OPERATING AND SERVICE MANUAL

Model 185B
Oscilloscope
Serials Prefixed: 144-
Stock No. 185B-901

HEWLETT hp PACKARD

hp MANUAL CHANGES

MODEL 185B

OSCILLOSCOPE

Manual Serial Prefixed: 144-
Manual Printed: OCT 1962

Make all changes in this manual according to the Errata below. Also check the following table for your instrument serial prefix (3 digits) and/or serial number (8 digits) and make any listed change(s) in the manual:

Serial Prefix or Number	Make Manual Changes	Serial Prefix or Number	Make Manual Changes	Serial Prefix or Number	Make Manual Changes
203-	1	250-	1 thru 6	432-	1 thru 11
210-	1, 2	317-	1 thru 7	446-	1 thru 12
222-	1 thru 3	317-00901 thru 01000	1 thru 8	525-	1 thru 14
230-	1 thru 4	348-	1 thru 9	534-	1 thru 13, 15
245-	1 thru 5	430-	1 thru 10		

ERRATA

Page 2-1, Paragraph 2-11 h,
Change to read ". . . five cycles/cm."

Page 4-9, Paragraph 4-74,
Third from last line, change R231 to R213.

Page 5-8, Table 5-5,
Delete first 3 lines (below column heading); In bottom line, change Display to "1/4".

Page 5-11, Figure 5-6,
Change Q413 to Q402.

Page 5-12, Figure 5-8,
Change Q408 to Q416, Q409 to Q405, and R309 to R308.

Page 5-13/5-14, Figure 5-9,
Change Q402 to Q409 and Q405 to Q413.

Page 5-16, under COMPONENT LOCATION, Change C152 LOCATOR area to C3.

Page 5-17, Figure 5-13,
R145 (39K): Change to R154 (39K); R145 (270K) is correct.

Page 5-18, Figure 5-16,
S201 (left side of page): Change R213 to R212.

Figure 5-17 and Section VI,
R259: Add * to value; factory selected part.
R266: Change to hp Stock No. 0761-0006; R: fxd, mfgl, 10K ohms, 5%, 1W; Mfr. 28480; Mfr. Part No. 0761-0006.

Table 6-1,
C312: Change description to C: fxd, paper, 0.0015 μf, 20%, 500VDCW.

Tables 6-1 and 6-2,
CR202, CR203, CR215, CR217: Change to hp Stock No. 1901-0146 (replacement for discontinued item).
CR131, CR132: Change to hp Stock No. 1901-0040 (replacement for discontinued item).
Q107, Q208: Change to hp Stock No. 1850-0148; Mfr. 56289; Mfr. Part No. 2N2100.
△ R3, R5, R25, R27: Change to hp Stock No. 0764-0044; R: fxd, met ox, 8.2K ohms, 5%, 2W; Mfr. 28480. (Replacement for discontinued item).
R132: Change to hp Stock No. 0727-0129.
R259: Change to factory selected value.
△ R265: Change to hp Stock No. 0698-3647; R: fxd, met ox, 15K ohms, 5%, 2W; Mfr. 28480. (Replacement for discontinued item).
△ R271: Change to hp Stock No. 0698-3657; R: fxd met ox, 68K ohms, 5%, 2W; Mfr. 28480. (Replacement for discontinued item).
△ R464: Change to hp Stock No. 0811-1704.
△ R507: Change to hp Stock No. 0698-3646; R: fxd, met ox, 12K ohms, 5%, 2W; Mfr. 28480. (Replacement for discontinued item.)
V201, V301: Change to hp Stock No. 1932-0046; Mfr. 13396; Mfr. Part No. 12AU7. (Preferred replacement.)

Serial Prefix or Number	Make Manual Changes
203-	1
210-	1, 2
222-	1 thru 3
230-	1 thru 4
245-	1 thru 5
250-	1 thru 6
317-	1 thru 7
317-00901 thru 01000	1 thru 8
348-	1 thru 9
430-	1 thru 10
432-	1 thru 11
446-	1 thru 12
525-	1 thru 14
534-	1 thru 13, 15

ERRATA (cont'd) Add the following:

A302: HV Transformer Assembly: includes C309, C310, T301, V303, and V304; ⓗⓟ Stock No. 185A-11A; Mfr. 28480; Mfr. Part No. 185A-11A; TQ 1; RS 0.

C309, C310: Same description and ⓗⓟ Stock No. as C312; change TQ column to 3.

L603: Same description and ⓗⓟ Stock No. as L601, L602.

T301: HV Transformer; ⓗⓟ Stock No. 130B-11B-1; Mfr. 28480; Mfr. Part No. 130B-11B-1; TQ 1; RS 1.

V303, V304: Tube electron: 5642; ⓗⓟ Stock No. 1920-0001; Mfr. 28480; Mfr. Part No. 1920-0001; TQ 2; RS 2.

CHANGE 1 Section VI and schematic diagrams,
Add the following:

Reference Designation	Value	Description	ⓗⓟ Stock No.
C123	0.05 μf	C: fxd, cer, 0.05 μf, 20%, 400VDCW. (Between ground and junction of R128 and +100V.)	0150-0052
C160	0.005μf	C: fxd, cer, 0.005 μf, 500VDCW. (Between T103, pin 8, and ground.)	0150-0014
L115	360 μh	Coil: fxd, RF, 360 μh. (On +6.3V line between R107 and C110.)	9140-0038
C425	0.05 μf	C: fxd, cer, 0.05 μf, +80% -20%, 100VDCW. (Between J1, pin 10 [+12.6V], and ground.)	0150-0096
C426	8200 pf	C: fxd, cer, 8200 pf, 500VDCW. (Between J1, pin 9 [-100V], and ground	0150-0082
C427	0.05 μf	C: fxd, cer, 0.05 μf, +80% -20%, 100VDCW. (Between J1, pin 5 [-12.6V], and ground.)	0150-0096
C614	0.05 μf	C: fxd, cer, 0.05 μf, +80% -20%, 100VDCW. (On A602 between -12.6V and ground.)	0150-0096
C615	0.05 μf	C: fxd, cer, 0.05 μf, +80% -20%, 100VDCW. (On A602 between +12.6VF and ground.)	0150-0096
C616	0.1 μf	C: fxd, cer, 0.1 μf, +80% -20%, 50VDCW. (On S601A between +12.6V [BRN wire], and ground.)	0150-0121
L608	100 μh	Coil: fxd, RF, 100 μh. (On A602 between C614 [added by this change] and C607 on -12.6V line.)	9140-0029

CHANGE 2 (Note: For instruments serial prefixed 222- and above, make all component changes listed under CHANGE 2 except Q209.)

Section VI and schematic diagrams,

C616: Delete.

Q101, Q102, Q103, Q209: Change to ⓗⓟ Stock No. 1851-0024; Transistor 2N388A; Mfr. 01295; Mfr. Part No. 2N388A.

R611: Change to ⓗⓟ Stock No. 2100-0351; R: var, WW, 4K ohms, 10%, 4W; Mfr. 28480; Mfr. Part No. 2100-0351.

The Internal Graticule Cathode-Ray Tube is now supplied as a standard part of the Model 185B Oscilloscope. The CRT formerly supplied, without internal graticule, is still available as Option 05. This change obsoletes Option 03.

Figure 5-26,
Change wiring as shown in Figure 1.

Serial Prefix or Number	Make Manual Changes
203-	1
210-	1, 2
222-	1 thru 3
230-	1 thru 4
245-	1 thru 5

Serial Prefix or Number	Make Manual Changes
250-	1 thru 6
317-	1 thru 7
317-00901 thru 01000	1 thru 8
348-	1 thru 9
430-	1 thru 10

Serial Prefix or Number	Make Manual Changes
432-	1 thru 11
446-	1 thru 12
525-	1 thru 14
534-	1 thru 13, 15

CHANGE 2
(cont'd)

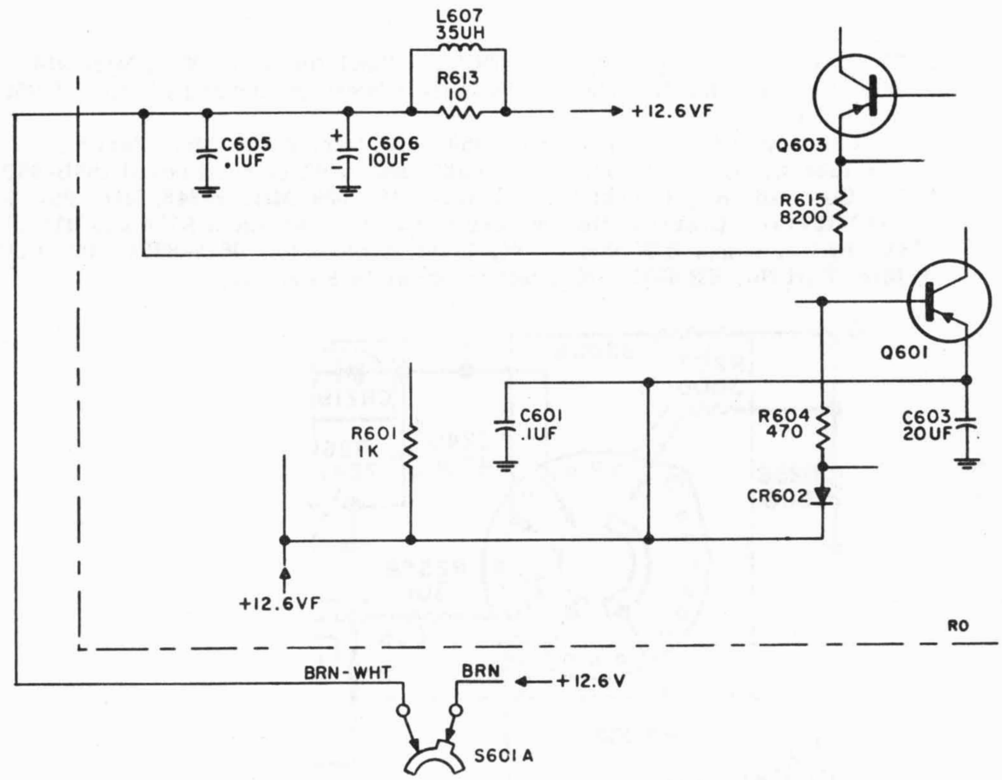


Figure 1.

CHANGE 3 Section VI and schematic diagrams,

Q209: Change to hp Stock No. 1854-0013; Transistor: silicon, 2N2218; Mfr. 04713; Mfr. Part No. 2N2218.

Q603: Change to hp Stock No. 1850-0041; Transistor: germanium, 2N384; Mfr. 02735; Mfr. Part No. 2N384.

R436: Change to hp Stock No. 0819-0023; R: fxd, WW, 5 ohms, 5%, 55W; Mfr. 28480; Mfr. Part No. 0819-0023.

R604: Change to factory selected value.

R607: Change to hp Stock No. 0683-3015; R: fxd, comp, 300 ohms, 5%, 1/4W; Mfr. 01121; Mfr. Part No. CB 3015.

R610: Change to hp Stock No. 0767-0011; R: fxd, metal film, 20K ohms, 5%, 3W; Mfr. 28480; Mfr. Part No. 0767-0011.

Add the following:

C134: C: fxd, elect, 20 µf, 25VDCW; hp Stock No. 0180-0076; Mfr. 56289; Mfr. Part No. 40D-181-A2. (Connects between ground and junction of R154 and R155.) Note: See Errata section of this manual change sheet concerning reference designation corrections.

Serial Prefix or Number	Make Manual Changes
203-	1
210-	1, 2
222-	1 thru 3
230-	1 thru 4
245-	1 thru 5

Serial Prefix or Number	Make Manual Changes
250-	1 thru 6
317-	1 thru 7
317-00901 thru 01000	1 thru 8
348-	1 thru 9
430-	1 thru 10

Serial Prefix or Number	Make Manual Changes
432-	1 thru 11
446-	1 thru 12
525-	1 thru 14
534-	1 thru 13, 15

CHANGE 3 (cont'd)

C617: C: fxd, cer, 62 pf, 10%, 500VDCW; ⓗⓟ Stock No. 0150-0087; Mfr. 91418; Mfr. Part No. SM-62-N1500. (Connects between ground and junction of R607 and R610.)

J604: Connector: BNC; ⓗⓟ Stock No. 1250-0083; Mfr. 91737; Mfr. Part No. UG-1094/U. (Insert in line between J601 and A602 [circuit board 185B-65P] .)

L116: Coil: fxd, RF, 100 µh; ⓗⓟ Stock No. 9140-0029; Mfr. 99848; Mfr. Part No. 3100-15-101. (Insert in line between S101A and junction of R154 and R155.)

R268: R: fxd, comp, 82K ohms, 10%, 1/2W; ⓗⓟ Stock No. 0687-8231; Mfr. 01121; Mfr. Part No. EB 8231. (Connect as shown in Figure 2.)

