4 \mu\text{v}$ 100v $\pm 4 \mu\text{v}$ 1000V $\pm 4 \mu\text{v}$
16	4-65	Final MA Range 1 MA CAL (<u>1.10 000000</u>) 10 MA CAL (<u>10.000000</u>) 100 MA CAL (<u>100.00000</u>)	(DVM & LOAD at OUTPUT - FLUKE 7105A) 1v $\pm 1 \mu\text{v}$, 1k Std. 1 MA Range 1V $\pm 1 \mu\text{v}$, 100 Ω Std. 10 MA Range 1V $\pm 1 \mu\text{v}$, 10 Ω Std. 100 MA Range

4-66. TROUBLESHOOTING

4-67. Introduction

4-68. The following paragraphs present a general method of locating the cause of a malfunction. However, before any of these procedures are undertaken, it should be determined that the following conditions do exist:

- The instrument is being operated properly.
- It does not require calibration.
- The plug-in circuit boards are properly seated.
- An inspection has been made for loose wires, physically damaged components, or other obvious problems.

4-69. Major Circuit Isolation

4-70. The circuitry in the Model 3330B is composed of four major sections:

- Auxiliary dc supplies.
- Pre-regulator.
- Main regulator.
- Control circuitry

4-71. Isolation of a trouble in the dc supplies can be done using the information in Table 4-17. Problems in the preregulator or main regulator can be located using

the information in paragraph 4-72. Control circuitry problems can be isolated using the information in paragraph 4-73.

WARNING!

Avoid contact with the inner chassis and exposed parts. This circuitry is at the same potential as the +OUTPUT terminal. Also avoid contact with the Pre-regulator circuitry as it is at line power above ground. Always turn off the Model 3330B and wait a few seconds before removing any plug-in assemblies.

4-72. REGULATOR LOOP ISOLATION. The basic circuitry of the Model 3330B consists of two interacting loops: The Pre-regulator and the Main Regulator. Consequently, problems in one loop can affect the operation of the other. Isolation of a trouble to the appropriate loop can be done in the following manner:

- Turn off the Model 3330B
- Remove the A5A2 Pre-regulator.
- Connect the output of a general purpose power supply to the Model 3330B circuitry (+lead to the collector of Q1 in the A4A5 Series Pass and the -lead to the -OUTPUT terminal).
- Set the power supply output to 70 volts above the selected output voltage of the Model 3330B. For example, if the output of the Model 3330B is set to 20.00000, the power supply output should be 90 vdc.

Table 4-17. AUXILIARY DC SUPPLY CHECKS

TITLE	DESIGNATION	MEASUREMENT POINTS		VOLTAGE
		(+)	(-)	
Sink Supply	HVPS (A4A6)	Pin 11	+ SENSE	+700 \pm 30 vdc
\pm 35V	CURRENT LIMITER (A4A7)	Pin 1 Pin 3	+ SENSE + SENSE	-36 \pm 3 vdc + 36 \pm 3 vdc
+25 -15V	+25 -15V PWR. SUPPLY (A4A8)	Pin 9 Pin 10	+ SENSE + SENSE	-15 \pm 1 vdc + 25 \pm 2 vdc
-25 -5V	-25 -5V PWR SUPPLY (A5A1)	Pin 6 Pin 16	Pin 5 Pin 5	-25 \pm 3 vdc -5 \pm 1 vdc
\pm V	PREREGULATOR (A5A2)	Pin 15 R17 C4 (+)	Pin 13 Pin 13 Pin 13	-14V peak + 14V peak + 13 \pm 1 vdc
+130 6.8V	SERIES PASS (A4A5)	Q8 (c) CR6	+ SENSE + SENSE	+130 \pm 10 vdc (STDBY/RESET) +6.8 \pm 0.7 vdc

- e. Turn on the Model 3330B and select the OPR mode.

FAULT ANALYSIS

If the selected output of the Model 3330B is present, the problem is in the Pre-regulator loop. Should an incorrect output be observed, the problem is in the Main Regulator loop.

4-73. **CONTROL CIRCUITRY.** Correct operation of the control circuitry can be verified by checking for proper response of all front panel controls. Remote programming can be checked in essentially the same manner using the information in Section II. Problems in relay drivers will normally appear in both local or remote operation. Incorrect relay operation can cause problems in other sections of the instrument. This presents added troubleshooting dimensions that should be taken into consideration.

4-74. Preregulator Troubleshooting

4-75. Once a problem has been isolated to the Pre-regulator circuitry, the source of trouble can be located using the following procedure:

- a. Turn off the Model 3330B.
- b. Remove the A5A2 Pre-regulator.
- c. Install the A4A5 Series Pass in the extender card.
- d. Set the Model 3330B controls as follows:

POWER	PUSH ON, STBY/RESET
METER READING	VOLTAGE
MODE	VOLTS 100
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	50.00000

WARNING!

In performing step e use an ungrounded oscilloscope. This assures that the scope chassis and thus the LOW input is not connected to the high potential side of the power line.

- e. Connect the high input of an ungrounded oscilloscope to A4A5 terminal 15 and the low input to terminal 14.

FAULT ANALYSIS

There should be positive pulses having an amplitude of 1 to 2 volts peak-to-peak present on the oscilloscope display (sweep speed set to 1 msec/cm). If the pulses are not observed, the problem is in the VCO circuitry in the A4A5 Series Pass.

- f. Turn off the Model 3330B and install the A4A5 Series Pass.
- g. Install the A5A2 Pre-regulator on the extender card.
- h. Connect the input of the oscilloscope to the base of A5A2Q1 and its common to the emitter.
- i. Turn on the Model 3330B and select the STDBY/RESET mode.

FAULT ANALYSIS

Positive going pulse trains having an amplitude of 1 to 2 volts peak-to-peak should be observed on the oscilloscope display. Intervals between pulse trains should be approximately 8 msec. If the pulse trains are not observed, the problem is in the A5A2 Pre-regulator.

4-76. Main Regulator Troubleshooting

4-77. Once a problem is isolated to the Main Regulator it must be then further isolated to one of four sections which comprise this loop. These sections are as follows:

- a. High Voltage
- b. EREF and Ladder
- c. Series Pass
- d. Amplifier

4-78. **HIGH VOLTAGE.** The High Voltage can be checked by the substitution method given in paragraph 4-72 and the Preregulator checks given in 4-74. If these circuits are functioning normally, the problem is in the A4A6 H.V.P.S.

Table 4-18. SERIES PASS VOLTAGE CHECKS

MODE	DECADE DIALS	OUTPUT LOAD (MA)	LINE VOLTAGE (VAC)	CHECK POINT (A4A5)	CHECK POINT VOLTAGE
VOLTS, 10	10.000000	110	100	Q1 thru Q7 (Emitter to Collector)	Less than 4 vdc
VOLTS, 10	0.000000	0	130	Q8 (Emitter to Collector)	60 to 80 vdc
VOLTS, 1000	1000.0000	100	100	Q8 (Emitter to Collector)	15 to 25 vdc

4-79. EREF AND LADDER. EREF can be checked with a dc voltmeter at the ± TEST points on the A4A1 ±10V Reference Supply. The voltage at this point should be 10V ±10uv. The Ladders (A4A10 through A4A16) can be checked by connecting the dc voltmeter to the OUTPUT terminals and rotating the Decade Dials through each setting, observing for proper output stepping.

4-80. SERIES PASS. The A4A5 Series Pass regulation capability can be checked by measuring the voltage across the series pass transistors. However, this must be done under certain conditions given in Table 4-18.

4-81. AMPLIFIER. The action of the Amplifier, which is a combined function of the A4A3 Differential Amplifier, A4A2 Chopper Amplifier, and A4A4 Series Pass Driver, can be checked by monitoring the VCO pulses in the A4A5 Series Pass. To perform this check, proceed as follows:

Turn off the Model 3330B and remove the A5A2 Pre-regulator.

Connect a general purpose power supply to the OUTPUT terminals, observing proper polarity. Set the power supply output to 5.5 vdc.

Connect the input of an ungrounded oscilloscope to A4A5 terminal 15 and its common to 14.

d. Set the Model 3330B controls as follows:

POWER	PUSH ON STBY/RESET
METER READING	VOLTAGE
MODE	VOLTS, 10
VOLTAGE TRIP	1000, VERNIER HI
CURRENT LIMIT	HI
CROWBAR	OFF
Decade Dials	5.000000

e. Positive VCO pulses having an amplitude of 1 to 2 volts peak-to-peak should be present on the oscilloscope display (sweep speed set to 1 msec/cm).

f. Set the Decade Dials to 6.000000. The VCO pulse should disappear.

FAULT ANALYSIS

If the VCO pulses are present with the Decade Dials set to 6.000000, the problem is in the Amplifier section. General troubleshooting of the associated circuitry should then reveal the source of trouble. Additional checks are given in Table 4-19.

Table 4-19. RANGE CIRCUITRY CHECKS

MODE	DECADE DIALS	VCO PULSES
VOLTS, 100	05.00000	Present
VOLTS, 100	06.00000	Not Present
VOLTS, 1000	005.0000	Present
VOLTS, 1000	006.0000	Not Present

Section 5

Lists of Replaceable Parts

5-1. INTRODUCTION

5-2. This section of the manual is a complete illustrated parts list breakdown itemizing all assemblies and their components for this instrument. Illustrations with each listing aid in locating the assemblies and components. A Cross Reference List of Fluke stock numbers to original manufacturers' part numbers is included at the rear of this section.

5-3. Assemblies and subassemblies are identified by a reference designation beginning with the letter A, followed by a number (e.g., A1 etc.). Electrical components appearing on the schematic diagram are identified by their reference designation. Components not appearing on the schematic diagram are identified by Fluke stock numbers on the illustrations. Flagnotes are sometimes used and refer to special ordering explanations.

5-4. PARTS LIST COLUMN DESCRIPTIONS

- a. The REF DESIG column indexes the item description to the associated illustration. In general, the reference designations are listed under each assembly in alpha-numeric order. Subassemblies of minor proportions are sometimes listed with the assembly of which they are a part. In this case, the reference designations for the components of the subassembly may appear out of order.
- b. The DESCRIPTION column describes the salient characteristics of the component. Identification of the description indicates the relationship to other assemblies, components, etc. In many cases it is necessary to abbreviate in this column. For abbreviations and symbols used, refer to Appendix B located at the rear of the manual.
- c. The six-digit part number, by which the item is identified at the John Fluke Mfg. Co., is listed in the STOCK NO. column. Use this number when ordering parts from the factory or authorized representatives.
- d. The TOT QTY column lists the total quantity of the items used and reflects the latest Use Code. Second and subsequent listings of the same items are referenced to the first listing with the abbreviation REF. The TOT QTY column lists the total quantity of the item in that particular assembly.
- e. Entries in the REC QTY column indicate the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of every part in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc. that are not always part of the instrument, or are deviations from the basic instrument model, the REC QTY column lists the recommended quantity of the item in that particular assembly.
- f. The USE CODE column identifies certain parts which have been added, deleted or modified during the production of the instrument. Each

part for which a Use Code has been assigned may be identified with a particular instrument serial number by consulting the Serial Number Effectivity List, paragraph 5-9. Sometimes when a part is changed, the new part can and should be used as a replacement for the original part. In this event a parenthetical note is added in the DESCRIPTION column.

5-5. MANUFACTURERS' CROSS REFERENCE LIST COLUMN DESCRIPTIONS

- a. The six-digit part number, by which the item is identified at the John Fluke Mfg. Co., Inc. is listed in the FLUKE STOCK NO. column. Use this number when ordering parts from the factory or authorized representatives.
- b. The Federal Supply Code for the item manufacturer is listed in the MFG column. An abbreviated list of Federal Supply Codes is included in Section 7.
- c. The part number which uniquely identifies the item to the original manufacturer is listed in the MFG. PART NO. column. If a component must be ordered by description, the type number is listed.

5-6. HOW TO OBTAIN PARTS

5-7. Standard components have been used wherever possible. These components may be ordered directly from the manufacturer by using the manufacturer's part number, or parts may be ordered from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the Fluke part number. In the event the part you order from Fluke has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-8. You can insure prompt and efficient handling of your order to the John Fluke Mfg. Co., Inc. if you include the following information:

- a. Quantity.
- b. FLUKE Stock Number.
- c. Description.
- d. Reference Designation.
- e. Instrument model and serial number.

Example: 2 each 266015, Transistor, 2N5138, A3Q4 & Q5 for 3330B S/N 193.

If you must order structural parts not listed in the parts list, describe the part as completely as possible. A sketch of the part, showing its location to other parts of the instrument, is usually most helpful.

5-9. SERIAL NUMBER EFFECTIVITY

5-10. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 3330B. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity List below. All parts with no code are used in all instruments with serial numbers above 193.

USE CODE	EFFECTIVITY
NONE	Model 3330B serial number 193 and on.
A	SN 193 thru 202
B	SN 203 and on
C	SN 193 thru 252
D	SN 253 and on

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
	PROGRAMMABLE VOLTAGE/CURRENT CALIBRATOR Figure 5-1	3330B	.		
A1	Front Panel Assembly (See Figure 5-2)		1		
A2	Rear Panel Assembly (See Figure 5-1)		1		
A3	Front Mother Board Assembly (3330B-4006) (See Figure 5-3)	286310	1		
A3A1	Decade Switch Assembly (333A-4019) (See Figure 5-4)	262790	1		
A3A2	Switch Board Assembly (3330B-4007) (See Figure 5-5)	288068	1		
A3A3	I/V Limit Vernier Assembly (333A-4012) (See Figure 5-6)	251991	1		
A4	Main Mother Board Assembly (3330B-4001) (See Figure 5-7)	285460	1		
A4A1	+10 Volt Reference Supply Assembly (333A-4005) (See Figure 5-8)	251926	1		
A4A2	Chopper Amplifier Assembly (333A-1004) (See Figure 5-9)	251918	1		
A4A3	Differential Amplifier Assembly (3330B-4003) (See Figure 5-10)	285569	1		
A4A4	Series Pass Driver Assembly (333A-4024) (See Figure 5-11)	275388	1		
A4A5	Series Pass Element Assembly (333A-4034) (See Figure 5-12)	283465	1		
A4A6	High Voltage Power Supply Assembly (3330B-4002) (See Figure 5-13)	285478	1		
A4A7	Current Limiter Assembly (333A-4032) (See Figure 5-14)	282848	1		
A4A8	+25 & -15 Volt Power Supply Assembly (335A-4059) (See Figure 5-15)	219188	1		
A4A9	Relay Driver Assembly (333A-4009) (See Figure 5-16)	251967	1		
A4A10	Ladder Driver No. 1 Assembly (3330B-4031) (See Figure 5-17)	405476	1		
A4A11	Ladder Driver No. 2 Assembly (333A-4029) (See Figure 5-18)	275420	1		
A4A12	Ladder Driver No. 3 Assembly (333A-4028) (See Figure 5-18)	275412	1		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A13	Ladder Driver No. 4 Assembly (333A-4016) (See Figure 5-19)	252031	1		
A4A14	Ladder Driver No. 5 Assembly (333A-4002) (See Figure 5-20)	251892	3		
A4A15	Ladder Driver No. 6 Assembly (333A-4002) (See Figure 5-20)	251892	REF		
A4A16	Ladder Driver No. 7 Assembly (333A-4002) (See Figure 5-20)	251892	REF		
A4A17	Range Shunt Network Assembly (333A-4008) (See Figure 5-21)	251959	1		
A5	Rear Mother Board Assembly (3330B-4005) (See Figure 5-22)	286013	1		
A5A1	-25 & -5 Volt Power Supply Assembly (333A-4003) (See Figure 5-23)	251900	1		
A5A2	Preregulator Assembly (335A-4082) (See Figure 5-24)	222000	1		
A6	Relay Board Assembly (3330B-4004) (See Figure 5-25)	286195	1		
A7	Inner Chassis Assembly (See Figure 5-1)		1		
	Extender Card PCB	187344	1		
	Card puller ring	170951	1		
	Connector, male, 50 contact (mates with J8)	266056	1		
	Cover, bottom	287177	1		
	Cover, top	287169	1		
	Foot	230037	4		
	Line cord	226100	1		
	Rack mounting kit	243279	1		
	Tilt stand	231407	1		

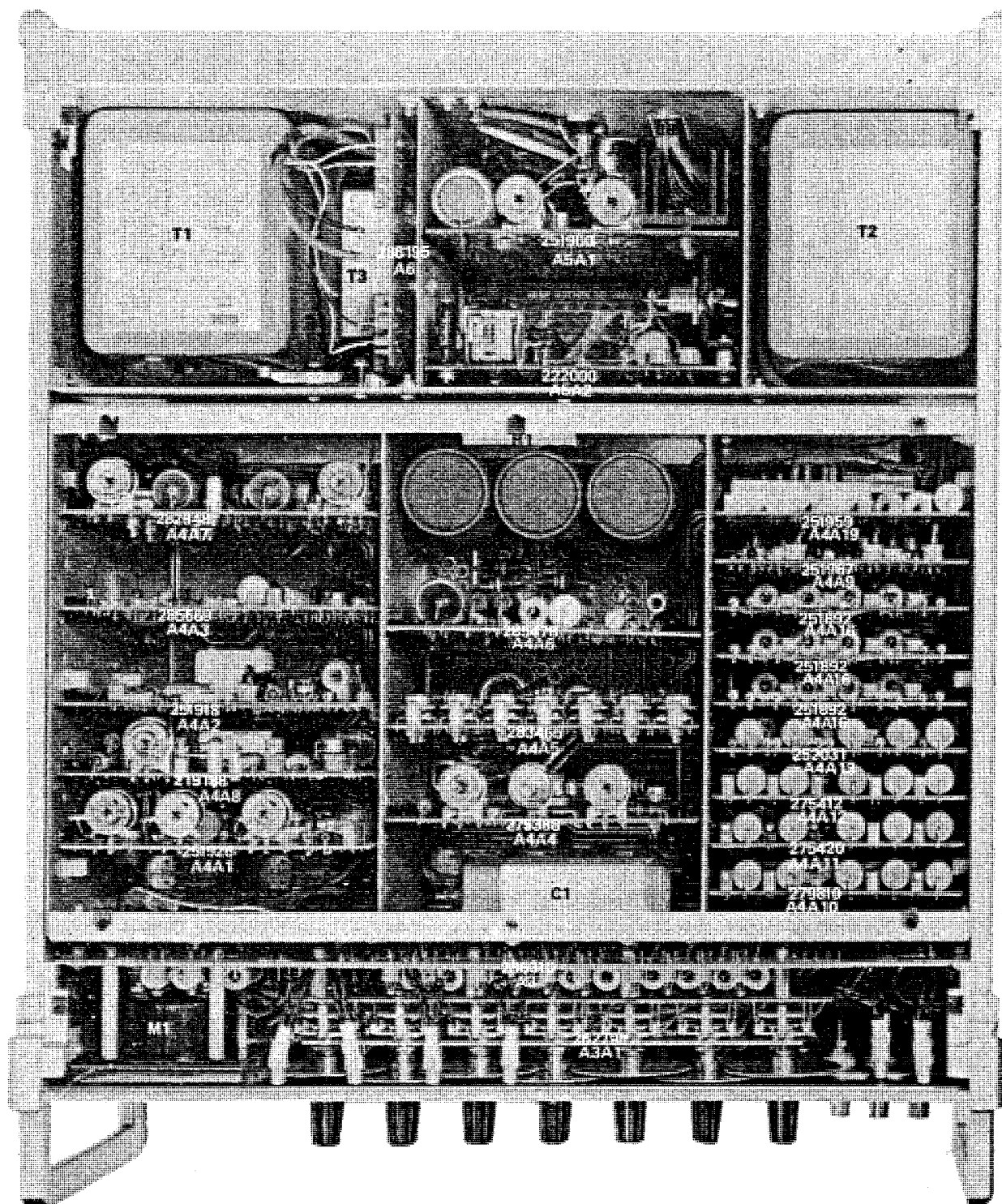


Figure 5-1. 3330B PROGRAMMABLE VOLTAGE/CURRENT CALIBRATOR (Sheet 1 of 2)

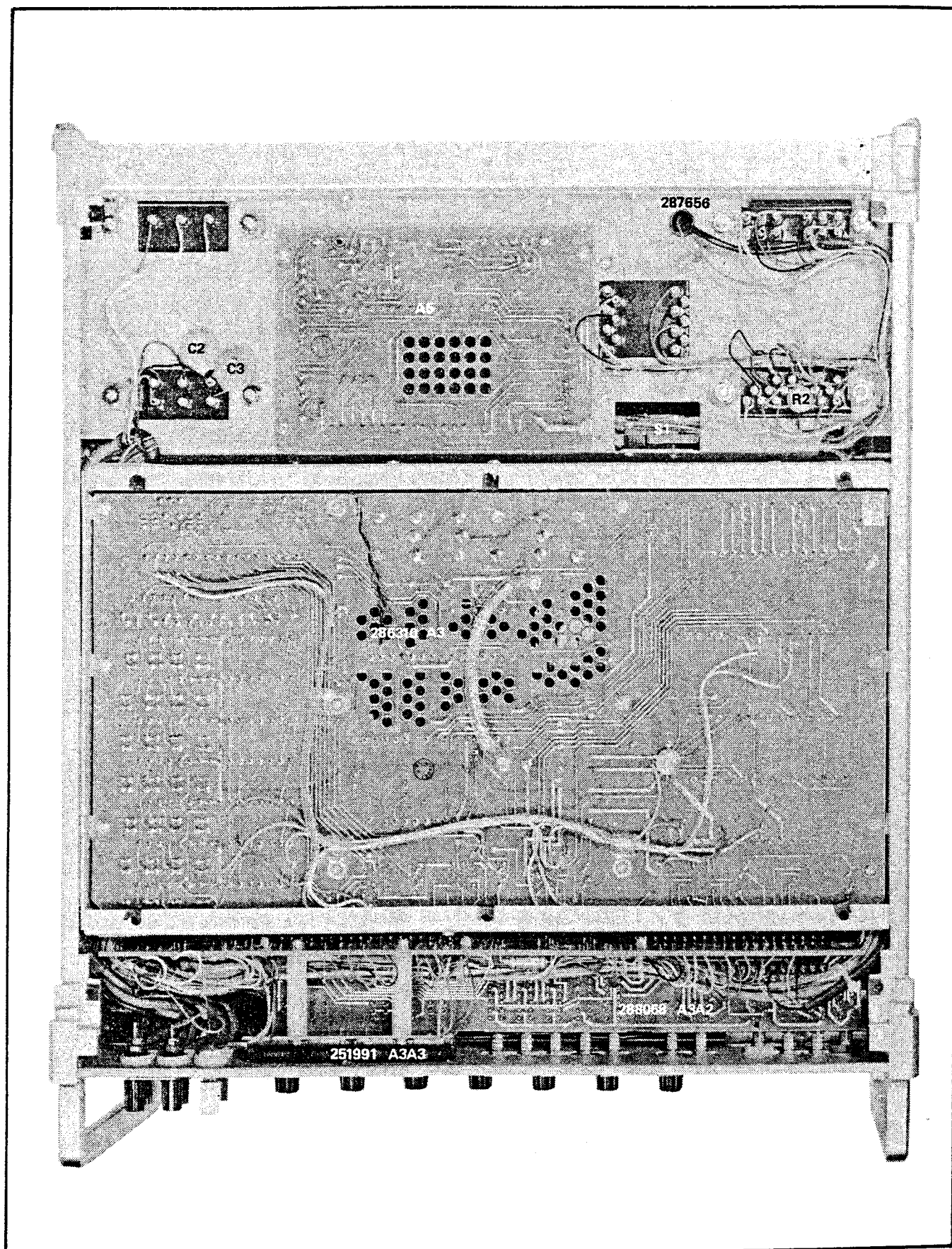


Figure 5-1. 3330B PROGRAMMABLE VOLTAGE/CURRENT CALIBRATOR (Sheet 2 of 2)

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A2	REAR PANEL ASSEMBLY See Figure 5-1		REF		
F1	Fuse, fast acting, 1/8 amp, 250v	196790	1	10	
F2	Fuse, slo blow, 3 amp 250v (for 115v operation)	109280	1	10	
F2	Fuse, slo blow, 1½ amp, 250v (for 230v operation)	109231	1	10	
J7	Connector, male, 3 contact	159012	1		
TB1	Barrier strip	160879	1		
XF1, XF2	Fuse holder	160846	2		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A7	INNER CHASSIS ASSEMBLY See Figure 5-1		REF		
C1	Cap, oil, 4 uf $\pm 10\%$, 1200v	183541	1		
C2, C3	Cap, cer, 0.02 uf $\pm 20\%$, 1 kv	217810	2		
C4, C5	Cap, cer, 0.01 uf, 500v (mounted on J7)	105684	2		
J8	Connector, female, 50 contact	267252	1		
M1	Meter, 0-100 μ a	248021	1		
R1	Res, ww, 250 Ω $\pm 3\%$, 50 w	283804	1		
R2	Res, var, ww, 5k $\pm 5\%$, 1w	149260	1		
S1, S2	Switch, interlock	187708	2		
T1	Transformer, primary power	269860	1		
T2	Transformer, high voltage	222307	1		
T3	Transformer, -25 & -5 vps	224790	1		
	AC Cable	287656	1		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A1	FRONT PANEL ASSEMBLY Figure 5-2		REF		
DS1 thru DS10	Lamp, incandescent, 28v	246686	10	10	
J1, J2	Binding post, red	275552	2		
J3, J4	Binding post, black	275560	2		
J5	Binding post, blue	275578	1		
J6	Binding post, white	275586	1		
XDS1 thru XDS10	Lampholder	278986	10		
	Dial, 0 - X	232645	6		
	Dial, 0 - 10	232207	1		
	Handle	246298	2		
	Lens, decimal lamp, clear	271643	8		
	Lens, decimal lamp, red	282475	2		
	Link, shorting, copper	190728	2		
	Knob	158949	7		
	Pushbutton, green	268862	1		

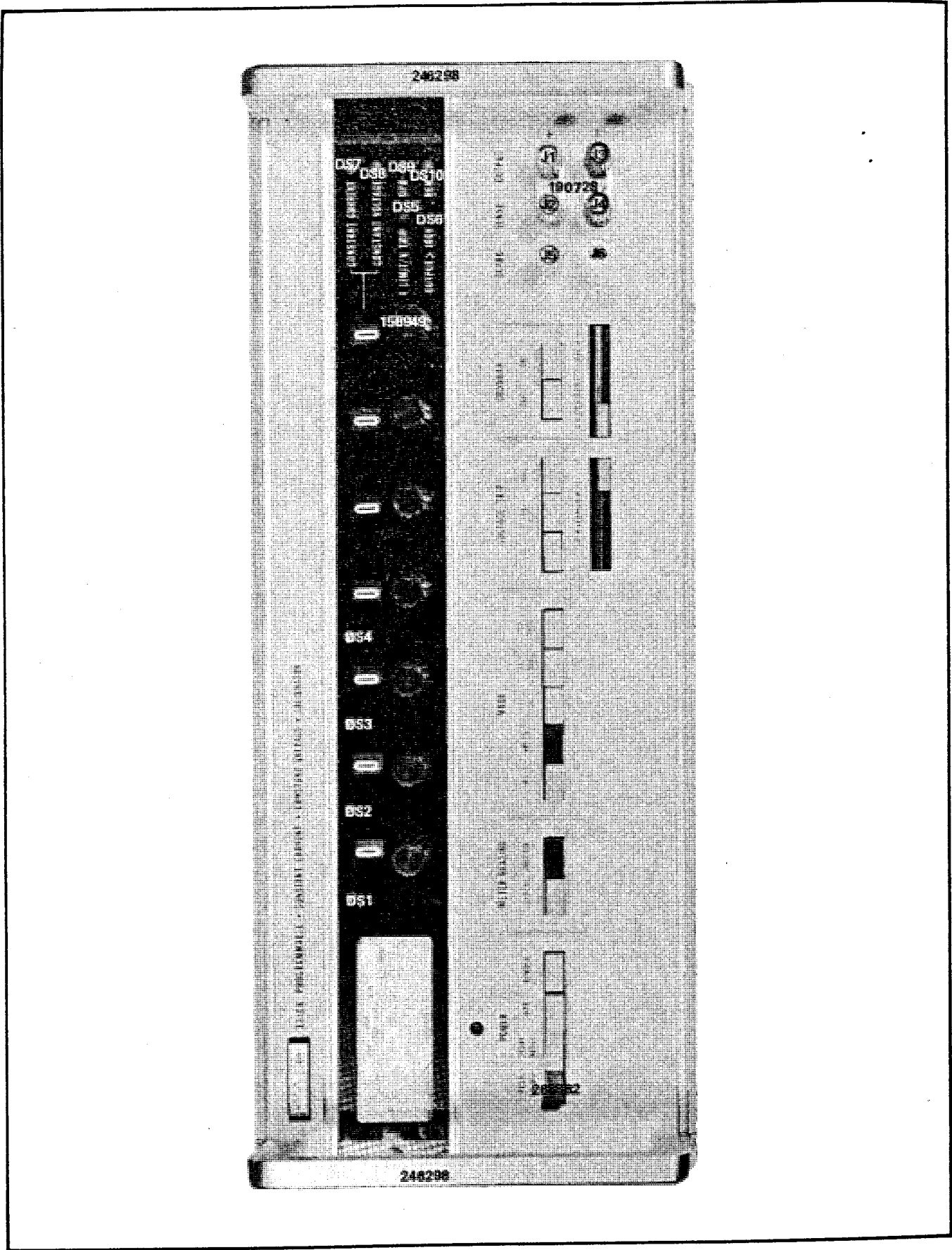


Figure 5-2. FRONT PANEL ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A3	FRONT MOTHER BOARD ASSEMBLY Figure 5-3	286310	REF		
A3A1	Decade Switch Assembly (See Figure 5-4)	262790	REF		
A3A2	Switch Board Assembly (See Figure 5-5)	288063	REF		
A3A3	I/V Limit Vernier Assembly (See Figure 5-6)	251991	REF		
C1	Cap, elect, 50 uf +50/-10%, 25v	168823	1		
C2	Cap, cer, 0.05 uf \pm 20%, 100v	149161	1		
CR1	Diode, silicon, 150 ma	113308	1		
CR2 thru CR10, CR13 thru CR24	Diode, silicon, 150 ma	203323	21	2	
CR11	Diode, zener, 20v	180463	1		
CR12	Diode, zener, 3.9v	113316	1		
IC1	IC, RTL, Quad 2-Input Gate	223214	1		
K1 thru K10	Reed relay switch	267708	10	5	
K11 thru K13	Reed relay switch	268060	3	1	
K1 thru K13	Coil, reed relay, 24v	272708	13	2	
Q1	Tstr, silicon, PNP	225599	1		
Q2	Tstr, silicon, PNP	159491	1		
Q3	Tstr, silicon, NPN	203489	1		
Q4 thru Q13 Q16, Q17, Q18	Tstr, silicon, PNP	266015	13	2	
Q14	Tstr, silicon, NPN	168716	1		
Q15	Tstr, silicon, NPN	218396	1		
R1	Res, met flm, 150k \pm 1%, $\frac{1}{2}$ w	247213	1		
R2	Res, car flm, 9M \pm 0.5%, 1w	107557	1		
R3, R5	Res, comp, 4.7k \pm 5%, $\frac{1}{2}$ w	108886	2		
R4	Res, comp, 15k \pm 10%, $\frac{1}{2}$ w	108530	1		
R6, R7	Res, car flm, 5M \pm 1%, 1w	107458	2		
R8	Res, met flm, 1M \pm 1%, $\frac{1}{2}$ w	161075	1		

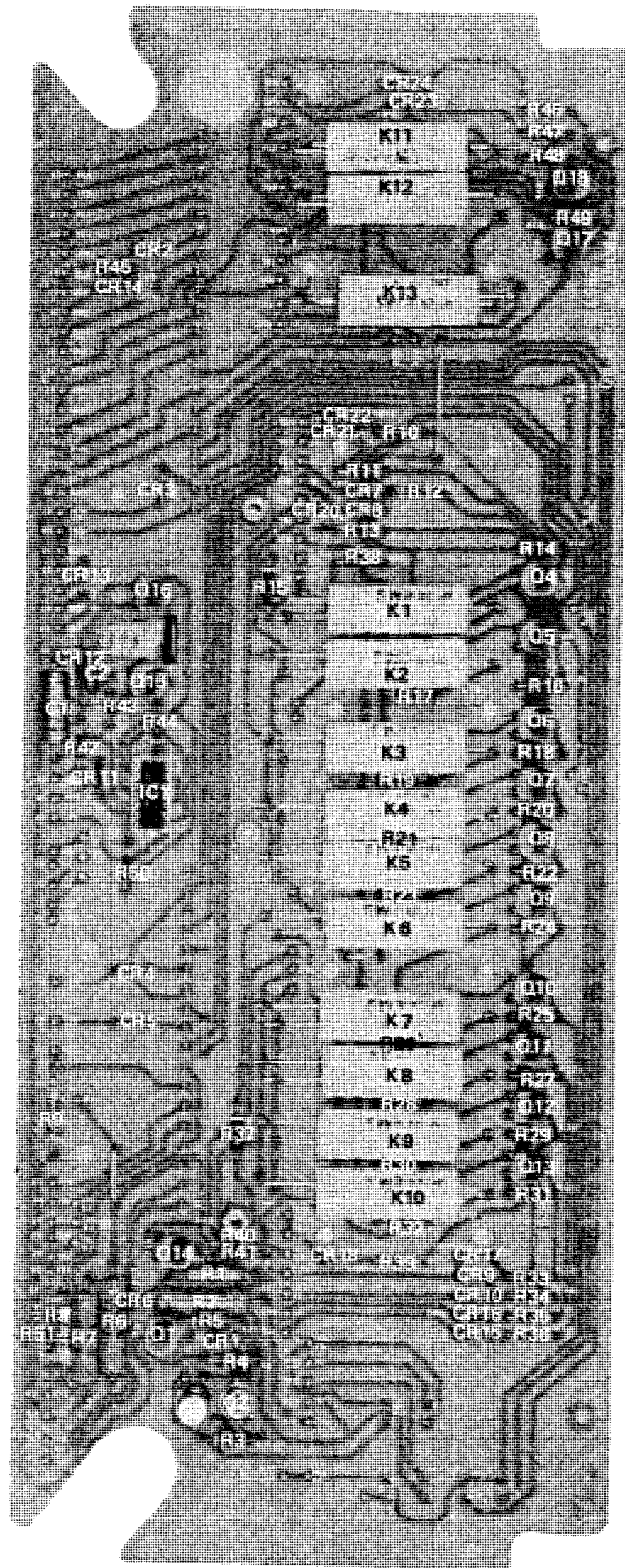


Figure 5-3. FRONT MOTHER BOARD ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R9	Res, met flm, 100k $\pm 1\%$, $\frac{1}{2}w$	151316	1		
R10 thru R13, R33 thru R36, R38, R39, R46, R47	Res, comp, 2.2k $\pm 5\%$, $\frac{1}{4}w$	148049	12		
R14, R16 R18, R20, R22, R24, R25, R27, R29, R31, R48 thru R50	Res, comp, 2k $\pm 5\%$, $\frac{1}{4}w$	202879	13		
R15	Res, comp, 910 Ω $\pm 5\%$, $\frac{1}{2}w$	170704	1		
R17	Res, comp, 10k $\pm 5\%$, $\frac{1}{4}w$	148106	1		
R19	Res, comp, 5.1k $\pm 5\%$, $\frac{1}{4}w$	193342	1		
R21, R23	Res, comp, 2.4k $\pm 5\%$, $\frac{1}{4}w$	193433	2		
R26	Res, comp, 100k $\pm 5\%$, $\frac{1}{4}w$	148189	1		
R28	Res, comp, 51k $\pm 5\%$, $\frac{1}{4}w$	193334	1		
R30, R32	Res, comp, 24k $\pm 5\%$, $\frac{1}{4}w$	193425	2		
R40	Res, comp, 220k $\pm 5\%$, $\frac{1}{4}w$	160937	1		
R41	Res, comp, 1.6M $\pm 5\%$, $\frac{1}{4}w$	218008	1		
R42	Res, comp, 51 Ω $\pm 5\%$, $\frac{1}{4}w$	221879	1		
R43	Res, comp, 330 Ω $\pm 5\%$, $\frac{1}{4}w$	147967	1		
R44	Res, comp, 430 Ω $\pm 5\%$, $\frac{1}{4}w$	203869	1		
R45	Res, comp, 1k $\pm 5\%$, $\frac{1}{4}w$	148023	1		
R51	Res, comp, 20k $\pm 5\%$, $\frac{1}{4}w$	221614	1		
	Connector, 22 contact	233742	1		
	Connector, 18 contact	235010	1		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A3A1	DECADE SWITCH ASSEMBLY (333A-4019) Figure 5-4	262790	REF	.	
CR1 thru CR28	Diode, silicon, 150 ma	203323	28	3	
S1 thru S7	Switch, rotary, 0-10 decade	257048	7	5	