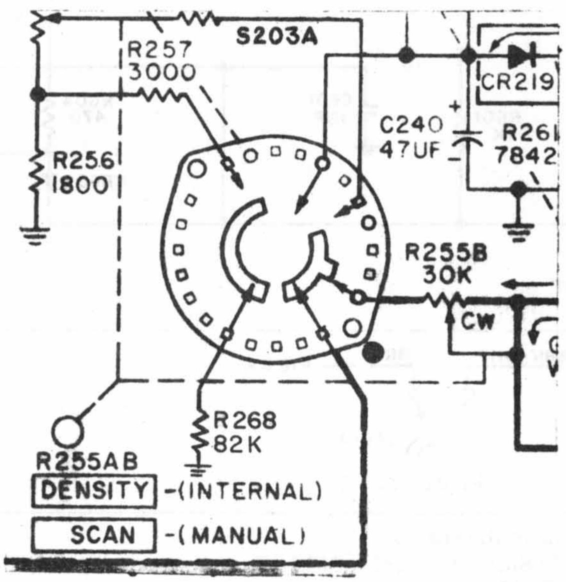


Figure 2.

CHANGE 4

Section VI and schematic diagrams,

Add C244: C: fxd, cer, 0.1 µf, +80% -20%, 50VDCW; ⓗⓟ Stock No. 0150-0084; Mfr. 56289; Mfr. Part No. 33C41. (Connects in parallel with CR221.)

CR107, CR108, CR112, CR113, CR114: Change to ⓗⓟ Stock No. 1901-0040; Diode: silicon; Mfr. 28480; Mfr. Part No. 1901-0040.

Add CR223: Diode: germanium; ⓗⓟ Stock No. 1910-0016; Mfr. 28480; Mfr. Part No. 1910-0016. (Connects between R267 and S203A; anode side connects to S203A.)
Note: Do not add CR223 if instrument serial prefix is 250- or above.

Q103: Change to ⓗⓟ Stock No. 1854-0003; Transistor: silicon; Mfr. 28480; Mfr. Part No. 1854-0003.

Q201: Change to ⓗⓟ Stock No. 1850-0062; Transistor: germanium; Mfr. 28480; Mfr. Part No. 1850-0062.

Q603: Change to ⓗⓟ Stock No. 1850-0029; Transistor: germanium; Mfr. 28480; Mfr. Part No. 1850-0029.

Figure 5-17,

Disconnect R272 end which attaches to junction of Q210 and R255B and reconnect to junction of R501 and S204.

Serial Prefix or Number	Make Manual Changes	Serial Prefix or Number	Make Manual Changes	Serial Prefix or Number	Make Manual Changes
203-	1	250-	1 thru 6	432-	1 thru 11
210-	1, 2	317-	1 thru 7	446-	1 thru 12
222-	1 thru 3	317-00901 thru 01000	1 thru 8	525-	1 thru 14
230-	1 thru 4	348-	1 thru 9	534-	1 thru 13, 15
245-	1 thru 5	430-	1 thru 10		

CHANGE 5

Figure 5-29 and Section VI,

△ Q401, Q402, Q405, Q416: Change to hp Stock No. 5080-0427; Transistor: germanium, PNP, selected; Mfr. 28480; Mfr. Part No. 5080-0427.

CHANGE 6

Figure 5-29 and Section VI,

CR407, CR410, CR413: Change to hp Stock No. 1902-0034; Diode: breakdown, 5.76V, 10%; Mfr. 28480; Mfr. Part No. 1902-0034.

R444: Change to hp Stock No. 0758-0015; R: fxd, metal film, 220 ohms, 5%, 1/2W; Mfr. 28480; Mfr. Part No. 0758-0015.

R458: Change to hp Stock No. 0758-0014; R: fxd, metal film, 180 ohms, 5%, 1/2W; Mfr. 28480; Mfr. Part No. 0758-0014.

R463: Change to hp Stock No. 0816-0022; R: fxd, ww, 1500 ohms, 5%, 10W; Mfr. 28480; Mfr. Part No. 0816-0022.

Section VI and schematic diagrams,

Add the following:

L114: Core: ferrite bead; hp Stock No. 9170-0029; Mfr. 02114; Mfr. Part No. 56-590-65/4A. (Connects in series with C152 between capacitor and junction of C151 and R179.)

R196: R: fxd, comp, 10 ohms, 10%, 1/4W; hp Stock No. 0684-1001; Mfr. 01121; Mfr. Part No. CB 1001. (Connects in series with C141 between capacitor and ground.)

R447, R459: R: fxd, metal film, 680 ohms, 5%, 1/2W; hp Stock No. 0758-0031; Mfr. 28480; Mfr. Part No. 0758-0031. (Connect R447 between -12.6V output and junction of Q415 and CR410; connect R459 between ground and junction of Q412 and CR407.)

Table 6-2,

Delete hp Stock No. 185A-12G.

Add the following:

Probe: Clip Adapter; hp Stock No. 5040-0403; Mfr. 28480; Mfr. Part No. 5040-0403.
Probe: Clip; hp Stock No. 5040-0404; Mfr. 28480; Mfr. Part No. 5040-0404.

CHANGE 7

Figure 5-17 and Section VI,

Add C237: C: fxd, cer, 0.1 μf, +80% -20%, 50VDCW; hp Stock No. 0150-0084; Mfr. 56289; Mfr. Part No. 33C41. (Connects between ground and junction of +12.6VF and CR209.)

CR201: Change to hp Stock No. 1901-0050; Diode: silicon; Mfr. 28480; Mfr. Part No. 1901-0050.

CR210, CR212, CR216: Change to hp Stock No. 1901-0040; Diode: silicon; Mfr. 28480; Mfr. Part No. 1901-0040.

CR219: Change to hp Stock No. 1901-0025; Diode: silicon; Mfr. 28480; Mfr. Part No. 1901-0025.

CR220: Change to hp Stock No. 1902-0068; Diode: breakdown, 80.6V, 5%; Mfr. 28480; Mfr. Part No. 1902-0068.

CR221: Change to hp Stock No. 1902-0074; Diode: breakdown, 7.15V, 5%; Mfr. 28480; Mfr. Part No. 1902-0074.

Q207: Change to hp Stock No. 1850-0091; Transistor: germanium, 2N2048; Mfr. 56289; Mfr. Part No. 2N2048. <u>Note:</u> Do not change Q207 if instrument serial prefix is 348- or above.

Serial Prefix or Number	Make Manual Changes	Serial Prefix or Number	Make Manual Changes	Serial Prefix or Number	Make Manual Changes
203-	1	250-	1 thru 6	432-	1 thru 11
210-	1, 2	317-	1 thru 7	446-	1 thru 12
222-	1 thru 3	317-00901 thru 01000	1 thru 8	525-	1 thru 14
230-	1 thru 4	348-	1 thru 9	534-	1 thru 13, 15
245-	1 thru 5	430-	1 thru 10		

CHANGE 8

Figure 5-29 and Section VI,
  Q418, Q419: Change to hp Stock No. 1850-0040; Transistor: 2N383; Mfr. 28480; Mfr. Part No. 1850-0040.
Tables 6-1 and 6-2,
  C402: Change to hp Stock No. 0180-0164.
  CR136: Change to hp Stock No. 1901-0050.

CHANGE 9

Figure 5-17,
  △ Q207: Change type to 2N2635.
Figure 5-26 (as modified by CHANGE 2),
  Add: electrolytic capacitor C618 (3000 μf); connects between +12.6VF at right of R613/L607 junction and ground (observe polarity). C618 is mounted by cable clamps to left-side gusset below CALIBRATOR switch. Wire from + lead to board A602 is BRN/ORN.
Tables 6-1 and 6-2,
  Add C618: hp Stock No. 0180-0271; C: fxd, elect, 3000 μf, -10% +100%, 15VDCW; Mfr. 56289; Mfr. Part No. 34D308H015JT4.
  △ Q207: Change to hp Stock No. 1850-0158; Transistor: GE, PNP, 2N2635; Mfr 04713. (Replacement for discontinued item.) (EIA type 2N2048 may be used if available.)

CHANGE 10

Figure 5-13,
  C160 (added in CHANGE 1): Change value to 2.2 μf.
  Add: C161 (200 pf); capacitor connects between ground and junction of R147/CR137.
Figure 5-26,
  C615 (added in CHANGE 1): Change value to 2.2 μf.
Tables 6-1 and 6-2,
  C160, C615: Change to hp Stock No. 0160-0128; C: fxd, cer, 2.2 μf, 20%, 25VDCW; Mfr. 56289; Mfr. Part No. 5C15.
  Add C161: C: fxd, cer, 200 pf, 5%, 500VDCW; Mfr. 56289; Mfr. Part No. 40C.

CHANGE 11

Figure 5-13,
  C130: Change value to 56 pf.
  C159: Change value to 3300 pf.
  Q102: Change transistor type to special 2N1310, hp Stock No. 1851-0036.
  R142: Change value to 47K.
Tables 6-1 and 6-2,
  C130: Change to hp Stock No. 0140-0081; C: fxd, mica, 56 pf, 1%, 500VDCW; Mfr. 28480; Mfr. Part No. 0140-0081.
  C159: Change to hp Stock No. 0150-0079; C: fxd, 3300 pf, 10%, 500VDCW; Mfr. 15450; Mfr. Part No. 811-000-Y5F0332K.
  Q102: Change to hp Stock No. 1851-0036; Transistor: special 2N1310; Mfr. 28480; Mfr. Part No. 1851-0036.
  R142: Change to hp Stock No. 0686-4735; R: fxd, comp, 47K ohms, 5%, 1/2W; Mfr. 01121; Mfr. Part No. EB 4735.

CHANGE 12

Figure 5-29 and Section VI,
  F405: Change to hp Stock No. 2110-0067; Fuse: cartridge, 0.3 amp; Mfr. 28480; Mfr. Part No. 2110-0067.

Serial Prefix or Number	Make Manual Changes
203-	1
210-	1, 2
222-	1 thru 3
230-	1 thru 4
245-	1 thru 5

Serial Prefix or Number	Make Manual Changes
250-	1 thru 6
317-	1 thru 7
317-00901 thru 01000	1 thru 8
348-	1 thru 9
430-	1 thru 10

Serial Prefix or Number	Make Manual Changes
432-	1 thru 11
446-	1 thru 12
525-	1 thru 14
534-	1 thru 13, 15

CHANGE 13

Figure 5-17,
- Cut out Figure 3 and tape in place on Figure 5-17.
- A204: Change stock number to 185B-65R.
- CR207, CR208: Delete.
- Q205, Q206: Delete 2N743 designation.
- R275: Change value to 11K ohms.

Figure 5-29,
- A401: Change stock number to 185B-65S.
- R469: Change value to 909 ohms.
- V401: Change tube type to 8228. Delete pin numbers and replace with dot to indicate anode.

Tables 6-1 and 6-2,
- Make changes as follows:

Action	Circuit Reference	hp Stock No.	Description	Mfr.	Mfr. Part No.
Change	A201	185B-19G	Assy: Switch, TIME SCALE MAGNIFIER	hp	
Change	A204	185B-65R	Assy: Etched circuit, TIME BASE	hp	
Change	A401	185B-65S	Assy: Etched circuit, LV POWER SUPPLY	hp	
Add	C220	0140-0152	C: fxd, mica, 1000 pf, 5%, 300 vdcw	04062	DM16F102J
Delete	CR207	1910-0016	---		
Delete	CR208	1910-0016	---		
Change	Q205	1854-0082	Transistor: Silicon, NPN	hp	
Change	Q206	1854-0082	Transistor: Silicon, NPN	hp	
Delete	R201	0767-0009	---		
Change	R210	0811-1509	R: fxd, ww, 27K ohms, 1%, 7w	hp	
Change	R213	2100-0497	R; var, ww, 500 ohms, 10% 5w	hp	
Delete	R214	0727-0060	---		
Delete	R215	0727-0090	---		
Delete	R216	0727-0047	---		
Delete	R217	0687-5601	---		
Delete	R218	0686-3305	---		
Delete	R219	0686-1005	---		
Delete	R220	0686-1005	---		
Change	R230	0757-0843	R: fxd, metflm, 15.0K ohms, 1%, 1/2w	hp	
Change	R275	0811-1507	R: fxd, ww, 11K ohms, 3%, 5w	hp	
Change	R277	0757-0442	R: fxd, metflm, 10.0K ohms, 1%, 1/8w	hp	
Change	R278	0698-3476	R: fxd, metflm, 6000 ohms, 1%, 1/8w	hp	
Change	R279	0757-0283	R: fxd, metflm, 2000 ohms, 1%, 1/8w	hp	

Serial Prefix or Number	Make Manual Changes
203-	1
210-	1, 2
222-	1 thru 3
230-	1 thru 4
245-	1 thru 5

Serial Prefix or Number	Make Manual Changes
250-	1 thru 6
317-	1 thru 7
317-00901 thru 01000	1 thru 8
348-	1 thru 9
430-	1 thru 10

Serial Prefix or Number	Make Manual Changes
432-	1 thru 11
446-	1 thru 12
525-	1 thru 14
534-	1 thru 13, 15

CHANGE 13
(Cont'd)

Action	Circuit Reference	hp Stock No.	Description	Mfr.	Mfr. Part No.
Change	R280	0757-0280	R: fxd, metflm, 1000 ohms, 1%, 1/8w	hp	
Change	R281	0757-1100	R: fxd, metflm, 600 ohms, 1%, 1/8w	hp	
Change	R282	0757-0407	R: fxd, metflm, 200 ohms, 1%, 1/8w	hp	
Change	R283	0757-0407	R: fxd, metflm, 200 ohms, 1%, 1/8w	hp	
Add	R288	0757-0280	R: fxd, metflm, 1000 ohms, 1%, 1/8w	hp	
Add	R289	0757-0273	R: fxd, metflm, 3.01K ohms, 1%, 1/8w	hp	
Add	R290	0757-0438	R: fxd, metflm, 5.11K ohms, 1%, 1/8w	hp	
Add	R291	0757-0442	R: fxd, metflm, 10.0K ohms, 1%, 1/8w	hp	
Add	R292	0757-0453	R: fxd, metflm, 30.1K ohms, 1%, 1/8w	hp	
Add	R293	0757-0416	R: fxd, metflm, 511 ohms, 1%, 1/8w	hp	
Add	R294	0757-0410	R: fxd, metflm, 301 ohms, 1%, 1/8w	hp	
Add	R295	0757-0401	R: fxd, metflm, 100 ohms, 1%, 1/8w	hp	
Add	R296	0757-0394	R: fxd, metflm, 51.1 ohms, 1%, 1/8w	hp	
Add	R297	0757-0388	R: fxd, metflm, 30.1 ohms, 1%, 1/8w	hp	
Add	R298	0683-2005	R: fxd, comp, 20 ohms, 5%, 1/4w	01121	CB 2005
Add	R299	0811-1335	R: fxd, ww, 11K ohms, 3%, 3w	hp	
Change	R414	0812-0051	R: fxd, ww, 15K ohms, 3%, 3w	hp	
Change	R415	0811-1508	R: fxd, ww, 17K ohms, 3%, 4w	hp	
Change	R429	0811-1337	R: fxd, ww, 20K ohms, 5%, 3w	hp	
Change	R431	0811-1337	R: fxd, ww, 20K ohms, 5%, 3w	hp	
Change	R469	0757-0819	R: fxd, metflm, 909 ohms, 1%, 1/2W	hp	
Change	V401	1940-0012	Tube: Electron, VR, sub-minat, type 8228	73445	8228/ZZ1000

CHANGE 14 Tables 6-1 and 6-2,
Q201, Q202: Change to hp Stock No. 1853-0009; Transistor: Silicon, PNP; Mfr 28480.

CHANGE 15 Tables 6-1 and 6-2,
Q201, Q202: Change to hp Stock No. 1853-0003; Transistor: Silicon, PNP; Mfr 28480.

Serial Prefix or Number	Make Manual Changes
203-	1
210-	1, 2
222-	1 thru 3
230-	1 thru 4
245-	1 thru 5

Serial Prefix or Number	Make Manual Changes
250-	1 thru 6
317-	1 thru 7
317-00901 thru 01000	1 thru 8
348-	1 thru 9
430-	1 thru 10

Serial Prefix or Number	Make Manual Changes
432-	1 thru 11
446-	1 thru 12
525-	1 thru 14
534-	1 thru 13, 15

CHANGE 13
(Cont'd)

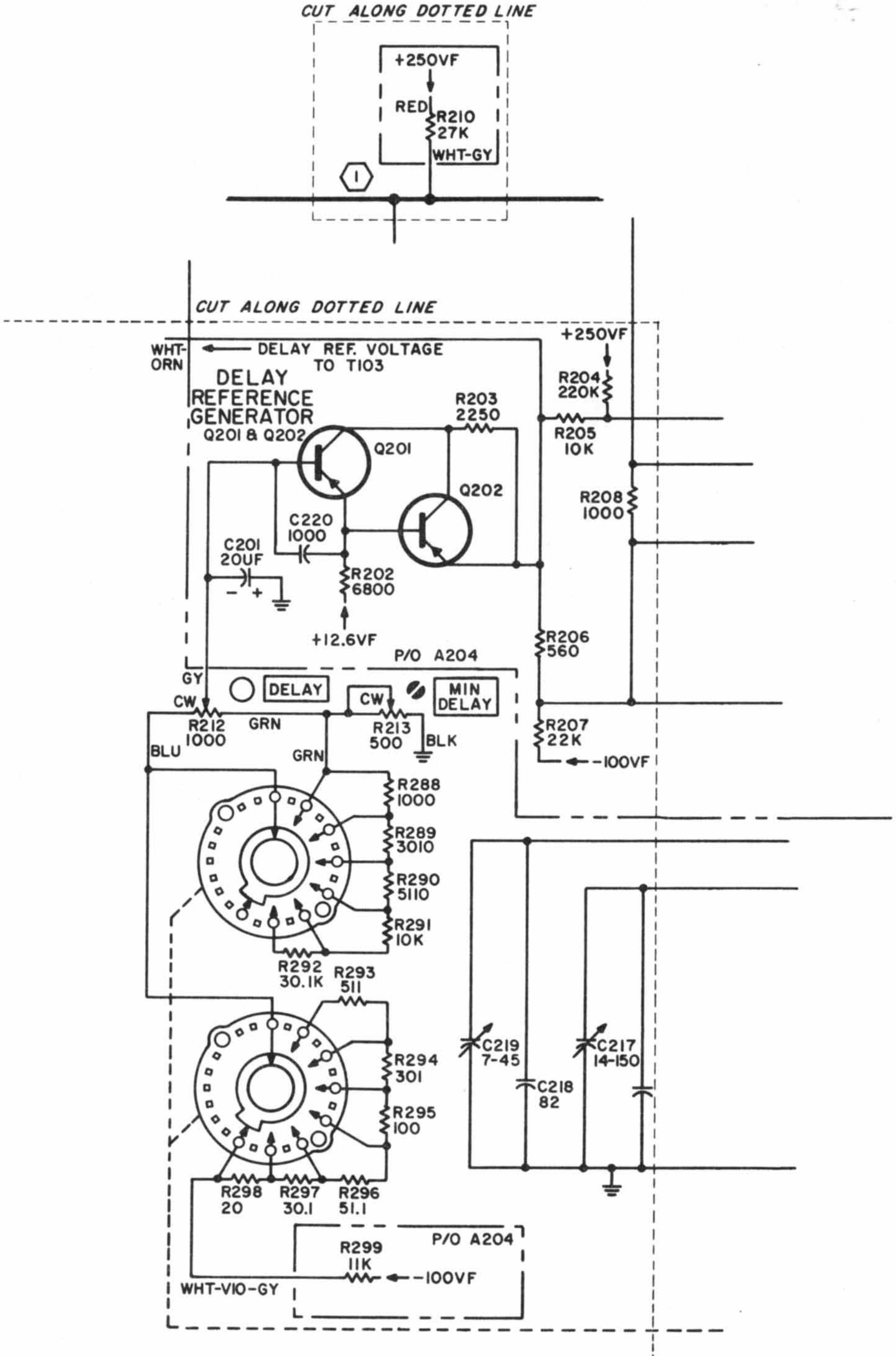


Figure 3

OPERATING AND SERVICE MANUAL

MODEL 185B

SERIALS PREFIXED: 144-

OSCILLOSCOPE

1501 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

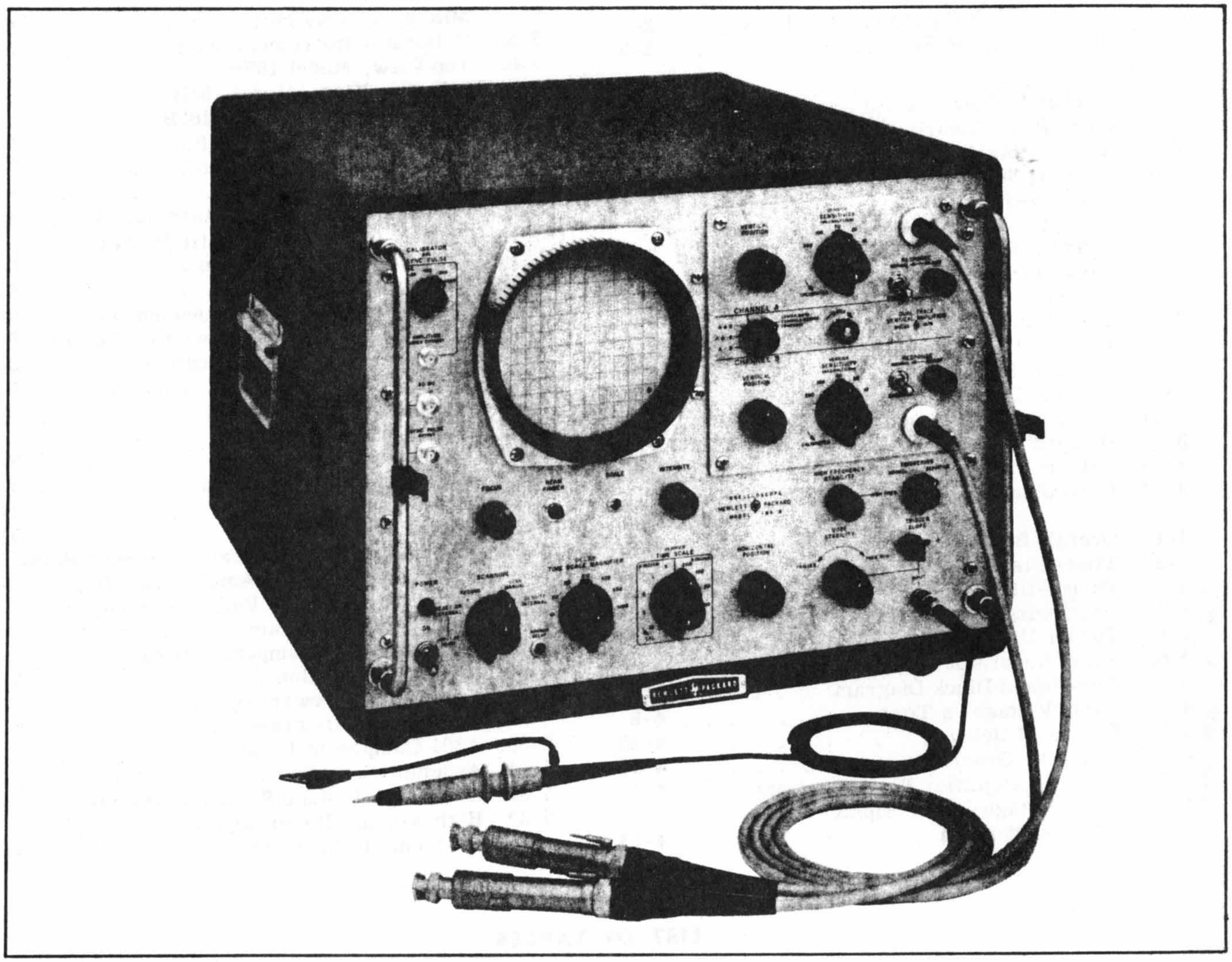


Figure 1-1. Model 185B Oscilloscope with Model 187B Dual-Trace Vertical Plug-In Unit

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This manual gives operation and maintenance information for the ⓗⓟ Model 185B Oscilloscope. An operational check to assure basic instrument operation is given in paragraph 2-10. A complete performance check that may be used for verifying specifications during incoming inspection is given in paragraph 5-67.

1-3. OPTIONS.

1-4. The Model 185B is normally supplied with a P2 phosphor with external graticule. The following options, however, are available:

a. Option 1. P1 phosphor

b. Option 3. Internal graticule in cathode ray tube

c. Option 7. P7 phosphor

d. Option 11. P11 phosphor

e. Option 31. P31 phosphor

1-5. Option 1 is not available with option 3, and option 31 is available only with option 3. Other than differences in crt persistence, color, and oscilloscope photography techniques, instruments with or without option 3 are operationally interchangeable. There are, however, some differences in component parts (see section VI). All references to the Model 185B in this manual apply to all options unless otherwise indicated.

1-6. INSTRUMENT IDENTIFICATION.

1-7. Hewlett-Packard Company uses a two-section eight-digit serial number (e.g. 000-00000). If the first three digits of the serial number on your instrument are not 144-, change sheets have been supplied with this manual which define differences between your instrument and this manual. If these change sheets are missing, your Hewlett-Packard engineering representative can supply you with the necessary information.

1-8. DESCRIPTION.

1-9. GENERAL. The ⓗⓟ Model 185B Oscilloscope provides a visual display of very high-speed phenomena with repetition rates to 1000 mc. The instrument will present a steady display of pulse repetition rates below 100 kc even when the signals are randomly spaced. For frequencies above 100 kc, the incoming signal is divided down so that the input circuitry will operate reliably. As the input frequency increases above 100 kc, more uniform spacing is required to obtain jitter-free presentation.

1-10. PRESENTATION. The Model 185B obtains its high speed characteristics by using the sampling technique. Using this system the entire signal under examination is scanned, with each succeeding sample taken on different occurrences of the input at slightly later points along the waveform. Each time such a

Table 1-1. Specifications

HORIZONTAL

Sweep Speeds:
10 ranges, 10 nsec/cm to 10 μsec/cm, accuracy within ±5%. Vernier gives continuous adjustment between ranges and increases fastest unmagnified sweep speed to 4 nsec/cm. Accuracy of the basic sweep is maintained at all magnifier settings with the exception of time represented by first 1/4 cm of the unmagnified sweep.