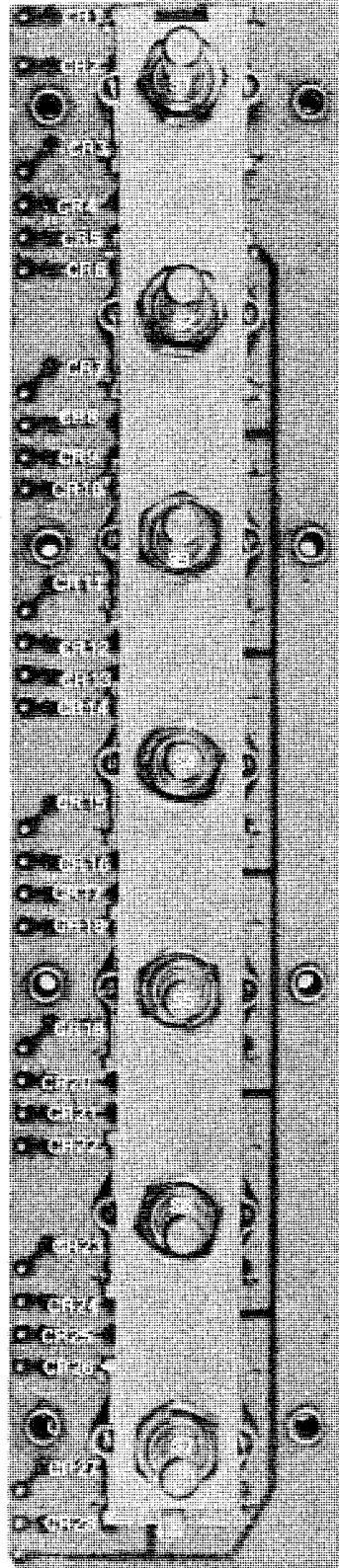


Figure 5-4. DECADE SWITCH ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A3A2	SWITCH BOARD ASSEMBLY Figure 5-5	288068	REF		
S1 thru S5	Switch Assembly, POWER/METER switches	257063	1		
S6 thru S10	Switch Assembly, MODE switches	257071	1		
S11 thru S14	Switch Assembly, VOLTAGE LIMIT/CROWBAR switches	257089	1		
	Connector, 18 contact	234906	1		
	Connector, 22 contact	234914	1		

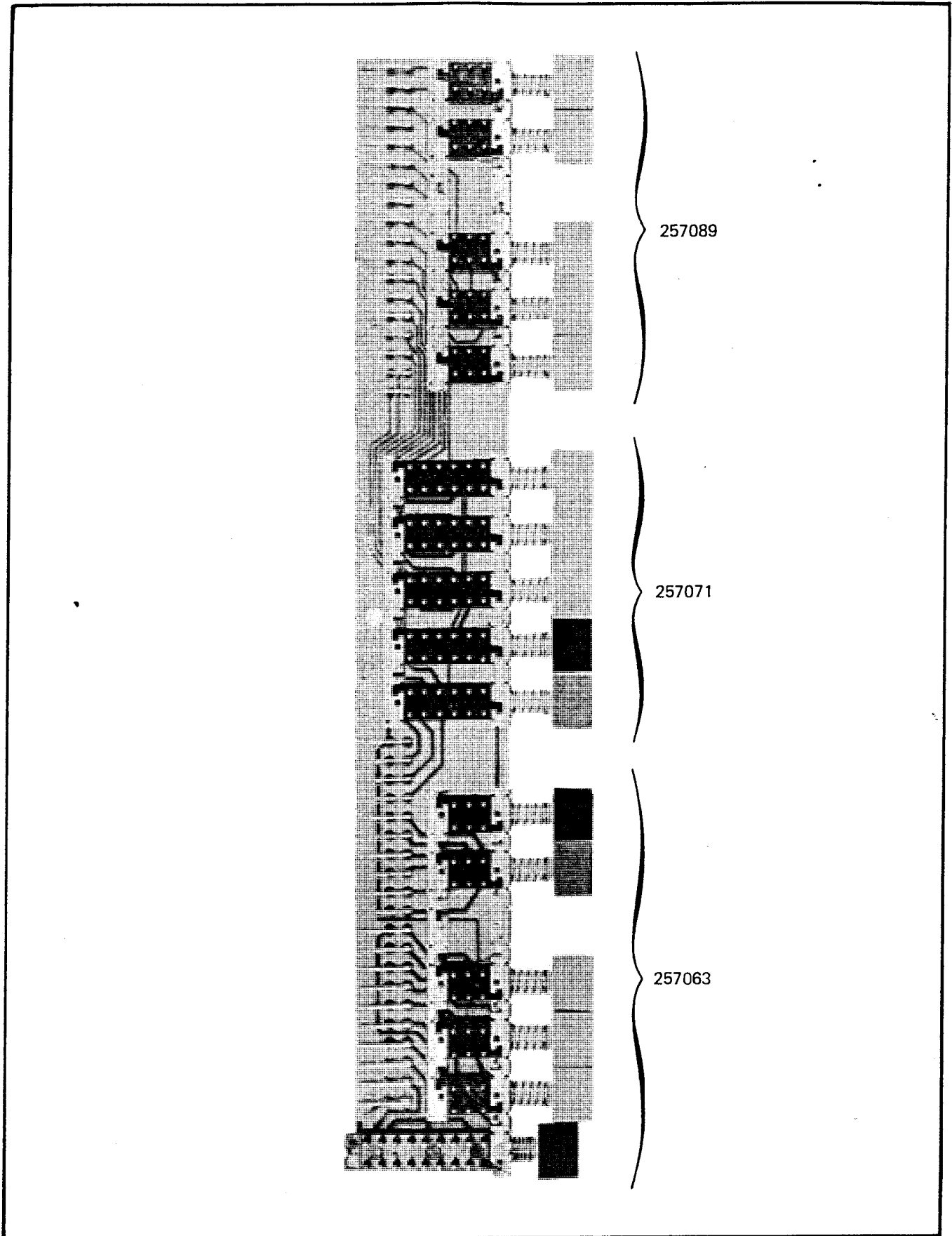


Figure 5-5. SWITCH BOARD ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A3A3	I/V LIMIT VERNIER ASSEMBLY Figure 5-6	251991	REF		
R1	Res, var, ww, 5k $\pm 30\%$, 1w	266049	1		
R2	Res, var, ww, 270 $\pm 30\%$, 1¼ W	268201	1		

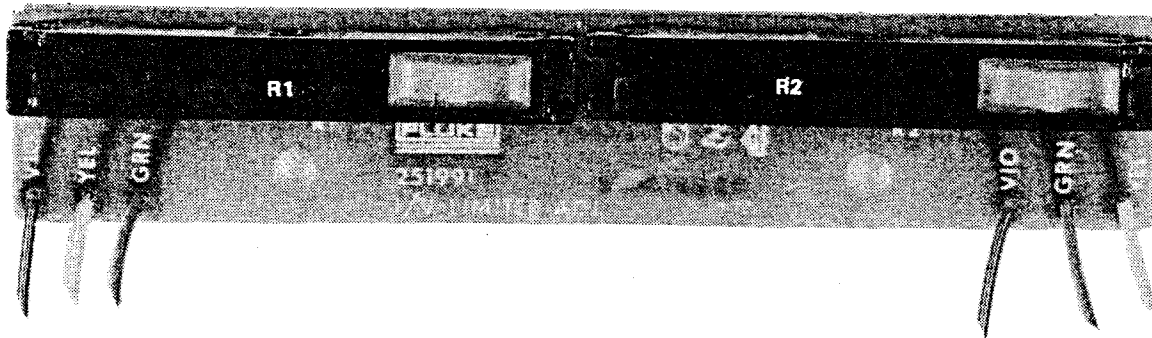


Figure 5-6. I/V LIMIT VERNIER ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4	MAIN MOTHER BOARD ASSEMBLY Figure 5-7	285460	REF		
A4A1	+10 Volt Reference Supply Assembly (See Figure 5-8)	251926	REF		
A4A2	Chopper Amplifier Assembly (See Figure 5-9)	251918	REF		
A4A3	Differential Amplifier Assembly (See Figure 5-10)	285569	REF		
A4A4	Series Pass Driver Assembly (See Figure 5-11)	275388	REF		
A4A5	Series Pass Element Assembly (See Figure 5-12)	283469	REF		
A4A6	High Voltage Power Supply Assembly (See Figure 5-13)	285478	REF		
A4A7	Current Limiter Assembly (See Figure 5-14)	282848	REF		
A4A8	+25 & -15 Volt Power Supply Assembly (See Figure 5-15)	219188	REF		
A4A9	Relay Driver Assembly (See Figure 5-16)	251967	REF		
A4A10	Ladder Driver No. 1 Assembly (See Figure 5-17)	279810	REF		
A4A11	Ladder Driver No. 2 Assembly (See Figure 5-18)	275420	REF		
A4A12	Ladder Driver No. 3 Assembly (See Figure 5-18)	275412	REF		
A4A13	Ladder Driver No. 4 Assembly (See Figure 5-19)	252031	REF		
A4A14	Ladder Driver No. 5 Assembly (See Figure 5-20)	251892	REF		
A4A15	Ladder Driver No. 6 Assembly (See Figure 5-20)	251892	REF		
A4A16	Ladder Driver No. 7 Assembly (See Figure 5-20)	251892	REF		
A4A17	Range Shunt Network Assembly (See Figure 5-21)	251959	REF		
C1	Cap, plstc, 0.047 uf $\pm 20\%$, 1200v	190561	1		
C2	Cap, plstc, 1 uf $\pm 20\%$, 200v	106450	1		
C3, C4	Cap, Ta, 10 uf $\pm 10\%$, 20v	160259	1		

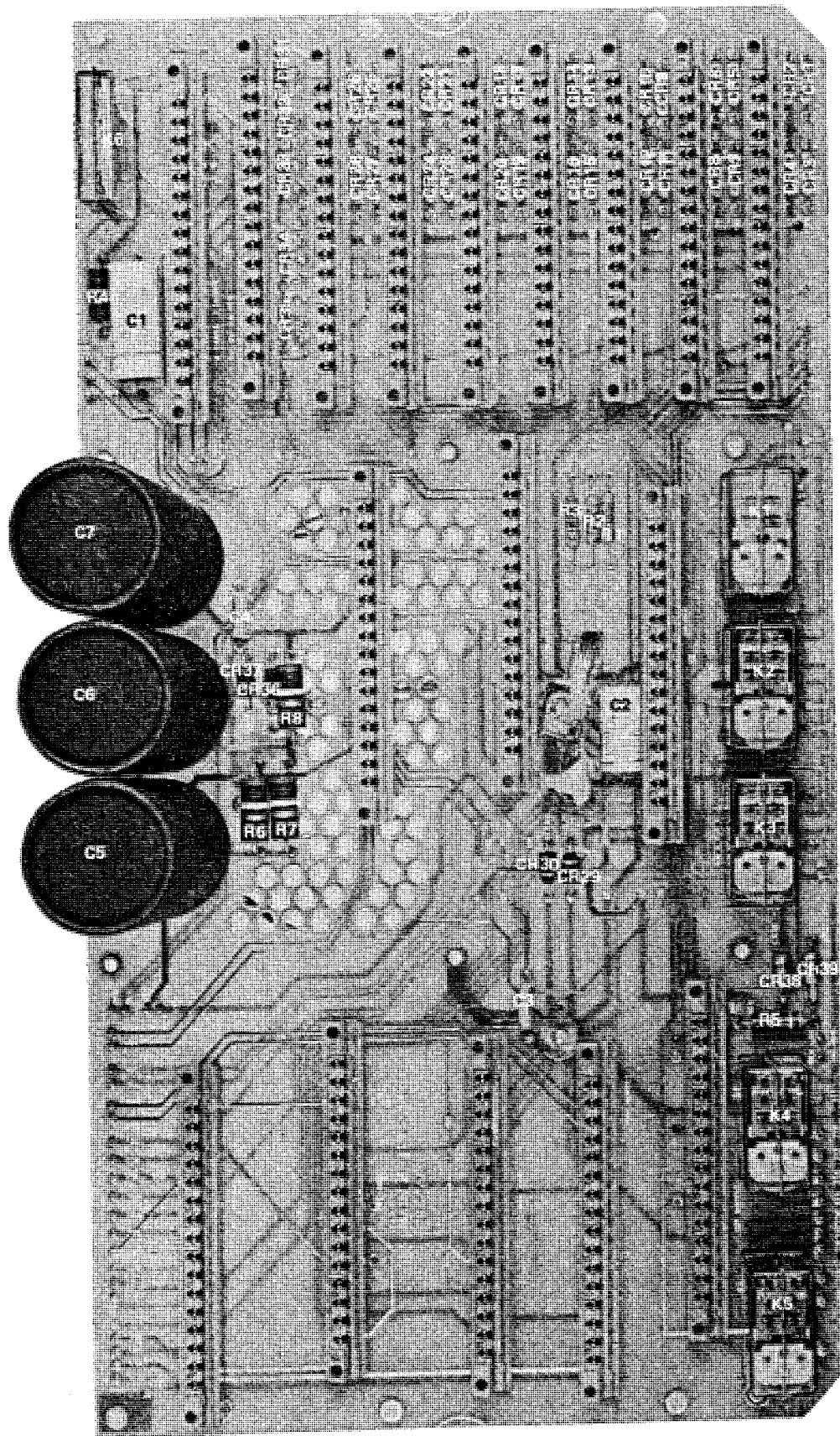


Figure 5-7. MAIN MOTHER BOARD ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
C5, C6, C7	Cap, elect, 125 uf +50/-10%, 450v	106336	3		
CR1 thru CR8, CR13, thru CR35	Diode, silicon, 150 ma	203323	33	3	
CR27, CR29, CR30, CR36	Diode, silicon, 1 amp, 600 piv	112383	4		
CR38, CR39	Diode, zener, 75v	168096	2	2	
K1 thru K5	Relay, 24 VDC, DPDT	281170	5	5	
K6	Relay, 24 VDC, DPDT	284745	1	1	A
K6	Relay, 24 VDC, DPDT	271429	1	1	B
R1, R2, R3	Res, car flm, 1.82M $\pm 1\%$, $\frac{1}{2}w$	219089	3		
R4	Res, comp, 5.1 Ω $\pm 5\%$, 1w	219071	1		
R5	Res, comp, 330 Ω $\pm 5\%$, 1w	163394	1		
R6, R7, R8	Res, comp, 150k $\pm 5\%$, 2w	110112	3		
	Connector, 16 contact, female	187732	17		
	Socket, relay	281253	5		
	Socket, relay	284752	1		A

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A1	+10 VOLT REFERENCE SUPPLY ASSEMBLY Figure 5-8	251926	REF		
C3	Cap, plstc, 1 uf $\pm 10\%$, 250v	190330	2		
C2	Cap, elect, 400 uf $+10/-50\%$, 25v	168153	1		
C4	Cap, plstc, 0.047 uf $\pm 10\%$, 40v	162008	1		
C5	Cap, elect, 4uF	340281	1		
CR1	Diode, silicon, 150 ma	203323	1		
CR2	Diode, zener, 5.2v	233627	1		
IC1	IC, 5 transistor array	248906	1		
Q1	Tstr, silicon, NPN	168708	1	1	
Q2	Tstr, silicon, PNP	195974	1	1	
R1	Res, comp, 39k $\pm 5\%$, $\frac{1}{2}w$	186049	1		
R3	Res, met flm, 16.5k $\pm 1\%$, $\frac{1}{2}w$	162529	1		
R4	Res, met flm, 2.32k $\pm 1\%$, $\frac{1}{2}w$	262014	1		
R5	Res, met flm, 10k $\pm 1\%$, $\frac{1}{2}w$	151274	1		
R6	Res, met flm, 1k $\pm 1\%$, $\frac{1}{2}w$	151324	1		
R7	Res, comp, 9.1k $\pm 5\%$, $\frac{1}{2}w$	160028	1		
R8	Res, comp, 11k $\pm 5\%$, $\frac{1}{2}w$	108613	1		
R9, R23	Res, comp, 10k $\pm 5\%$, $\frac{1}{2}w$	109165	2		
R10	Res, var, cermet, 50 Ω $\pm 20\%$, $\frac{3}{4}w$	267815	1		
R14	Res, met flm, 1.15k $\pm 1\%$, $\frac{1}{2}w$	155010	1		
R16, R17, R18	Res, met flm, 6.04k $\pm 1\%$, $\frac{1}{2}w$	162586	3		
R19, R20, R21	Res, var, ww, 10k $\pm 10\%$, 1 $\frac{1}{4}w$	195164	3		
R22	Res, ww, 73.586k $\pm 0.01\%$, 1w	260109	1		
IC2, R2, R11, R15	Reference Amplifier matched Set (must be replaced as entire set)	224824	1		
R12, R13	Matched Resistor Set (must be replaced as entire set)	252023	1		
	Connector, male, 16 contact	187724	1		

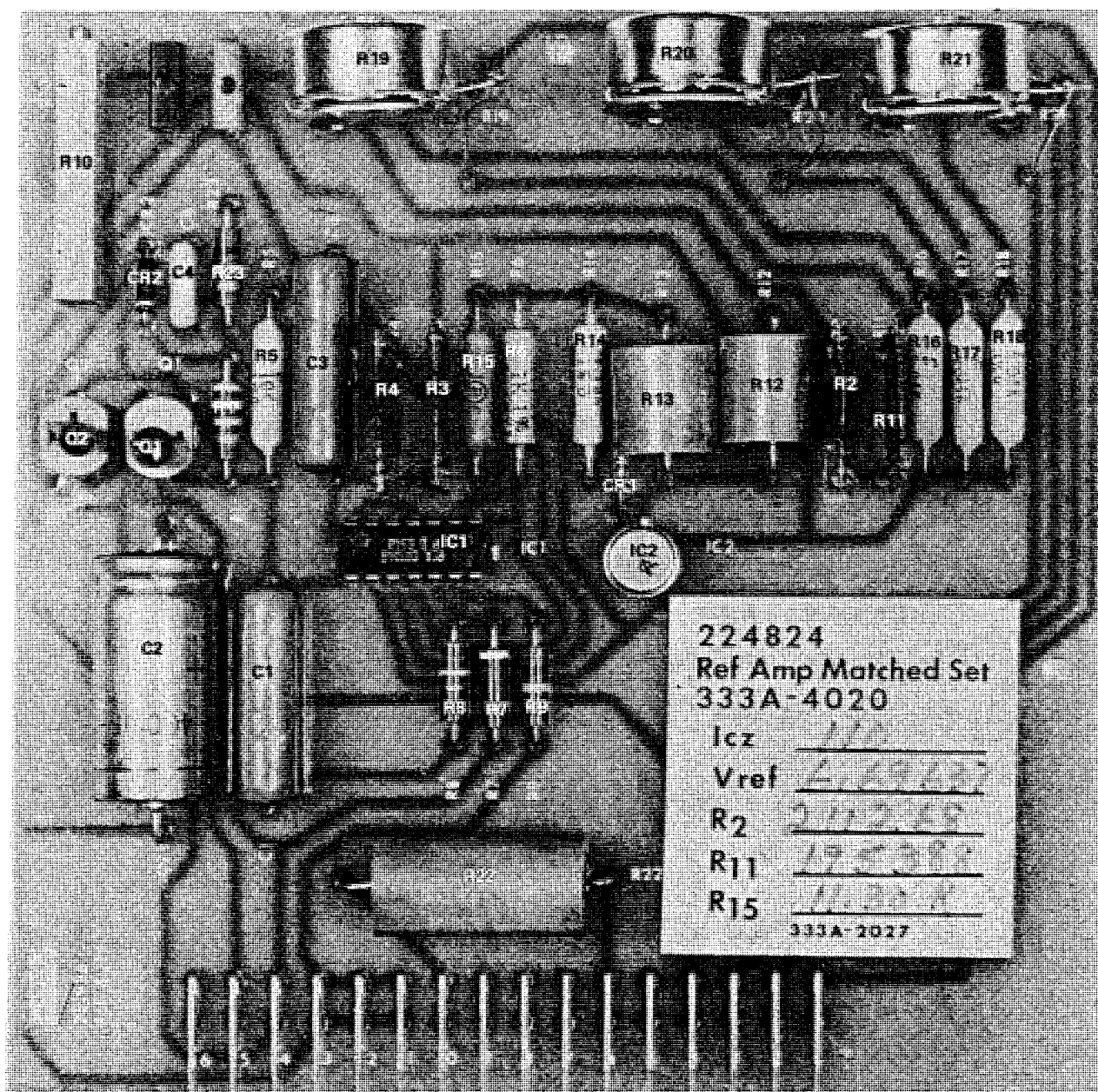


Figure 5-8. +10 VOLT REFERENCE SUPPLY ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A2	CHOPPER AMPLIFIER ASSEMBLY Figure 5-9	251918	REF		
C1	Cap, plstc, 0.1 uf $\pm 10\%$, 250v	161992	1		
C2, C3	Cap, plstc, 0.0068 uf $\pm 20\%$, 200v	106070	2		
C4	Cap plstc, 0.047 uf $\pm 10\%$, 250v	162008	1		
C5	Cap, mica, 4pf $\pm 5\%$, 500v	190397	1		
C6	Cap, mica, 640 pf $\pm 5\%$, 500v	215251	1		
C7, C13	Cap, elect, 5 uf + 75/-10%, 25v	152009	2		
C8, C21	Cap, elect, 50 uf +50/-10%, 25v	168823	2		
C9, C23	Cap, elect, 100 uf +75/-10%, 3v	106534	2		
C10	Cap, mica, 220 pf $\pm 5\%$, 500v	170423	1		
C11	Cap, cer, 100 pf $\pm 10\%$, 1 kv	105593	1		
C12	Cap, mica, 5 pf $\pm 10\%$, 500 v	148577	1		
C14, C16	Cap, Ta, 33 uf $\pm 10\%$, 10v	182832	2		
C15, C17	Cap, elect, 15 uf +75/-10%, 6v	105700	2		
C18	Cap, Ta, 100 uf $\pm 10\%$, 10v	170456	1		
C19, C20	Cap, plstc, 0.015 uf $\pm 2\%$, 100v	182154	2		
C22	Cap, Ta, 0.47 uf $\pm 20\%$, 35v	161349	1		
CR1	Diode, zener, silicon	150334	1		
CR2 thru CR5	Diode, silicon, 1 amp, 100 piv	116111	4		
CR6, CR7	Diode, silicon, 150 ma	203323	2		
IC1	IC, operational amplifier	246603	1		
Q1	Tstr, MOS FET, P-channel	226043	1		
Q2	Tstr, FET, N-channel	166223	1		
Q3	Tstr, silicon, PNP	195974	1		
Q4	Tstr, silicon, PNP	261032	1		
Q5 thru Q7	Tstr, silicon, NPN	218396	3		
R1	Res, comp, 51k $\pm 5\%$, $\frac{1}{4}w$	193334	1		
R2, R21, R22	Res, comp, 100k $\pm 5\%$, $\frac{1}{4}w$	148189	3		

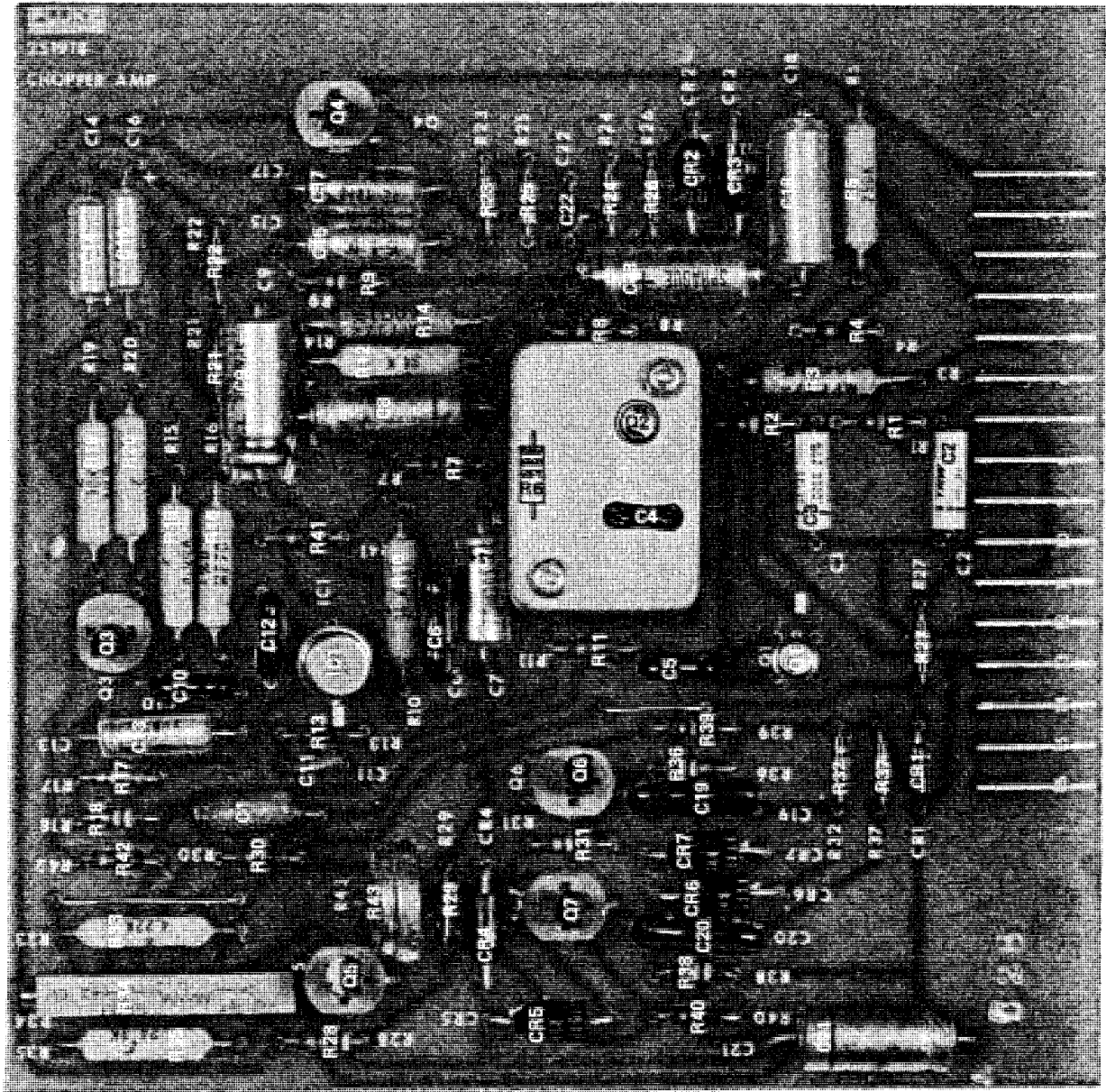


Figure 5-9. CHOPPER AMPLIFIER ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R3	Res, met flm, 604k $\pm 1\%$, $\frac{1}{2}w$	182493	1		
R4	Res, comp, 10 Ω $\pm 5\%$, $\frac{1}{4}w$	147868	1		
R5	Res, met flm, 750k $\pm 1\%$, $\frac{1}{2}w$	155192	1		
R6	Res, comp, 3.3M $\pm 5\%$, $\frac{1}{4}w$	208389	1		
R7	Res, comp, 13k $\pm 5\%$, $\frac{1}{4}w$	221598	1		
R8, R41, R42	Res, comp, 200 Ω $\pm 5\%$, $\frac{1}{4}w$	193482	3		
R9, R32, R37, R39, R40	Res, comp, 22k $\pm 5\%$, $\frac{1}{4}w$	148130	5		
R10, R12	Res, met flm, 34k $\pm 1\%$, $\frac{1}{2}w$	151241	2		
R11	Res, comp, 10M $\pm 5\%$, $\frac{1}{4}w$	194944	1		
R13	Res, comp, 1.5k $\pm 5\%$, $\frac{1}{4}w$	148031	1		
R14	Res, met flm, 301 $\pm 1\%$, $\frac{1}{2}w$	167494	1		
R15	Res, met flm, 8.06k $\pm 1\%$, $\frac{1}{2}w$	159467	1		
R16	Res, met flm, 68.1k $\pm 1\%$, $\frac{1}{2}w$	161083	1		
R17	Res, comp, 68k $\pm 5\%$, $\frac{1}{4}w$	148171	1		
R18	Res, comp, 24k $\pm 5\%$, $\frac{1}{4}w$	193425	1		
R19, R20	Res, met flm, 10k $\pm 1\%$, $\frac{1}{2}w$	151274	2		
R23	Res, comp, 33k $\pm 5\%$, $\frac{1}{4}w$	148155	1		
R24	Res, comp, 10k $\pm 5\%$, $\frac{1}{4}w$	148106	1		
R25	Res, comp, 36k $\pm 5\%$, $\frac{1}{4}w$	221929	1		
R26	Res, comp, 18k $\pm 5\%$, $\frac{1}{4}w$	148122	1		
R27	Res, comp, 560 Ω $\pm 5\%$, $\frac{1}{4}w$	147991	1		
R28	Res, comp, 47k $\pm 5\%$, $\frac{1}{4}w$	148163	1		
R29	Res, comp, 180k $\pm 5\%$, $\frac{1}{4}w$	193441	1		
R30	Res, comp, 8.2k $\pm 5\%$, $\frac{1}{4}w$	160796	1		
R31	Res, comp, 15k $\pm 5\%$, $\frac{1}{4}w$	148114	1		
R33	Res, met flm, 4.22k $\pm 1\%$, $\frac{1}{2}w$	223396	1		
R34	Res, var, cermet, 5k $\pm 20\%$, $\frac{3}{4}w$	159905	1		
R35	Res, met flm, 24.3k $\pm 1\%$, $\frac{1}{2}w$	217430	1		
R36, R38	Res, met flm, 237k $\pm 1\%$, 1/8w	288373	2	C D	
R36, R38	Res, met flm, 187k $\pm 1\%$, 1/8w	289462	2		
R43	Res, var, comp, 10k $\pm 30\%$, $\frac{1}{4}w$	223131	1		
	Connector, male, 16 contact	187724	1		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A3	DIFFERENTIAL AMPLIFIER ASSEMBLY Figure 5-10	285569	REF		
C1	Cap, plstc, 0.1 uf $\pm 10\%$, 50 v	150318	1		
C2	Cap, cer, 510 pf $\pm 5\%$, 500 v	148411	1		
C3	Cap, Ta, 15 uf $\pm 10\%$, 20v	153056	1		
C4	Cap, elect, 250 uf $+50/-10\%$, 40v	178616	1		
C5	Cap, cer, 0.05 uf $+80/-20$, 25v	148924	1		
CR1 thru CR13, CR15	Diode, silicon, 1 amp, 100 piv	116111	14	2	
CR14	Diode, zener, 10v	113324	1		
Q1, Q12	Tstr, silicon, NPN	177105	2		
Q2	Tstr, FET, N-Channel	166223	1		
Q3, Q5, Q7	Tstr, silicon, PNP	190389	3		
Q4, Q6	Tstr, tested, silicon, NPN	198812	2		
Q8	Tstr, silicon, NPN	203489	1		
Q9, Q10 Q11	Tstr, silicon, PNP	183558	3		
Q13	Tstr, silicon, PNP	195974	1		
Q14	Tstr, silicon, NPN	218396	1		
R1	Res, comp, 22k $\pm 5\%$, $\frac{1}{2}w$	186064	1		
R2, R3 R5, R6	Res, comp, 100 Ω $\pm 5\%$, $\frac{1}{2}w$	188508	4		
R4	Res, ww, 10k $\pm 0.02\%$, $\frac{1}{4}w$	112177	1		
R7	Res, comp, 1k $\pm 5\%$, $\frac{1}{2}w$	108597	1		
R8, R9, R10	Res, comp, 510 Ω $\pm 5\%$, $\frac{1}{2}w$	108951	3		
R11	Res, comp, 22M $\pm 10\%$, $\frac{1}{2}w$	108233	1		
R12	Res, comp, 6.2k $\pm 5\%$, $\frac{1}{2}w$	108621	1		
R13	Res, comp, 2.2k $\pm 5\%$, $\frac{1}{2}w$	108506	1		

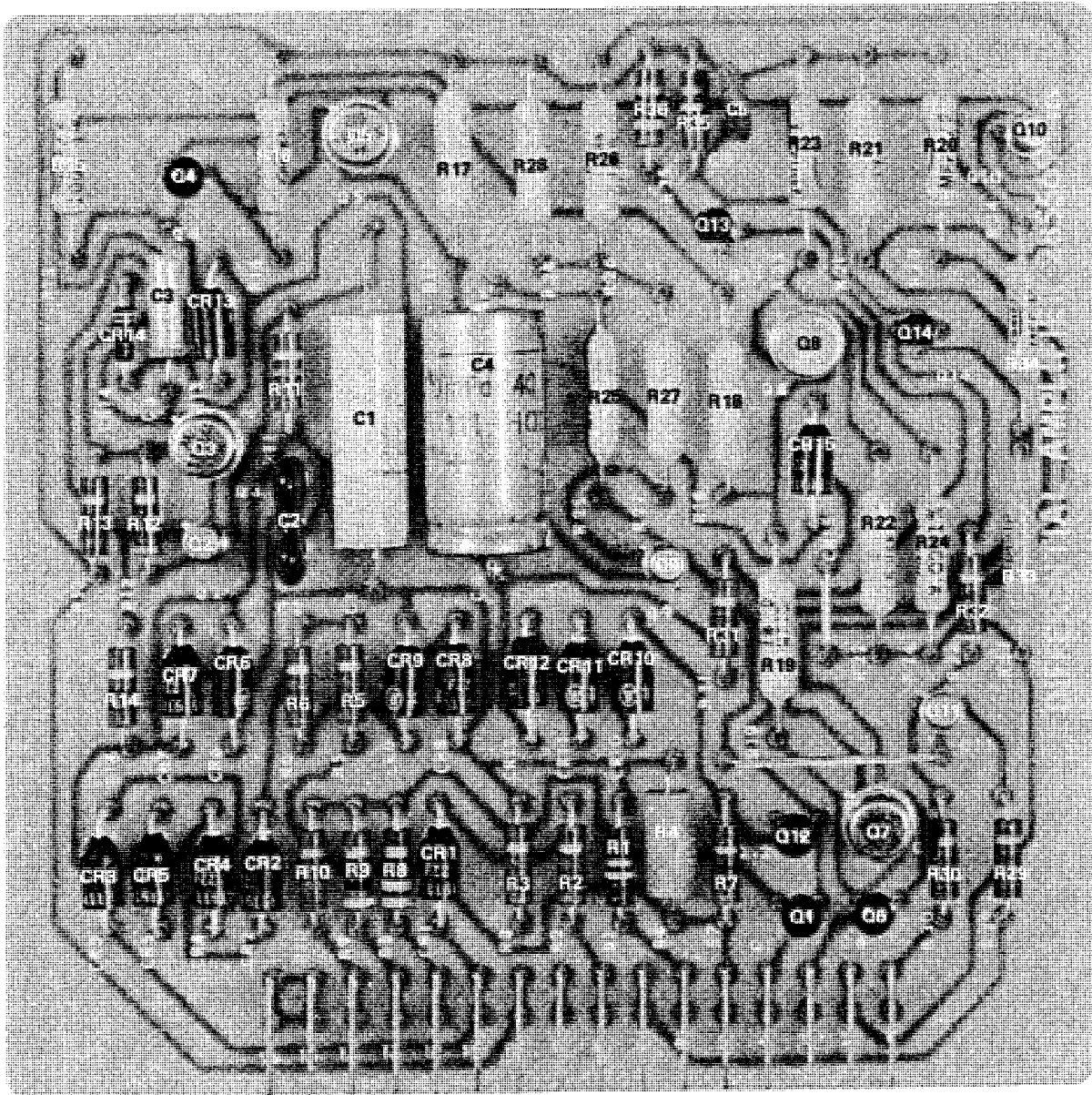


Figure 5-10. DIFFERENTIAL AMPLIFIER ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R14	Res, comp, 1.2k $\pm 10\%$, $\frac{1}{2}w$	108803	1		
R15	Res, met flm, 100k $\pm 1\%$, $\frac{1}{2}w$	151316	1		
R16, R20	Res, met flm, 221k $\pm 1\%$, $\frac{1}{2}w$	182527	2		
R17, R21	Res, met flm, 40.2k $\pm 1\%$, $\frac{1}{2}w$	161059	2		
R18, R19	Res, met flm, 75 Ω $\pm 1\%$, $\frac{1}{2}w$	150870	2		
R22	Res, met flm, 6.04k $\pm 1\%$, $\frac{1}{2}w$	162586	1		
R23	Res, met flm, 42.2k $\pm 1\%$, $\frac{1}{2}w$	182501	1		
R24, R34	Res, met flm, 9.09k $\pm 1\%$, $\frac{1}{2}w$	151258	2		
R25	Res, met flm, 15k $\pm 1\%$, $\frac{1}{2}w$	151498	1		
R26, R27	Res, met flm, 1.58k $\pm 1\%$, $\frac{1}{2}w$	182543	2		
R28	Res, met flm, 9.76k $\pm 1\%$, $\frac{1}{2}w$	182485	1		
R29, R30	Res, comp, 5.1k $\pm 5\%$, $\frac{1}{2}w$	109108	2		
R31, R32	Res, comp, 2k $\pm 5\%$, $\frac{1}{2}w$	169854	2		
R33	Res, met flm, 5.9k $\pm 1\%$, $\frac{1}{2}w$	247833	1		
R35	Res, comp, 20k $\pm 5\%$, $\frac{1}{2}w$	109041	1		
R36	Res, comp, 1.3k $\pm 5\%$, $\frac{1}{2}w$	109157	1		
	Connector, male, 16 contact	187724	1		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A4	SERIES PASS DRIVER ASSEMBLY Figure 5-11	275388	REF		
C1	Cap, plstc, 0.47 uf $\pm 10\%$, 250v	184366	1		
C2	Cap, plstc, 0.22 uf $\pm 10\%$, 250v	194803	1		
C3	Cap, plstc, 0.1 uf $\pm 20\%$, 200v	106435	1		
C4	Cap, plstc, 0.22 uf $\pm 10\%$, 80v	159392	1		
C5	Cap, elect 5 uf $+75/-10\%$, 25v	152009	1		
CR1, CR2, CR4, CR6, thru CR9, CR13, CR15, thru CR19	Diode, silicon, 1 amp, 100 piv	116111	13		
CR3, CR5	Diode, zener, 10v	113324	2		
CR 10, CR11, CR12	Diode, silicon, 150 ma, 6 piv	113308	3		
CR14	Diode, zener, 4.3v	180455	1		
Q1, Q4, Q6, Q8	Tstr, silicon, PNP	159491	4	1	
Q2, Q5, Q7	Tstr, silicon, NPN	203489	3	1	
Q3	Tstr, silicon, NPN	183004	1		
R1, R4	Res, met flm, 4.02k $\pm 1\%$, $\frac{1}{2}w$	167478	2		
R2	Res, var, ww, 2k $\pm 10\%$, $1\frac{1}{4}w$	198416	1		
R3	Res, comp, 2.7k $\pm 10\%$, 1w	109496	1		
R5, R13	Res, var, ww, 3k $\pm 20\%$, $1\frac{1}{4}w$	149781	2		
R6	Res, met flm, 5.62 k $\pm 1\%$, $\frac{1}{2}w$	219014	1		
R7	Res, comp, 100K $\pm 10\%$, $\frac{1}{2}w$	108126	1		
R9	Res, comp, 2.4k $\pm 5\%$, $\frac{1}{2}w$	108902	1		
R10, R11	Res, comp, 27 Ω $\pm 10\%$, 1 w	109868	2		
R12	Res, comp, 36k $\pm 5\%$, $\frac{1}{2}w$	185991	1		
R14	Res, met flm, 1k $\pm 1\%$, $\frac{1}{2}w$	151324	1		
R15	Res, met flm, 221k $\pm 1\%$, $\frac{1}{2}w$	182527	1		