Magnification:
7 calibrated ranges X1, X2, X5, X10, X20, X50, and X100. Increases maximum calibrated sweep speed to 0.1 nsec/cm; with vernier, maximum sweep speed is further extended to 0.04 nsec/cm. Intensity and sample density are not affected by magnification.

Delay Control:
Three-turn variable delay control is available when using magnified sweep. Permits any portion of unmagnified trace to be viewed on screen.

Minimum Delay (input trigger to start of trace):
Less than 120 nsec at 100 nsec/cm sweep and faster. On slower sweep speeds, minimum delay increases to a maximum of approximately 5 μsec on the 10-μsec/cm range.

Sample Density:
Continuously adjustable from approximately 70 samples per trace to 1000 samples per trace.

Scanning Functions:
Internal - X axis driven by internal staircase for normal viewing.
Record - X axis driven by internal slow ramp; approximately 60 seconds for one trace.
Manual - X axis driven by manual scan control knob.
External - X axis driven by external voltage; approximately 12 volts for 10-cm deflection, input impedance greater than 25,000 ohms.

Specifications cont'd

Table 1-1. Specifications (cont'd)

TRIGGER FUNCTIONS

Normal-External Trigger
Amplitude: ±150 mv to ±2 volts peak. Up to 5 volts rms or 100 volts peak will not damage input circuit.
Width: 5 nsec at minimum amplitude.
Rate: 50 cps to 1 mc on the 10-μsec/cm sweep speed setting. Maximum rate increases to 100 mc on the 200 nsec/cm and faster ranges.
Jitter: Less than 0.03 nsec or 0.02% of the time represented by the unmagnified speed, whichever is greater (fast rise signals). Reduced approximately 5:1 in the "smoothed" response position.
Input Impedance: 50 ohms nominal dc coupled. Reflection from step of 1/2 nsec is less than 8%.

Sensitive-External Trigger
Amplitude: ±15 to ±200 mv peak. Up to 5 volts rms or 10 volts peak will not damage input circuit.
Width: 5 nsec at minimum amplitude
Rate: Same as normal
Jitter: Same as normal
Input Impedance: 50 ohms nominal, dc coupled

High Frequency
Input Frequency: 50 to 1000 mc for sweep speeds of 200 nsec/cm and faster
Sensitivity: 200 mv peak-to-peak. Operates from smaller signals at some increase in jitter. Up to 5 volts rms or 15 volts peak will not damage input circuit.
Jitter: 4% of cycle from 50 to 400 mc; 8% of cycle from 400 to 1000 mc
Signal at Input Connector: Less than 15 mv peak-to-peak, approximately 10 mc
Input Impedance: 50 ohms nominal, ac coupled. Reflection from step of 1/2 nsec rise time is less than 8%.

SYNC PROBE

The 185B-21A (use with any trigger function) increases input impedance to more than 7500 ohms, ac coupled; reduces sensitivity by approximately 4:1 at 10 mc and higher and by approximately 20:1 at low frequencies.

SYNC PULSE OUTPUT

Amplitude: Positive; at least 1.5 v into 50 ohms

Rise Time: Less than 2 nsec

Width: Approximately 5 μsec

Recurrence: One pulse per sample

CALIBRATOR

Voltage:
20 mv, 100 mv, 200 mv, and 1000 mv; ±3%

Time:
Approximately 5 μsec burst of 50 mc sinewave. Frequency accuracy ±2%.

X-Y RECORDER OUTPUT

X- and Y-axis signals are available at rear terminals in all positions of the scanning control. In the MANUAL and RECORD positions the voltage can be used to make pen recordings with a conventional X-Y recorder.

Horizontal Output: Approximately 0 volt at start of sweep to +13 volts at end of sweep (1.2 v/cm). Source impedance approx. 20,000 ohms.

Vertical Output: Approximately +1 volt at top of graticule, -1 volt at bottom (0.2 v/cm). Source impedance approximately 1,000 ohms.

GENERAL

Cathode Ray Tube:
5AQ mono accelerator with P2 phosphor normally supplied. 2900-volt accelerating potential. P1, P7, and P11 phosphors available.

External Graticule (standard):
Edge lighted with controlled illumination, 10 cm by 10 cm, marked in centimeter squares. Major axes have 2-millimeter subdivisions.

Power: 115 or 230 volts ±10%, 50 to 60 cps, approximately 300 watts

Dimensions:
Cabinet Mount: 14-5/8 inches high, 19 inches wide, 22-1/8 inches deep
Rack Mount: 12-1/4 inches high, 19 inches wide, 21 inches deep behind panel

Weight:
Cabinet Mount: Net 65 lb

Accessories Furnished: 185B-21A Sync Probe

Accessories Available:
185A-39A Plug-In Extender
185A-21C Resistive Divider Probe, 5:1 division, 250 ohms
185A-21D Resistive Divider Probe, 10:1 division, 500 ohms
185A-21E Resistive Divider Probe, 50:1 division, 2500 ohms
185A-21F Resistive Divider Probe, 100:1 division, 5000 ohms
AC-16W 3-ft RG-55 cable for 185A-21C,D,E,F

Associated Instruments:
187B Dual Trace Vertical Amplifier
187B accessories available:
187A-76A BNC Adapter
187A-76B Type N Adapter
187B-76C 10:1 Divider
187A-76D Blocking Capacitor
187B-76E 50-ohm T Connector
Model 1100A Delay Line
Model 908A 50-ohm Coaxial Termination
187B-76F Adapters
187B-76G Probe Socket
Model 213A Pulse Generator, less than 0.5 nsec rise time ±350 mv amplitude

sample is taken, the "spot" on the crt is moved horizontally along the waveform. Thus, a complete picture of a repetitive high speed signal is synthesized by a buildup of image-retaining "dots" on the oscilloscope face as a graph is plotted point by point.

1-11. The Model 185B provides 10 basic time scales ranging from 10 microseconds per centimeter to 10 nanoseconds per centimeter depending on the setting of the TIME SCALE switch. Any part of this basic time scale can be expanded without loss of calibration, by adjusting the TIME SCALE MAGNIFIER switch. Built-in time and amplitude calibrators provide a convenient means of checking both horizontal and vertical calibration. Intensity of the trace is independent of duty cycle, and vertical deflection may be adjusted up to 10 centimeters. In addition, the Model 185B provides output signals for X-Y recorders and provides means for controlling the display either manually or externally.

1-12. VERTICAL AMPLIFIER. The vertical system of the Model 185B includes a plug-in vertical amplifier such as the Model 187B. It is this amplifier which determines vertical characteristics such as bandpass, sensitivity, etc. The vertical plug-in unit is not part of the basic Model 185B Oscilloscope.

1-13. Figure 1-1 illustrates the Model 185B. The 185B-21A Sync Probe shown in the figure is supplied with the oscilloscope. The Model 187B Dual Trace Vertical Amplifier is shown installed, although the plug-in unit is not part of the basic oscilloscope. Table 1-1 lists the specifications for the Model 185B.

1-14. CATHODE-RAY TUBE WARRANTY.

1-15. The cathode-ray tube supplied with the Model 185B is guaranteed against electrical failure for one year from the date of sale by the Hewlett-Packard Company. The cathode-ray tube warranty is illustrated in figure 1-2. A sheet for your use is included in the appendix of this manual.

CATHODE RAY TUBE WARRANTY

The cathode ray tube supplied in your Hewlett-Packard Oscilloscope and replacement cathode ray tubes purchased from hp, are guaranteed against electrical failure for one year from the date of sale by the Hewlett-Packard Company. Broken tubes or tubes with burned phosphor are not included in this guarantee.

Your local Hewlett-Packard representative maintains a stock of replacement tubes and will be glad to process your warranty claim for you. Please consult him.

Whenever a tube is returned for a warranty claim, the reverse side of this sheet must be filled out in full and returned with the tube. Follow shipping instructions carefully to insure safe arrival, since no credit can be allowed on broken tubes.

SHIPPING INSTRUCTIONS

1) Carefully wrap the tube in 1/4" thick cotton batting or other soft padding material.
2) Wrap the above in heavy kraft paper.
3) Pack in a rigid container which is at least 4 inches larger than the tube in each dimension.
4) Surround the tube with at least four inches of packed excelsior or similar shock absorbing material. Be certain that the packing is tight all around the tube.
5) Tubes returned from outside the continental United States should be packed in a wooden box.
6) Ship prepaid preferably by AIR FREIGHT or RAILWAY EXPRESS. We do not recommend parcel post or air parcel post shipment.

HEWLETT-PACKARD CO. PAGE MILL ROAD, PALO ALTO, CALIF. U.S.A.

CRT WARRANTY CLAIM

FROM: DATE: ______

NAME: ______

COMPANY: ______

ADDRESS: ______

Person to contact for further information:

NAME: ______

TITLE: ______

COMPANY: ______

ADDRESS: ______

To process your claim quickly please enter the information indicated below:

1) hp INSTRUMENT MODEL ______ SERIAL ______
2) TUBE TYPE ______ SERIAL ______
3) ORIGINAL TUBE ______ REPLACEMENT TUBE ______
4) YOUR PURCHASE ORDER NO. ______
5) DATE PURCHASED ______
6) PURCHASED FROM ______
7) COMPLAINT: (Please describe nature of trouble) ______
8) OPERATING CONDITIONS: (Please describe conditions prior to and at time of failure ______

SIGNATURE ______

Figure 1-2. Cathode-Ray Tube Warranty

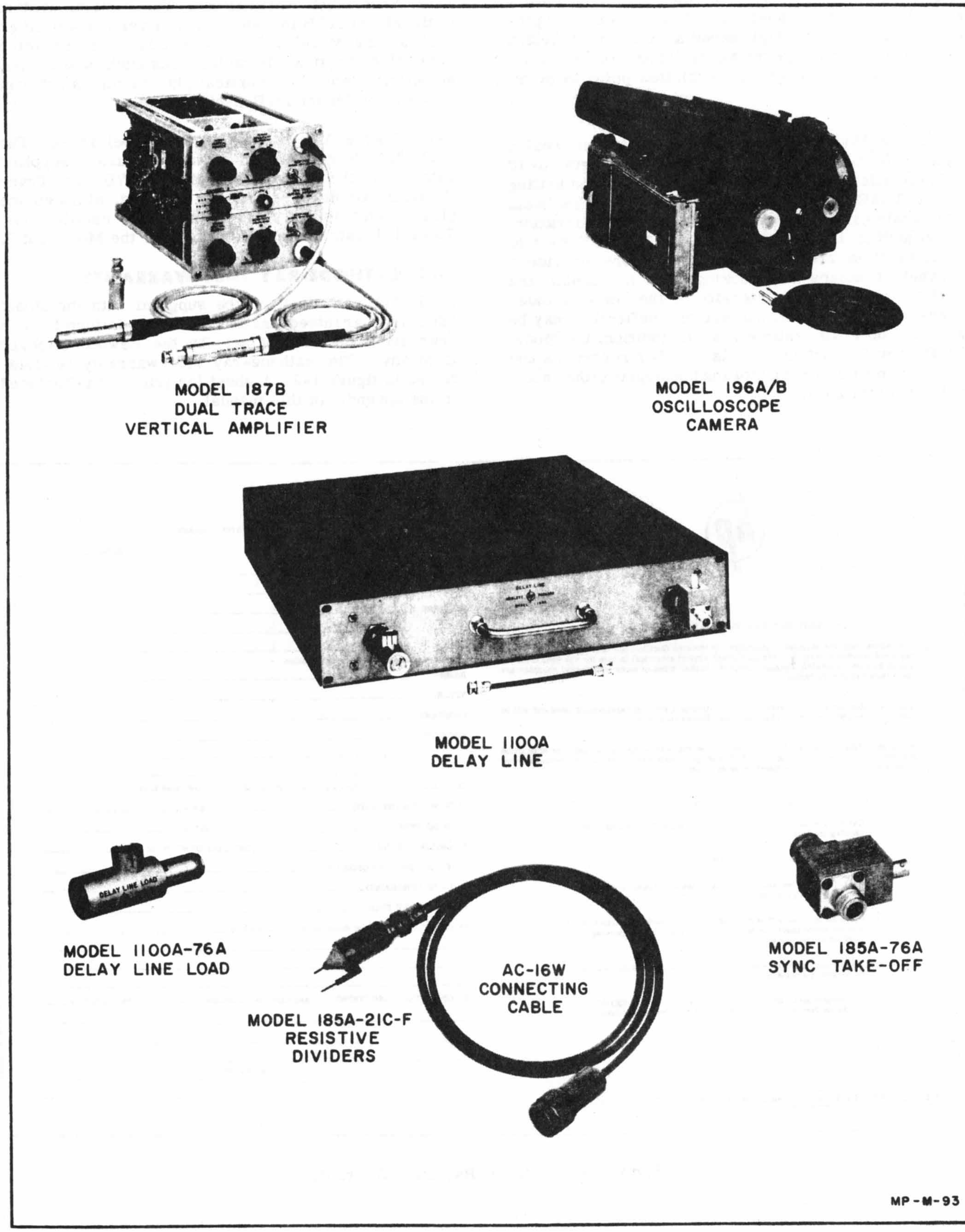


Figure 2-1. Associated ⓗ Equipment Available

SECTION II

PREPARATION FOR USE

2-1. INCOMING INSPECTION.

2-2. MECHANICAL INSPECTION.

2-3. Upon receipt of your Model 185B, check the contents against the packing list and inspect the instrument for any obvious damage received in transit. If damage is evident, file claim with the carrier. (Refer to the warranty sheet in this manual for additional information.) To facilitate reshipment, keep all re-usable packing material until an operational check has been successfully completed.

2-4. POWER REQUIREMENTS.

2-5. The Model 185B requires a power source of 115 or 230 volts ±10%, single phase, 50 to 60 cps, which can deliver approximately 300 watts.

2-6. 230-VOLT OPERATION.

2-7. If 230-volt operation is desired, a screwdriver-operated switch is provided on the rear of the instrument. The existing fuse should be replaced with a 2-ampere slow-blow fuse.

CAUTION

Be sure to set the 115-230 volt switch properly for the line voltage to be used. The power supplies may be damaged if this switch is set to the wrong position.

2-8. THREE-CONDUCTOR POWER CABLE.

2-9. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground pin. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail to ground.

2-10. OPERATIONAL CHECK.

2-11. The following procedure is given as a means for checking basic operation of the Model 185B. All controls mentioned in the following procedure are shown in figure 3-1. A complete check-out procedure to verify specifications is given in paragraph 5-67.

a. Install the vertical plug-in unit. Set vertical gain to approximately 50 mv/cm.

b. Turn INTENSITY full counterclockwise.

c. Set SCANNING to INTERNAL, TIME SCALE to 100 NSEC/CM, DENSITY full clockwise, MODE to FREE RUN, TIME SCALE MAGNIFIER and CALIBRATOR AND SYNC PULSE OUTPUT switches full counterclockwise.

d. Center HORIZONTAL POSITION and VERTICAL POSITION controls.

e. Turn the Model 185B on and allow about two minutes for the instrument to stabilize. Connect the vertical plug-in input to the 50-mc connector.

f. Rotate INTENSITY clockwise until a trace appears. If the crt remains blank, press BEAM FINDER and readjust HORIZONTAL POSITION and VERTICAL POSITION controls as necessary.

g. Adjust FOCUS for a thin, well-defined trace.

h. The resultant presentation should be approximately five cycles of a 50-mc sine wave.

2-12. INSTALLATION.

2-13. COOLING.

2-14. The Model 185B uses a forced-air cooling system to maintain tolerable operating temperatures within the cabinet. The air intake and filter are located on rear of instrument. When mounting instrument, choose a site that provides at least three inches of clearance around rear and sides of cabinet.

2-15. AIR FILTER. Before operating the Model 185B, the air filter, located at rear of instrument, should be coated with a filter adhesive such as Filter Coat No. 3 from Research Products Co. In addition, the filter should be cleaned periodically to insure proper cooling. Refer to paragraph 5-6 for proper cleaning procedures.

2-16. CABINET MOUNT.

2-17. The Model 185B cabinet mount is a portable instrument. The instrument is intended to be operated with its front panel in a vertical or near-vertical plane. A bail is provided for raising front of instrument to a better viewing angle. Be sure to maintain clearance required for proper cooling mentioned in paragraph 2-14.

2-18. RACK MOUNT.

2-19. The standard rack model is supplied with two rear-support pins and bushings. The bushings are installed on rear flanges. The pins are for use in mounting the instrument at installation and are intended to mate with bushings when instrument is installed. Do not mount the instrument with only front-panel screws, particularly if installation is subject to any vibration or shock. Location dimensions for support pins are shown in figure 2-2. Screws for securing front panel to rack are not supplied. Install instrument as follows:

Table 2-1. Associated Equipment Available

ⓗ Model	Use	Features
196A/B Oscilloscope Camera	A High quality camera for use in permanently recording oscilloscope presentations	Image to object ratio: 1:0.9 (1:1 available) Model 196B allows oscilloscope photograph on either internal or external graticule oscilloscopes
187B Dual Trace Amplifier	A dual-channel vertical amplifier (plug-in) for Model 185B (shown installed in figure 1-1)	Sensitivity: 4 mv/cm to 200 mv/cm Bandwidth: DC to 800 mc usable to 1000 mc Input Impedance: 100K shunted by 2 pf nominal
1100A Delay Line	Overcomes inherent oscilloscope delay, allowing rise times of slow repetition rate pulses to be viewed	Rise Time: 0.25 ns Delay: 120 ns
185A-76A Sync Take-Off	Inserted between signal line and delay line to permit sync take-off (normally supplied with Model 1100A system)	Insertion Loss: 6 db for both channels
1100A-76A Delay Line Load	Termination for 1100A Delay Line (normally supplied with Model 1100A system)	Termination Resistance: 50 ohms
Resistive Dividers 185A-21C 185A-21D 185A-21E 185A-21F	These dividers provide a means for obtaining a high-impedance, low-capacitance input to Model 1100A Delay Line or other 50-ohm systems. (All dividers must be used with a cable terminated in 50 ohms)	Input Res. / Division Ratio / Max Input VRMS 250 / 5:1 / 10 500 / 10:1 / 15 2500 / 50:1 / 35 5000 / 100:1 / 50
AC-16W Cable	Connecting cable for 185A-21C/F Dividers	
186A Switching Time Tester	Measures switching time of transistors, diodes and tunnel diodes. Tests pulse response of active and passive networks. Triggers Model 185B in advance of pulse output. Accessory universal adapter available.	Pulse Output: 0.1 to 20 volts peak Pulse Rise Time: Less than 1 nsec Pulse Repetition Rate: 5 kc to 50 kc, continuously variable Collector Supply: 0 to ±30 volts Base Supply: 0 to ±10 volts

a. Fabricate a bracket for rear support pins and fasten pins in place.

b. Install bracket at rear of rack.

c. Lift instrument into place, engaging rear-support pins, and secure front panel firmly to rack.

2-20. ASSOCIATED EQUIPMENT AVAILABLE.

2-21. Figure 2-1 and table 2-1 show equipment that is available from Hewlett-Packard Company to increase the usefulness of your Model 185B. Additional equipment is available for use with the vertical plug-in unit. Refer to the manual for operating information regarding your particular plug-in or contact your nearest ⓗ representative and he will supply you with this information.

2-22. RESHIPMENT.

2-23. If, after incoming inspection, damage is evident, repack the instrument using the following procedure as a guide.

a. If possible, repack the Model 185B in its original shipping container, taking care to replace all pads in their original positions. (If the packing material was discarded, more may be obtained from your Hewlett-Packard Engineering Representative.)

b. If the original packaging material is not available, proceed as follows:

(1) Wrap instrument in heavy paper or plastic.

(2) Use plenty of packing material (at least 4 in.) around all sides of instrument and protect panel with cardboard strips.

(3) Place instrument thus protected in a heavy cardboard or wooden box, and use heavy tape or metal bands to seal container.

(4) Mark the packing box with "Fragile", "Delicate Instrument", etc.

Note

If instrument is to be shipped to Hewlett-Packard Company for service or repair, attach a tag identifying owner and indicating type of service or repair desired. In any correspondence, refer to instrument by model number and complete eight-digit serial number.

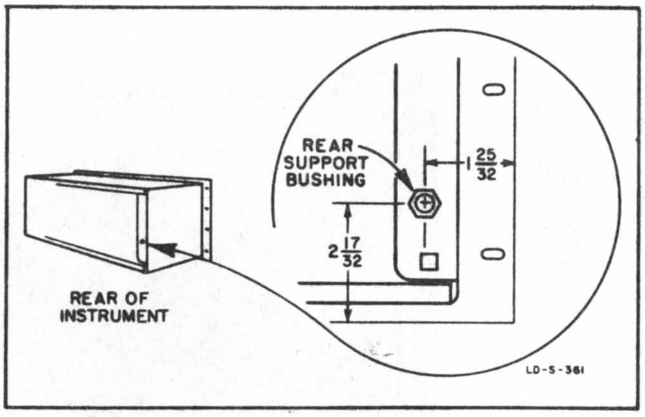
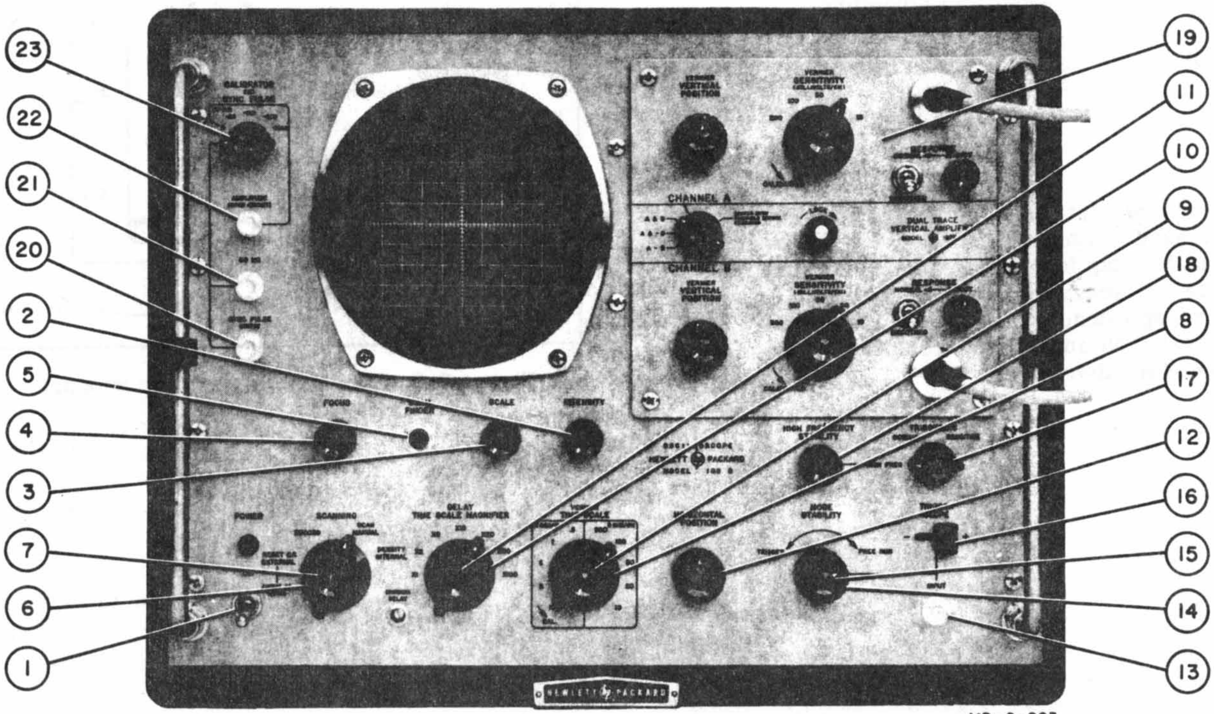


Figure 2-2. Dimensions for Rear Support



MP-S-983

1. Power switch. Energizes instrument.

2. INTENSITY. Adjusts brilliance of spot on the cathode-ray tube.

3. SCALE. Adjusts scale brilliance. (Aligns trace with graticule on option 3 instruments.)

4. FOCUS. Adjusts focus of spot on the cathode-ray tube.

5. BEAM FINDER. Helps locate a presentation that is deflected off the crt.

6. SCANNING. Adjusts mode of horizontal deflection.

7. SCAN (MANUAL) or DENSITY (INTERNAL). Used to manually scan display or to adjust scan density.

8. TIME SCALE. Adjusts basic time scale of presentation.

9. VERNIER. Provides continuously variable time scale between TIME SCALE ranges.

10. TIME SCALE MAGNIFIER. Expands the basic time scale selected by TIME SCALE control.

11. DELAY. Enables operator to view any part of magnified presentation.

12. HORIZONTAL POSITION. Adjusts horizontal positioning of presentation.

13. INPUT. Connection for trigger input. Sensitivity: SENSITIVE ±200 mv; NORMAL ±200 mv to 2 volts.

14. STABILITY. Adjusts trigger stability.

15. MODE. Adjusts trigger sensitivity. May be set to FREE RUN.

16. TRIGGER SLOPE. Selects desired trigger slope polarity.

17. TRIGGERING. Set this switch according to frequency and amplitude of trigger signal.

18. HIGH FREQUENCY STABILITY. Adjusts trigger stability on HIGH FREQ. position of TRIGGERING.

19. Model 187B Dual Channel Vertical Amplifier plug-in unit. Not part of basic oscilloscope.

20. SYNC. PULSE OUTPUT. Provides a delayed sync pulse out for triggering test circuits, or to use as a test pulse.

21. 50 MC. Provides a pulsed 50-mc output.