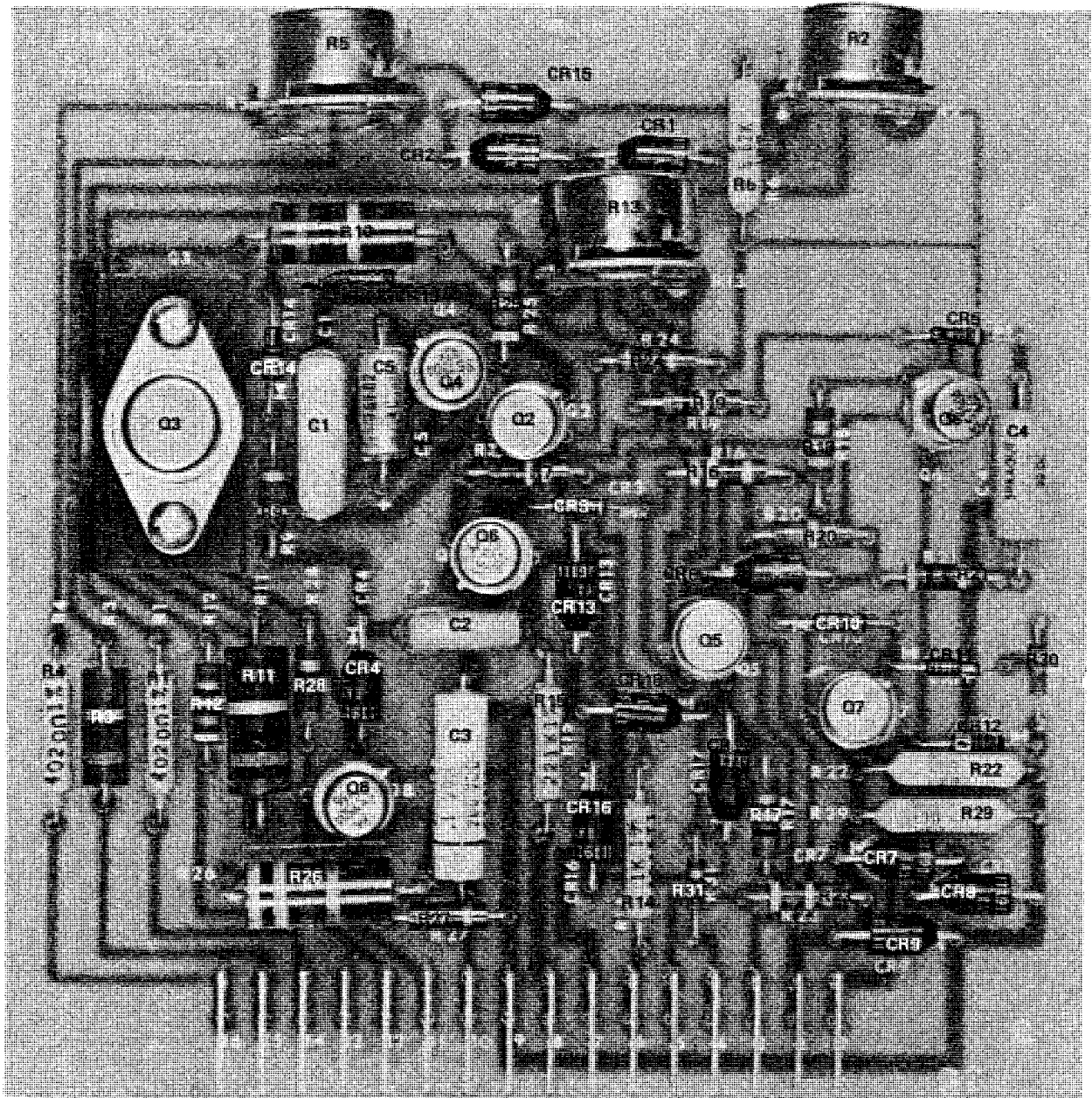



Figure 5-11. SERIES PASS DRIVER ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R16	Res, comp, 3.9k $\pm 10\%$, $\frac{1}{2}w$	161406	1		
R17	Res, comp, 20k $\pm 5\%$, $\frac{1}{2}w$	109041	1		
R18	Res, comp, 16k $\pm 5\%$, $\frac{1}{2}w$	159632	1		
R19	Res, comp, 10k $\pm 10\%$, $\frac{1}{2}w$	108118	1		
R20	Res, comp, 27k $\pm 5\%$, $\frac{1}{2}w$	186023	1		
R21	Res, comp, 30 Ω $\pm 5\%$, $\frac{1}{2}w$	218792	1		
R22, R29	Res, met flm, 10 Ω $\pm 1\%$, $\frac{1}{2}w$	151043	2		
R23, R25	Res, comp, 47k $\pm 5\%$, $\frac{1}{2}w$	108738	2		
R24	Res, comp, 620 Ω $\pm 5\%$, $\frac{1}{2}w$	108704	1		
R26	Res, comp, 330 Ω $\pm 5\%$, 2w	219063	1		
R27	Res, comp, 2k $\pm 5\%$, $\frac{1}{2}w$	169854	1		
R28	Res, comp, 8.2k $\pm 5\%$, $\frac{1}{2}w$	147777	1		
R30	Res, comp, 120 Ω $\pm 5\%$, $\frac{1}{4}w$	170712	1		
R31	Res, comp, 10 Ω $\pm 5\%$, $\frac{1}{4}w$	147868	1		
	Connector, male, 16 contact	187724	1		
	Heat sink, Q3	186759	1		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A5	SERIES PASS ELEMENT ASSEMBLY Figure 5-12	283465	REF		
C1, C3	Cap, cer, 0.05 uf +80/-10%, 500v	194068	2		
C2	Cap, elect, 8 uf +50/-10%, 450v	190468	1		
C4	Cap, plstc, 0.068 uf $\pm 10\%$, 100v	182170	1		
C5	Cap, plstc, 0.047 uf $\pm 10\%$, 80v	195099	1		
CR1 thru CR5, CR7 thru CR17, CR31	Diode, silicon, 1 amp, 600 piv	112383	17	4	
CR6	Diode, zener, 6.8v	187195	1		
CR18	Diode, zener, 20 v	113340	1		
CR19	Diode, zener, 12v	203547	1		
CR20, CR21, CR32	Diode, silicon, 1 amp, 100 piv	116111	3		
CR22	Diode, zener, 6.2v	180497	1		
CR23 thru CR30	Diode, zener, 200v	217422	8	16	
Q1 thru Q8	Tstr, silicon, NPN		8	16	
Q9	Tstr, silicon, unijunction	117176	1		
Q10	Tstr, silicon, NPN	203489	1		
R1, R2, R3	Res, comp, 1.8k $\pm 10\%$, 2w	185983	3		
R4, R8	Res, comp, 62k $\pm 5\%$, 1/2w	108522	2		
R5	Res, comp, 100k $\pm 10\%$, 2w	158659	1		
R6	Res, comp, 56k $\pm 5\%$, 1/2w	219048	1		
R7, R9, R11, R13, R15, R17, R19	Res, comp, 1k $\pm 5\%$, 1/2w	108597	7		

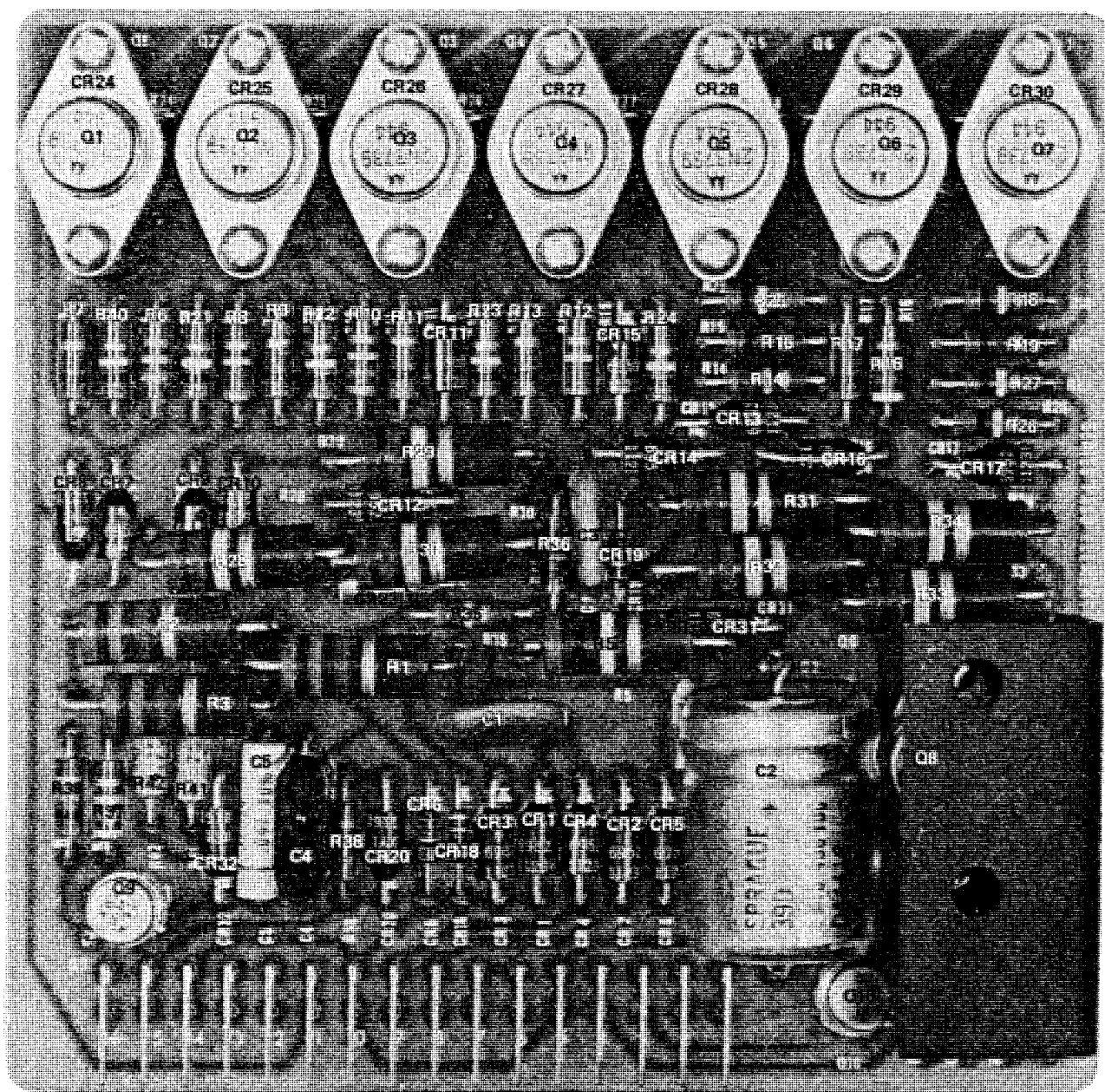


Figure 5-12. SERIES PASS ELEMENT ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R10	Res, comp, 68k $\pm 5\%$, $\frac{1}{2}w$	159624	1		
R12, R35, R36	Res, comp, 75k $\pm 5\%$, $\frac{1}{2}w$	108928	3		
R14	Res, comp, 82k $\pm 5\%$, $\frac{1}{2}w$	195966	1		
R16	Res, comp, 91k $\pm 5\%$, $\frac{1}{2}w$	219030	1		
R18, R21 thru R27, R40	Res, comp, 100k $\pm 5\%$, $\frac{1}{2}w$	168054	9		
R20	Res, comp, 1.1 Ω $\pm 5\%$, $\frac{1}{2}w$	163717	1		
R28 thru R34	Res, comp, 22k $\pm 10\%$, 2w	109975	7		
R37	Res, comp, 36k $\pm 5\%$, $\frac{1}{2}w$	185991	1		
R38	Res, comp, 180 Ω $\pm 5\%$, $\frac{1}{2}w$	108944	1		
R39	Res, comp, 100 Ω $\pm 5\%$, $\frac{1}{2}w$	188508	1		
R41, R42	Res, met flm, 4.75k $\pm 1\%$, $\frac{1}{2}w$	192500	2		
	Heat sink	192245	1		
	Connector, male, 16 contact	187724	1		



Q1 thru Q8 may be Fluke Part No. 190710, Mfr. 04713, Mfr. Part No. 2N3739; or Fluke Part No. 225573, Mfr. 95303, Mfr. Part No. 2N4299. It is necessary, however, that all eight must be the same type. Example; if all eight are 2N4299, a replacement of one or more should be a 2N4299.

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A6	HIGH VOLTAGE POWER SUPPLY ASSEMBLY Figure 5-13	285478	REF		
C1, C2	Cap, elect, 8 uf $\pm 50/-10\%$, 450v	194068	2		
C3	Cap, cer, 0.01 uf, gmv, 1.6 kv	106930	1		
C4	Cap, Ta, 330 uF $\pm 10\%$, 6V	193011	1		
C5	Cap, Ta, 220 uf $\pm 10\%$, 10v	182840	1		
C6	Cap, elect, 250 uf $+50/-10\%$, 40v	178616	1		
CR1 thru CR4	Diode, silicon, 250 ma	268342	4	2	
CR5 thru CR10	Diode, silicon, 1 amp, 600 piv	112383	6	2	
CR11 thru CR15	Diode, silicon, 150 ma	203323	5		
CR16 thru CR19	Diode, silicon, 1 amp, 100 piv	116111	4	2	
K1	Reed relay switch Coil, reed relay	184440 272708	1 1	1	
K2	Reed relay switch Coil, reed relay	219097 281857	1 1		
Q1	Tstr, silicon, PNP	195974	1		
Q2, Q3, Q4	Tstr, silicon, NPN	218396	3		
R1, R2	Res, ww, 200k $\pm 5\%$, 10w	246850	2		
R3	Res, met flm, 22.1 Ω $\pm 1\%$, $\frac{1}{2}$ w	151472	1		
R4, R5	Res, comp, 470k $\pm 5\%$, 2w	147710	2		
R6	Res, comp, 100 Ω $\pm 10\%$, 2w	109934	1	1	
R7	Res, ww, 2k $\pm 10\%$, 10w	155416	1		
R9	Res, met flm, 6.04k $\pm 1\%$, $\frac{1}{2}$ w	162586	1		
R10	Res, met flm, 17.4k $\pm 1\%$, $\frac{1}{2}$ w	247270	1		
R11	Res, comp, 5.1k $\pm 5\%$, $\frac{1}{2}$ w	109108	1		
R12	Res, comp, 10k $\pm 5\%$, $\frac{1}{2}$ w	109165	1		
R13, R14	Res, met flm, 10k $\pm 1\%$, $\frac{1}{2}$ w	151274	2		
	Connector, male, 16 contact	187724	1		

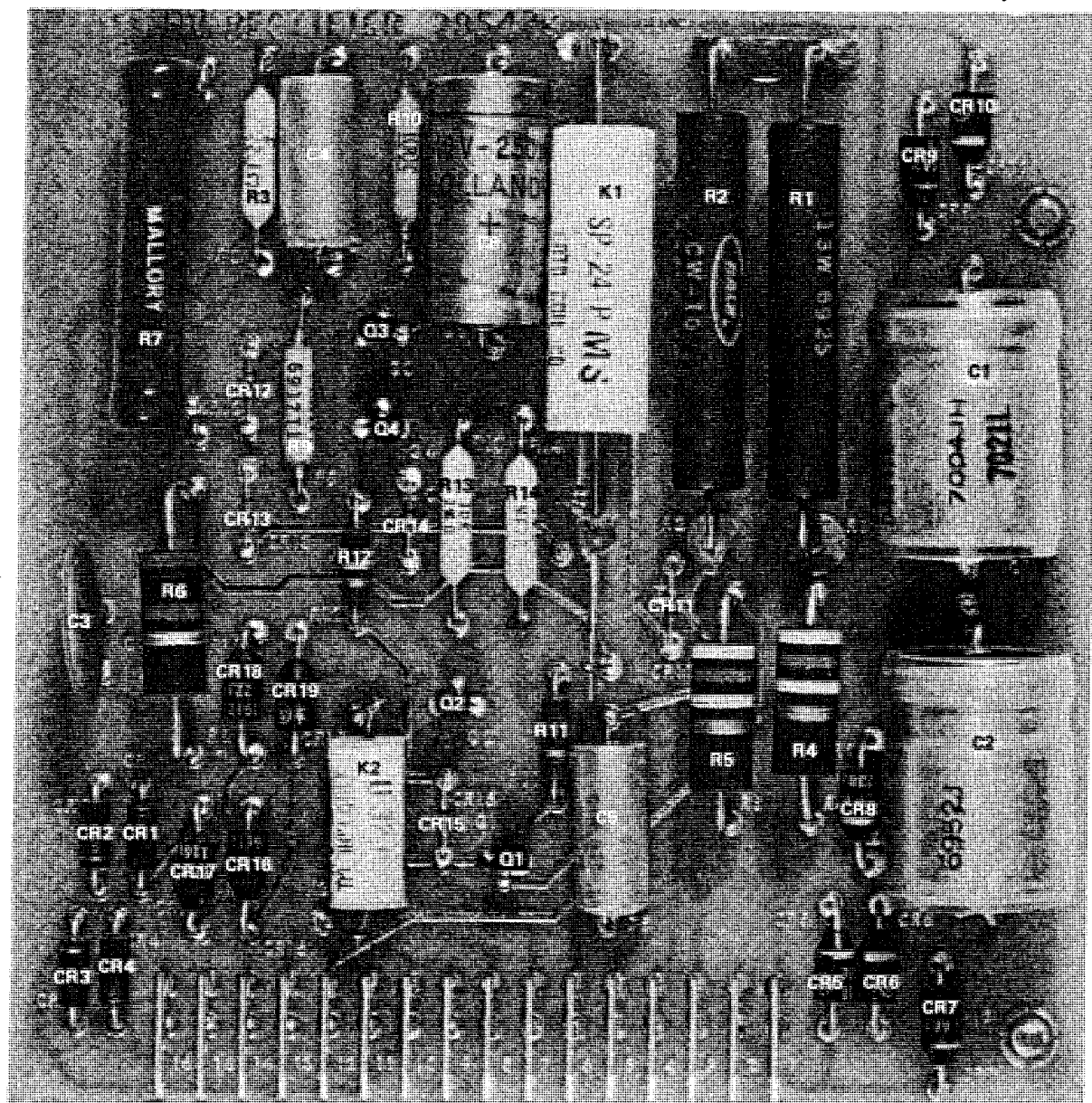


Figure 5-13. HIGH VOLTAGE POWER SUPPLY ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A7	CURRENT LIMITER ASSEMBLY Figure 5-14	282848	REF		
C1, C4, C6	Cap, elect 350 uF +75/-10%, 75V	292862	3		
C2, C3, C5	Cap, elect, 20 uf +75/-10%, 50v	106229	3		
C7	Cap, plstc, 0.047 uf ±20%, 100v	106096	1		
C9	Cap, elect, 2 uf +75/-10%, 50v	105197	1		
C10	Cap, plstc, 0.1 uf ±20%, 120v	167460	1		
CR1 thru CR4, CR8, CR12	Diode, silicon, 1 amp, 600 piv	112383	6	2	
CR5	Diode, zener, 36v	186163	1	1	
CR6	Diode, zener, 3.9v	113316	1		
CR7	Diode, zener, 36v	237354	1	1	
CR9	Diode, zener, 12v	159780	1		
CR10, CR11	Diode, silicon, 1 amp, 100 piv	116111	2		
Q1	Tstr, silicon, NPN	183004	1	1	
Q2	Tstr, germanium, PNP	152868	1	1	
Q3, Q5 Q6	Tstr, silicon, PNP	159491	3		
Q4, Q7	Tstr, silicon, NPN	203489	2		
R1, R4	Res, comp, 10Ω ±10%, 2w	110163	2		
R2, R5 R19	Res, comp, 3.3k ±5%, ½w	165761	3		
R3	Res, comp, 150Ω ±5%, 2w	235192	1		
R6	Res, comp, 7.5k ±5%, ½w	108910	1		
R7, R16	Res, comp, 100k ±10%, ½w	108126	2		
R8, R9 R25, R26	Res, comp, 120Ω ±10%, 2w	155531	4		
R10	Res, comp, 4.7k ±10%, ½w	108381	1		
R11, R12	Res, comp, 10k ±10%, ½w	108118	2		

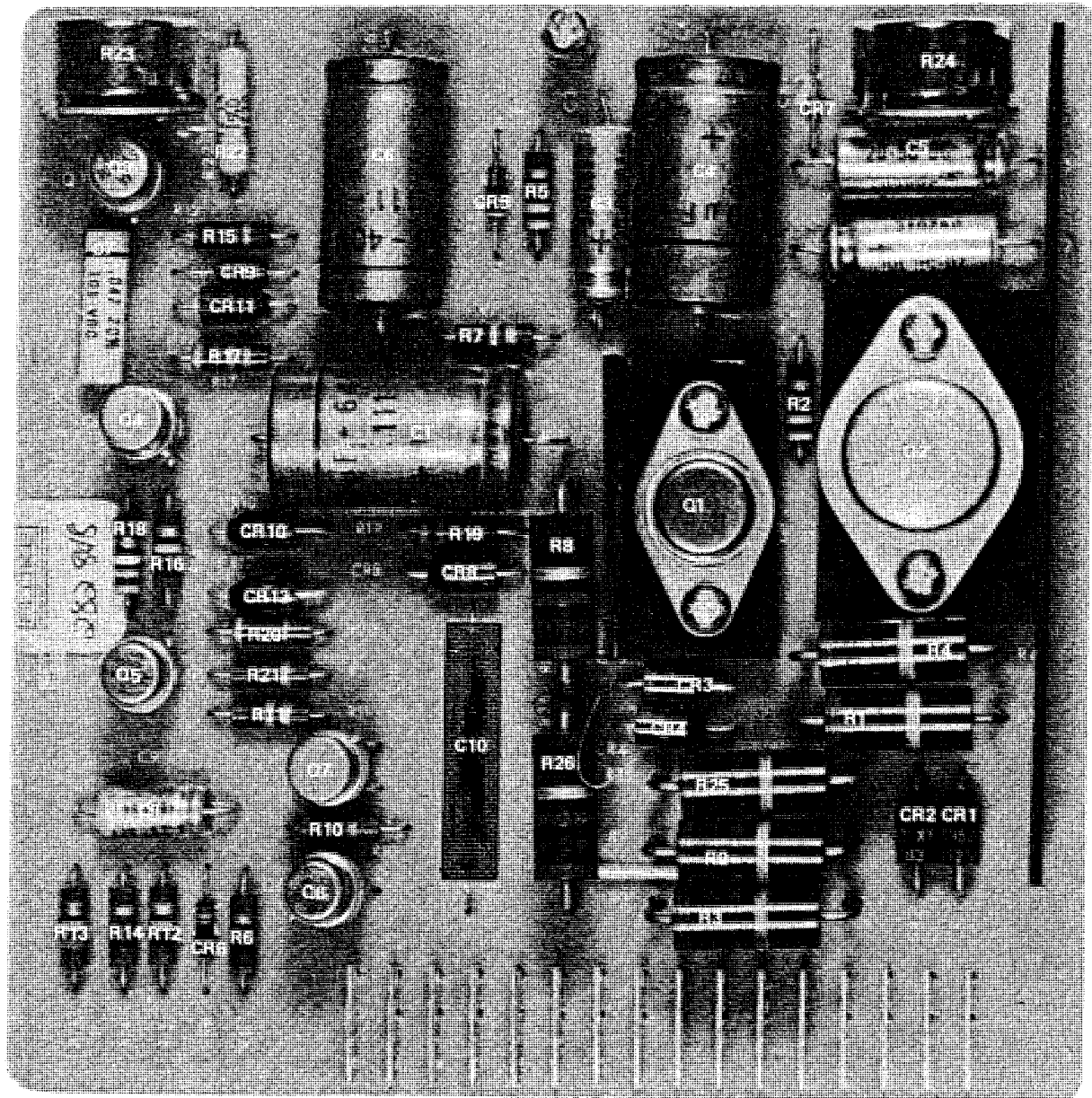


Figure 5-14. CURRENT LIMITER ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R13	Res, comp, 16k $\pm 5\%$, $\frac{1}{2}w$	159632	1		
R14, R21	Res, comp, 1k $\pm 10\%$, $\frac{1}{2}w$	108563	2		
R15	Res, comp, 2.2k $\pm 10\%$, $\frac{1}{2}w$	108605	1		
R17	Res, comp, 36k $\pm 5\%$, $\frac{1}{2}w$	185991	1		
R18	Res, comp, 330k $\pm 5\%$, $\frac{1}{2}w$	150201	1		
R20	Res, comp, 3k $\pm 5\%$, $\frac{1}{2}w$	109090	1		
R22	Res, met flm, 12.1k $\pm 1\%$, $\frac{1}{2}w$	182535	1		
R23	Res, var, ww, 10k $\pm 10\%$, $1\frac{1}{4}w$	162115	1		
R24	Res, var, ww, 150 Ω $\pm 10\%$, $1\frac{1}{4}w$	113092	1		
	Heat sink, Q1	186759	1		
	Heat sink, Q2	186742	1		
	Connector, male, 16 contact	187724	1		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A8	+25 & -15 VOLT POWER SUPPLY ASSEMBLY Figure 5-15	219188	REF		
C1	Cap, Ta, 68 uf $\pm 10\%$, 15v	182824	1		
C2	Cap, elect, 250 uf $+50/-10\%$, 64v	185850	1		
C3, C8	Cap, elect, 50 uf $+75/-10\%$, 50v	105122	2		
C5, C10	Cap, plstc, 2 uf $\pm 20\%$, 100v	106963	2		
C6, C12	Cap, plstc, 0.1 uf $\pm 20\%$, 200v	106435	1		
C7, C11	Cap, elect, 20 uf $+75/-10\%$, 50v	106229	2		
C9	Cap, elect, 0.0012 uf $\pm 10\%$, 200v	106088	1		
CR1 thru CR4, CR7 thru CR10	Diode, silicon, 1 amp, 100 piv	116111	8	4	
CR5	Diode, zener, 3.9v	113316	1		
CR6	Diode, zener, 6.3v	172148	1		
Q1	Silicon controlled rectifier, 1.6 amp, 50v	192567	1		
Q2	Tstr, silicon, PNP	159491	1		
Q3, Q5 Q6, Q8, Q9	Tstr, silicon, NPN	203489	5		
Q4, Q7	Tstr, silicon, NPN	183004	2	2	
R1	Res, comp, 10k $\pm 5\%$, $\frac{1}{2}w$	109165	1		
R2	Res, comp, 390 Ω $\pm 5\%$, $\frac{1}{2}w$	109182	1		
R3	Res, comp, 5.6k $\pm 5\%$, $\frac{1}{2}w$	187880	1		
R4	Res, comp, 15 Ω $\pm 10\%$, 2w	155549	1		
R5	Res, comp, 15k $\pm 10\%$, $\frac{1}{2}w$	108530	1		
R6	Res, comp 3k, $\pm 5\%$, $\frac{1}{2}w$	109090	1		
R7	Res, comp, 33k $\pm 10\%$, $\frac{1}{2}w$	178541	1		
R8	Res, met flm, 7.15k $\pm 1\%$, $\frac{1}{2}w$	186072	1		
R9	Res, var, ww, 1k $\pm 20\%$, $1\frac{1}{4}w$	113266	1		
R10	Res, met flm, 2.55k $\pm 1\%$, $\frac{1}{2}w$	176362	1		
R11	Res, comp, 6.2k $\pm 5\%$, $\frac{1}{2}w$	108621	1		
R12	Res, met flm, 2.37 k $\pm 1\%$, $\frac{1}{2}w$	182519	1		
R13	Res, comp, 12k $\pm 10\%$, $\frac{1}{2}w$	108977	1		

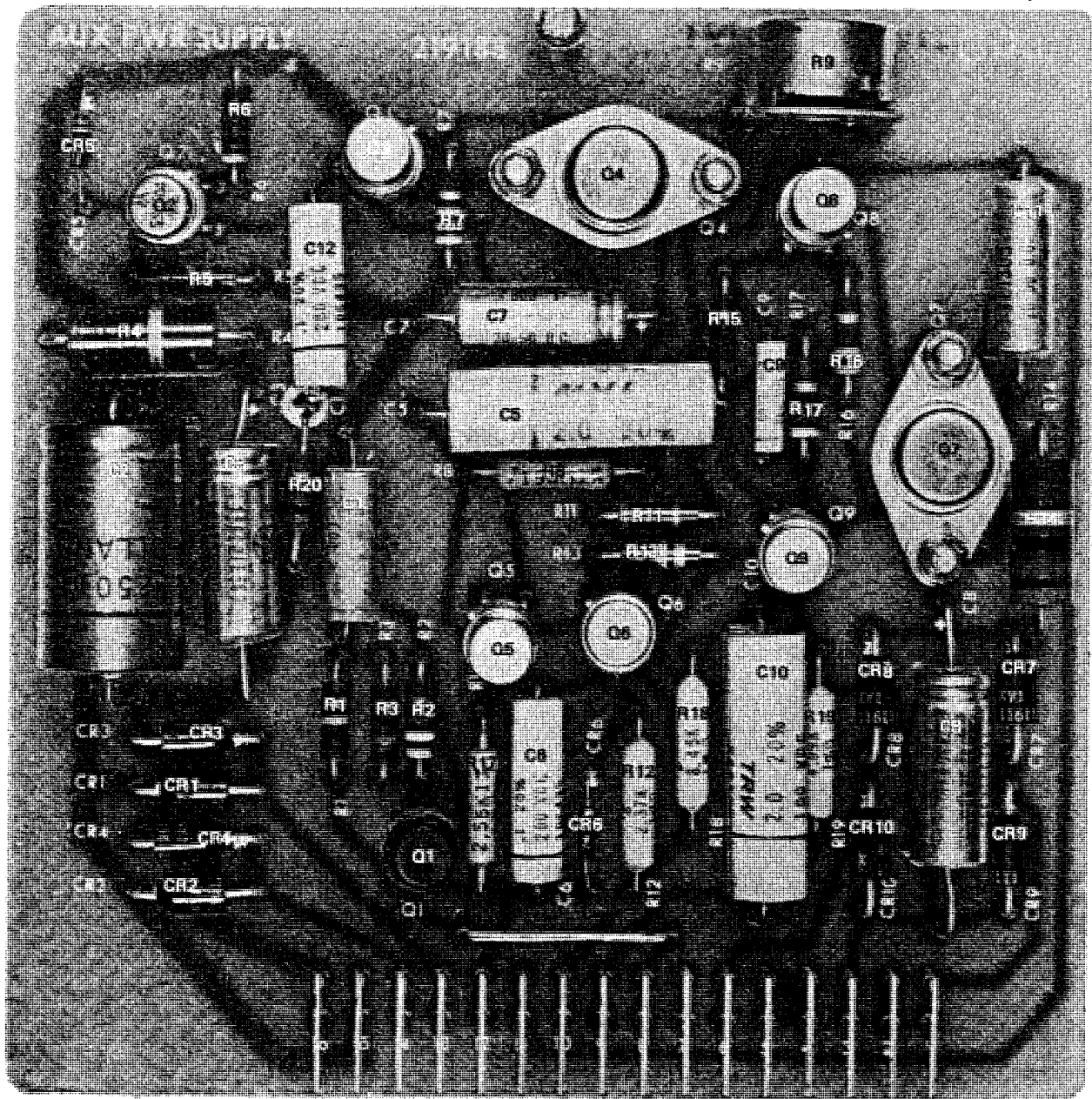


Figure 5-15. +25 AND -15 VOLT POWER SUPPLY ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R14	Res, comp, $82\Omega \pm 10\%$, 2w	110239	1		
R15	Res, comp, $8.2k \pm 5\%$, $\frac{1}{2}w$	147777	1		
R16	Res, comp, $3.3k \pm 10\%$, $\frac{1}{2}w$	108373	1		
R17	Res, comp, $4.7k \pm 10\%$, $\frac{1}{2}w$	108381	1		
R18	Res, met flm, $8.45k \pm 1\%$, $\frac{1}{2}w$	159475	1		
R19	Res, met flm, $4.99k \pm 1\%$, $\frac{1}{2}w$	148890	1		
R20	Res, comp, $2k \pm 5\%$, $\frac{1}{2}w$	169854	1		
	Connector, male, 16 Contact	187724	1		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A9	DRIVER RELAY ASSEMBLY Figure 5-16	251967	REF		
C1, C2	Cap, elect, 20 uf +50/-10%, 16v	241356	2		
C3 thru C6	Cap, Ta, 10 uf $\pm 20\%$, 15v	193623	4		
C7	Cap, Ta, 5.6 uf $\pm 10\%$, 6v	198259	1		
CR1, CR2, CR6	Diode, zener, 30v	272633	3		
CR3, CR5, CR7	Diode, zener, 56v	187757	3		
CR4, CR9 thru CR16	Diode, silicon, 150 ma	203323	9	3	
CR8	Diode, zener, 5.2v	233627	1		
K1, K2, K3	Reed relay switch	219097	3	2	
	Coil, reed relay	281857	3	1	
Q1, Q2, Q6, Q8 thru Q13	Tstr, silicon, PNP	195974	9	3	
Q3, Q5, Q7	Tstr, silicon, PNP	159491	3	1	
R1, R5, R7	Res, comp, 2.2k $\pm 5\%$, $\frac{1}{4}w$	148049	3		
R2, R3, R8, R10, R12, R14, R18, R20, R22, R29, R31	Res, comp, 1k $\pm 5\%$, $\frac{1}{4}w$	148023	11		
R4, R11	Res, comp, 360 Ω $\pm 5\%$, $\frac{1}{4}w$	192559	2		
R6, R15	Res, comp, 2.7k $\pm 5\%$, $\frac{1}{4}w$	170720	2		
R9, R13	Res, comp, 5.6k $\pm 5\%$, $\frac{1}{4}w$	148080	2		
R16, R17	Res, comp, 5.1k $\pm 5\%$, $\frac{1}{4}w$	193342	2		
R19	Res, comp, 2k $\pm 5\%$, $\frac{1}{4}w$	202879	1		
R21, R32	Res comp, 3.3k $\pm 5\%$, $\frac{1}{4}w$	148056	2		
R23, R24, R25, R28, R30	Res, comp, 6.8k $\pm 5\%$, $\frac{1}{4}w$	148098	5		
R26	Res, comp, 24k $\pm 5\%$, $\frac{1}{4}w$	193425	1		