22. AMPLITUDE DC (OPEN CIRCUIT). Provides output of four calibrated dc voltages.

23. CALIBRATOR AND SYNC PULSE. Selects calibrated dc voltages or sync pulse outputs to appropriate connectors.

Figure 3-1. Operating Controls and Connectors

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section contains information on the function of all controls in the Model 185B Oscilloscope. If more theoretical information is desired, refer to Section IV, Principles of Operation.

3-3. The vertical amplifier system for the Model 185B includes a plug-in unit. Detailed instructions for operating the plug-in unit are contained in the instruction manual for that particular unit.

3-4. FRONT PANEL CONTROLS AND CONNECTORS.

3-5. Figure 3-1 shows all front panel operating controls and gives a short description of their use. Numbers in figure 3-1 are given to relate the text in figure 3-1 to the photograph and do not necessarily indicate operational procedure. More detailed information related to these controls is listed below:

a. BEAM FINDER. Pressing the BEAM FINDER reduces gain of horizontal and vertical amplifiers to a point where a "lost" presentation may be found and adjusted to center of cathode-ray tube using the HORIZONTAL POSITION and VERTICAL POSITION controls.

b. SCALE. The SCALE control adjusts intensity of graticule on those instruments provided with an external graticule. On internal graticule instruments, SCALE aligns trace with graticule.

c. INPUT. This connector is the input to the synchronizing circuits. These circuits insure an exact time relationship between input signal and moment of sampling. To operate properly, the sampling oscilloscope either must be accurately triggered by a signal that is time-related to the input signal, or must supply a sync pulse to trigger circuit under test (see step i).

d. TRIGGERING. The TRIGGERING switch may be set to SENSITIVE, NORMAL or HIGH FREQ. depending on amplitude and frequency of trigger signal. SENSITIVE position is used for trigger signals below 200 millivolts with a frequency below 100 mc. Do not exceed 10 volts peak input on SENSITIVE position. NORMAL position is used for higher amplitude signals (200 mv to 2 volts) below 100 mc. HIGH FREQ. position should be used for trigger signals of all amplitudes above 100 mc. The input circuits on HIGH FREQ. position will divide down signals as high as 1000 mc so they may be used to operate synchronizing circuits.

CAUTION

Do not connect any voltage exceeding 10 volts peak to INPUT when TRIGGERING is on SENSITIVE. Doing so may damage input circuits.

e. HIGH FREQUENCY STABILITY. This control adjusts frequency of count-down oscillator, enabling it to lock in at a submultiple of input trigger frequency.

f. TRIGGER SLOPE. The TRIGGER SLOPE switch may be used to synchronize Model 185B circuits on either positive-going or negative-going slope of trigger signal.

g. MODE. The MODE control adjusts sensitivity of input circuits so they will trigger reliably at the same point on input signal. If MODE control is set full clockwise to FREE RUN position, Model 185B sync circuits will free run, i.e. sample automatically at a 100-kc rate. If they are triggered with a frequency above 100 kc, they will operate at a frequency near 100 kc but will synchronize with a submultiple of the input signal.

h. STABILITY. The STABILITY control adjusts triggering stability for repetition rates above 100 kc by varying hold-off time in triggering circuits.

i. SYNC PULSE OUTPUT. The SYNC PULSE OUTPUT connector provides a fast rise time pulse that is delayed 130 nanoseconds from trigger initiation. With sync pulse from SYNC PULSE OUTPUT connected to circuit under test, inherent delay (0.1 μsec) in Model 185B is overcome. The effect is similar to delaying input signal for the purpose of examining fast rise time.

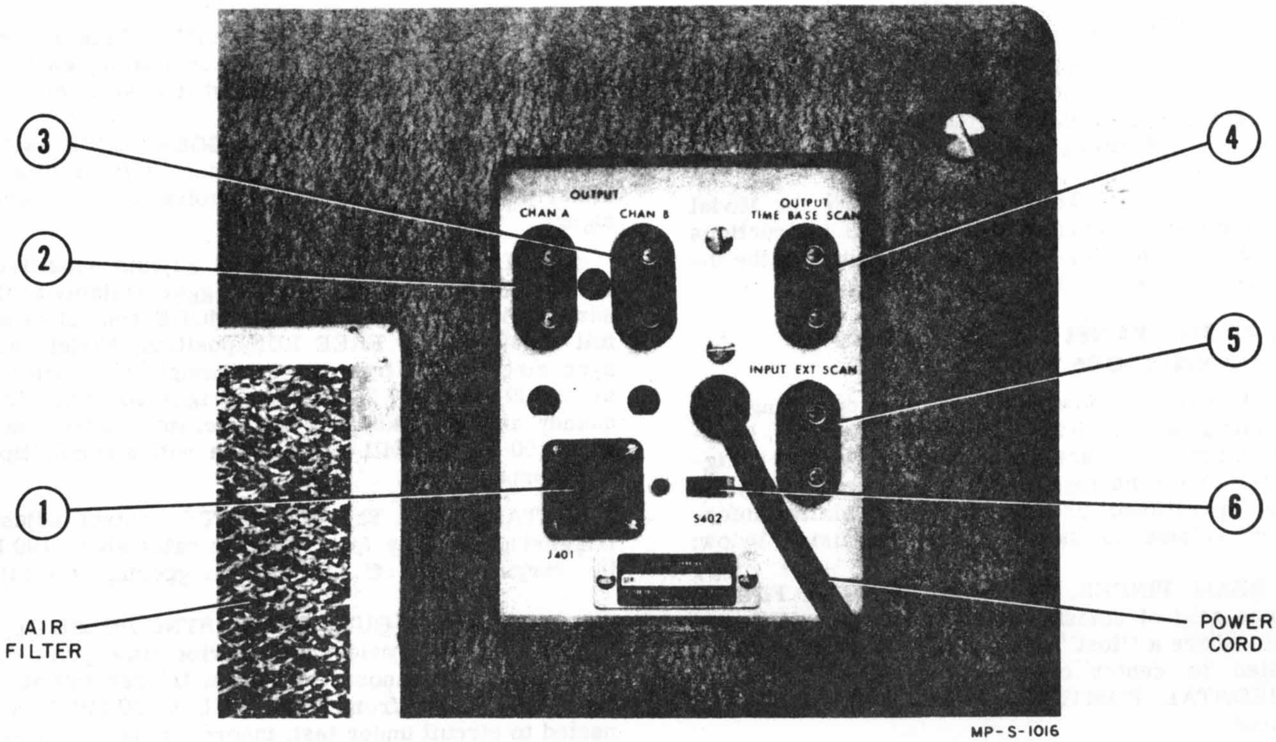
j. 50 MC. This connector provides a pulsed sine wave output, synchronized with pulse from SYNC PULSE OUTPUT. Frequency of sine wave is 50 megacycles. This signal is valuable for setting up a time reference on the cathode ray tube, or for checking time scales on oscilloscope.

k. AMPLITUDE (DC OPEN CIRCUIT). This connector provides dc voltages selected by CALIBRATOR AND SYNC PULSE switch for calibration of vertical amplifier in oscilloscope. Voltages selected are accurate to within $\pm 3\%$ of selected value.

m. CALIBRATOR AND SYNC PULSE. This switch, when in full counterclockwise position, connects both sync pulse output and pulsed 50-mc output to appropriate jacks. On other positions of this switch, a dc voltage is supplied to AMPLITUDE (DC OPEN CIRCUIT) connector as explained in step k.

n. TIME SCALE. The TIME SCALE switch determines time scale in nsec or μ sec per centimeter. The time calibration of this switch is correct within specifications when VERNIER control is full counterclockwise.

p. VERNIER. The VERNIER control provides a fine adjustment between any two steps selected by TIME SCALE switch, resulting in continuous variation of time scale from 10 μsec/cm to 3 nsec/cm.



1. Regulated dc output connector for use with future instruments.

2. Channel A vertical output voltage for vertical deflection present on this connector (with Model 187B). Sensitivity 0.2 volt/cm, Graticule Center: 0 volt. For use with X-Y recorder.

3. Channel B vertical output. Same characteristics as item 2.

4. OUTPUT TIME BASE SCAN. Horizontal drive voltage is available at this connector. For use with X-Y recorder. Sensitivity: 1.2 volts/cm, Sweep Start: 0 volt.

5. INPUT EXT SCAN. Connect external horizontal drive signal to this connector. Sensitivity: 1.2 volts/cm, Input Range: 0 to 12 volts.

6. 115-230 Volt Switch. Set to line voltage being used. Use 4-ampere slow-blow fuse for 115-volt operation, 2-ampere slow-blow fuse for 230-volt operation (see section VI).

Figure 3-2. Rear-Panel Controls

q. TIME SCALE MAGNIFIER. The TIME SCALE MAGNIFIER switch divides the value that has been selected by TIME SCALE switch by number selected by TIME SCALE MAGNIFIER switch.

r. DELAY. The DELAY control selects any part of unmagnified presentation for magnification; i.e., with delay control you effectively slide cathode-ray tube along expanded presentation to view portion you want.

s. SCANNING. The SCANNING switch determines type of horizontal deflection that will be used. At this point it should be emphasized that apparent speed of beam across the face of the cathode-ray tube has no relation to its time scale in seconds per centimeter. The beam may take 10 seconds to go across the face of the tube and yet the time scale could be, for example, 50 nanoseconds per centimeter. The Model 185B provides a choice of four modes of horizontal deflection; they are as follows:

(1) INTERNAL. The time scale is determined by setting of TIME SCALE and TIME SCALE MAGNIFIER switches. On INTERNAL, the beam is automatically swept across the face of the tube at an actual speed determined by DENSITY control and sampling frequency.

(2) MANUAL. On MANUAL position, scanning is accomplished by adjusting SCAN (MANUAL) - DENSITY (INTERNAL) control. Manual operation may be thought of as a condition where sweep is always present on oscilloscope, but the only visible portion of trace is that part illuminated by setting of MANUAL SCAN control. The time scale in seconds per centimeter is determined again by setting of TIME SCALE MAGNIFIER and TIME SCALE switches. Manual scan is useful in X-Y recorder work when it is necessary to carefully trace presentation, e.g., when fast spikes are present on waveform.

(3) RECORD. On RECORD position, operation is exactly the same as on MANUAL except that in this case the beam is automatically swept very slowly across the face of the tube at a time scale determined by setting of TIME SCALE MAGNIFIER and TIME SCALE switches.

(4) RESET OR EXTERNAL. The RESET OR EXTERNAL position has two functions: 1) it provides a means for resetting scan when operating on RECORD position, or 2) it provides a means of scanning with an external signal. An input connector, INPUT EXTERNAL SCAN, is provided on rear of instrument for external horizontal input.

t. SCAN (MANUAL) - DENSITY (INTERNAL). The function of this control depends on setting of SCANNING switch. With SCANNING switch set to INTERNAL, the SCAN (MANUAL) - DENSITY (INTERNAL) control adjusts number of samples per centimeter and hence the density of sample dots as seen by the viewer. Reducing scan density has the effect of speeding up the physical speed of horizontal sweep, i.e., the actual speed to produce one complete picture on oscilloscope face. However, turning this control has no effect on time scale in seconds per centimeter on cathode-ray tube. On the MANUAL position of the SCANNING switch, the SCAN (MANUAL) - DENSITY (INTERNAL) control moves dot along presentation as explained in step s(2). On RECORD and RESET OR EXTERNAL positions of SCANNING, the SCAN (MANUAL) - DENSITY (INTERNAL) control is inoperative.

3-6. REAR PANEL CONNECTORS.

3-7. Figure 3-2 shows all connectors on rear panel and gives a short description of their uses. As in figure 3-1, the numbers in figure 3-2 relate text in the figure to the photograph and do not necessarily indicate operational procedure. The following paragraphs give more detailed information about these connectors:

a. J401, regulated dc output connector. This connector is intended to supply dc power to future accessory instruments. The following voltages are available with reference to ground (pin a):

1) Pin b, +12.6 volts
2) Pin c, -12.6 volts
3) Pin d, +250 volts
4) Pin e, -100 volts

b. OUTPUT CHAN A. The vertical output from Channel A of the plug-in unit is available at these terminals for use in driving an X-Y recorder with the Model 187B installed. The output from this connector is approximately +1 volt at top of graticule, 0 volt in center, and -1 volt at bottom of graticule (0.2 volt/cm). Source impedance is approximately 20,000 ohms.

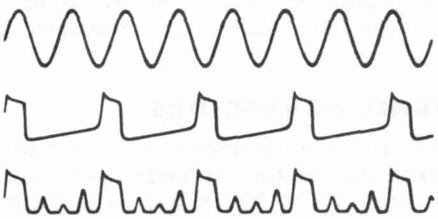
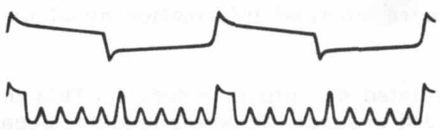
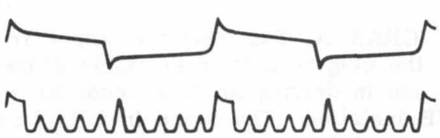
c. OUTPUT CHAN B. The vertical output from Channel B of the plug-in unit is available at these terminals. Output characteristics of CHAN B are identical to those of CHAN A.

d. OUTPUT TIME BASE SCAN. The horizontal scan voltage that has been selected by SCANNING is available at this connector to drive horizontal axis of X-Y recorder. The output from OUTPUT TIME BASE SCAN is approximately 0 volt at sweep start and +12 volts at sweep termination (1.2 volts/cm). Source impedance is approximately 20,000 ohms.

e. INPUT EXT SCAN. This connector provides a means of controlling scan with an external signal. The scan voltages required are the same as those supplied by OUTPUT TIME BASE SCAN connectors, i.e., 0 volt to position scan at left edge of crt, and about +13 volts to position scan at right edge (with HORIZONTAL POSITION centered). Input resistance varies with setting of time scale VERNIER but the minimum is 32.3K.

f. 115-230 volt switch. This switch automatically connects Model 185B power transformer for line voltage setting selected. Be sure to use correct line fuse (see section VI).