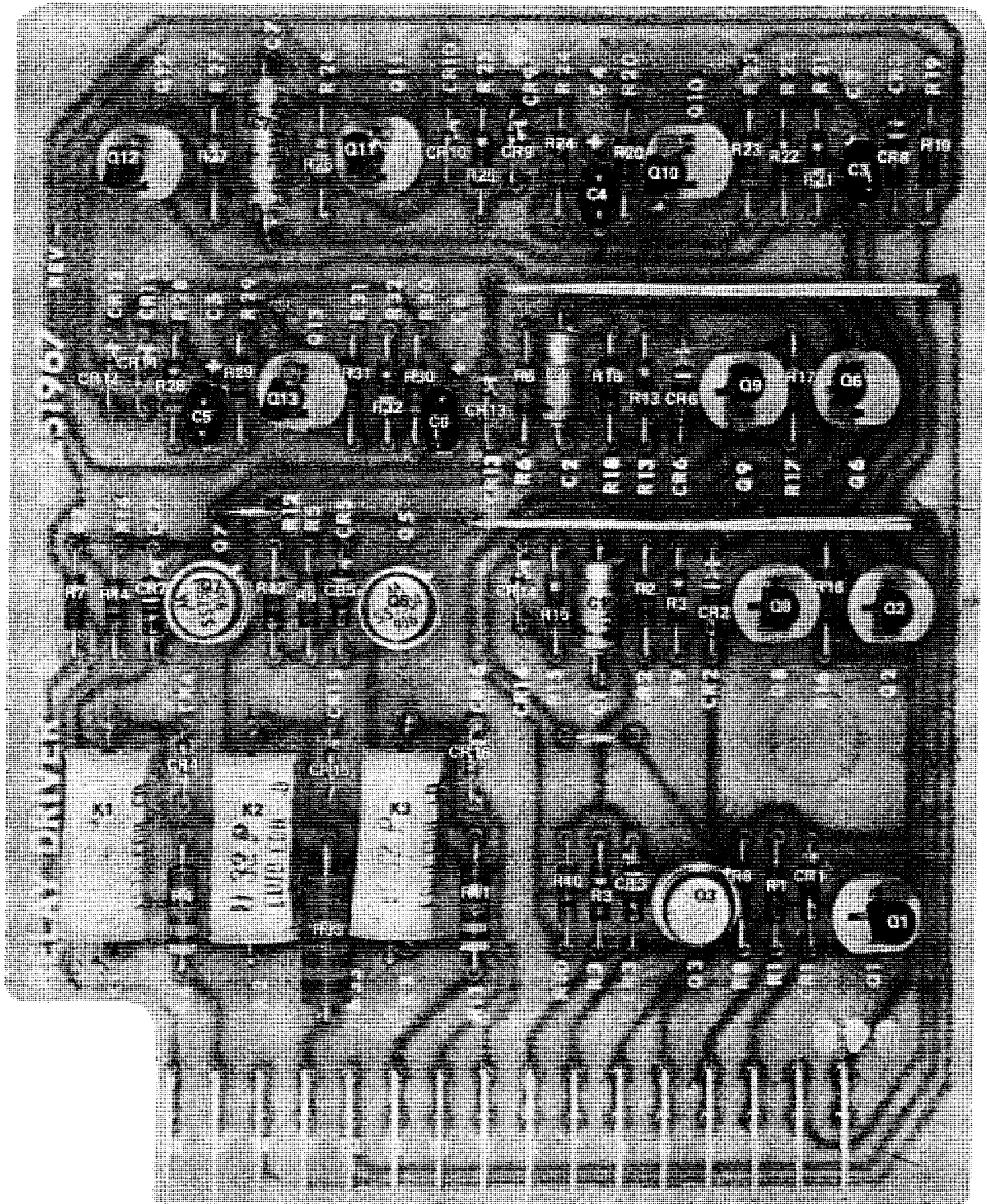


Figure 5-16. DRIVER RELAY ASSEMBLY

[illegible]

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A10	LADDER DRIVER NO. 1 ASSEMBLY Figure 5-17	405746	REF		
C1 thru C4	Cap, Ta, 10 uf $\pm 20\%$, 15v	193623	4		
CR1 thru CR6	Diode, silicon, 150 ma	203323	6		
K1 thru K4	Relay, dpdt, 24 vdc coil	277186	4		
Q1 thru Q4	Tstr, silicon, PNP	218388	4	2	
R1	Res, ww, 73.586k $\pm 0.01\%$, 1w	260109	1		
R2, R10	Res, var, cermet, 100 Ω $\pm 20\%$, $\frac{1}{4}$ w	159889	2		
R3, R5	Res, ww, 24.990k $\pm 0.01\%$, 1w	260125	2		
R4	Res, var, cermet, 20 Ω $\pm 30\%$, $\frac{1}{4}$ w	186197	1		
R6	Res, met flm, 10 Ω $\pm 1\%$, $\frac{1}{2}$ w	151043	1		
R7	Res, ww, 49.975k $\pm 0.01\%$, 1w	260133	1		
R8	Res, var, cermet, 50 Ω $\pm 20\%$, $\frac{1}{4}$ w	186189	1		
R9	Res, ww, 99.95k $\pm 0.01\%$, 1w	277756	1		
R11 thru R14	Res, comp, 1k $\pm 5\%$, $\frac{1}{4}$ w	148023	4		
R15 thru R18	Res, comp, 1.5k $\pm 5\%$, $\frac{1}{4}$ w	148031	4		
R19 thru R22	Res, comp, 2.4k $\pm 5\%$, $\frac{1}{4}$ w	193433	4		
	Connector, male, 16 contact	187724	1		

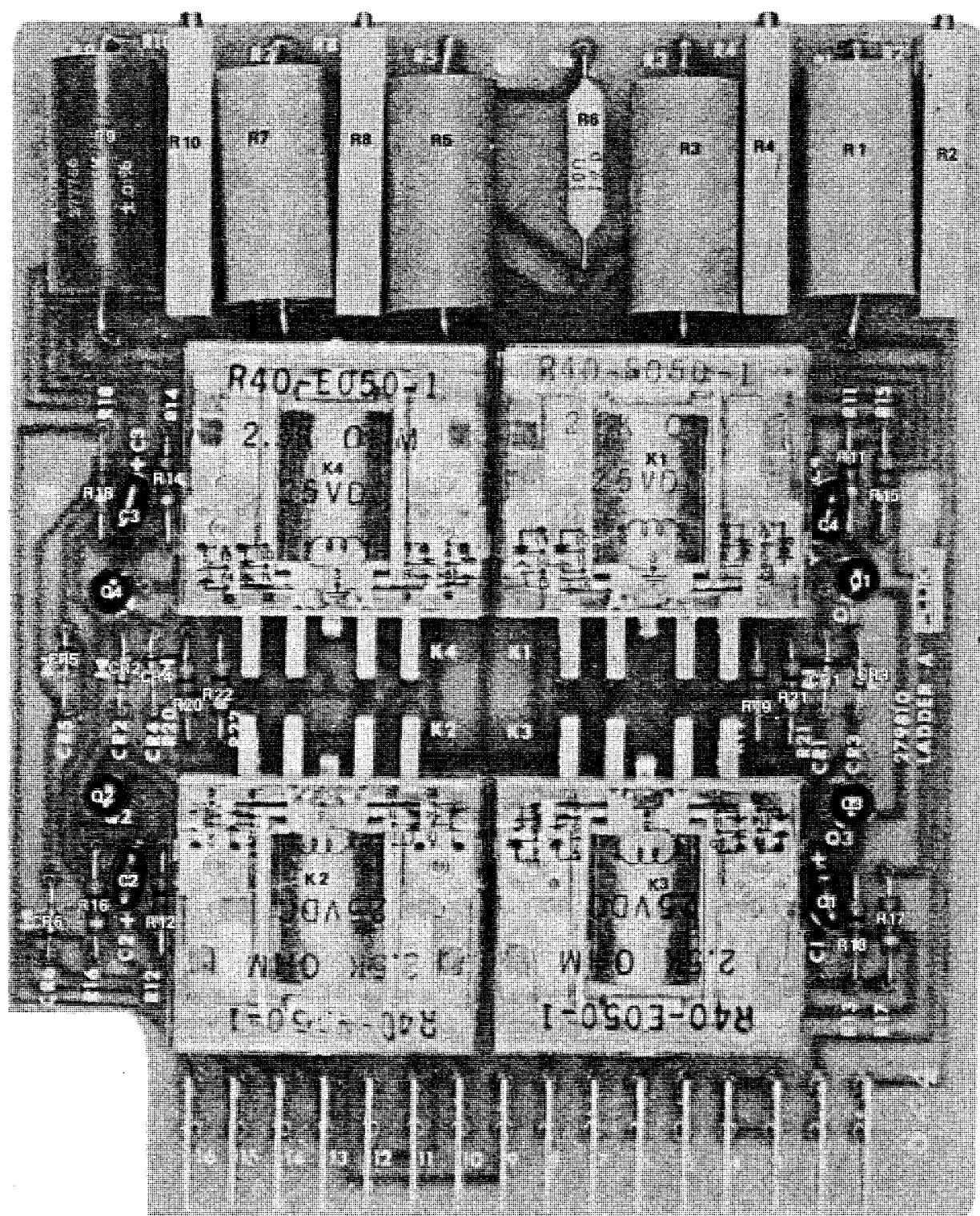


Figure 5-17. LADDER DRIVER NO. 1 ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A11	LADDER DRIVER NO. 2 ASSEMBLY Figure 5-18	275420	REF		
C1 thru C4	Cap, Ta, 10 uf $\pm 20\%$, 15v	193623	4		
CR1 thru CR4	Diode, silicon, 1 amp, 100 piv	116111	4		
CR5, CR6	Diode, silicon, 150 ma	203323	2		
K1 thru K4	Reed relay, Coil, reed relay	267708 272708	4 4	2 1	
Q1 thru Q4	Tstr, silicon, PNP	266015	4	2	
R1	Res, ww, 73.586k $\pm 0.01\%$, 1w	277749	1		
R2, R10	Res, var, cermet, 100 Ω $\pm 20\%$, $\frac{3}{4}$ w	159889	2		
R3, R5	Res, ww, 24.990k $\pm 0.01\%$, 1w	277723	2		
R4, R6	Res, var, cermet, 20 Ω $\pm 30\%$, $\frac{3}{4}$ w	186197	2		
R7	Res, ww, 49.975k $\pm 0.01\%$, 1w	277731	1		
R8	Res, var, cermet, 50 Ω $\pm 20\%$, $\frac{3}{4}$ w	186189	1		
R9	Res, ww, 99.95k $\pm 0.01\%$, 1w	260117	1		
R11 thru R14	Res, comp, 1k $\pm 5\%$, $\frac{1}{4}$ w	148023	4		
R15 thru R18	Res, comp, 2.2k $\pm 5\%$, $\frac{1}{2}$ w	108506	4		
	Connector, male, 16 contact	187724	1		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A12	LADDER DRIVER NO. 3 ASSEMBLY Figure 5-18	275412	REF		
C1 thru C4	Cap, Ta, 10 uf ±20%, 15v	193623	4		
CR1 thru CR4	Diode, silicon, 1 amp, 100 piv	116111	4		
CR5, CR6	Diode, silicon, 150 ma	203323	2		
K1 thru K4	Reed relay, Coil, reed relay	267708 186155	4 4	2 1	
Q1 thru Q4	Tstr, silicon, PNP	266015	4	2	
R1	Res, ww, 73.586k ±0.02%, 1w	277707	1		
R2, R10	Res, var, cermet, 100Ω ±20%, ¼w	159889	2		
R3, R5	Res, ww, 24.990k ±0.02%, 1w	277681	2		
R4, R6	Res, var, cermet, 20Ω ±30%, ¼w	186197	2		
R7	Res, ww, 49.975k ±0.02%, 1w	277699	1		
R8	Res, var, cermet, 50Ω ±20%, ¼w	186189	1		
R9	Res, ww, 99.95k ±0.02%, 1w	277715	1		
R11 thru R14	Res, comp, 1k ±5%, ¼w	148023	4		
R15 thru R18	Res, comp, 2.2k ±5%, ¼w	108506	4		
	Connector, male, 16 contact	187724	1		

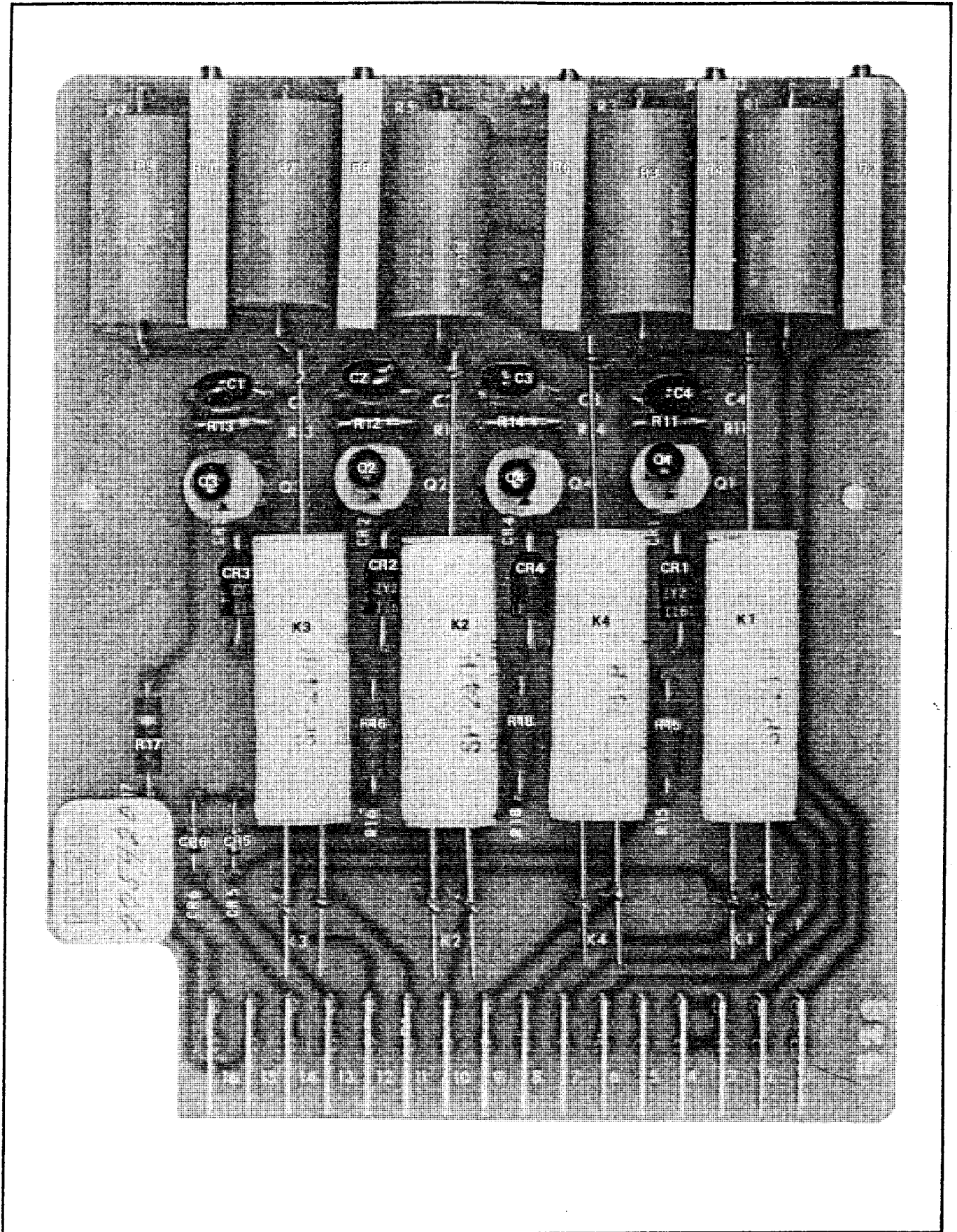


Figure 5-18. LADDER DRIVER NO. 2 AND NO. 3 ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A13	LADDER DRIVER NO. 4 ASSEMBLY Figure 5-19	252031	REF		
CR1 thru CR4	Diode, silicon, 1 amp, 100 piv	116111	4		
CR5, CR6	Diode, silicon, 150 ma	203323	2		
K1 thru K4	Reed relay	267708	4	1	
	Coil, reed relay	186155	4		
Q1 thru Q4	Tstr, silicon, PNP	266015	4	1	
R1	Res, ww, 73.586k $\pm 0.02\%$, 1w	277707	1		
R2, R10	Res, met flm, 23.2 Ω $\pm 1\%$, $\frac{1}{2}w$	200790	2		
R3, R5	Res, ww, 24.990k $\pm 0.02\%$, 1w	277681	2		
R4, R6, R8, R19, R20	Res, met flm, 10 Ω $\pm 1\%$, $\frac{1}{2}w$	151043	5		
R7	Res, ww, 49.975k $\pm 0.02\%$, 1w	277699	1		
R9	Res, ww, 99.95k $\pm 0.02\%$, 1w	277715	1		
R11 thru R14	Res, comp, 1k $\pm 5\%$, $\frac{1}{4}w$	148023	4		
R15 thru R18	Res, comp, 2.2k $\pm 5\%$, $\frac{1}{2}w$	108506	4		
	Connector, male, 16 contact	187724	1		

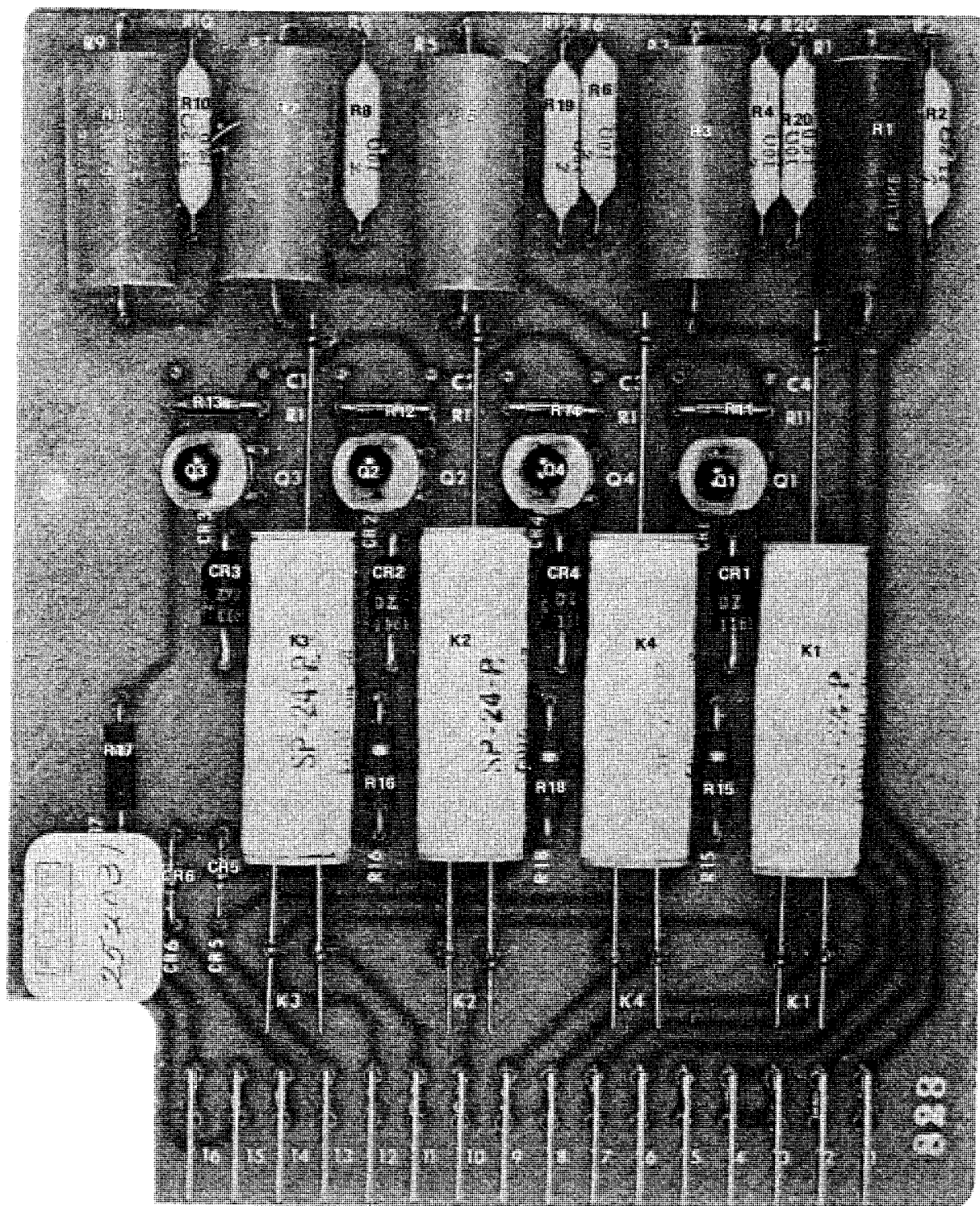


Figure 5-19. LADDER DRIVER NO. 4 ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A14, A4A15, A4A16	LADDER DRIVER NO. 5, NO. 6 & NO. 7 ASSEMBLY Figure 5-20	251892	REF		
CR1 thru CR4	Diode, silicon, 1 amp, 100 piv	116111	4		
CR5, CR6	Diode, silicon, 150 ma	203323	2		
K1 thru K4	Reed relay Coil, reed relay	267708 186155	4 4	1	
Q1 thru Q4	Tstr, silicon, PNP	266015	4	1	
R1	Res, met flm, 73.2k $\pm 0.5\%$, $\frac{1}{2}w$	268516	1		
R2	Res, met flm, 432 Ω $\pm 0.5\%$, $\frac{1}{2}w$	268508	1		
R3, R5	Res, met flm, 24.9k $\pm 0.5\%$, $\frac{1}{2}w$	268474	2		
R4, R6	Res, met flm, 105 Ω $\pm 1\%$, $\frac{1}{2}w$	151100	2		
R7	Res, met flm, 49.9k $\pm 0.5\%$, $\frac{1}{2}w$	268490	1		
R8	Res, met flm, 113 Ω $\pm 1\%$, $\frac{1}{2}w$	151118	1		
R9	Res, met flm, 100k $\pm 0.5\%$, $\frac{1}{2}w$	268482	1		
R10	Res, met flm, 23.2 Ω $\pm 1\%$, $\frac{1}{2}w$	200790	1		
R11 thru R14	Res, comp, 1k $\pm 5\%$, $\frac{1}{4}w$	148023	4		
R15 thru R18	Res, comp, 2.2k $\pm 5\%$, $\frac{1}{2}w$	108506	4		
	Connector, male, 16 contact	187724	1		

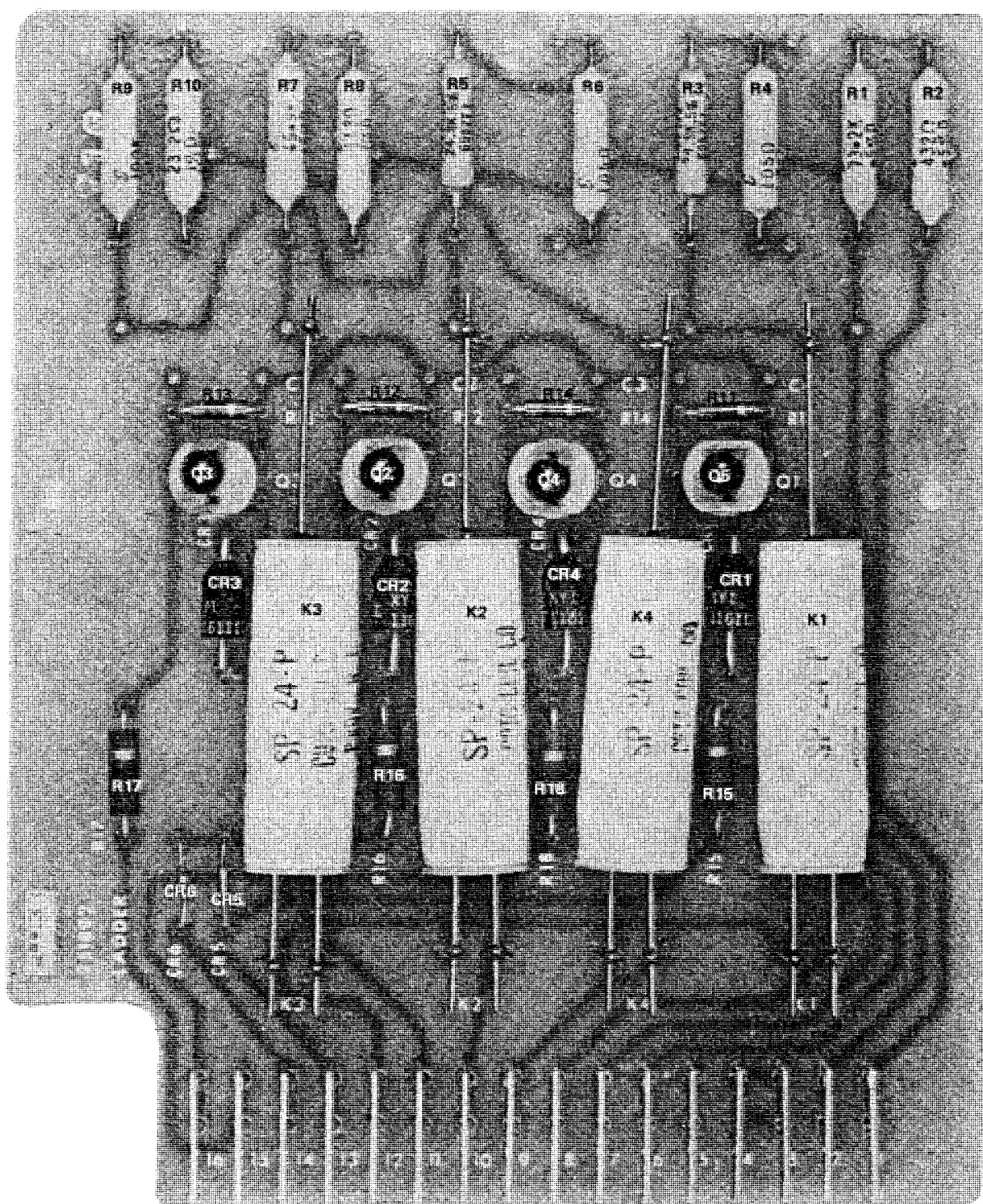


Figure 5-20. LADDER DRIVER NO. 5, NO. 6, AND NO. 7 ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A4A17	RANGE SHUNT NETWORK ASSEMBLY Figure 5-21	251959	REF		
C1	Cap, plstc, 0.1 uf $\pm 10\%$, 1200v	233718	1		
R1	Res, var, cermet, 100k $\pm 20\%$, $\frac{3}{4}w$	275826	1		
R2	Res, met flm, 1.07M $\pm 1\%$, $\frac{1}{2}w$	281162	1		
R5	Res, var, cermet, 10k $\pm 20\%$, $\frac{3}{4}w$	159913	1		
R6	Res, met flm, 107k $\pm 1\%$, $\frac{1}{2}w$	247080	1		
R9, R21	Res, var, cermet, 1k $\pm 20\%$, $\frac{3}{4}w$	190538	2		
R10	Res, met flm, 10.2k $\pm 1\%$, $\frac{1}{2}w$	247049	1		
R15	Res, var, cermet, 10 Ω $\pm 30\%$, $\frac{3}{4}w$	186205	1		
R18	Res, var, cermet, 100 Ω $\pm 20\%$, $\frac{3}{4}w$	159889	1		
R3, R4, R7, R8, R11 thru R14	Matched I Shunt Resistor Set	262774	1		
R16, R17, R19, R20, R22 thru R26	Matched V Range Resistor Set	262782	1		
	Connector, male, 16 contact	187724	1		

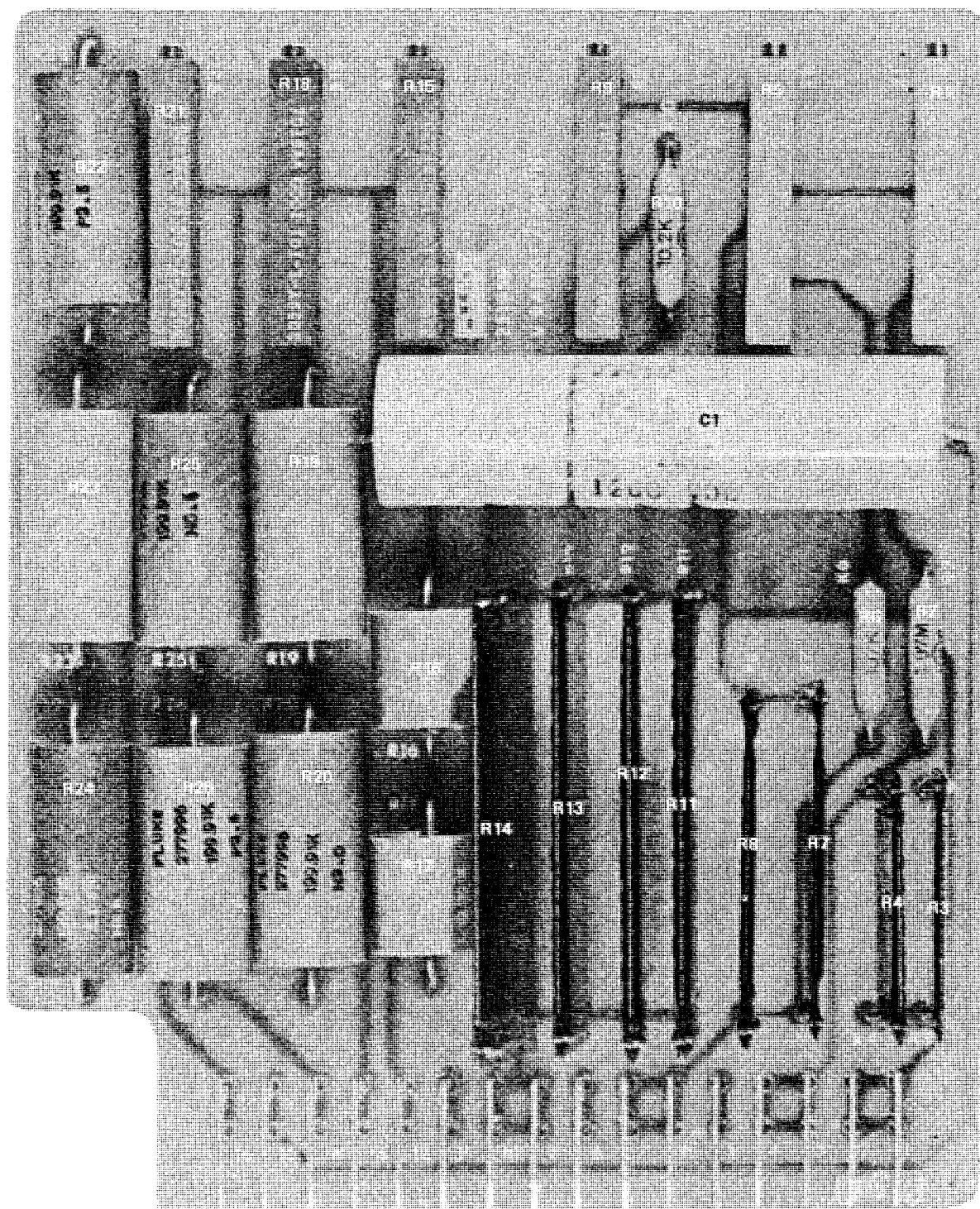


Figure 5-21. RANGE SHUNT NETWORK ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A5	REAR MOTHER BOARD ASSEMBLY Figure 5-22	268013	REF		
A5A1	-25 & -5 Volt Power Supply Assembly (See Figure 5-23)	251900	REF		
A5A2	Preregulator Assembly (See Figure 5-24)	222000	REF		
C1	Cap, plstc, 2 uf $\pm 10\%$, 200v	106443	1		
C2	Cap, plstc, 0.047 uf $\pm 20\%$, 1200v	182683	1		
C3	Cap, Ta, 100 uf $\pm 10\%$, 10v	170456	1		
C4	Cap, plstc, 1 uf $\pm 10\%$, 50v	271890	1		
CR1 thru CR3	Diode, silicon, 150 ma	203323	3		
K1	Relay reed switch Relay coil	219097 269019	2 1		
K2	Relay reed switch Relay coil	219097 281857	REF 1		
K3	Relay reed switch Relay coil	267708 272708	1 1		
Q1	Tstr, silicon, NPN	218396	1		
R1	Res, comp, $10\Omega \pm 10\%$, 2w	110163	1		
R2	Res, comp, 1.5k $\pm 5\%$, $\frac{1}{2}w$	266353	1		
T1	Transformer, pulse	185827	1		
	Connector, female, 16 contact	187732	2		

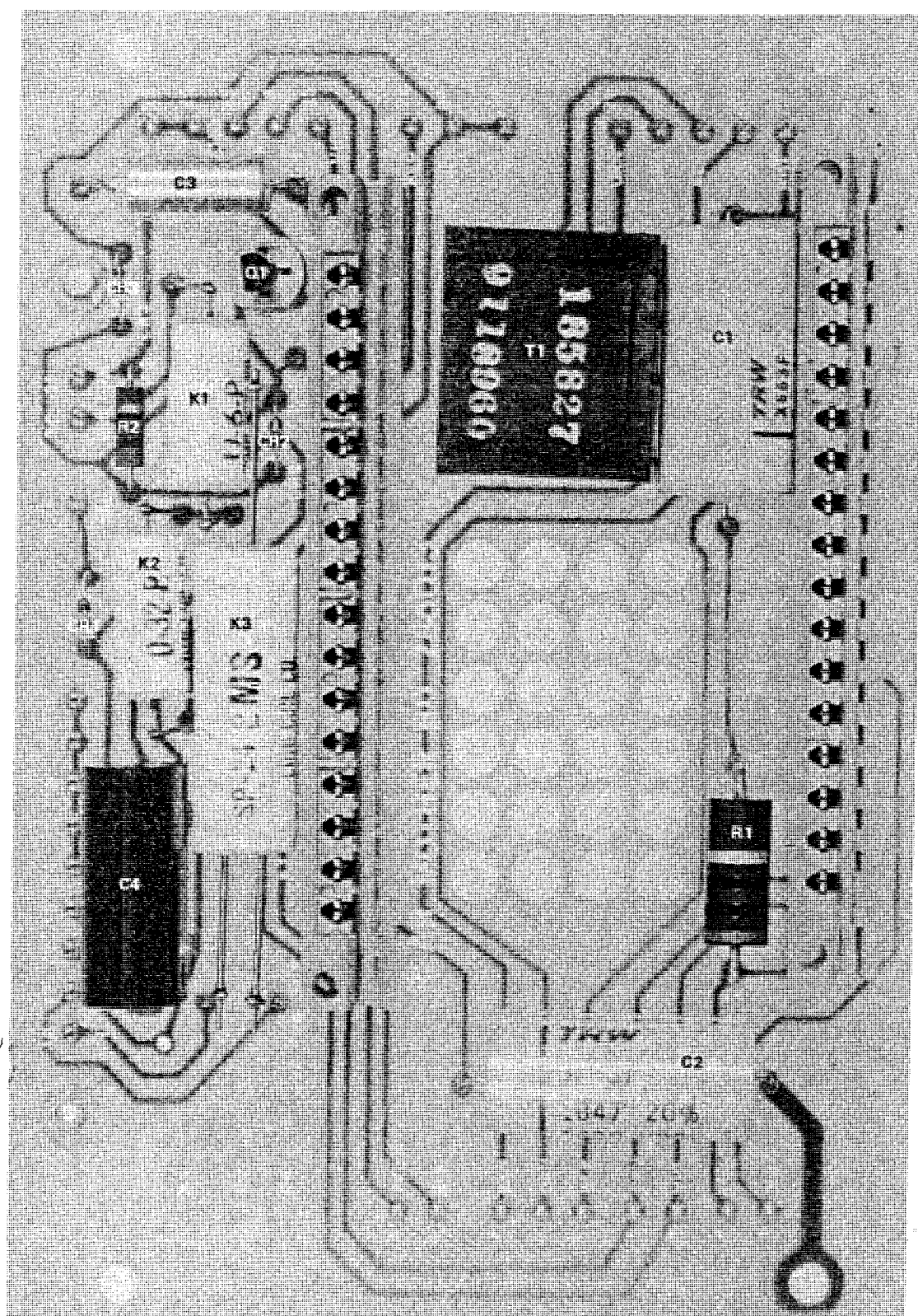


Figure 5-22. REAR MOTHER BOARD ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A5A1	-25 & -5 VOLT POWER SUPPLY ASSEMBLY Figure 5-23	251900	REF	.	.
C1	Cap, elect, 1,000 uf +75/-10% 50v	276741	1		
C2	Cap, elect, 250 uf +50/-10%, 64v	185850	1		
C3	Cap, plstc, 0.47 uf ±10%, 50v	271882	1		
C4	Cap, elect, 150 uf +75/-10%, 15v	150292	1		
C5	Cap, elect, 3,800 uf +75/-10%, 15v	276758	1		
C6	Cap, plstc, 0.1 uf ±10%, 50v	271866	1		
C7	Cap, elect. 20 uf +50/-10%, 16v	241356	1		
CR1 thru CR10, CR14	Diode, silicon, 1 amp, 100 piv	116111	11	4	
CR11	Diode, zener, 3.9v	113316	1		
CR12	Diode, zener, 12v	203547	1		
CR13	Diode, zener, 6.2v	180497	1		
K1	Reed relay switch	233916	1		
	Coil, reed relay, 24v	186155	1		
Q1	Tstr, silicon, NPN	168716	1		
Q2	Tstr, silicon, NPN	203489	1		
Q3	Tstr, silicon, NPN	183004	1	1	
Q4	Tstr, silicon, NPN	218396	1		
Q5	Tstr, silicon, PNP	190389	1	1	
Q6, Q7, Q8	Tstr, silicon, PNP	195974	3		
R1, R9	Res, comp, 1k ±5%, ¼w	148023	2		
R2	Res, comp, 750Ω ±5%, ½w	108894	1		
R3	Res, comp, 2.2k ±5%, ½w	108506	1		
R4	Res, comp, 7.5k ±5%, ¼w	193326	1		
R5	Res, var, ww, 5k ±5%, 1¼w	163709	1		
R6	Res, comp, 10k ±5%, ¼w	148106	1		
R7	Res, comp, 51k ±5%, ½w	165753	1		