Table 3-1. Methods of Triggering

Waveform Types	Trigger Freq	Possible to Trigger Ckt under Measurement?	Ext Trig Gen Available?	Delay Line Required?	Refer to Figure
	Over 10 kc	---	---	no	3-3
	Below 10 kc	yes	yes	yes (no, if test ckt delay > 120 ns)	3-4
	Below 10 kc	yes	no	no	3-5
 W-3-307	Below 10 kc	no	---	yes	3-6

3-8. THE PRINCIPLE OF THE SAMPLING OSCILLOSCOPE.

3-9. The action of the sampling oscilloscope is similar to a strobe light that is slightly out of synchronization with a turning device, resulting in an apparent slow motion--or the effect of taking moving pictures of a rapidly spinning wheel where the camera shutter speed is nearly the same as the time for one rotation of the wheel, causing the wheel to appear to be turning very slowly, or even turning backwards.

3-10. The sampling of the signal with the sampling oscilloscope is accomplished in almost exactly the same way. The sampler plug-in in this case would represent the camera shutter and lens. The sampling circuit is opened for very short periods of time and input voltage at that time is carefully measured. This occurs over and over again, with each succeeding sample taken on a succeeding repetition of input signal and at a slightly later time with respect to same reference point on input signal.

3-11. THE VIEWING "WINDOW". There is a certain maximum and minimum time during which sampling oscilloscope may complete each observation. In the Model 185B, maximum time is 100 μseconds and minimum time approximately 0.3 nanoseconds. This time is referred to as the viewing "window". Since it takes 120 nanoseconds for the "window" to open after trigger is received, signals with a period greater than 100 μseconds will require special triggering techniques when it is necessary to view rise time.

3-12. In this case, either the signal to sampling circuits must be delayed, or an advanced trigger must be used to permit viewing leading edge of this type of signal. The following paragraphs will describe different methods available for solving some synchronization problems you may encounter in sampling oscilloscope technique.

3-13. TRIGGERING THE MODEL 185B.

3-14. GENERAL.

3-15. As in any oscilloscope, the Model 185B must be synchronized with a signal that is time-related to signal received by vertical amplifiers. Furthermore, the system must be externally synchronized. This is because sampled signal never actually enters oscilloscope circuits, and therefore is not available internally for synchronization (in the case of Model 187B, signal is sampled at probes). Table 3-1 and figures 3-3 to 3-6 list common types of waveforms and measurement situations, and give recommended instrument arrangement.

3-16. TRIGGER REPETITION RATE. Model 185B accepts triggers with repetition rates between 50 cps and 1000 mc. However, an internal hold-off circuit limits maximum sampling rate to about 100 kc. STABILITY provides limited control over hold-off circuit to permit adjustment for maximum stability when the trigger rate exceeds 100 kc. For frequencies above 100 mc, a countdown circuit (adjusted with HIGH FREQ. STABILITY) reduces frequency of trigger signal to approximately 10 mc so that synchronizing circuits will be triggered reliably.

3-17. TRIGGERING METHODS.

3-18. When limited time-scale speed is not a problem, and jitter is not excessive, the simplest method of synchronizing Model 185B is to trigger on one pulse in a train, and to view several succeeding pulses on the screen. For this to be possible, however, the signal frequency must be at least 10 kc so that more than one pulse will occur in the 100 μsec viewing "window" of oscilloscope. The following paragraphs describe a few conditions that dictate the method of synchronization, and therefore the instrument setup that should be used.

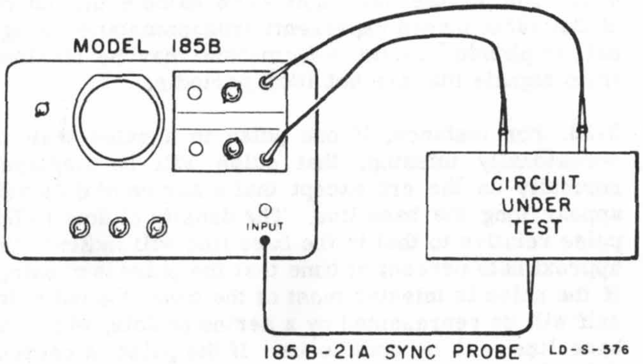


Figure 3-3. Viewing Signals Above 10 kc

3-19. SIGNAL REPETITION RATES ABOVE 10 KC. Synchronizing on signals above 10 kc presents few problems since one or more pulses of a train may be viewed in oscilloscope "window". The recommended instrument setup for viewing signals above 10 kc is shown in figure 3-3, while operating procedures are described in figures 3-7 to 3-9. Remember that for signals above 100 mc, TRIGGERING must be set to HIGH FREQ., and STABILITY adjusted with both HIGH FREQUENCY STABILITY and STABILITY controls.

Note

If it is necessary to examine very fast rise time (e.g., 10 ns) signals between 10 kc and approximately 100 kc, it will not be possible using the above method, to magnify presentation sufficiently to examine rise time. It will be necessary in this case to resort to one of the trigger methods given for signals below 10 kc.

3-20. SIGNAL REPETITION RATES BELOW 10 KC. When signal repetition rate is below 10 kc, signal does not occur frequently enough to allow a full cycle

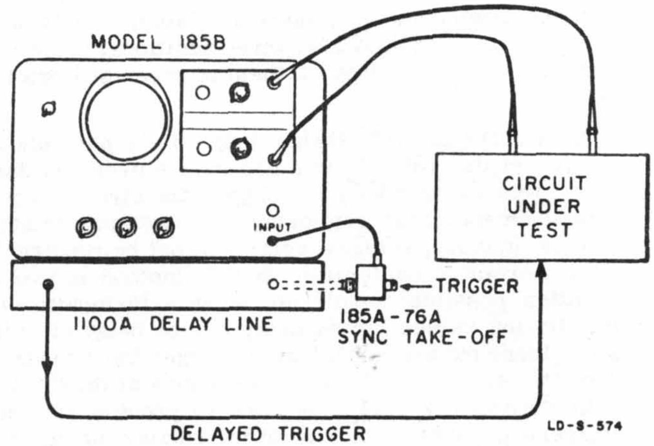


Figure 3-4. Viewing Signals Below 10 kc by Using Delayed Trigger to Drive Circuit under Test

to fall within 100 μsec window. In order to see the leading edge, then, you must trigger oscilloscope just ahead of an input pulse to allow the leading edge to fall within time window.

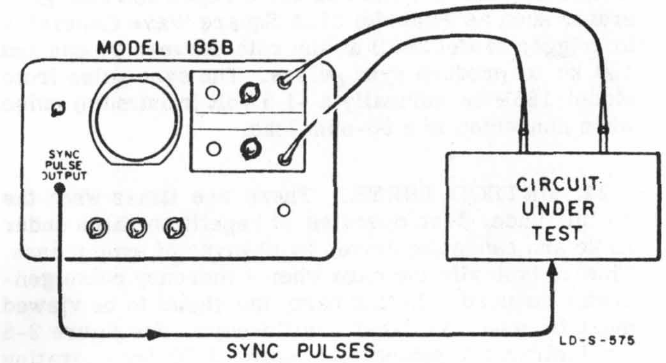


Figure 3-5. Viewing Signals Below 10 kc by Using SYNC PULSE OUT to Drive Circuit under Test

3-21. Several methods are available for synchronizing on signals under 10 kc. Generally the method used will depend on characteristics of circuit under test

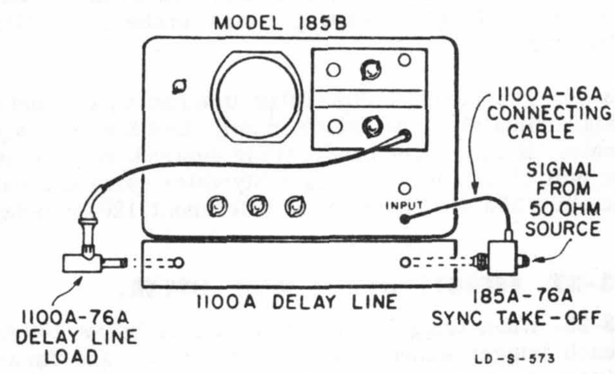


Figure 3-6. Viewing Signals Below 10 kc when the Circuit under Test Cannot be Driven by Synchronizing Pulses

and the associated equipment available. Table 3-1 and figures 3-4 to 3-6 give three additional basic instrument setups. Each of them is described briefly below:

3-22. METHOD ONE (figure 3-4). It is possible to trigger Model 185B from a separate source and then delay this same signal to trigger the circuit under measurement (if inherent delay of measured circuit is 120 ns or more, external delay will not be required). An important consideration in this method is that it is often possible to tolerate some deterioration of the driving pulses by the delay line or delay circuit, since these pulses serve only to trigger the measured circuit. As long as drive pulses arrive at the circuit with sufficiently fast rise time to provide reliable triggering, there is no loss of information on signals presented to oscilloscope.

3-23. METHOD TWO (figure 3-5). You may use the signal from SYNC PULSE OUTPUT connector to trigger circuit under test. This signal is a fast rise pulse that is suitably delayed from triggering of oscilloscope sweep. See figure 3-12 for basic operating procedures. If you cannot drive test circuit at trigger frequency (100 kc), you can use a repetition rate generator such as ⓗⓟ Model 211A Square Wave Generator to trigger Model 185B at any rate between 50 cps and 100 kc to produce sync pulses. The sync pulse from Model 185B is normally a +1.5 volt (minimum) pulse when connected to a 50-ohm load.

3-24. METHOD THREE. There are times when the circuit under test operates at repetition rates under 10 kc and cannot be driven by any type of sync pulses. This is typically the case when a mercury pulse generator is used. In this case, the signal to be viewed must be used to trigger oscilloscope. See figure 3-6 for instrument setups and figure 3-10 for operating instructions.

3-25. The signal, decreased in amplitude by any attenuation in the resistive sync probe, is fed to Model 185A-76A sync take-off where it is divided in half. Half the signal is used directly to trigger Model 185B, while the other half is delayed and fed to vertical plug-in unit. When using method three, remember that the resultant vertical calibration will be the product of SENSITIVITY setting times probe attenuation times 2.

3-26. The Model 1100A delay line has a passband of approximately 1 gc, which is sufficient for most signals. If still wider bandwidth is desired, you can use a coil of 3/4 inch or larger Styroflex cable approximately 105 feet long to provide about 120-ns delay.

3-27. EFFECTS OF FM AND JITTER.

3-28. When trigger repetition rate is below 100 kc, each trigger actuates a sampling cycle, and fm and jitter in trigger signal have no effect upon display (provided there is no jitter between trigger and signal being viewed). For trigger repetition rates between 100 kc and 100 mc, the internal hold-off circuit of Model 185B comes into play, and effects of trigger-signal fm and jitter become more severe as trigger repetition rate increases. As a general guide, the maximum fm or jitter which can be present in the trigger signal without affecting the display can be expressed as:

$$\text{Maximum \% fm} = 5/f$$

where f = trigger repetition rate in mc

The formula indicates a maximum of 5% fm for a 1-mc trigger, 0.05% fm for a 100-mc trigger.

3-29. For trigger repetition rates above 100 mc, there are two count-down circuits in series, and the situation is more complex. However, triggering should be reliable with up to 0.05% fm in the 100-200 mc region and correspondingly less fm at higher frequencies.

3-30. PULSE ANALYSIS.

3-31. OBSERVATION OF INTERMITTENT PULSES.

3-32. Due to the fact that each sample plotted on Model 185B screen represents true instantaneous signal amplitude, useful information may be obtained from signals that are not 100% periodic.

3-33. For instance, if one pulse in a pulse train is occasionally missing, that pulse will be displayed normally on the crt except that a series of dots will appear long the base line. The density of dots in the pulse relative to that in the base line will indicate the approximate percent of time that the pulse is missing. If the pulse is missing most of the time, the pulse itself will be represented by a series of dots, while the base line will be continuous. If the pulse is present 50% of the time, pulse and base line will appear the same.