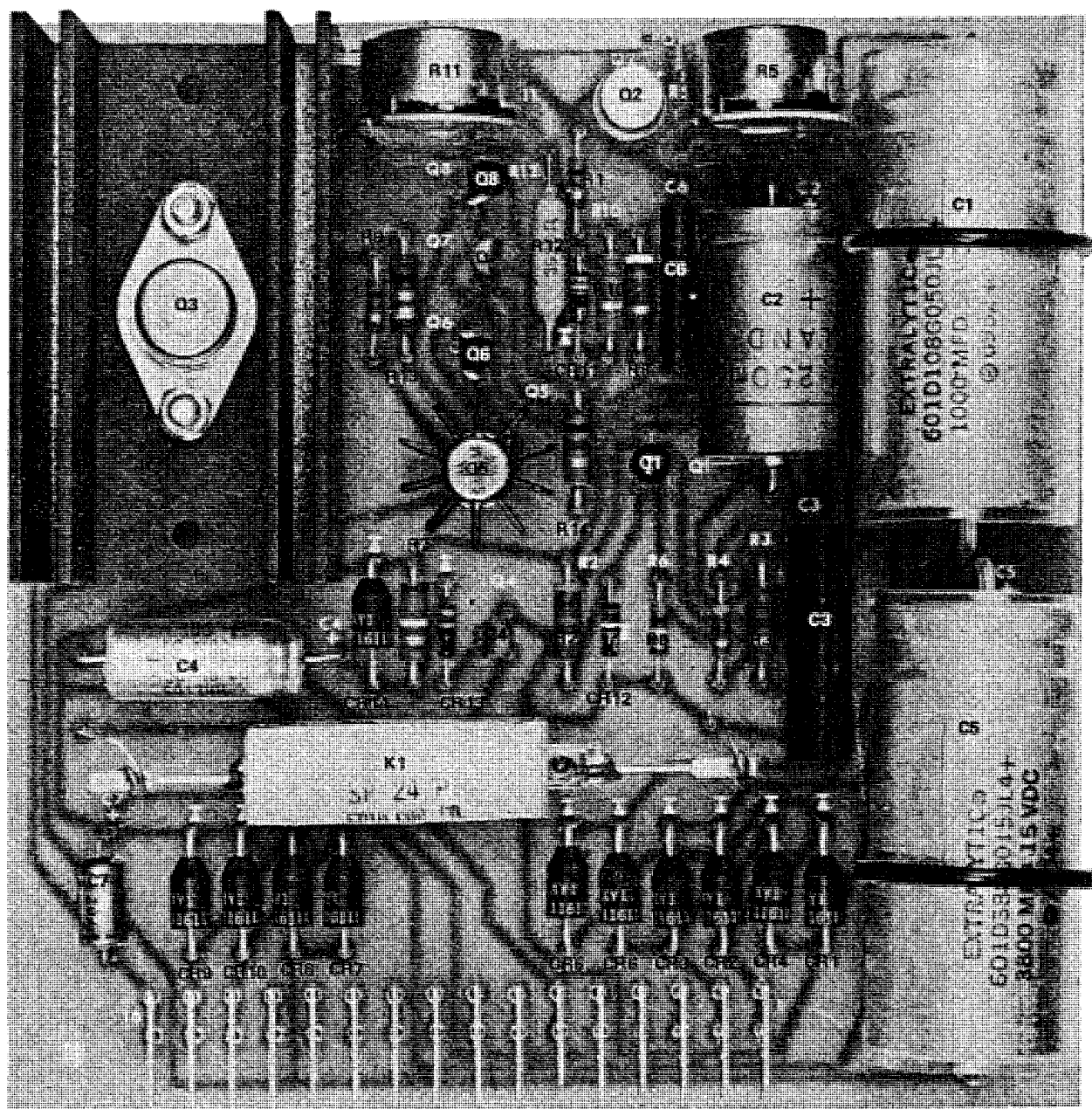


Figure 5-23. -25 AND -5 VOLT POWER SUPPLY ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R8	Res, comp, 9.1k $\pm 5\%$, $\frac{1}{2}w$	160028	1		
R10	Res, comp, 1.2k $\pm 10\%$, $\frac{1}{2}w$	108803	1		
R11	Res, var, ww, 1k $\pm 20\%$, $1\frac{1}{4}w$	113266	1		
R12	Res, met flm, 3.92k $\pm 1\%$, $\frac{1}{2}w$	160713	1		
R13	Res, comp, 2Ω $\pm 5\%$, $\frac{1}{2}w$	218735	1		
R14	Res, comp, 2k $\pm 5\%$, $\frac{1}{2}w$	169854	1		
	Connector, male, 16 contact	187724	1		
	Heat sink, Q3	240432	1		
	Heat sink, Q5	104646	1		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A5A2	PREREGULATOR ASSEMBLY Figure 5-24	222000	REF		
C1, C2 C5, C6	Cap, cer, 0.05uf +80/-10%, 500v	105676	4		
C3	Cap, plstc, 1 uf $\pm 20\%$, 200v	106450	1		
C4	Cap, elect, 1,000 uf +50/-10%, 16v	193896	1		
C7	Cap, cer, 0.01 uf +80/-20%, 500v	105668	1		
C8	Cap, mica, 510 pf $\pm 5\%$, 500v	148411	1		
CR1, CR3, CR15, CR16	Diode, silicon, 1 amp, 100 piv	116111	4		
CR2, CR4 CR5, CR10 thru CR13	Diode, silicon, 3 amp, 200 piv (CR12 under Q1)	187716	7	2	
CR6 thru CR9	Diode, silicon, 1 amp, 600 piv	112383	4		
CR14	Diode, zener, 200 v	187617	1	1	
K1	Relay, armature, 115 vac, dpdt	106864	1		
K2	Relay, reed, 500v Coil, reed relay, 24v	136630 186155	1 1		
L1	Inductor, 1,000 uh, 140 ma	147819	1		
L2	Inductor, 220 uh, 280 ma	147835	1		
Q1	Tstr, silicon, NPN	193953	1	1	
Q2	Tstr, silicon, NPN	183004	1	1	
Q3, Q4, Q6	Tstr, silicon, PNP	159491	3		
Q5, Q7	Tstr, silicon, NPN	203489	2		
R1	Res, comp, $68\Omega \pm 10\%$, 2w	110205	1		
R2	Res, ww, $0.192\Omega \pm 1\%$, 3w	238741	1		
R4	Res, ww, 2k $\pm 5\%$, 5w	113506	1		
R5	Res, comp, 22k $\pm 5\%$, $\frac{1}{2}$ w	186064	1		
R6, R7	Res, ww, $10\Omega \pm 5\%$, 5w	112300	2		
R8	Res, comp, $560\Omega \pm 5\%$, $\frac{1}{2}$ w	109124	1		

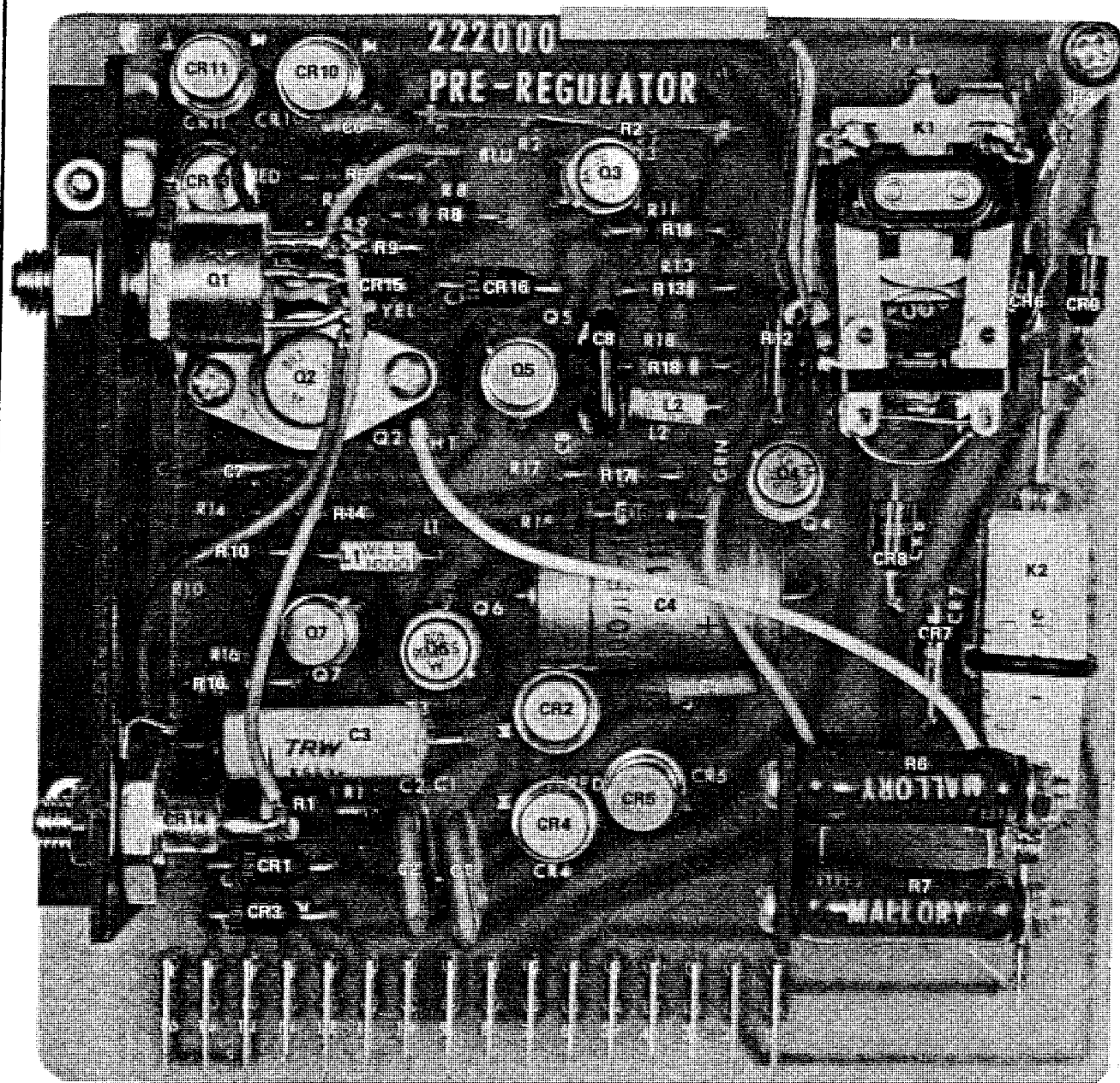


Figure 5-24. PREREGULATOR ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
R9	Res, comp, 360 Ω \pm 5%, 1/2w	192559	1		
R10	Res, comp 20k \pm 5%, 1/2w	109041	1		
R11	Res, comp, 100 Ω \pm 10%, 1/2w	188508	1		
R12	Res, comp, 1k \pm 5%, 1/2w	108597	1		
R13, R17	Res, comp, 270 Ω \pm 5%, 1/2w	159616	2		
R14	Res, comp, 180 Ω \pm 5%, 1/2w	108944	1		
R15	Res, comp, 4.7k \pm 5%, 1/2w	108886	1		
R16	Res, comp, 3.3k \pm 5%, 1/2w	165761	1		
R18	Res, comp, 620 Ω \pm 5%, 1/2w	108704	1		
	Heat sink	227256	1		
	Heat sink	186767	1		
	Connector, male, 16 contact	187724	1		

REF DESIG	DESCRIPTION	STOCK NO	TOT QTY	REC QTY	USE CODE
A6	RELAY BOARD ASSEMBLY Figure 5-25	286195	REF		
K1, K2	Relay, dpdt, 24 vdc coil	272690	2	1	
R1	Res, comp, 5.1 Ω \pm 5%, 1w	219071	1		

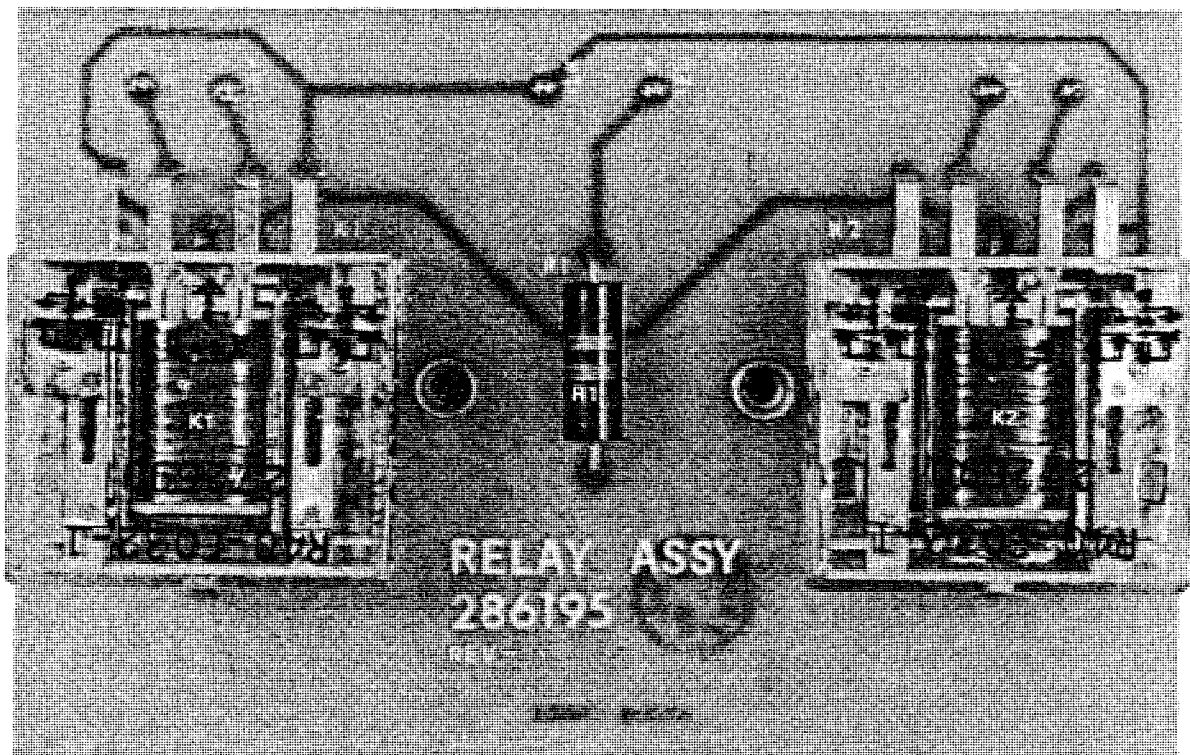


Figure 5-25. RELAY BOARD ASSEMBLY

MANUFACTURERS' CROSS REFERENCE LIST					
FLUKE STOCK NO.	MFR.	MFR. PART NO.	FLUKE STOCK NO.	MFR.	MFR. PART NO.
104646	05820	NF207	108563	01121	EB1021
105122	56289	30D506G050CC4	108597	01121	EB1025
105197	56289	30D205G050BA4	108605	01121	EB2221
105528	72982	315-024X5UD221K	108613	01121	EB1135
105593	71590	DD-101	108621	01121	EB6225
105668	56289	C023B501J103M	108704	01121	EB6215
105676	56289	33C58	108738	01121	EB4735
105684	56289	41C92	108803	01121	EB1221
105700	56289	30D156G006BA4	108886	01121	EB4725
106070	56289	192P68202	108894	01121	EB7515
106088	56289	192P12292	108902	01121	EB2425
106096	72928	355B473M	108910	01121	EB7525
106229	56289	30D206G050DC4	108928	01121	EB7535
106336	56289	Type 66D	108944	01121	EB1815
106435	56289	192P10402	108951	01121	EB5115
106443	84411	Type X663F	108977	01121	EB1231
106450	84411	Type X663F	109041	01121	EB2035
106534	56289	30D107G003CB4	109082	01121	EB3915
106864	28478	100-DPDT	109090	01121	EB3025
106930	71590	DD16-103	109108	01121	EB5125
106963	84411	Type X663FR	109124	01121	EB5615
107458	75042	Type DCF	109157	01121	EB1325
107557	75042	Type DCF	109165	01121	EB1035
108118	01121	EB1031	109231	71400	Type MDX
108126	01121	EB1041	109280	71400	Type MDA
108233	01121	EB2261	109496	01121	GB2721
108373	01121	EB3321	109934	01121	HB1011
108381	01121	EB4721	109975	01121	HB2231
108506	01121	EB2225	109868	01121	GB2701
108522	01121	EB6235	110112	01121	HB1545
108530	01121	EB1531	110163	01121	HB1001

MANUFACTURERS' CROSS REFERENCE LIST

FLUKE STOCK NO.	MFR.	MFR. PART NO.	FLUKE STOCK NO.	MFR.	MFR. PART NO.
110205	01121	HB6801	148122	01121	CB1835
110239	01121	HB8201	148130	01121	CB2235
112177	89536	112177	148155	01121	CB3335
112300	63743	Type 5F	148163	01121	CB4735
112383	05277	1N4822	148171	01121	CB6835
113092	71450	Type 110	148189	01121	CB1045
113266	71450	Type 110	148411	14655	CD19F511J
113308	07910	CD13161	148577	14655	CD15C050K
113316	07910	1N748	148890	91637	Type MFF 1/2
113324	07910	1N961A	148924	72982	5855-Y5U-503Z
113340	07910	1N968A	149161	56289	55C23A1
113506	63743	Type 5F	149260	75042	Type 100-1
116111	05277	1N4817	150201	01121	EB3345
117176	03508	2N16718	150292	56289	30D157G015CC4
136630	12617	Type DRG-2	150318	56289	194P10495R
144360	01121	HB2701	150334	07910	CD36612
147710	01121	HB4745	150342	93332	1N277
147777	01121	EB8225	150870	91637	Type MFF 1/2
147819	72259	WEE-1,000	151043	91637	Type MFF 1/2
147835	72259	WEE-220	151100	91637	Type MFF 1/2
147868	01121	CB1005	151118	91637	Type MFF 1/2
147967	01121	CB3315	151241	91637	Type MFF 1/2
147991	01121	CB5615	151258	91637	Type MFF 1/2
148023	01121	CB1025	151274	91637	Type MFF 1/2
148031	01121	CB2725	151316	91637	Type MFF 1/2
148049	01121	CB2225	151324	91637	Type MFF 1/2
148056	01121	CB3325			
148080	01121	CB5625	151472	91637	Type MFF 1/2
148098	01121	CB6825	151498	91637	Type MFF 1/2
148106	01121	CB1035	152868	95303	2N2869
148114	01121	CB1535	153056	52689	150D156X9020B2

MANUFACTURERS' CROSS REFERENCE LIST

FLUKE STOCK NO.	MFR.	MFR. PART NO.	FLUKE STOCK NO.	MFR.	MFR. PART NO.
155010	91637	Type MFF 1/2	162115	71450	Type 110
155192	91637	Type MFF 1/2	162529	91637	Type MFF 1/2
155416	63743	Type 10F	162586	91637	Type MFF 1/2
155531	01121	EB1211	163394	01121	GB3315
155549	01121	HB1501	163709	71450	Type 110
158659	01121	HB1041	163717	01121	EB11G5
158949	89536	158949	165753	01121	EB5135
159012	02660	MS3102A-10SL-3P	165761	01121	EB3325
159467	91637	Type MFF 1/2	166223	15818	U-1249
159475	91637	Type MFF 1/2	167460	84411	Type 863UW-JF39
159491	04713	SS7504	167478	91637	Type MFF 1/2
159616	01121	EB2715	167494	91637	Type MFF 1/2
159624	01121	EB6835	168054	01121	EB1045
159632	01121	EB2035	168096	04713	1N3041A
159780	07910	1N789	168153	73445	C437ARF400
159889	73138	78PR100	168435	56289	C128B101H253M
159905	73138	78PR5K	168708	03508	2N3391
160028	01121	EB9125	168716	07263	S19254
160259	56289	150D106X9020A2	168823	73445	C426ARF50
160713	91637	Type MFF 1/2	169854	01121	EB2025
160796	01121	CB8225	170423	14655	CD15F221J
160846	75915	342004	170456	56289	150D107X9010R2
160879	75382	601-Y-10B	170704	01121	EB9115
160937	01121	CB2245	170712	01121	CB1215
161059	91637	Type MFF 1/2	170951	89536	170951
161075	91637	Type MFF 1/2	172148	03877	1N3496
161083	91637	Type MFF 1/2	176362	91637	Type MFF 1/2
161349	56289	196D474X0035	177105	07263	2N3565
161406	01121	EB3921	178541	01121	EB3331
161992	73445	C280AE/A100K	178616	73445	C437ARG250
162008	73445	C280AE/A47K	180455	07910	1N749A
			180463	07910	1N968B

MANUFACTURERS' CROSS REFERENCE LIST

FLUKE STOCK NO.	MFR.	MFR. PART NO.	FLUKE STOCK NO.	MFR.	MFR. PART NO.
180497	07910	1N753	186197	73138	Type 78P
182154	14655	DMF2S15	186742	89536	186742
182170	14655	DMF1S68	186759	89536	186759
182485	91637	Type MFF 1/2	186767	89536	186767
182493	91637	Type MFF 1/2	187195	07910	CD36554
182501	91637	Type MFF 1/2	187344	89536	187344
182519	91637	Type MFF 1/2	187617	04713	SZ1625
182527	91637	Type MFF 1/2	187708	91929	V3L-78
182535	91637	Type MFF 1/2	187716	04713	MR1032B/1N4999
182543	91637	Type MFF 1/2	187724	91662	02-106-013-5-200
182550	91637	Type MFF 1/2	187732	91662	00-5009-016-153-001
182683	84411	Type 663UW	187757	07910	1N979B
182824	56289	150D686X9015R2	187880	01121	EB5625
182832	56289	150D336X9010B2	188508	01121	EB1015
182840	56289	150D227X9010A2	190330	73445	C280AE/A1M
183004	95303	40250	190389	04713	SM4144
183541	01884	CMLE405K12	190397	14655	CD15C040K
183558	04713	2N3250	190561	99217	PR473L12
184366	73445	C280AE/A470K	190611	01121	GB1815
184440	12617	DRV1-1	190710	04713	2N3739
185827	89536	185827	192245	89536	192245
185850	73445	C437ARH250	192500	91637	Type MFF 1/2
185983	01121	HB1821	192559	01121	EB3615
185991	01121	EB3635	192567	03508	Type C-6F
186023	01121	EB2735	193011	KEMET	K330J6K
186049	01121	EB3935	193326	01121	CB7525
186064	01121	EB2235	193334	01121	CB5135
186072	91637	Type MFF 1/2	193342	01121	CB5125
186155	71707	SP24P	193425	01121	CB2435
186163	07910	Type 1N974B	193433	01121	CB2425
186189	73138	Type 78P	193441	01121	CB1845
			193482	01121	CB2015

MANUFACTURERS' CROSS REFERENCE LIST					
FLUKE STOCK NO.	MFR.	MFR. PART NO.	FLUKE STOCK NO.	MFR.	MFR. PART NO.
193623	56289	196D106X0015	218792	01121	EB3005
193896	73445	C437ARE1000	219014	91637	Type MFF 1/2
193953	05277	1642031	219030	01121	EB9135
194068	73445	39D805F450HE4	219048	01121	EB5635
194803	73445	C280AE/A220K	219063	01121	EB3315
194944	01121	CB1065	219071	01121	GB51G5
195099	56289	192P4739R8	219089	75042	Type DCC
195164	71450	Type 115 special	219097	15898	765972
195966	01121	EB8235	219188	89536	219188
195974	04713	2N3906	221598	01121	CB1335
196790	71400	Type AGC	221614	01121	CB2035
198259	56289	150D565X9006A2	221879	01121	CB5105
198416	71450	Type 110	221929	01121	CB3635
198812	89536	198812	222000	89536	222000
200790	91637	Type MFF 1/2	222307	89536	222307
202879	01121	CB2025	223131	37942	Type MTC
203323	03508	DHD1105	223214	04713	MC824P
203489	07910	CDQ10656	223396	91637	Type MFF 1/2
203547	07910	1N759A	224790	89536	224790
203869	01121	CB4315	224824	89536	224824
208389	01121	CB3355	225573	95303	2N4299
215251	14655	CD19F641J	225599	07263	S22650
217422	04713	1N3051	226043	07263	FT704
217430	91637	Type MFF 1/2	226100	70903	17258
217810	56289	41C301A2	227256	89536	227256
218008	01121	CB1655	230037	89536	230037
218016	01121	CB2445	231407	89536	231407
218388	07263	2N3645	233577	02799	IPC-153-G
218396	04713	2N3904	233627	07910	331686
218735	01121	EB20G5	233742	91662	02-22-115-3-200
			233916	12617	DRVT-10
			234906	91662	02-018-013-5-200

MANUFACTURERS' CROSS REFERENCE LIST					
FLUKE STOCK NO.	MFR.	MFR. PART NO.	FLUKE STOCK NO.	MFR.	MFR. PART NO.
234914	91662	02-022-013-5-200	260125	89536	260125
235010	91662	02-18115-3-200	260133	89536	260133
235192	01121	HB1515	261032	04713	MPS404A
237354	04713	1N3036	262014	91637	Type MFF 1/2
238741	89536	238741	262790	89536	262790
240432	89536	240432	266015	07263	2N5138
241356	73445	C426ARE20	266049	78488	Type S-6505
243279	89536	243279	266056	02660	57-30500
246603	07263	U5B770939X	266353	01121	EB1525
246850	91637	Type CW10	267252	02660	57-40500
247213	91637	Type MFF 1/2	267708	95348	MR201
247270	91637	Type MFF 1/2	267815	11236	190PC500B
247833	91637	Type MFF 1/2	268060	12617	Type DRRDTH
248021	89536	248021	268201	78488	Type S-6505
248906	95303	CA3406	268342	04713	MR995A
251892	89536	251892	268474	91637	Type MFF 1/2
251900	89536	251900	268482	91637	Type MFF 1/2
251918	89536	251918	268490	91637	Type MFF 1/2
251926	89536	251926	268508	91637	Type MFF 1/2
251959	89536	251959	268516	91637	Type MFF 1/2
251967	89536	251967	268862	71590	J61993
251983	89536	251983	269860	89536	269860
251991	89536	251991	271429	24796	R40-E038-2
252023	89536	252023	271866	06001	75F1R5A104
252031	89536	252031	271882	06001	75F6R5A474
257048	89536	257048	271890	06001	75F7R5A105
257063	89536	257063	272633	07910	1N972A
257071	89536	257071	272690	24796	R40-E032
257089	89536	257089	272708	71707	SP-24-P-MS
260109	89536	260109	275388	89536	275388
260117	89536	260117	275412	89536	275412
			275420	89536	275420
			275552	32767	820-65

MANUFACTURERS' CROSS REFERENCE LIST

FLUKE STOCK NO.	MFR.	MFR. PART NO.	FLUKE STOCK NO.	MFR.	MFR. PART NO.
275560	32767	820-45	282848	89536	282848
275578	32767	820-55	283469	89536	283469
275586	32767	820-25	283804	91637	Type RH-5 to 50
276741	56289	Type 601D	284745	24796	R40-EL-W2-V800
276758	56289	Type 601D	284752	24796	R40-5420
277186	24796	R40-E050-1	285460	89536	285460
277681	89536	277681	285478	89536	285478
277699	89536	277699	285569	89536	285569
277715	89536	277715	286013	89536	286013
277723	89536	277723	286310	89536	286310
277731	89536	277731	287169	89536	287169
277749	89536	277749	287177	89536	287177
277756	89536	277756	287656	89536	287656
279810	89536	279810	288063	89536	288063
281170	24796	R10-E1-M6-S1.2K24 VDC	288373	91637	Type MFF 1/8
281253	24796	A11-9	292862	99392	60075BAS351
281857	15898	U-32-P	340281	07233	X463UW-4RO 0.50W
			405476	89536	405476

Section 6

Option & Accessory Information

There are no options or accessories available for use with the 3330B, other than the rack-mounting kits described in Section 2 of this manual.

Section 7

General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable Parts contained in Section 5.

List of Abbreviations and Symbols

A or amp	ampere	hf	high frequency	(+) or pos	positive
ac	alternating current	Hz	hertz	pot	potentiometer
af	audio frequency	IC	integrated circuit	p-p	peak-to-peak
a/d	analog-to-digital	if	intermediate frequency	ppm	parts per million*
assy	assembly	in	inch(es)	PROM	programmable read-only memory
AWG	american wire gauge	intl	internal	psi	pound-force per square inch
B	bel	I/O	input/output	RAM	random-access memory
bcd	binary coded decimal	k	kilo (10^3)	rf	radio frequency
°C	Celsius	kHz	kilohertz	rms	root mean square
cap	capacitor	kΩ	kilohm(s)	ROM	read-only memory
ccw	counterclockwise	kV	kilovolt(s)	s or sec	second (time)
cer	ceramic	lf	low frequency	scope	oscilloscope
cermet	ceramic to metal(seal)	LED	light-emitting diode	SH	shield
ckt	circuit	LSB	least significant bit	Si	silicon
cm	centimeter	LSD	least significant digit	serno	serial number
cmrr	common mode rejection ratio	M	mega (10^6)	sr	shift register
comp	composition	m	milli (10^{-3})	Ta	tantalum
cont	continue	mA	milliamperes(s)	tb	terminal board
crt	cathode-ray tube	max	maximum	tc	temperature coefficient or temperature compensating
cw	clockwise	mf	metal film	tcxo	temperature compensated crystal oscillator
d/a	digital-to-analog	MHz	megahertz	tp	test point
dac	digital-to-analog converter	min	minimum	u or μ	micro (10^{-6})
dB	decibel	mm	millimeter	uhf	ultra high frequency
dc	direct current	ms	millisecond	us or μs	microsecond(s) (10^{-6})
dmm	digital multimeter	MSB	most significant bit	uut	unit under test
dvm	digital voltmeter	MSD	most significant digit	V	volt
elect	electrolytic	MTBF	mean time between failures	v	voltage
ext	external	MTTR	mean time to repair	var	variable
F	farad	mV	millivolt(s)	vco	voltage controlled oscillator
°F	Fahrenheit	mv	multivibrator	vhf	very high frequency
FET	Field-effect transistor	MΩ	megohm(s)	vlf	very low frequency
ff	flip-flop	n	nano (10^{-9})	W	watt(s)
freq	frequency	na	not applicable	ww	wire wound
FSN	federal stock number	NC	normally closed	xlfr	transformer
g	gram	(-) or neg	negative	xstr	transistor
G	giga (10^9)	NO	normally open	xtal	crystal
gd	guard	ns	nanosecond	xtlo	crystal oscillator
Ge	germanium	opnl ampl	operational amplifier	Ω	ohm(s)
GHz	gigahertz	p	pico (10^{-12})	μ	micro (10^{-6})
gmV	guaranteed minimum value	para	paragraph		
gnd	ground	pcb	printed circuit board		
H	henry	pF	picofarad		
hd	heavy duty	pn	part number		

Federal Supply Codes for Manufacturers

00213 Nytronics Comp. Group Inc. Subsidiary of Nytronics Inc. Formerly Sage Electronics Rochester, New York	02660 Bunker Ramo Corp., Conn Div. Formerly Amphenol-Borg Electric Corp. Broadview, Illinois	04946 Standard Wire & Cable Los Angeles, California	06751 Components, Inc. Semcor Div. Phoenix, Arizona
00327 Welwyn International, Inc. Westlake, Ohio	02799 Aero Capacitors, Inc. Chatsworth, California	05082 Replaced by 94988	06860 Gould Automotive Div. City of Industry, California
00656 Aerovox Corp. New Bedford, Massachusetts	03508 General Electric Co. Semiconductor Products Syracuse, New York	05236 Jonathan Mfg. Co. Fullerton, California	06961 Vernitron Corp., Piezo Electric Div. Formerly Clevite Corp., Piezo Electric Div. Bedford, Ohio
00686 Film Capacitors, Inc. Passaic, New Jersey	03614 Replaced by 71400	05245 Components Corp. now Corcom, Inc. Chicago, Illinois	06980 Eimac Div. Varian Associates San Carlos, California
00779 AMP Inc. Harrisburg, Pennsylvania	03651 Replaced by 44655	05277 Westinghouse Electric Corp. Semiconductor Div. Youngwood, Pennsylvania	07047 The Ross Milton Co. South Hampton, Pennsylvania
01121 Allen-Bradley Co. Milwaukee, Wisconsin	03797 Eldema Div. Genisco Technology Corp. Compton, California	05278 Replaced by 43543	07115 Replaced by 14674
01281 TRW Electronic Comp. Semiconductor Operations Lawndale, California	03877 Transistron Electronic Corp. Wakefield, Massachusetts	05279 Southwest Machine & Plastic Co. Glendora, California	07138 Westinghouse Electric Corp., Electronic Tube Div. Horsehead, New York
01295 Texas Instruments, Inc. Semiconductor Group Dallas, Texas	03888 KDI Pyrofilm Corp. Whippany, New Jersey	05397 Union Carbide Corp. Materials Systems Div. New York, New York	07233 TRW Electronic Components Cinch Graphic City of Industry, California
01537 Motorola Communications & Electronics Inc. Franklin Park, Illinois	03911 Clairex Electronics Div. Clairex Corp. Mt. Vernon, New York	05571 Use 56289 Sprague Electric Co. Pacific Div. Los Angeles, California	07256 Silicon Transistor Corp. Div. of BBF Group Inc. Chelmsford, Massachusetts
01686 RCL Electronics Inc. Manchester, New Hampshire	03980 Muirhead Inc. Mountainside, New Jersey	05574 Viking Industries Chatsworth, California	07261 Aumet Corp. Culver City, California
01730 Replaced by 73586	04009 Arrow Hart Inc. Hartford, Connecticut	05704 Replaced by 16258	07263 Fairchild Semiconductor Div. of Fairchild Camera & Instrument Corp. Mountain View, California
01884 Use 56289 Sprague Electric Co. Dearborn Electronic Div. Lockwood, Florida	04062 Replaced by 72136	05820 Wakefield Engineering Inc. Wakefield, Massachusetts	07344 Bircher Co., Inc. Rochester, New York
02114 Ferroxcube Corp. Saugerties, New York	04202 Replaced by 81312	06001 General Electric Co. Electronic Capacitor & Battery Products Dept. Columbia, South Carolina	07597 Burndy Corp. Tape/Cable Div. Rochester, New York
02131 General Instrument Corp. Harris ASW Div. Westwood, Maine	04217 Essex International Inc. Wire & Cable Div. Anaheim, California	06136 Replaced by 63743	07792 Lerma Engineering Corp. Northampton, Massachusetts
02395 Rason Mfg. Co. Brooklyn, New York	04221 Aemco, Div. of Midtex Inc. Mankato, Minnesota	06383 Panduit Corp. Tinley Park, Illinois	07910 Teledyne Semiconductor Formerly Continental Device Hawthorne, California
02533 Snelgrove, C.R. Co., Ltd. Don Mills, Ontario, Canada M3B 1M2	04222 AVX Ceramics Div. AVX Corp. Myrtle Beach, Florida	06473 Bunker Ramo Corp. Amphenol SAMS Div. Chatsworth, California	07933 Use 49956 Raytheon Co. Semiconductor Div. HO Mountain View, California
02606 Fenwal Labs Div. of Travenel Labs. Morton Grove, Illinois	04423 Telonic Industries Laguna Beach, California	06555 Beede Electrical Instrument Co. Penacook, New Hampshire	08225 Industro Transistor Corp. Long Island City, New York
	04645 Replaced by 75376	06739 Electron Corp. Littleton, Colorado	
	04713 Motorola Inc. Semiconductor Products Phoenix, Arizona	06743 Clevite Corp. Cleveland, Ohio	

Federal Supply Codes for Manufacturers (cont)

08261 Spectra Strip Corp. Garden Grove, California	11726 Qualidyne Corp. Santa Clara, California	13606 Use 56289 Sprague Electric Co. Transistor Div. Concord, New Hampshire	16299 Corning Glass Electronic Components Div. Raleigh, North Carolina
08530 Reliance Mica Corp. Brooklyn, New York	12014 Chicago Rivet & Machine Co. Bellwood, Illinois	13839 Replaced by 23732	16332 Replaced by 28478
08806 General Electric Co. Miniature Lamp Products Dept Cleveland, Ohio	12040 National Semiconductor Corp. Danbury, Connecticut	14099 Semtech Corp. Newbury Park, California	16473 Cambridge Scientific Ind. Div. of Chemed Corporation Cambridge, Maryland
08863 Nylomatic Corp. Norrisville, Pennsylvania	12060 Diodes, Inc. Chatsworth, California	14140 Edison Electronic Div. Mc Gray-Edison Co. Manchester, New Hampshire	16742 Paramount Plastics Fabricators, Inc. Downey, California
08988 Use 53085 Skottie Electronics Inc. Archbald, Pennsylvania	12136 Philadelphia Handle Co. Camden, New Jersey	14193 Cal-R-Inc. formerly California Resistor, Corp. Santa Monica, California	16758 Delco Electronics Div. of General Motors Corp. Kokomo, Indiana
09214 G.E. Co. Semi-Conductor Products Dept. Power Semi-Conductor Products OPN Sec. Auburn, New York	12300 Potter-Brumfield Div. AMF Canada LTD. Guelph, Ontario, Canada	14298 American Components, Inc. an Insilco Co. Conshohocken, Pennsylvania	17001 Replaced by 71468
09353 C and K Components Watertown, Massachusetts	12323 Presin Co., Inc. Shelton, Connecticut	14655 Cornell-Dublier Electronics Division of Federal Pacific Electric Co. Govt. Control Dept. Newark, New Jersey	17069 Circuit Structures Lab. Burbank, California
09423 Scientific Components, Inc. Santa Barbara, California	12327 Freeway Corp. formerly Freeway Washer & Stamping Co. Cleveland, Ohio	14752 Electro Cube Inc. San Gabriel, California	17338 High Pressure Eng. Co., Inc. Oklahoma City, Oklahoma
09922 Burndy Corp. Norwalk, Connecticut	12443 The Budd Co. Polychem Products Plastic Products Div. Bridgeport, Pennsylvania	14869 Replaced by 96853	17545 Atlantic Semiconductors, Inc. Asbury Park, New Jersey
09969 Dale Electronics Inc. Yankton, S. Dakota	12615 U.S. Terminals Inc. Cincinnati, Ohio	14936 General Instrument Corp. Semi Conductor Products Group Hicksville, New York	17856 Siliconix, Inc. Santa Clara, California
10059 Barker Engineering Corp. Formerly Amerace, Amerace ESNA Corp. Kenilworth, New Jersey	12617 Hamlin Inc. Lake Mills, Wisconsin	15636 Elec-Trol Inc. Saugus, California	17870 Replaced by 14140
11236 CTS of Berne Berne, Indiana	12697 Clarostat Mfg. Co. Dover, New Hampshire	15801 Fenwal Electronics Inc. Div. of Kidde Walter and Co., Inc. Framingham, Massachusetts	18178 Vactec Inc. Maryland Heights, Missouri
11237 CTS Keene Inc. Paso Robles, California	12749 James Electronics Chicago, Illinois	15818 Teledyne Semiconductors, formerly Amelco Semiconductor Mountain View, California	18324 Signetics Corp. Sunnyvale, California
11358 CBS Electronic Div. Columbia Broadcasting System Newburyport, Minnesota	12856 Micrometals Sierra Madre, California	15849 Litton Systems Inc. Useco Div. formerly Useco Inc. Van Nuys, California	18612 Vishay Resistor Products Div. Vishay Intertechnology Inc. Malvern, Pennsylvania
11403 Best Products Co. Chicago, Illinois	12954 Dickson Electronics Corp. Scottsdale, Arizona	15898 International Business Machines Corp. Essex Junction, Vermont	18736 Voltronics Corp. Hanover, New Jersey
11503 Keystone Columbia Inc. Warren, Michigan	12969 Unitrode Corp. Watertown, Massachusetts	15909 Replaced by 14140	18927 GTE Sylvania Inc. Precision Material Group Parts Division Titusville, Pennsylvania
11532 Teledyne Relays Hawthorne, California	13103 Thermalloy Co., Inc. Dallas, Texas	16258 Space-Lok Inc. Burbank, California	19451 Perine Machinery & Supply Co. Seattle, Washington
11711 General Instrument Corp. Rectifier Division Hicksville, New York	13327 Solitron Devices Inc. Tappan, New York		19701 Electro-Midland Corp. Mepco-Electra Inc. Mineral Wells, Texas
	13511 Amphenol Cadre Div. Bunker-Ramo Corp. Los Gatos, California		20584 Enochs Mfg. Inc. Indianapolis, Indiana

Federal Supply Codes for Manufacturers (cont)

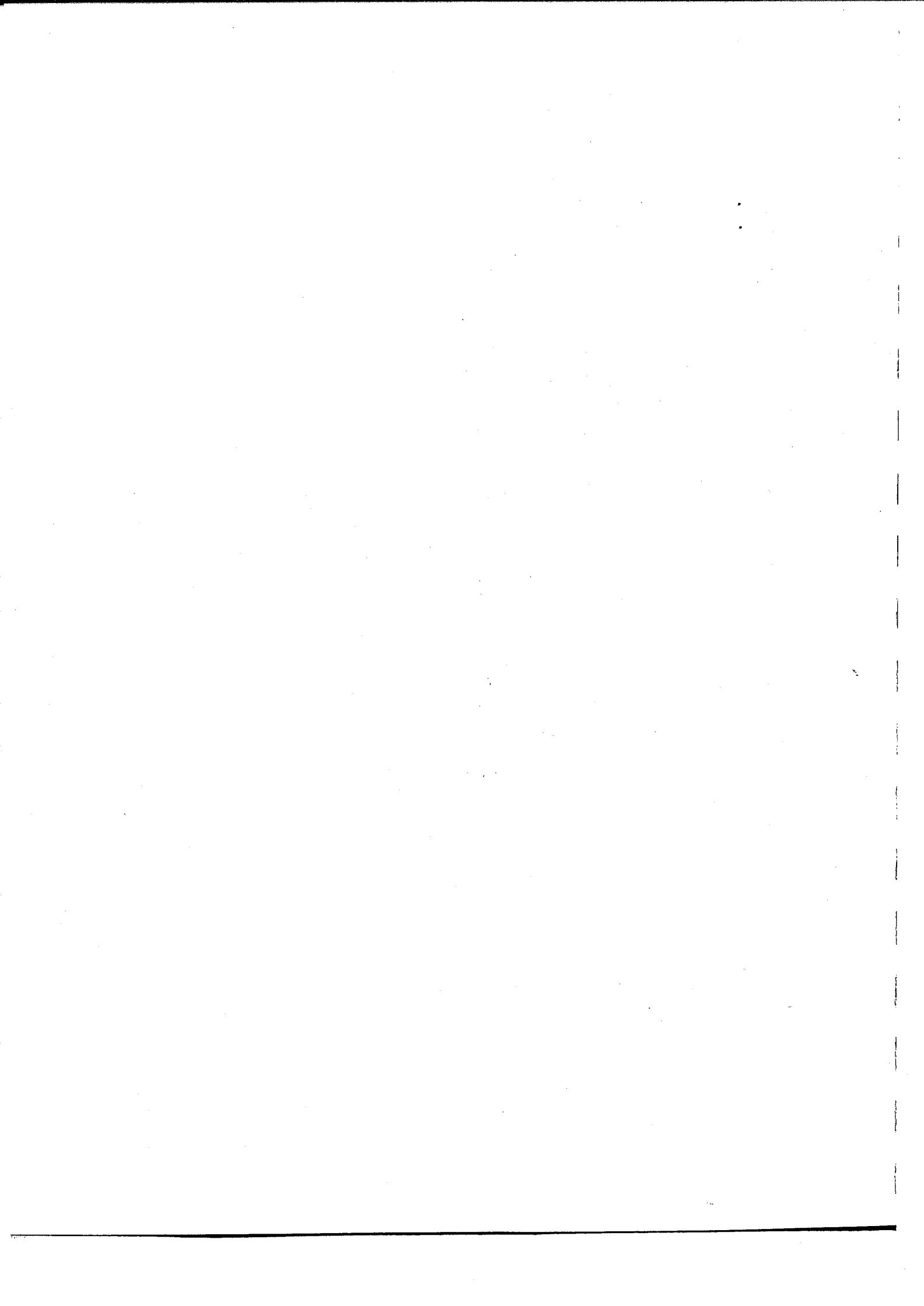
20891 Self-Organizing Systems, Inc. Dallas, Texas	28480 Hewlett Packard Co. Corporate HQ Palo Alto, California	43543 Nytronics Inc. Transformer Co. Div. Geneva, New York	70903 Belden Corp. Geneva, Illinois
21604 Bucheys Stamping Co. Columbus, Ohio	28520 Heyman Mfg. Co. Kenilworth, New Jersey	44655 Ohmite Mfg. Co. Skokie, Illinois	71002 Birnbach Radio Co., Inc. Freeport, New York
21845 Solitron Devices Inc. Transistor Division Riviera Beach, Florida	29083 Monsanto, Co., Inc. Santa Clara, California	49671 RCA Corp. New York, New York	71400 Bussmann Mfg. Div. of McGraw-Edison Co. Saint Louis, Missouri
22767 ITT Semiconductors Palo Alto, California	29604 Stackpole Components Co. Raleigh, North Carolina	49956 Raytheon Company Lexington, Massachusetts	71450 CTS Corp. Elkhart, Indiana
23050 Product Comp. Corp. Mount Vernon, New York	30148 AB Enterprise Inc. Ahsokie, North Carolina	50088 Mostek Corp. Carrollton, Texas	71468 ITT Cannon Electric Inc. Santa Ana, California
23732 Tracor Inc. Rockville, Maryland	30323 Illinois Tool Works, Inc. Chicago, Illinois	50579 Litronix Inc. Cupertino, California	71482 Clare, C.P. & Co. Chicago, Illinois
23880 Stanford Applied Engrng. Santa Clara, California	31091 Optimax Inc. Colmar, Pennsylvania	51605 Scientific Components Inc. Linden, New Jersey	71590 Centrelab Electronics Div. of Globe Union Inc. Milwaukee, Wisconsin
23936 Pamotor Div., Wm. J. Purdy Co. Burlingame, California	32539 Mura Corp. Great Neck, New York	53021 Sangamo Electric Co. Springfield, Illinois	71707 Coto Coil Co., Inc. Providence, Rhode Island
24248 Replaced by 94222	32767 Griffith Plastic Corp. Burlingame, California	54294 Cutler-Hammer Inc. formerly Shallcross, A Cutter-Hammer Co. Selma, North Carolina	71744 Chicago Miniature Lamp Works Chicago, Illinois
24355 Analog Devices Inc. Norwood, Massachusetts	32879 Advanced Mechanical Components Northridge, California	55026 Simpson Electric Co. Div. of Am. Gage and Mach. Co. Elgin, Illinois	71785 TRW Electronics Components Cinch Connector Operations Div. Elk Grove Village Chicago, Illinois
24655 General Radio Concord, Massachusetts	32897 Erie Technological Products, Inc. Frequency Control Div. Carlisle, Pennsylvania	56289 Sprague Electric Co. North Adams, Massachusetts	72005 Wilber B. Driver Co. Newark, New Jersey
24759 Lenox Fugle Electronics Inc. South Plainfield, New Jersey	32997 Bourns Inc. Trimpot Products Division Riverside, California	58474 Superior Electric Co. Bristol, Connecticut	72092 Replaced by 06980
25088 Siemen Corp. Isilen, New Jersey	33173 General Electric Co. Products Dept. Owensboro, Kentucky	60399 Torin Corp. formerly Torrington Mfg. Co. Torrington, Connecticut	72136 Electro Motive Mfg. Co. Williamantic, Connecticut
25403 Amperex Electronic Corp. Semiconductor & Micro-Circuits Div. Slatersville, Rhode Island	34333 Silicon General Westminister, California	63743 Ward Leonard Electric Co., Inc. Mount Vernon, New York	72259 Nytronics Inc. Pelham Manor, New Jersey
27014 National Semiconductor Corp. Santa Clara, California	34335 Advanced Micro Devices Sunnyvale, California	64834 West Mfg. Co. San Francisco, California	72619 Dialight Div. Amperex Electronic Corp. Brooklyn, New York
27264 Molex Products Downers Grove, Illinois	34802 Electromotive Inc. Kenilworth, New Jersey	65092 Weston Instruments Inc. Newark, New Jersey	72653 G.C. Electronics Div. of Hydrometals, Inc. Brooklyn, New York
28213 Minnesota Mining & Mfg. Co. Consumer Products Div. St. Paul, Minnesota	37942 P.R. Mallory & Co., Inc. Indianapolis, Indiana	66150 Winslow Tele-Tronics Inc. Eaton Town, New Jersey	72665 Replaced by 90303
28425 Serv.-Link formerly Bohannon Industries Fort Worth, Texas	42498 National Radio Melrose, Massachusetts	70485 Atlantic India Rubber Works Chicago, Illinois	72794 Dzus Fastener Co., Inc. West Islip, New York
28478 Deltrol Controls Div. Deltrol Corporation Milwaukee, Wisconsin		70563 Amperite Company Union City, New Jersey	72928 Gulton Ind. Inc. Gudeman Div. Chicago, Illinois

Federal Supply Codes for Manufacturers (cont)

72982 Erie Tech. Products Inc. Erie, Pennsylvania	75382 Kuika Electric Corp. Mount Vernon, New York	80583 Hammarlund Mfg. Co., Inc. Red Bank, New Jersey	83594 Burroughs Corp. Electronic Components Div. Plainfield, New Jersey
73138 Bechman Instrument Inc. Helipot Division Fullerton, California	75915 Littlefuse Inc. Des Plaines, Illinois	80640 Arnold Stevens, Inc. South Boston, Massachusetts	83740 Union Carbide Corp. Battery Products Div. formerly Consumer Products Div. New York, New York
73293 Hughes Aircraft Co. Electron Dynamics Div. Torrance, California	76854 Oak Industries Inc. Switch Div. Crystal Lake, Illinois	81073 Grayhill, Inc. La Grange, Illinois	84171 Arco Electronics Great Neck, New York
73445 Amperex Electronic Corp. Hicksville, New York	77342 AMF Inc. Potter & Brumfield Div. Princeton, Indiana	81312 Winchester Electronics Div. of Litton Industries Inc. Oakville, Connecticut	84411 TRW Electronic Components TRW Capacitors Omaha, Nebraska
73559 Carling Electric Inc. West Hartford, Connecticut	77638 General Instrument Corp. Rectifier Division Brooklyn, New York	81483 Therm-O-Disc Inc. Mansfield, Ohio	84613 Fuse Indicator Corp. Rockville, Maryland
73586 Circle F Industries Trenton, New Jersey	77969 Rubbercraft Corp. of CA. LTD. Torrance, California	81483 International Rectifier Corp. Los Angeles, California	84682 Essex International Inc. Industrial Wire Div. Peabody, Massachusetts
73734 Federal Screw Products, Inc. Chicago, Illinois	78189 Shakeproof Div. of Illinois Tool Works Inc. Elgin, Illinois	81590 Korby Mfg. Co. Seattle, Washington	86577 Precision Metal Products of Malden Inc. Stoneham, Massachusetts
73743 Fischer Special Mfg. Co. Cincinnati, Ohio	78277 Sigma Instruments, Inc. South Braintree, Massachusetts	81741 Chicago Lock Co. Chicago, Illinois	86684 Radio Corp. of America Electronic Components Div. Harrison, New Jersey
73899 JFD Electronics Co. Components Corp. Brooklyn, New York	78488 Stackpole Carbon Co. Saint Marys, Pennsylvania	82305 Palmer Electronics Corp. South Gate, California	86928 Seastrom Mfg. Co., Inc. Glendale, California
73949 Guardian Electric Mfg. Co. Chicago, Illinois	78553 Eaton Corp. Engineered Fastener Div. Tinnerman Plant Cleveland, Ohio	82389 Switchcraft Inc. Chicago, Illinois	87034 Illuminated Products Inc. Subsidiary of Oak Industries Inc. Anaheim, California
74199 Quan Nichols Co. Chicago, Illinois	79136 Waldes Kohinoor Inc. Long Island City, New York	82415 North American Phillips Controls Corp. Frederick, Maryland	88219 Gould Inc. Industrial Div. Trenton, New Jersey
74217 Radio Switch Corp. Marlboro, New Jersey	79497 Western Rubber Company Goshen, Indiana	82872 Roanwell Corp. New York, New York	88245 Litton Systems Inc. Litton Div. Van Nuys, California
74276 Signalite Div. General Instrument Corp. Neptune, New Jersey	79963 Zierick Mfg. Corp. Mt. Kisko, New York	82877 Rotron Inc. Woodstock, New York	88419 Cornell-Dubilier Electronic Div. Federal Pacific Co. Fuquay-Varian, North Carolina
74306 Piezo Crystal Co. Carlisle, Pennsylvania	80031 Electro-Midland Corp. Mepco Div. A North American Phillips Co. Norristown, New Jersey	82879 ITT Royal Electric Div. Pawtucket, Rhode Island	88486 Plastic Wire & Cable Jewett City, Connecticut
74542 Hoyt Elect. Instr. Works Penacook, New Hampshire	80145 LFE Corp., Process Control Div. formerly API Instrument Co. Chesterland, Ohio	83003 Varo Inc. Garland, Texas	88690 Replaced by 04217
74970 Johnson E.F., Co. Waseca, Minnesota	80183 Use 56289 Sprague Products North Adams, Massachusetts	83058 The Carr Co., United Can Div. of TRW Cambridge, Massachusetts	89536 John Fluke Mfg. Co., Inc. Seattle, Washington
75042 TRW Electronics Components IRC Fixed Resistors Philadelphia, Pennsylvania	80294 Bourns Inc., Instrument Div. Riverside, California	83298 Bendix Corp. Electric Power Div. Eatontown, New Jersey	89730 G.E. Co., Newark Lamp Works Newark, New Jersey
75376 Kurz-Kasch Inc. Dayton, Ohio		83330 Herman H. Smith, Inc. Brooklyn, New York	
75378 CTS Knights Inc. Sandwich, Illinois		83478 Rubbercraft Corp. of America, Inc. West Haven, Connecticut	

Federal Supply Codes for Manufacturers (cont)

90201 Mallory Capacitor Co. Div. of P.R. Mallory Co., Inc. Indianapolis, Indiana	91836 King's Electronics Co., Inc. Tuckahoe, New York	95354 Methode Mfg. Corp. Rolling Meadows, Illinois	98291 Sealectro Corp. Mamaroneck, New York
90211 Use 56365 Square D Co. Chicago, Illinois	91929 Honeywell Inc. Micro Switch Div. Freeport, Illinois	95712 Bendix Corp. Electrical Components Div. Microwave Devices Plant Franklin, Indiana	98388 Royal Industries Products Div. San Diego, California
90215 Best Stamp & Mfg. Co. Kansas City, Missouri	91934 Miller Electric Co., Inc. Div. of Aunet Woonsocket, Rhode Island	95987 Weckesser Co. Inc. Chicago, Illinois	98743 Replaced by 12749
90303 Mallory Battery Co. Div. of Mallory Co., Inc. Tarrytown, New York	92194 Alpha Wire Corp. Elizabeth, New Jersey	96733 San Fernando Electric Mfg. Co. San Fernando, California	98925 Replaced by 14433
91094 Essex International Inc. Suglex/IWP Div. Newmarket, New Hampshire	93332 Sylvania Electric Products Semiconductor Products Div. Woburn, Massachusetts	96853 Gulton Industries Inc. Measurement and Controls Div. formerly Rustrak Instruments Co. Manchester, New Hampshire	99120 Plastic Capacitors, Inc. Chicago, Illinois
91293 Johanson Mfg. Co. Boonton, New Jersey	94145 Replaced by 49956	96881 Thomson Industries, Inc. Manhasset, New York	99217 Bell Industries Elect. Comp. Div. formerly Southern Elect. Div. Burbank, California
91407 Replaced by 58474	94154 Use 94988 Wagner Electric Corp. Tung-Sol Div. Newark, New Jersey	97540 Master Mobile Mounts, Div. of Whitehall Electronics Corp. Ft. Meyers, Florida	99392 STM Oakland, California
91502 Associated Machine Santa Clara, California	94222 Southco Inc. formerly South Chester Corp. Lester, Pennsylvania	97913 Industrial Electronic Hardware Corp. New York, New York	99515 ITT Jennings Monrovia Plant Div. of ITT Jennings formerly Marshall Industries Capacitor Div. Monrovia, California
91506 Augat Inc. Attleboro, Massachusetts	95146 Alco Electronic Products Inc. Lawrence, Massachusetts	97945 Penwalt Corp. SS White Industrial Products Div. Piscataway, New Jersey	99779 Use 29587 Bunker-Ramo Corp. Barnes Div. Landsdowne, Pennsylvania
91637 Dale Electronics Inc. Columbus, Nebraska	95263 Leecraft Mfg. Co. Long Island City, New York	97966 Replaced by 11358	99800 American Precision Industries Inc. Delevan Division East Aurora, New York
91662 Elco Corp. Willow Grove, Pennsylvania	95264 Replaced by 98278	98094 Replaced by 49956	99942 Centrelab Semiconductor Centrelab Electronics Div. of Globe-Union Inc. El Monte, California
91737 Use 71468 Gremar Mfg. Co., Inc. ITT Cannon/Gremar Santa Ana, California	95275 Vitramon Inc. Bridgeport, Connecticut	98159 Rubber-Teck, Inc. Gardena, California	Toyo Electronics (R-Ohm Corp.) Irvine, California
91802 Industrial Devices, Inc. Edgewater, New Jersey	95303 RCA Corp. Receiving Tube Div. Cincinnati, Ohio	98278 Malco A Microdot Co., Inc. Connector & Cable Div. Pasadena, California	National Connector Minneapolis, Minnesota
91833 Keystone Electronics Corp. New York, New York	95348 Gordo's Corp. Bloomfield, New Jersey		



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(312) 398-0850
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John Fluke Mfg. Co., Inc.
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Suite 101
Indianapolis, IN 46268
(317) 875-7870

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John Fluke Mfg. Co., Inc.
900 Middlesex Turnpike
Building 8
Billerica, MA 01821
(617) 663-2400

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John Fluke Mfg. Co., Inc.
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(301) 770-1570

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John Fluke Mfg. Co., Inc.
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Bloomington, MN 55420
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MO, St. Louis

John Fluke Mfg. Co., Inc.
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Suite 105
St. Louis, MO 63146
(314) 993-3805

NC, Greensboro

John Fluke Mfg. Co., Inc.
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Greensboro, NC 27408
(919) 273-1918

NJ, Paramus

John Fluke Mfg. Co., Inc.
P.O. Box 930
Paramus, NJ 07653-0930
West 75 Century Road
Paramus, NJ 07652
(201) 262-9550

NY, Rochester

John Fluke Mfg. Co., Inc.
4515 Culver Road
Rochester, NY 14622
(716) 323-1400

OH, Cleveland

John Fluke Mfg. Co., Inc.
7830 Freeway Circle
Middleburg Heights, OH 44130
(216) 234-4540

Columbus

(614) 889-5715

Dayton

John Fluke Mfg. Co., Inc.
4756 Fishburg Rd.
Dayton, OH 45424
(513) 233-2238

PA, Malvern

John Fluke Mfg. Co., Inc.
200 Lindenwood Drive
Malvern, PA 19355
(215) 647-9550

TX, Dallas

John Fluke Mfg. Co., Inc.
1801 Royal Lane
Suite 307
Dallas, TX 75229
(214) 869-0311

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John Fluke Mfg. Co., Inc.
10417 Gulfdale
San Antonio, TX 78216
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WA, Seattle

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5020 148th Ave. N.E.
Suite 110
Redmond, WA 98052
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John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, WA 98206
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Buenos Aires, Argentina
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Concord, N.S.W. 2137
Australia
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Ringwood, Victoria 3134
Australia
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Tel: (8) 271-1839

Elmeasco Instruments Pty, Ltd.
P.O. Box 95
Gosnells, West Australia 6110
Australia
Tel: (9) 398-3362

Austria •

Walter Rekirsh Elektronische
Geräte GmbH & Co.
Vertrieb KG
Obachgasse 28
1220 Vienna, Austria
Tel: (222) 235555, TLX: (847) 134759

Bahrain

Basma
P.O. Box 5701
Manama, Bahrain
Tel: 251-364, TLX: (955) 9003

Bangladesh •

Motherland Corporation
24 Hathkolia Road, Tikatuli
Dacca-3, Bangladesh
Tel: 257249 or 255776
TLX: (950) 642022

Belgium •

Fluke (Belgium) S.A./N.V.
6 Rue de Geneve
1140 Brussels
Belgium
Tel: (2) 2164090, TLX: (846) 26312

Bolivia •

Coasin Bolivia S.R.L.
Casilla 7295
La Paz, Bolivia
Tel: (2) 40962, TLX: (336) 5255

Brazil •

Hi-Tek Electronica Ltda.
Al. Amazonas 422,
Alphaville, Barueri,
CEP 06420, Sao Paulo, Brazil
Tel: (11) 421-5477, TLX: (391) 01135589

Brunei •

Rank O'Connor's Bernad
No. 8 BIK D
Suft Shophouse Complex
Mile 1 Jalan Tutong
Bandar Seri Begawan
Negara Brunei Darussalam
Tel: (2) 23109 or 23557
TLX: (799) 2265 RANKOC

Canada •

Allan Crawford Assoc., Ltd.
5835 Coopers Avenue
Mississauga, Ontario
L4Z 1Y2 Canada
Tel: (416) 890-2010, TLX: 0696 1235

Allan Crawford Assoc., Ltd.
7018 Cote de Liesse
St. Laurent, Quebec
H4T 1E7 Canada
Tel: (514) 731-8564
TLX: 05824944

Allan Crawford Assoc., Ltd.
2625 Queensview Drive
Ottawa, Ontario
K2B 8K2 Canada
Tel: (613) 596-9300, TLX: 0533600

Allan Crawford Assoc., Ltd.
Suite No. 106
4180 Loughheed Hwy.
Burnaby, British Columbia
V5C 6A7 Canada
Tel: (604) 294-1326, TLX: 0454247

Allan Crawford Assoc., Ltd.
1935 30th Avenue, N.E.
Calgary, Alberta
T2E 6Z5 Canada
Tel: (403) 230-1341, TLX: 03821186

Allan Crawford Assoc., Ltd.

800 Windmill Road
Suite 205
Dartmouth, N.S.
B3B 1L1 Canada
Tel: (902) 463-8640

Chile •

Intronica Chile, Ltda.
Manuel Montt 024-Of. D
Casilla 16228
Santiago 9, Chile
Tel: (2) 44940, TLX: (332) 240301

China, Peoples Republic of •

Fluke International Corp.
P.O. Box C9090 M/S 206A
Everett, WA 98206 U.S.A.
Tel: (206) 356-5511
TLX: 185103 FLUKE UT

Colombia •

Sistemas E Instrumentacion, Ltda.
Carrera 13, No. 37-43, Of. 401
Ap. Aereo 29583
Bogota DE, Colombia
Tel: 232-4532, TLX: (396) 45787

Cyprus •

Chris Radiovision, Ltd.
P.O. Box 1989
Nicosia, Cyprus
Tel: (21) 66121, TLX: (826) 2395

Cyprus, Northern

Ucok Buroteknik
2C & 2D Muftu Ziyai Street
Lefkosa, Northern Cyprus
Mersin 10, Turkey
Tel: (741) 357-20-71777
TLX: (821) 57267

Czechoslovakia •

Amtest Associates Ltd.
Clarence House
31 Clarence Street
Staines, Middlesex TW18 4SY
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West Germany
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Rapifax: 49-89-9605166
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John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, WA 98206

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Section 8

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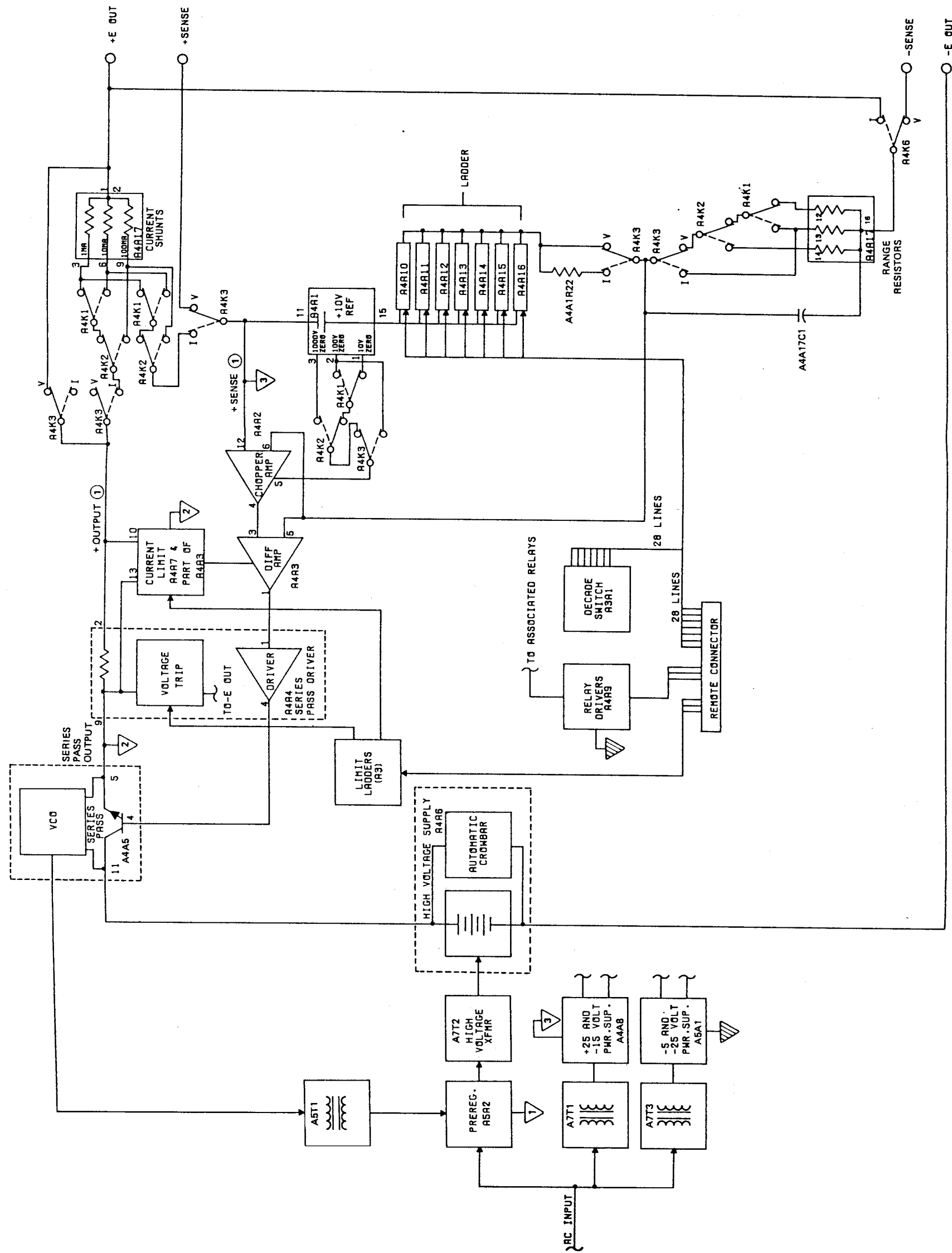


FIGURE 8-1 3330B FUNCTIONAL BLOCK DIAGRAM

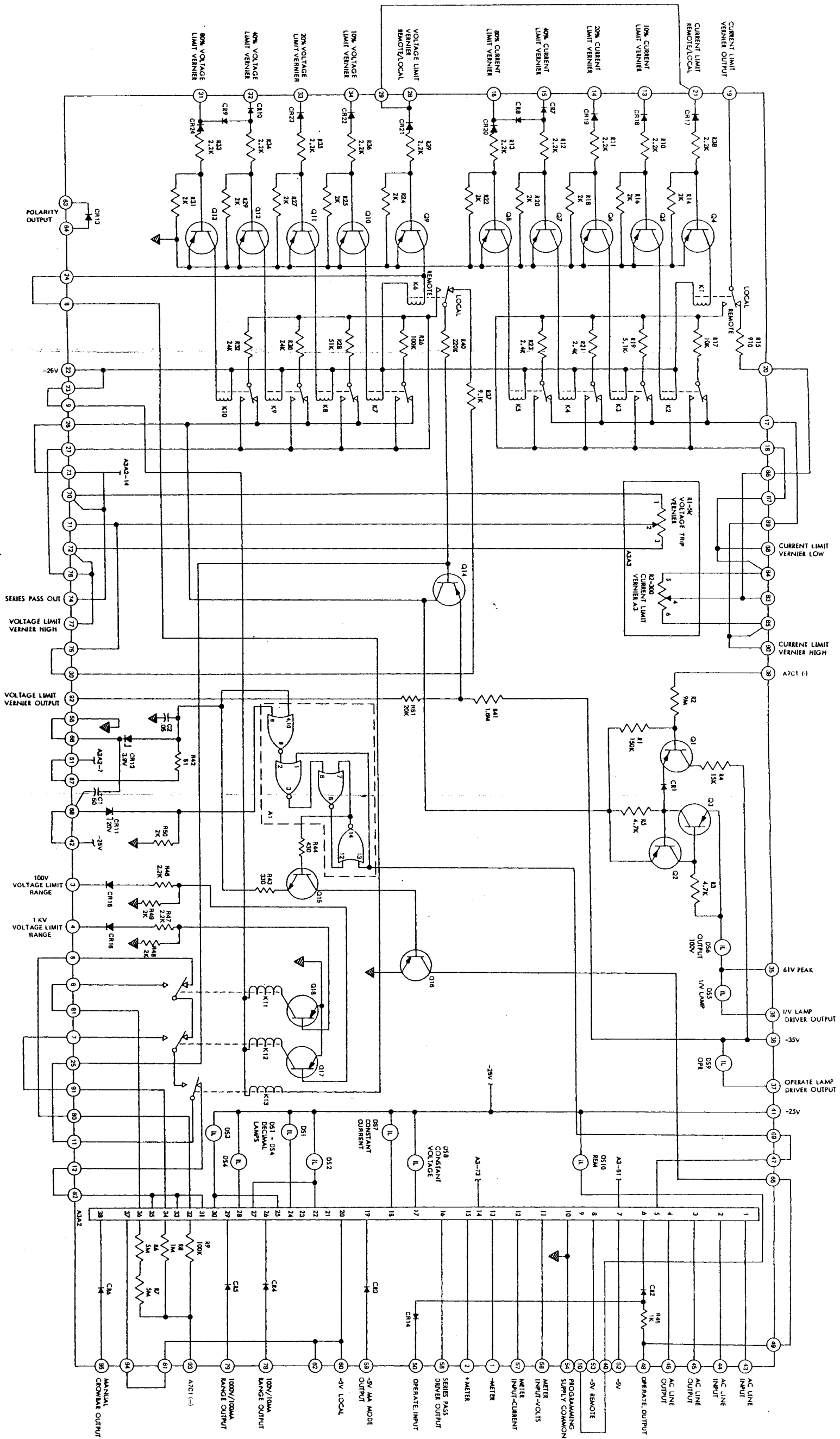
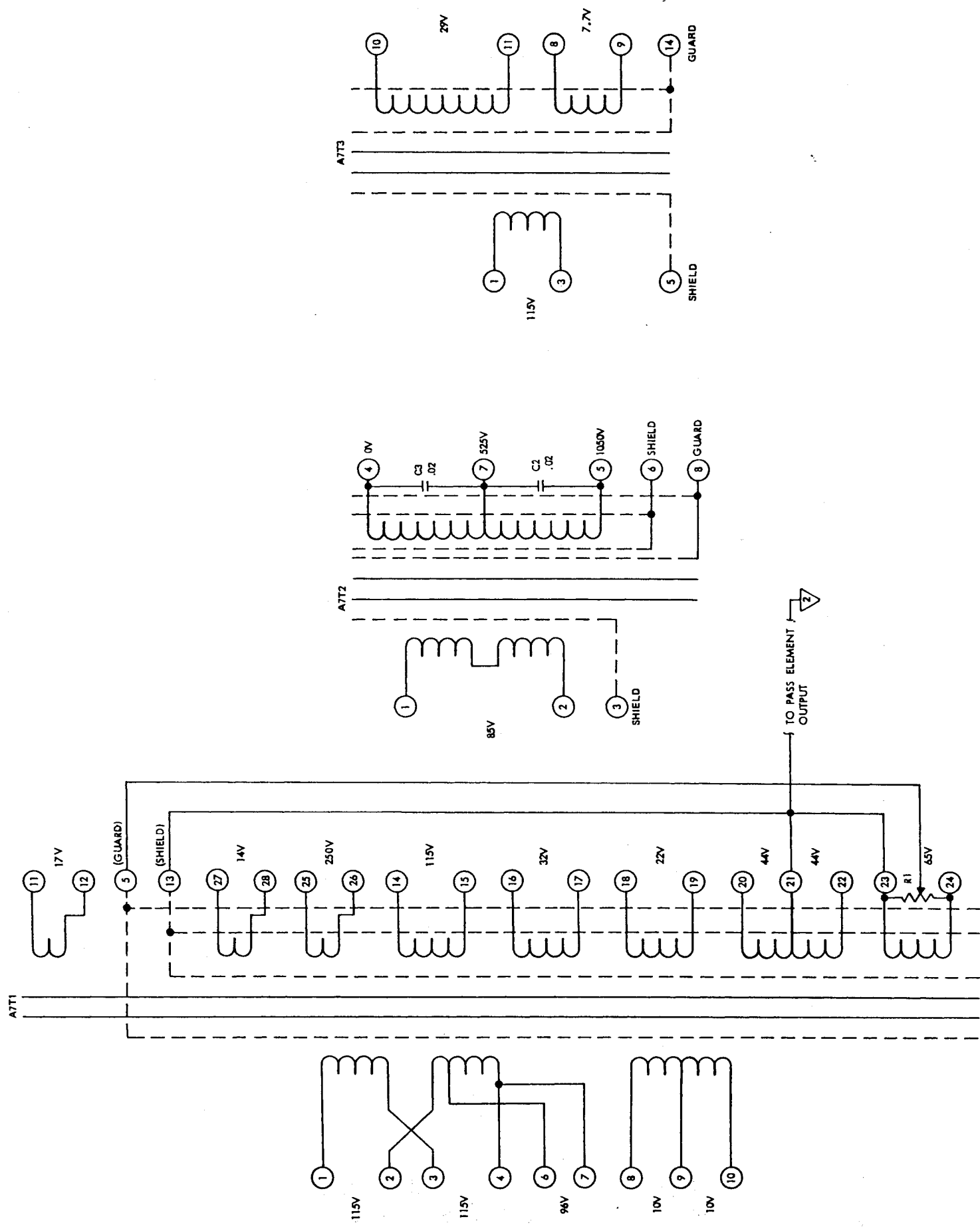


FIGURE 8-4 A3 FRONT MOTHER BOARD
ASSEMBLY (3330B-1006) AND
A3A3 I/V LIMIT VERNIER
ASSEMBLY (333A-1012)

8-6

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NOTES:
(1) ALL RESISTANCES IN OHMS AND ALL CAPACITANCES
IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
(2) \odot INDICATES INTERNAL ADJUSTMENT.
(3) ∇ INDICATES PROGRAMMING SUPPLY COMMON.



NOTES:
 (1) ALL RESISTANCES IN OHMS AND ALL CAPACITANCES
 IN MICROFARADS UNLESS OTHERWISE SPECIFIED
 (2) SERIES PASS OUTPUT COMMON
 (3) THESE TRANSFORMERS PART OF (A7)
 INNER CHASSIS.

FIGURE 8-3 A7 TRANSFORMER ASSEMBLY

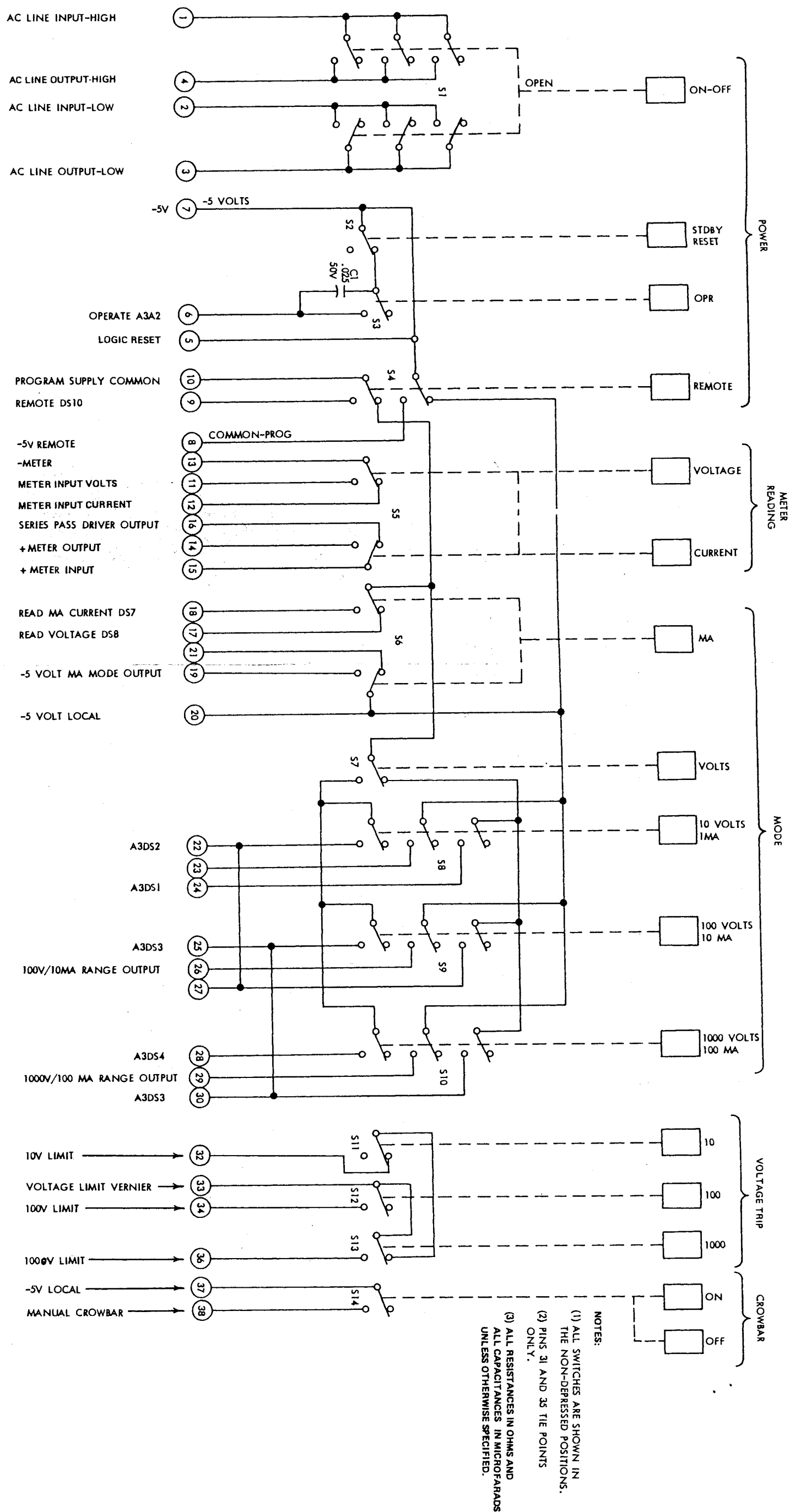
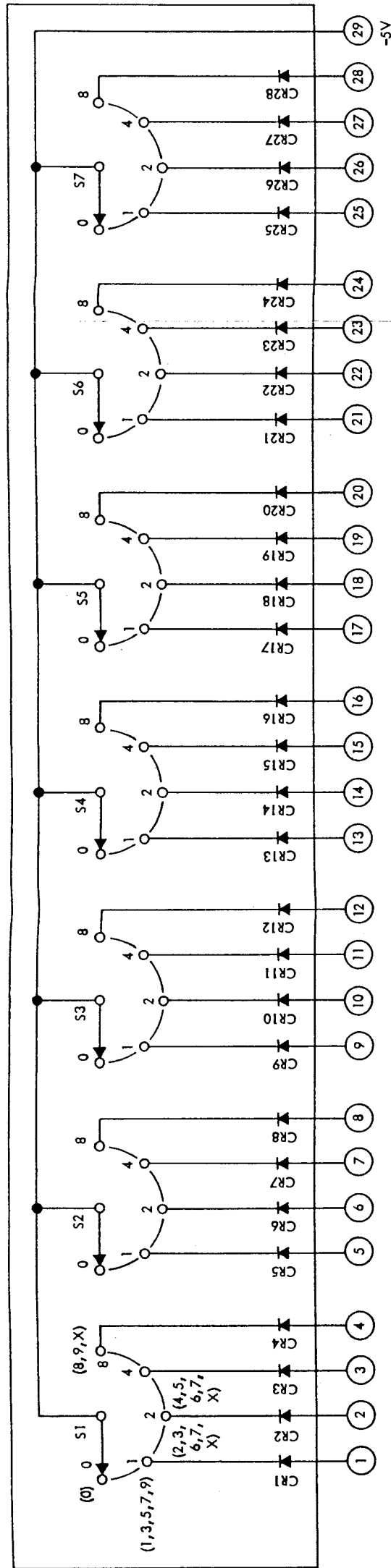


FIGURE 8-6 A3A2 SWITCH BOARD ASSEMBLY
(3330B-1007)

8-8

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- NOTE:
1. NUMBERS IN PARENTHESIS ARE SWITCH DIGIT POSITIONS.
 2. ALL RESISTANCE VALUES IN OHMS, CAPACITANCE IN MICROFARADS, AND INDUCTANCE IN HENRIES UNLESS OTHERWISE SPECIFIED.
 3. SERIES PASS OUTPUT COMMON

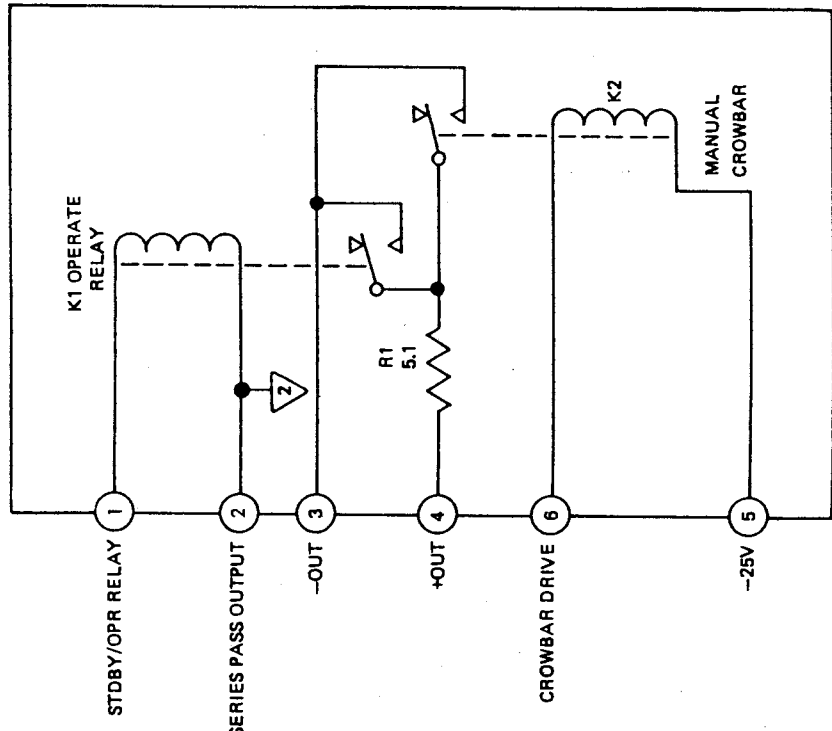




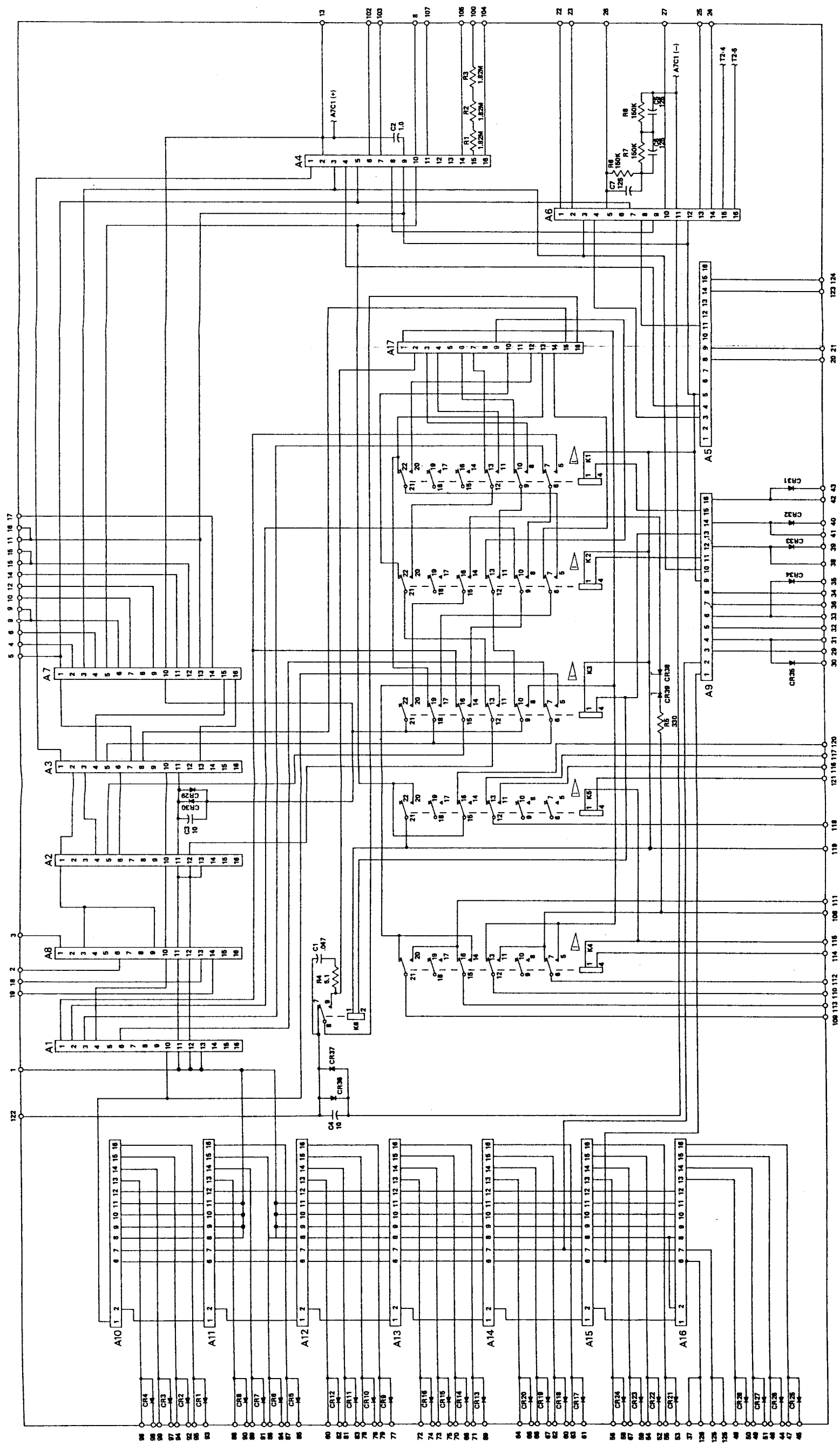


FIGURE 8-5 A3A1 DECADE SWITCH ASSEMBLY (333A-1019) AND A6 RELAY BOARD ASSEMBLY (3330B-1004)

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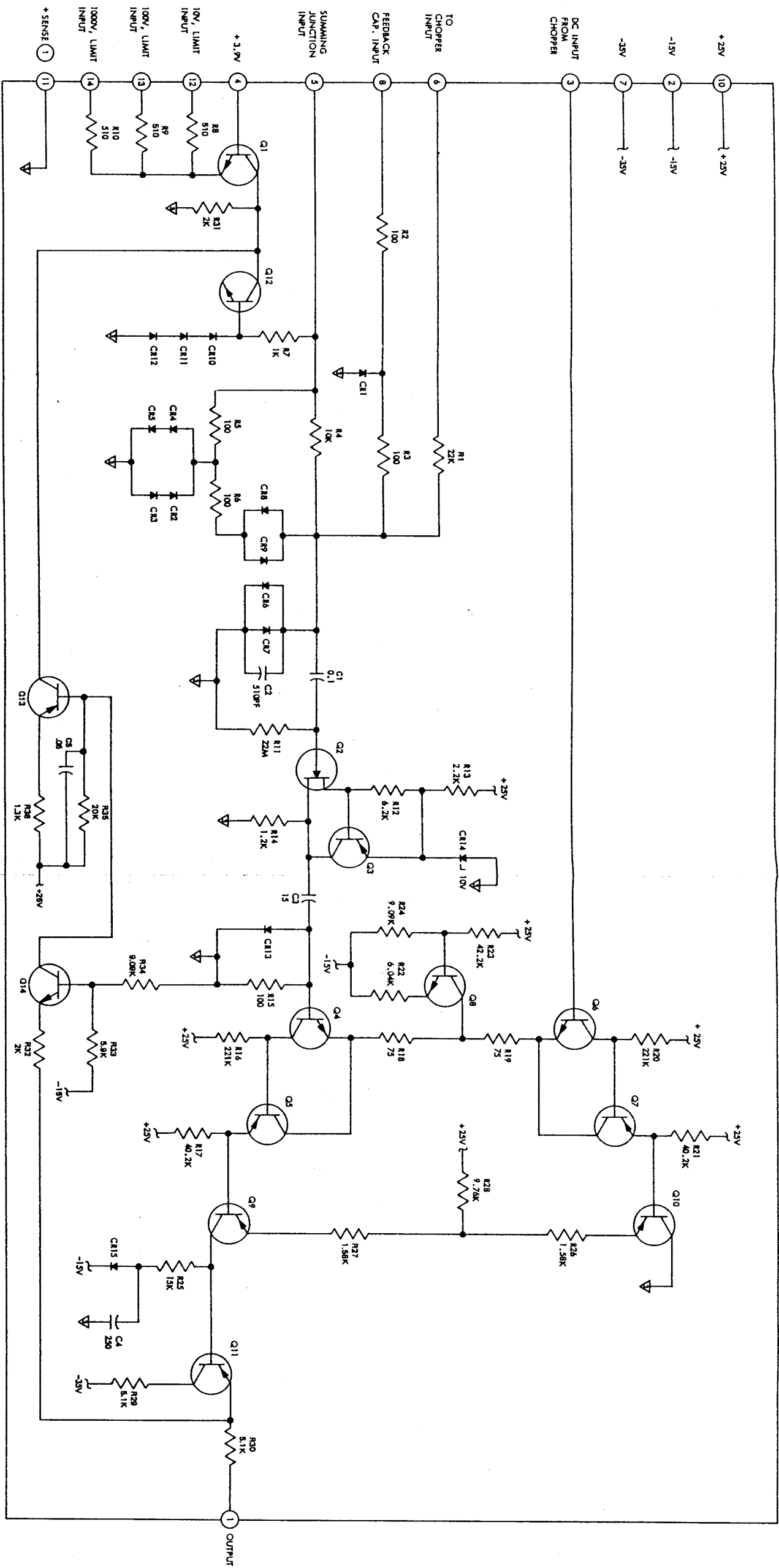
NOTES:

- (1) ALL RESISTANCES IN OHMS AND ALL CAPACITANCE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
- (2)  INDICATES INTERNAL ADJUSTMENT.
- (3)  DENOTES MATCHED SET.
- (4)  DENOTES MATCHED COMPONENTS.
- (5)  + SENSE COMMON



- NOTES:
- 1 ALL RESISTANCES IN OHMS AND CAPACITANCES IN MICROFARADS UNLESS OTHERWISE NOTED.
 - 2  K1 THRU K5 SHOWN IN ENERGIZED POSITIONS.

FIGURE 8-7 A4 MAIN MOTHER BOARD ASSEMBLY (3330B-1001)



NOTES:
(1) ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
(2) \odot INDICATES INTERNAL ADJUSTMENT.
(3) ∇ + SENSE COMMON

FIGURE 8-10 AA43 DIFFERENTIAL AMPLIFIER
(3330B-1003)

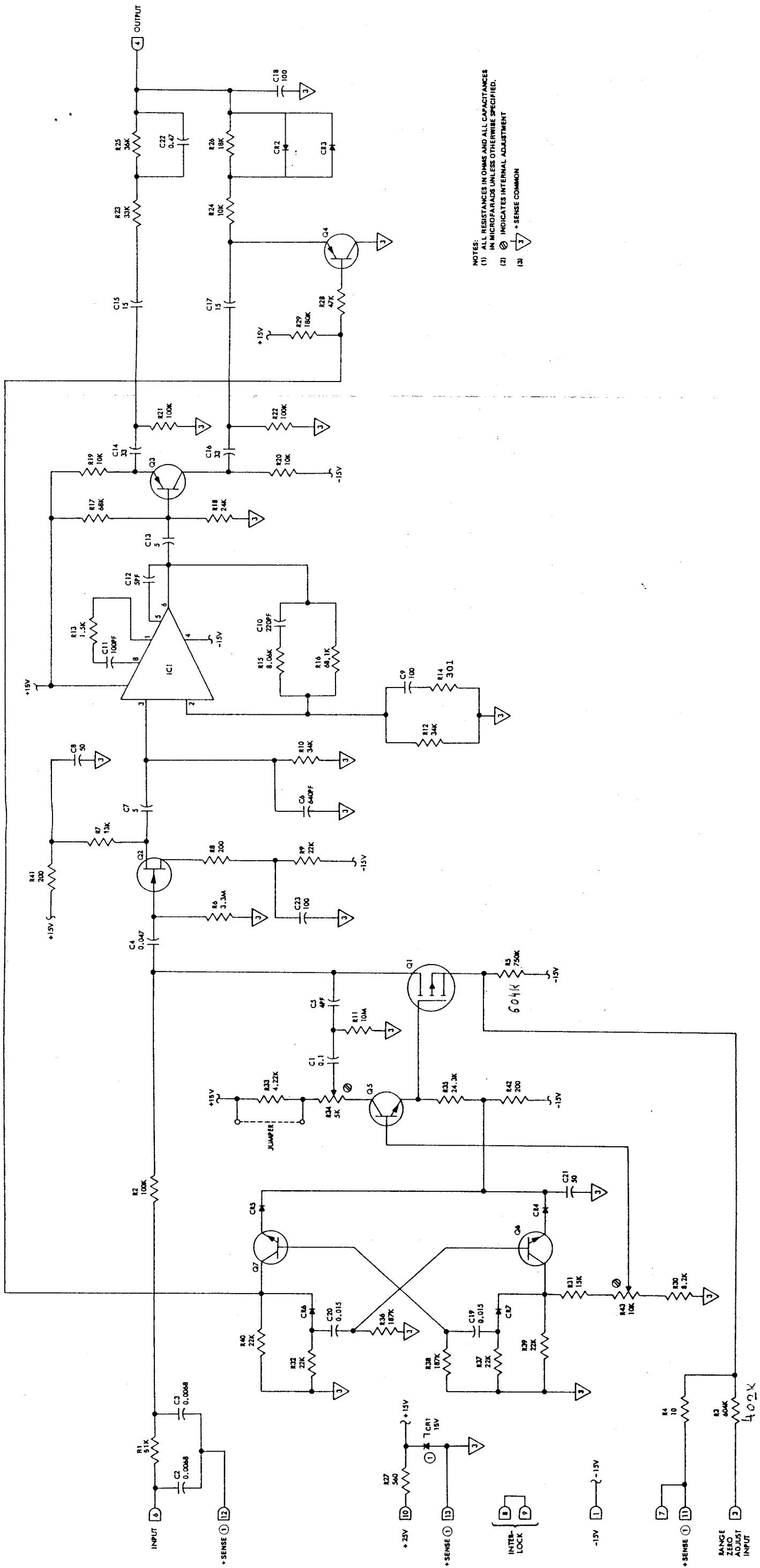


FIGURE 8-9 A4A2 CHOPPER AMPLIFIER (333A-1004)

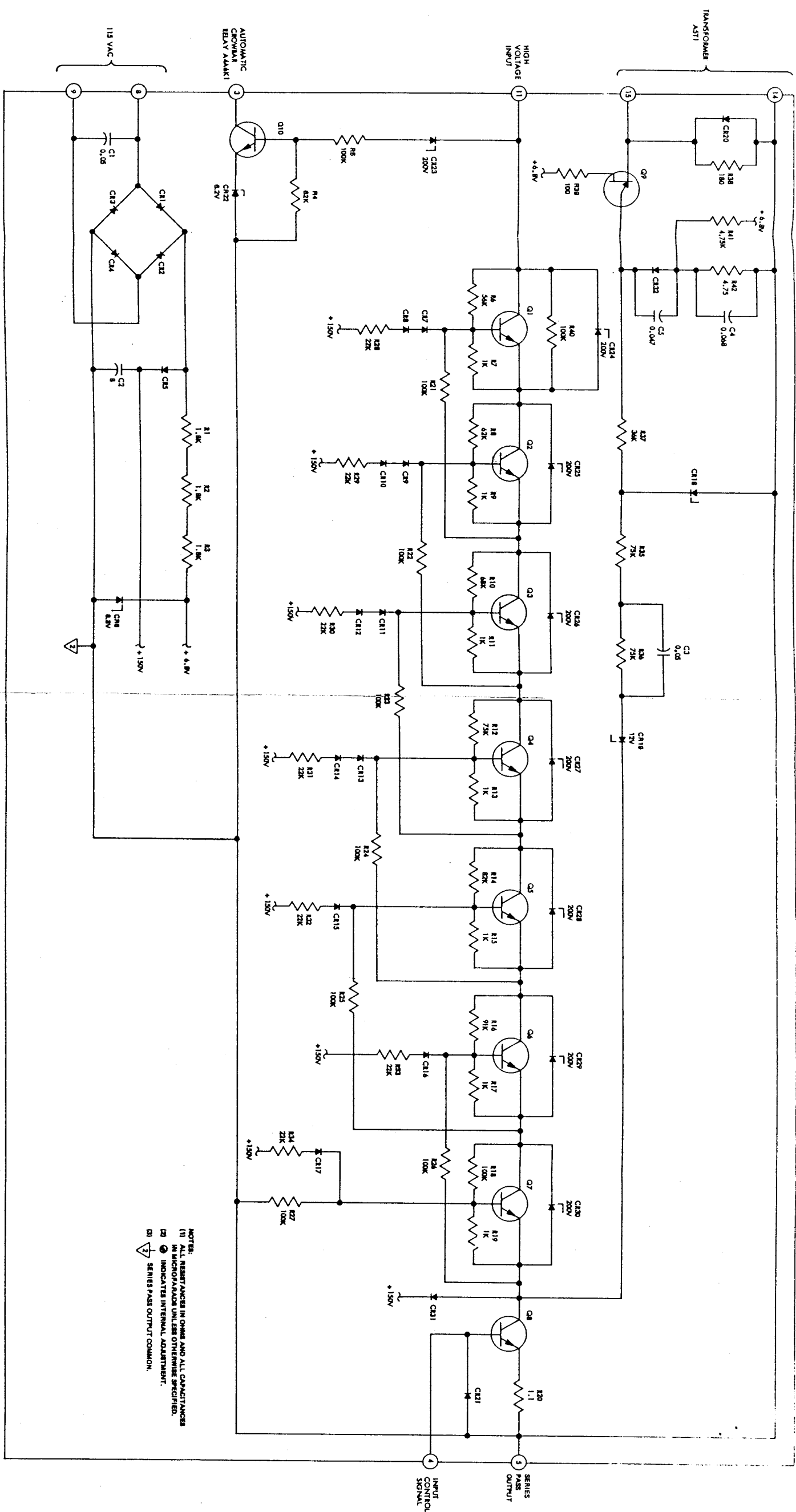


FIGURE 8-12 44A5 SERIES-PASS ELEMENT
(333A-1034)

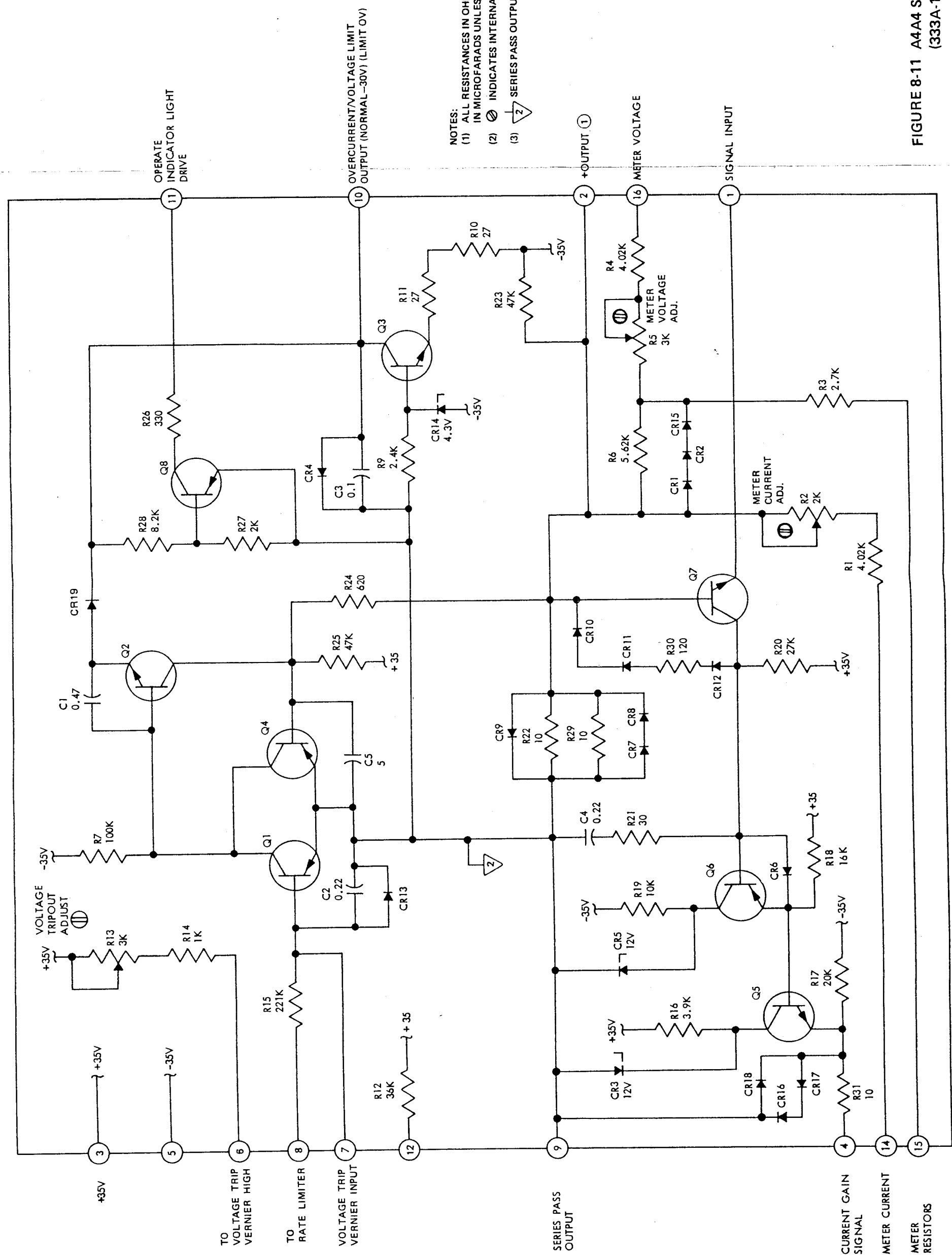


FIGURE 8-11 A4A4 SERIES-PASS DRIVER (333A-1024)

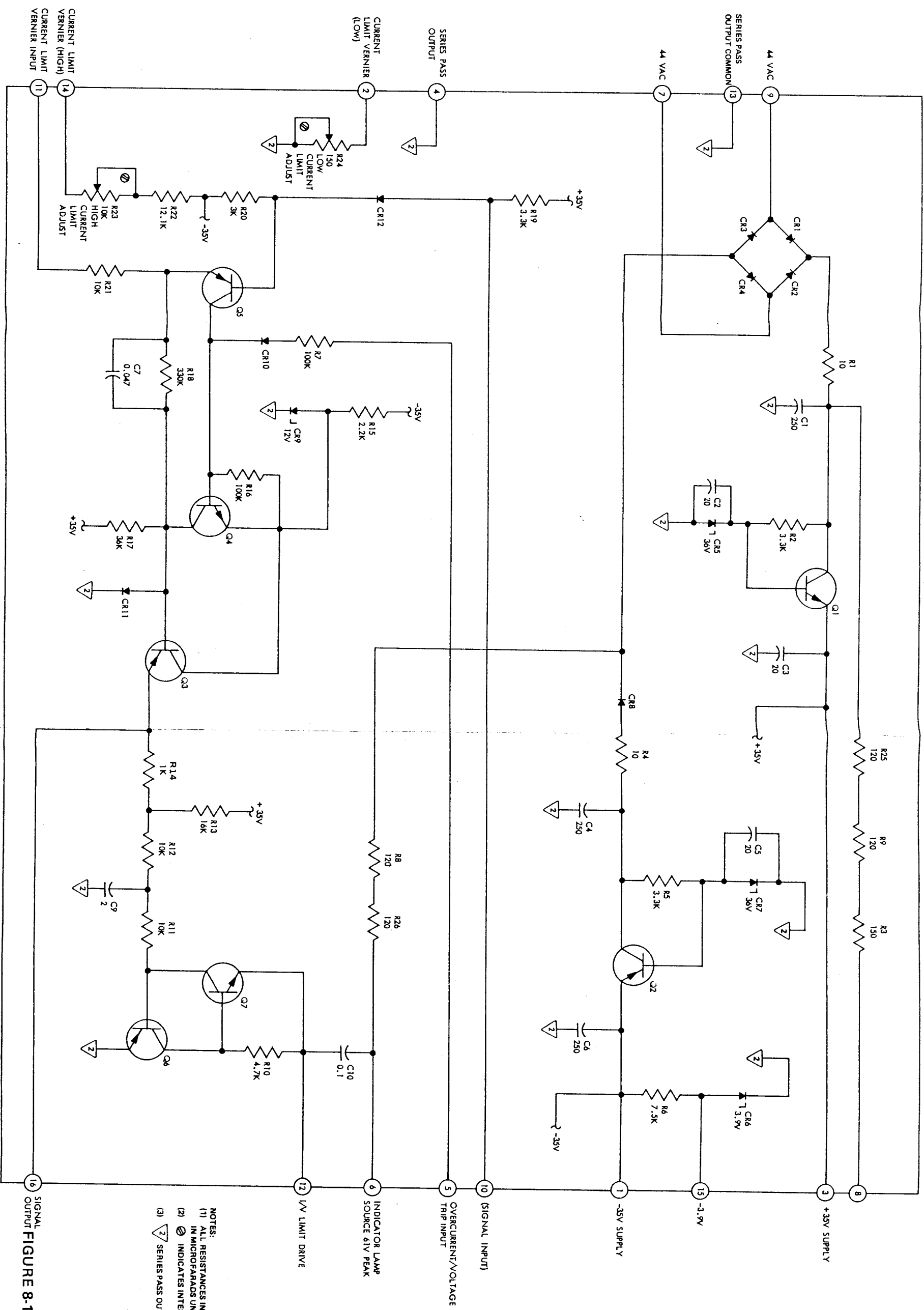
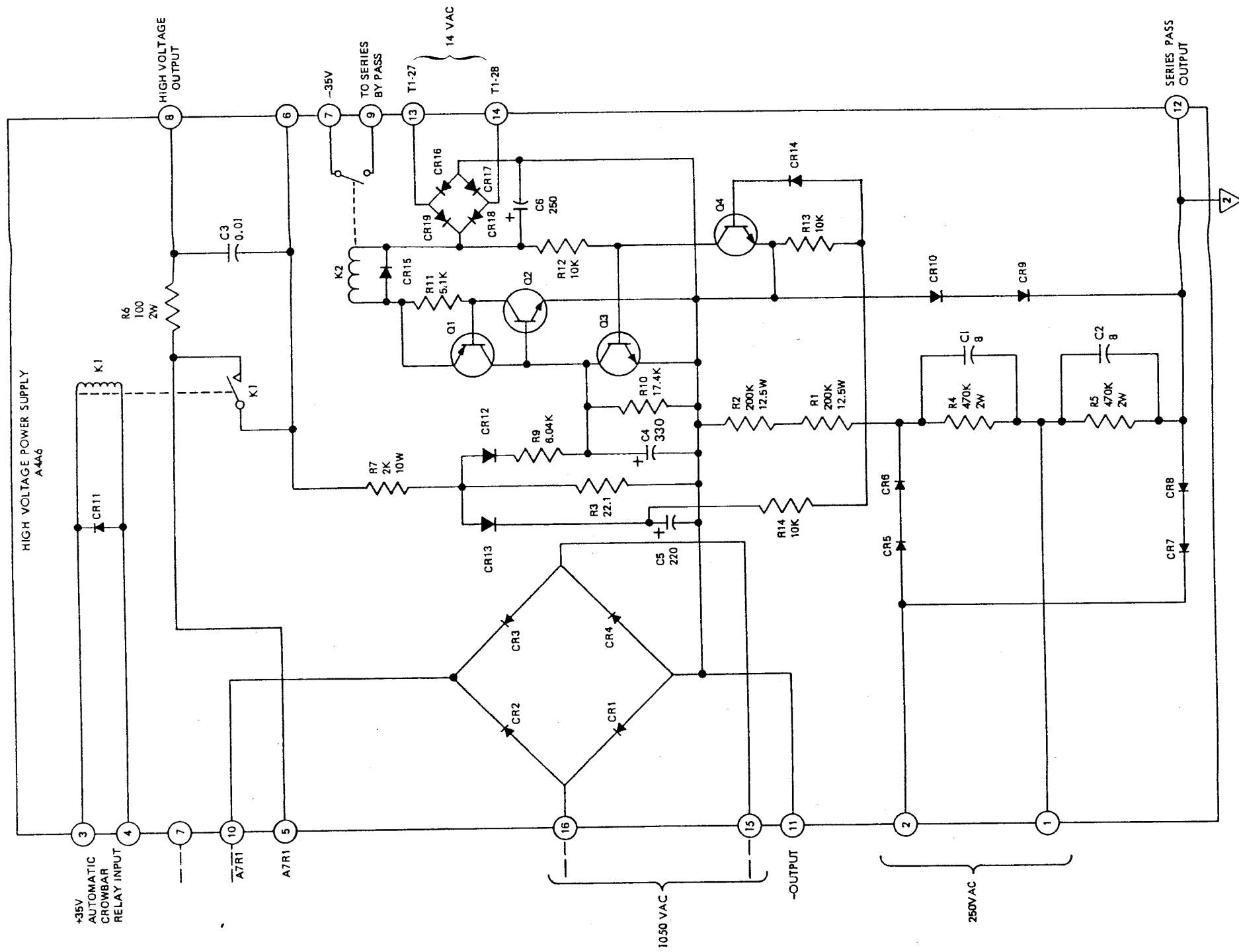


FIGURE 8-14 A4A7 CURRENT LIMITER
(333A-1032)



NOTES:
 (1) ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
 (2) INDICATES INTERNAL ADJUSTMENT
 (3) SERIES PASS OUTPUT COMMON

FIGURE 8-13 A4A6 HIGH VOLTAGE POWER SUPPLY (3330B-1002)

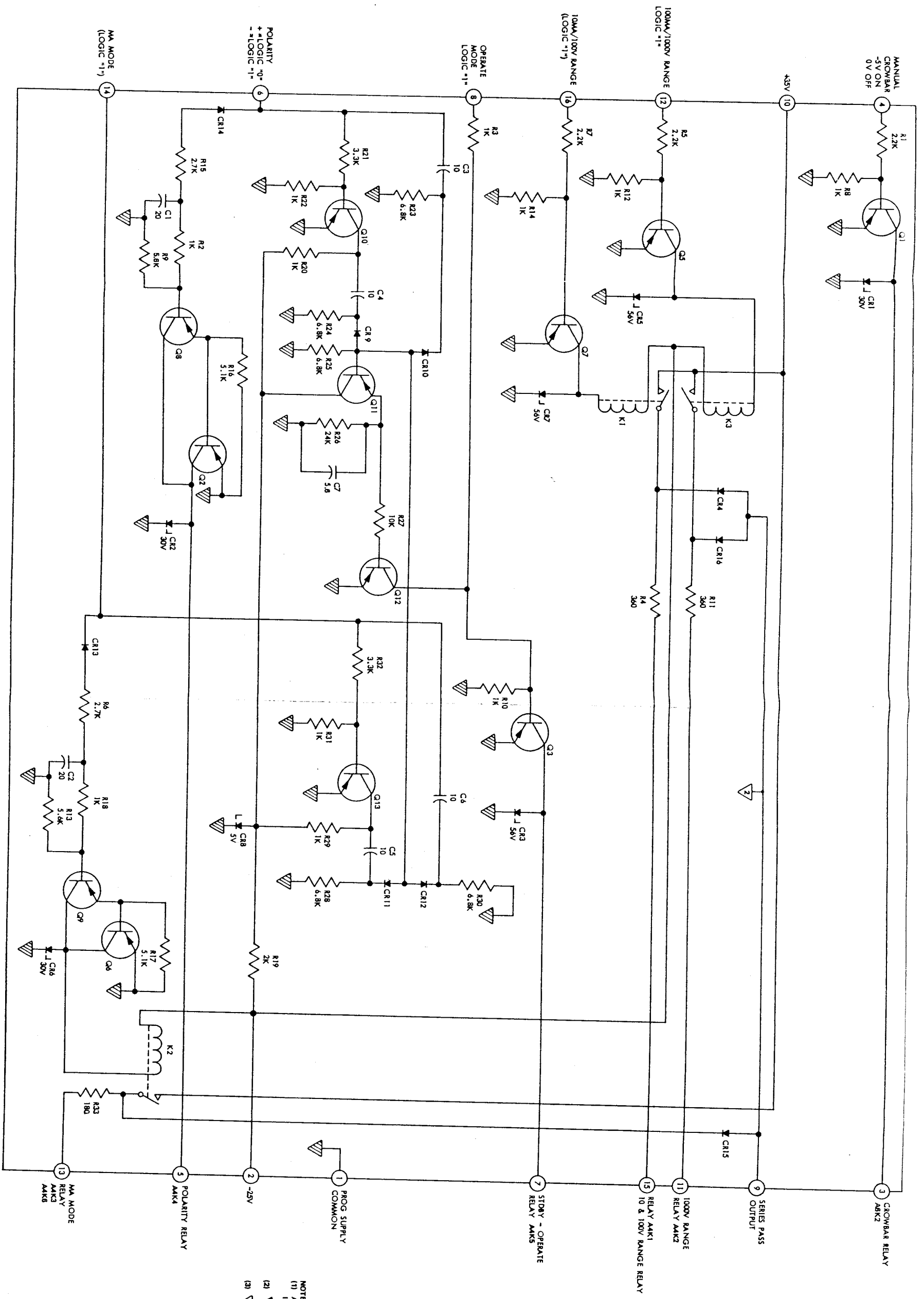
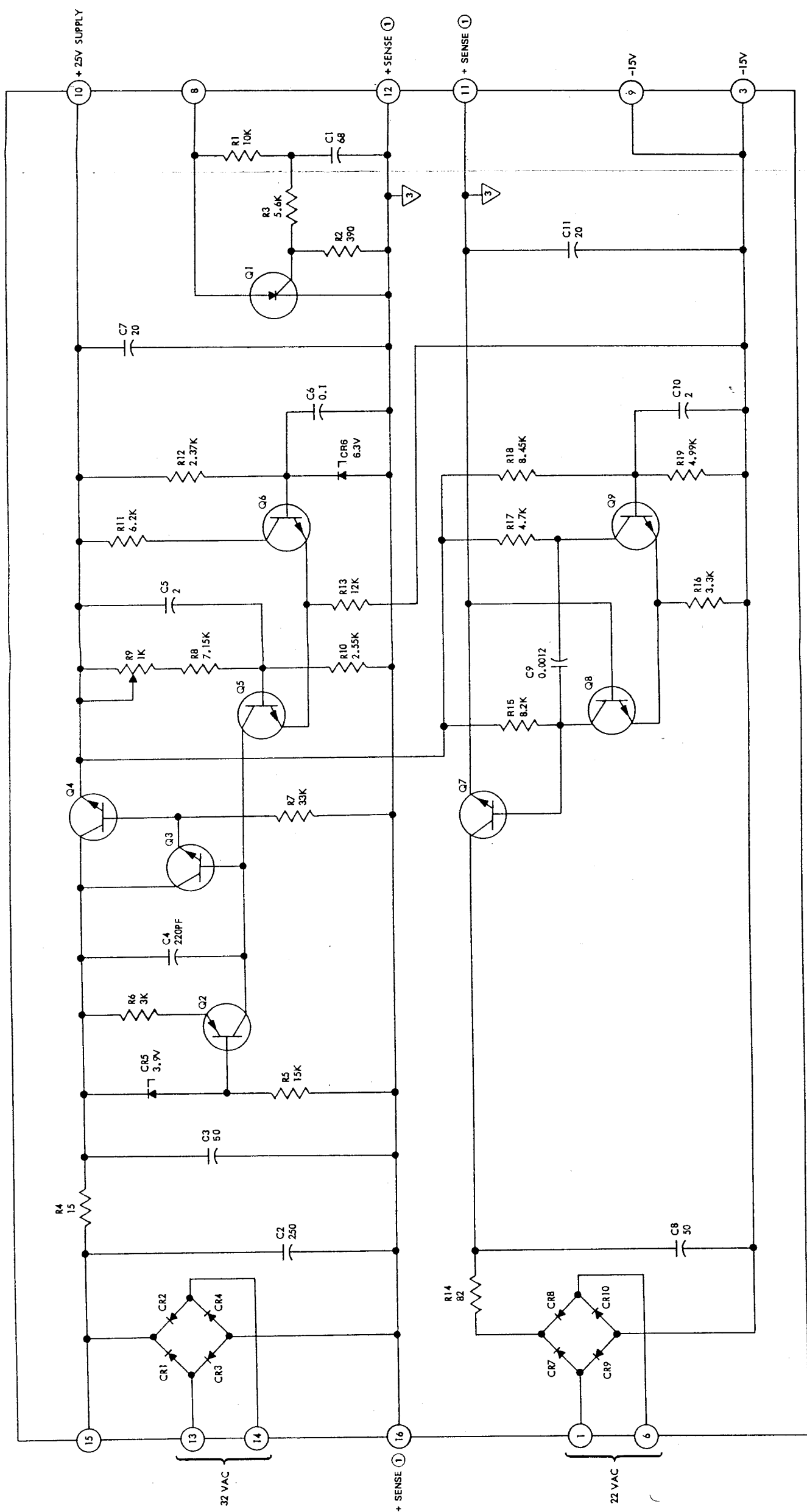


FIGURE 8-16 AAA9 RELAY DRIVER (333A-1009)

8-18

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- NOTES:
- (1) ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
 - (2) INDICATES PROGRAM SUPPLY COMMON
 - (3) SERIES PASS OUTPUT COMMON



NOTES:
 (1) RESISTANCES IN OHMS AND ALL CAPACITANCES
 IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
 (2) ∇ + SENSE COMMON.

FIGURE 8-15 A4A8 +25, -15 VOLT POWER
 SUPPLY (335A-1059)

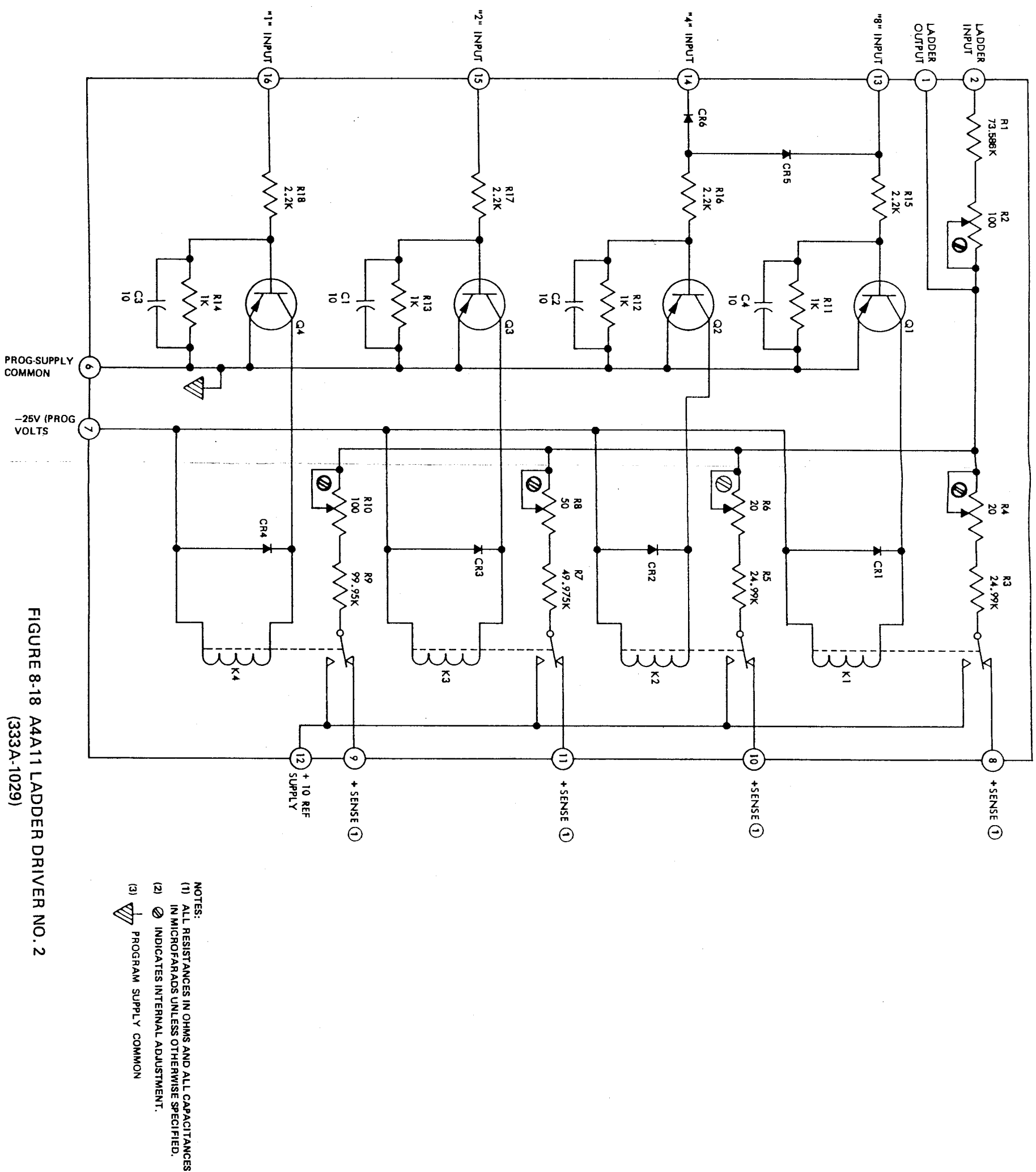


FIGURE 8-18 4A411 LADDER DRIVER NO. 2
(333A-1029)

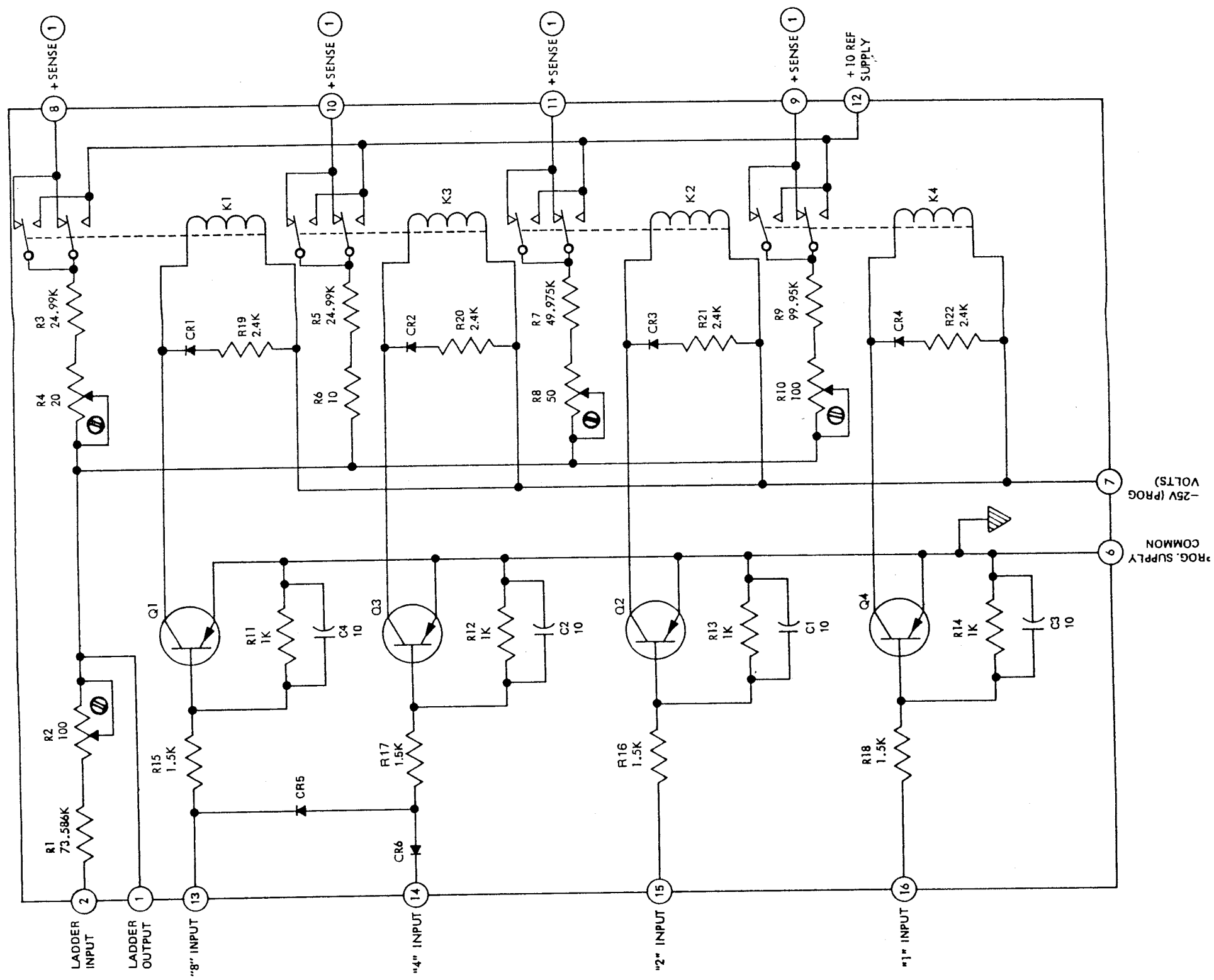


FIGURE 8-17 A4A10 LADDER DRIVER NO. 1
(3330B-1031)

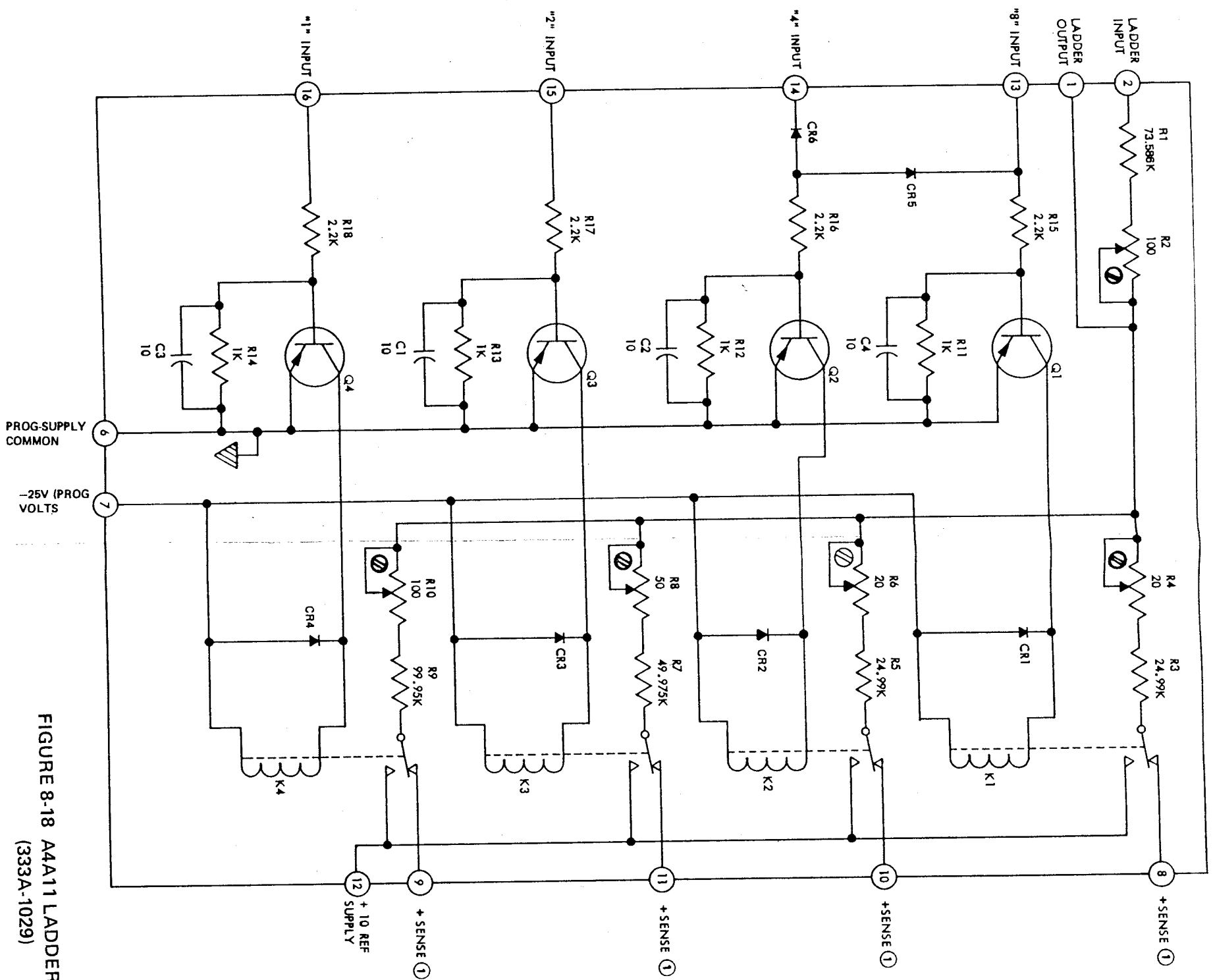


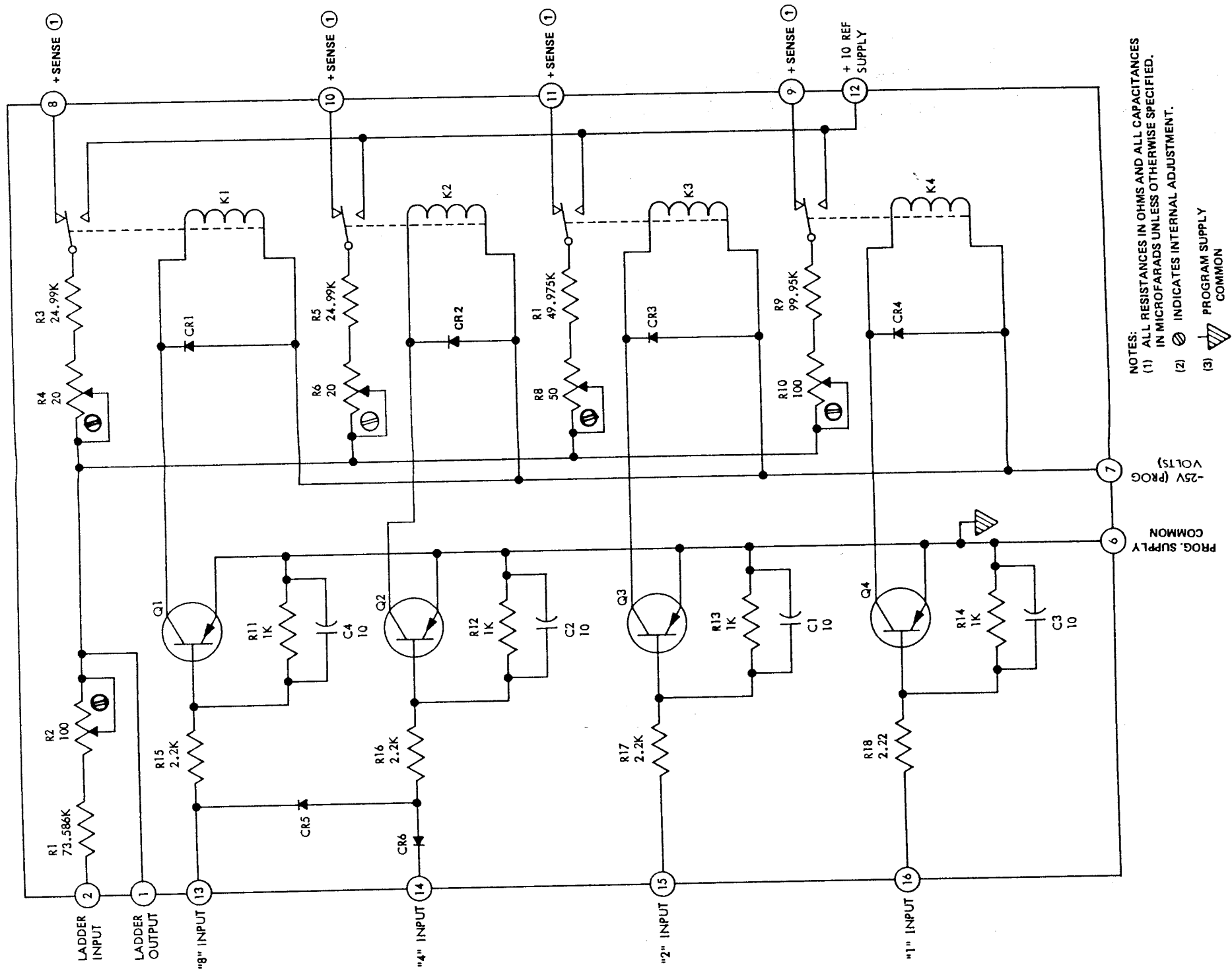


FIGURE 8-18 4A411 LADDER DRIVER NO. 2
(333A-1029)

8-20

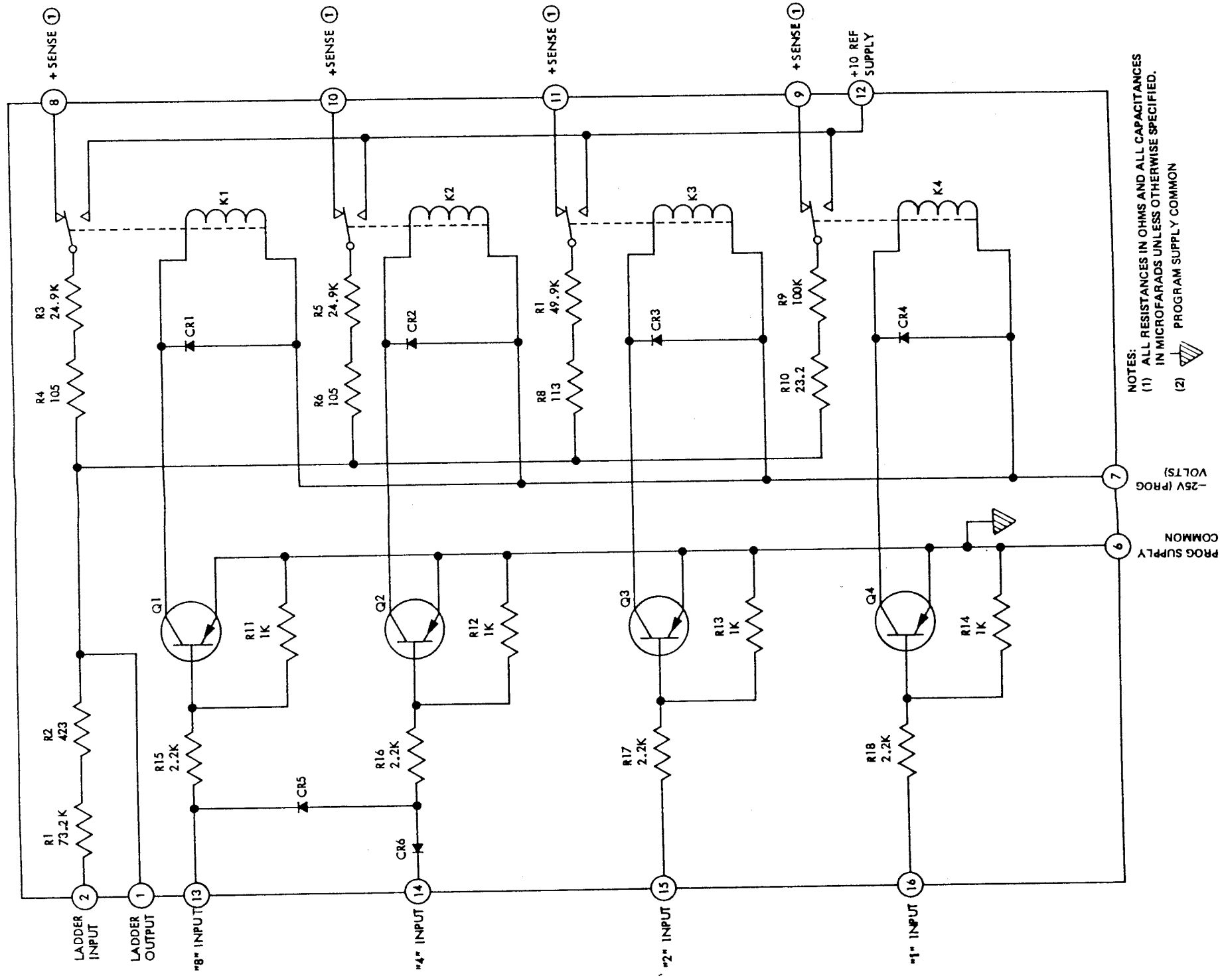
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- NOTES:
- (1) ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
 - (2)  INDICATES INTERNAL ADJUSTMENT.
 - (3)  PROGRAM SUPPLY COMMON


 FIGURE 8-19 A4A12 LADDER DRIVER NO. 3
 (333A-1028)

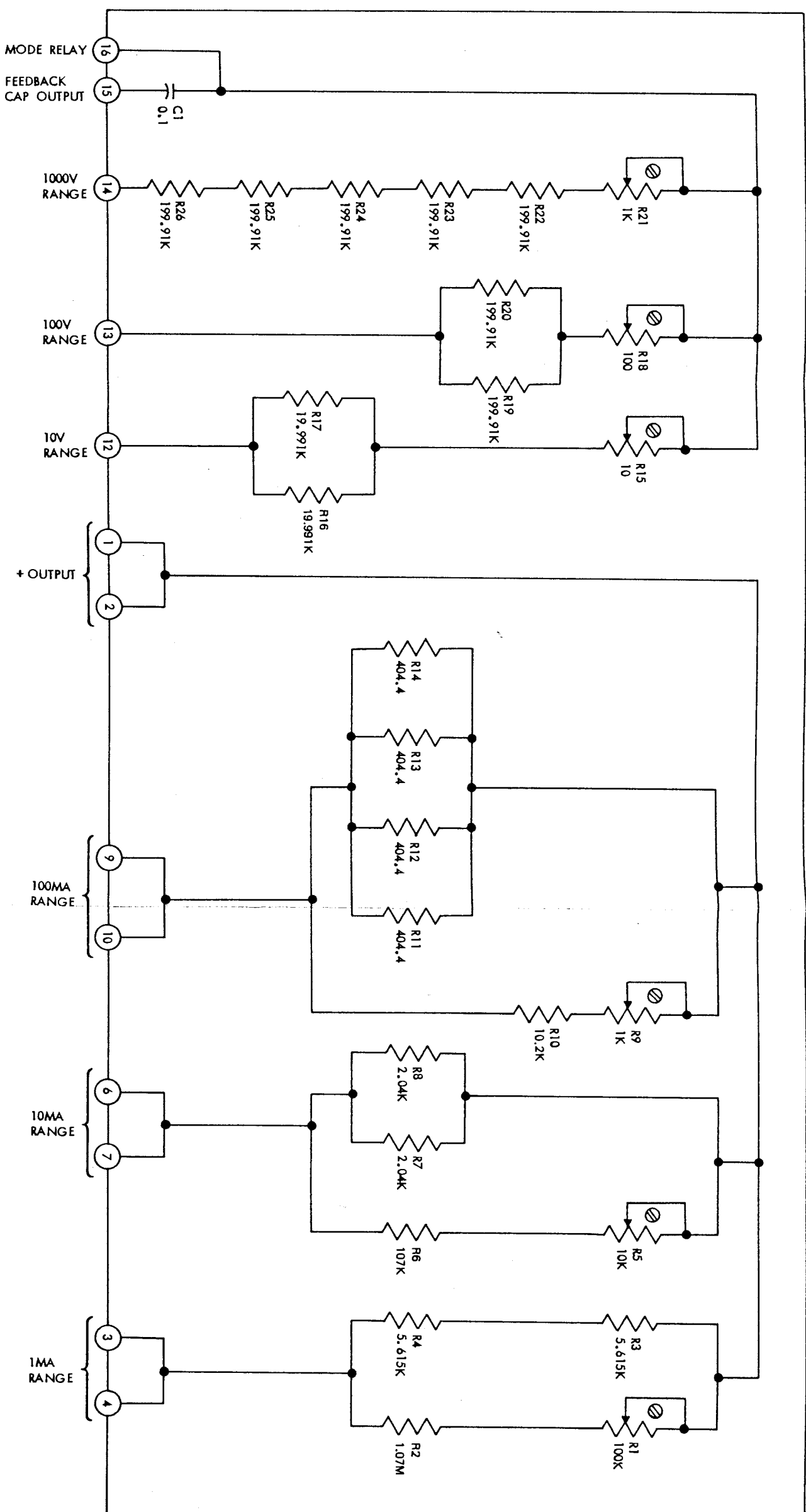
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NOTES:
(1) ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
(2) PROGRAM SUPPLY COMMON.



NOTES:
(1) ALL RESISTANCES IN OHMS AND ALL CAPACITANCES
IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
(2) PROGRAM SUPPLY COMMON

FIGURE 8-21 A4A14/A4A15/A4A16 LADDER
DRIVER NO. 5/6/7 (333A-1002)




NOTES:
(1) ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
(2)  INDICATES INTERNAL ADJUSTMENT.

FIGURE 8-22 44A17 RANGE SHUNT NETWORK
(333A-1008)

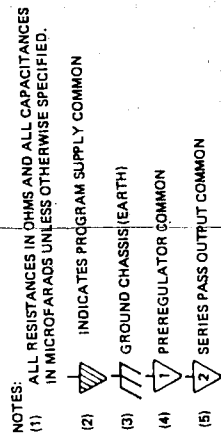
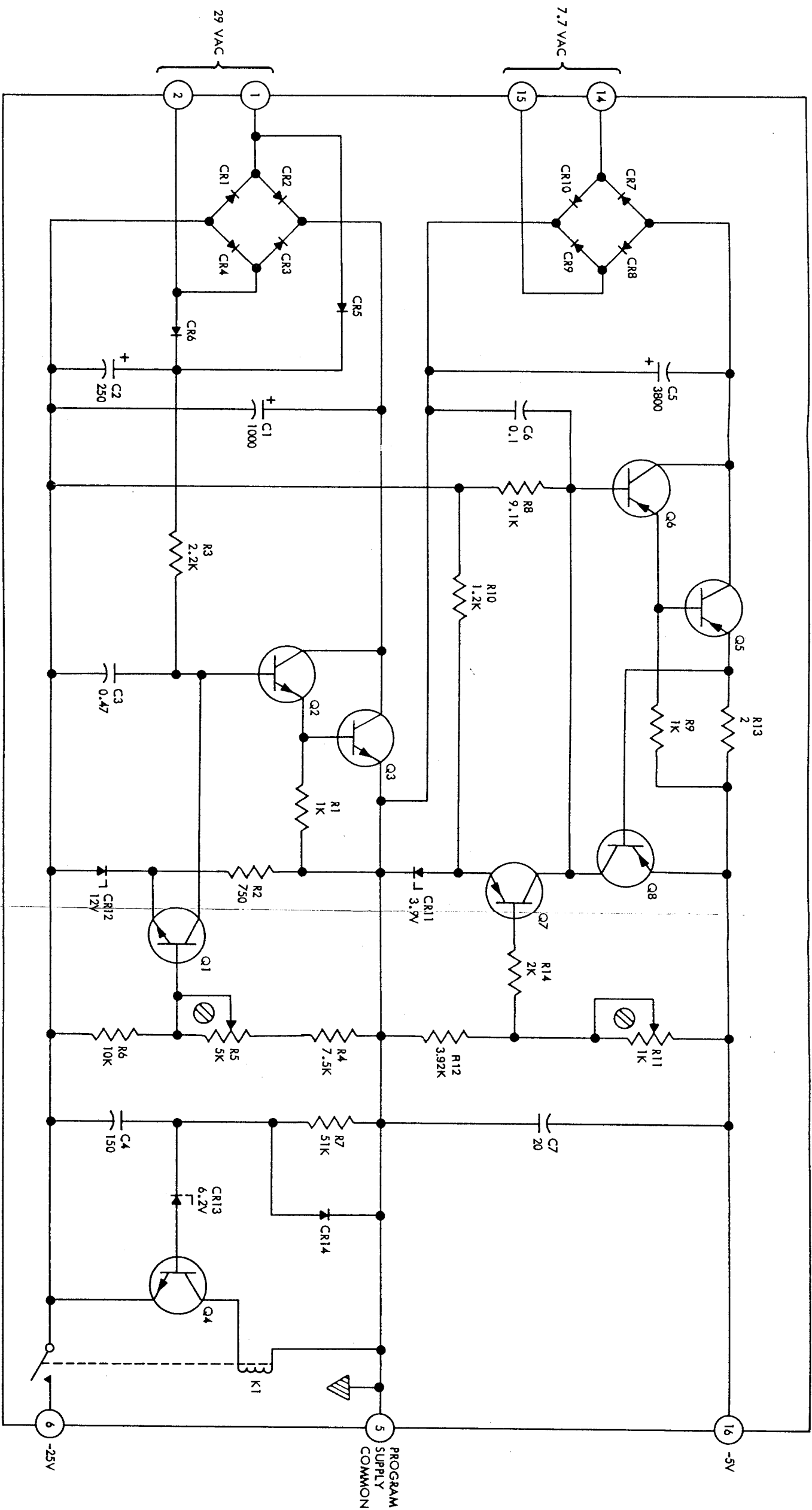


FIGURE 8-23 A5 REAR MOTHER BOARD ASSEMBLY (3330B-1005)



- NOTES:
- (1) ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
 - (2) INDICATES INTERNAL ADJUSTMENT
 - (3) PROGRAM SUPPLY COMMON

FIGURE 8-24 A5A1 -25, -5 VOLT POWER SUPPLY
(333A-1003)

FIGURE 8-25 A5A2 PRE-REGULATOR (335A-1082)

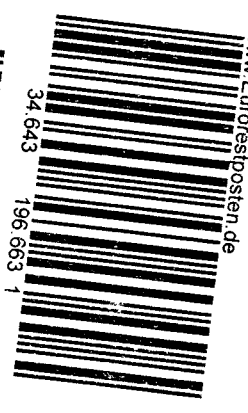
910-500-020
Christoph Lüders
Badenstedter Str. 4
30449 Hannover



(Deutschland)

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34 643 196 663 1



(96393984)

Birger Jettkant
Knappenstr. 31

44799 Bochum