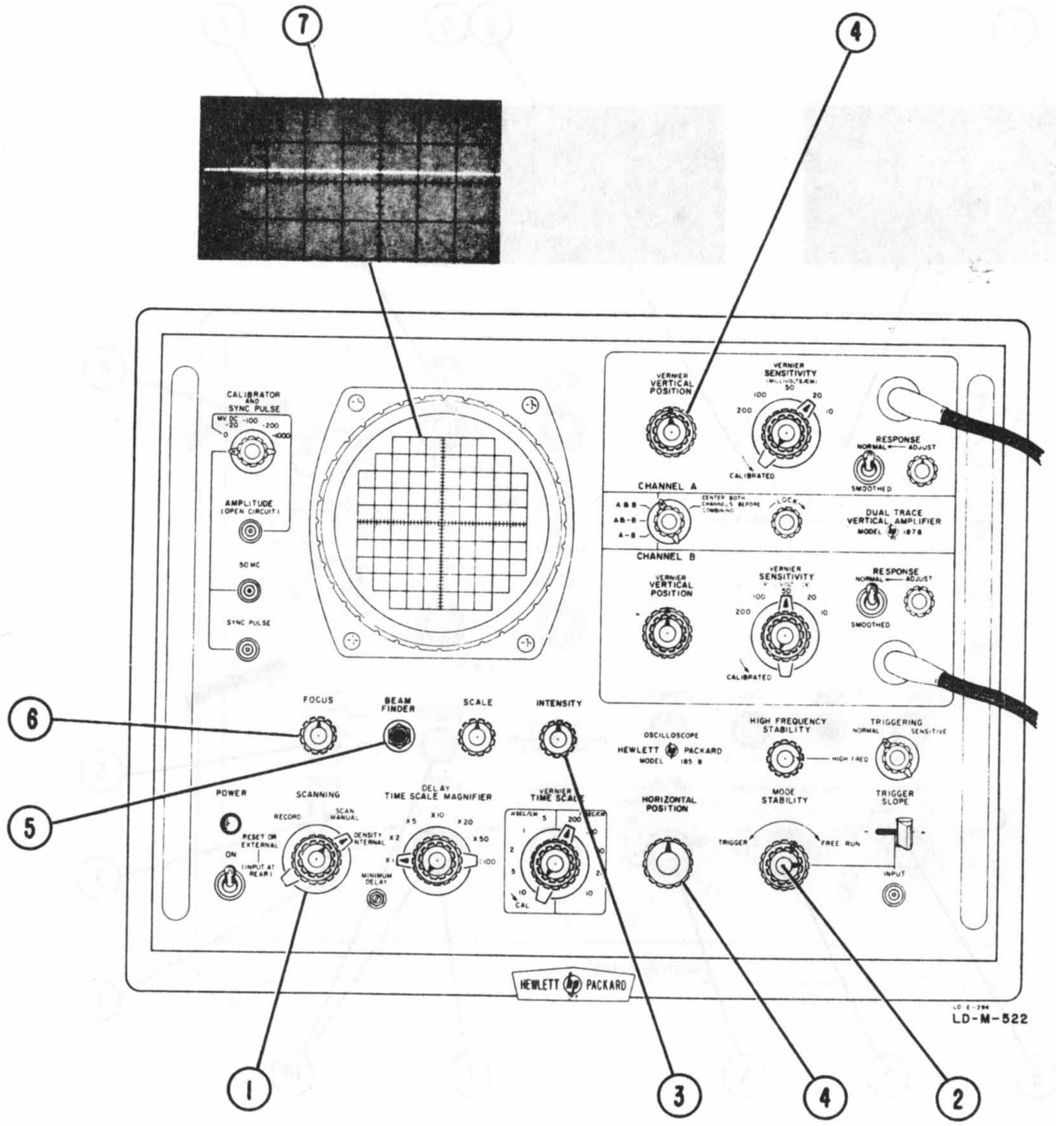
3-34. Conventional oscilloscopes indicate missing pulses by allowing base line to strike through. The brightness of wave compared to brightness of base line indicates relative frequency of occurrences. You can see that presentation in the form of relative number of dots is actually easier to interpret than an estimation of relative brightness of wave and base line.

3-35. EXAMINING PULSE IRREGULARITIES.

3-36. Figures 3-7 to 3-9 describe a method by which you may expand and examine any portion of a pulse. The horizontal axis may be expanded by a factor of 100 by setting the TIME SCALE MAGNIFIER. The vertical axis may be expanded, using the SENSITIVITY control on Model 187B, to a point where a signal that initially occupied 1/6000th of the screen may fill the entire 10 x 10 cm graticule.

3-37. OPERATING INSTRUCTIONS.

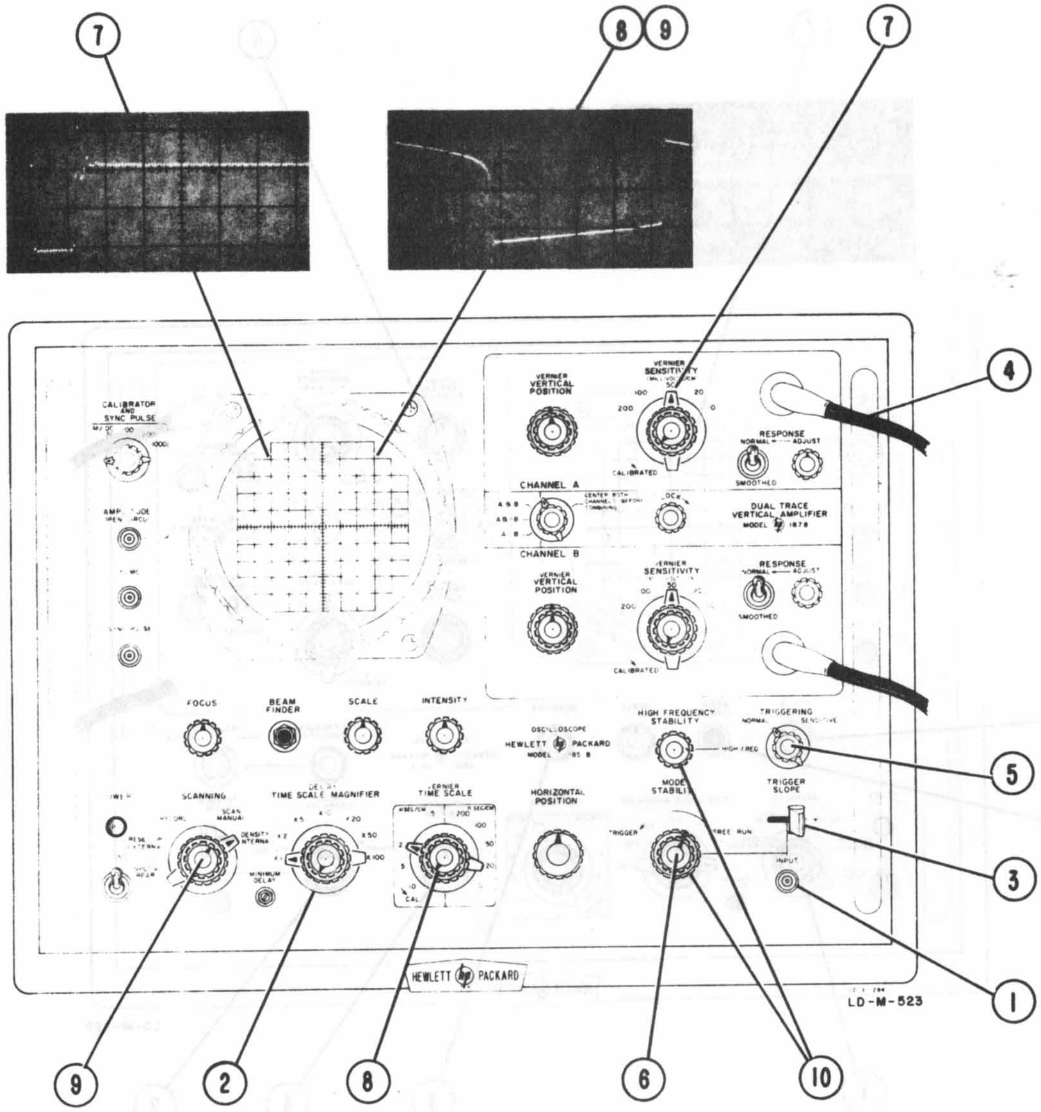
3-38. Figures 3-7 through 3-14 give step-by-step operating instructions. Each step is numbered and the control or connector to which the step refers is keyed by the same number.



(Power Switch on)

1. Set SCANNING to INTERNAL.
2. Set MODE full clockwise.
3. Set INTENSITY as desired.
4. Adjust position controls to place trace on crt.
5. If no trace is visible, press BEAM FINDER and readjust position controls as necessary.
6. Adjust FOCUS for a well-defined trace.
7. Trace should appear approximately as illustrated.

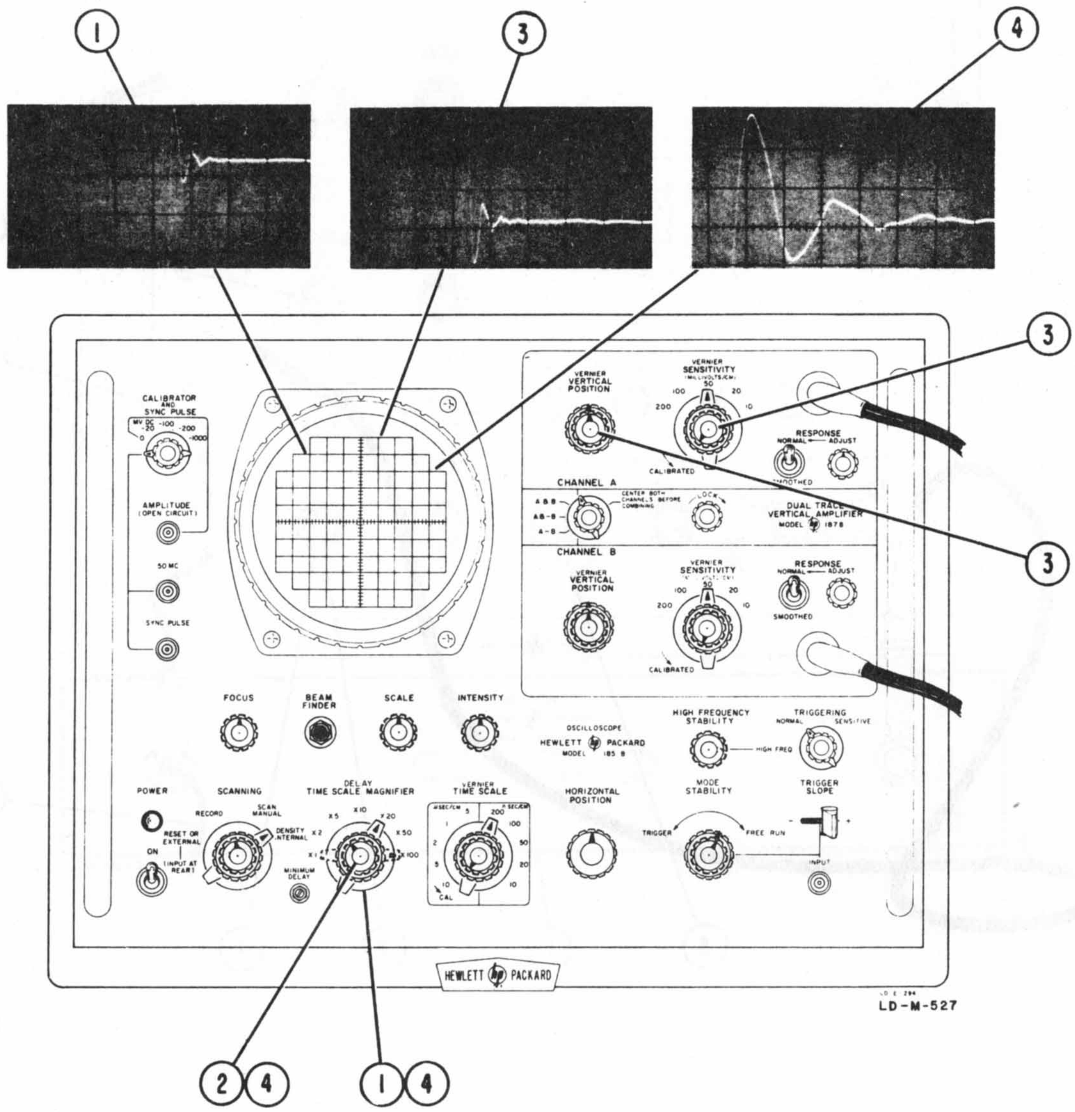
Figure 3-7. Free Running Trace



Follow instructions in figure 3-7.

1. Connect trigger signal to trigger INPUT.
2. Set TIME SCALE MAGNIFIER to X1.
3. Set TRIGGER SLOPE as appropriate.
4. Connect probe to signal to be viewed. Note: If delay is required (paragraph 3-17), refer to figure 3-10.
5. Set TRIGGERING as required, depending on trigger frequency and amplitude.
6. Set MODE as far counterclockwise as possible while maintaining reliable triggering.
7. Adjust SENSITIVITY for the desired signal amplitude.
8. Set TIME SCALE as desired (set VERNIER to CAL for calibrated time scale).
9. Set DENSITY as far clockwise as possible while maintaining minimum flicker.
10. If necessary, adjust STABILITY for stable presentation.

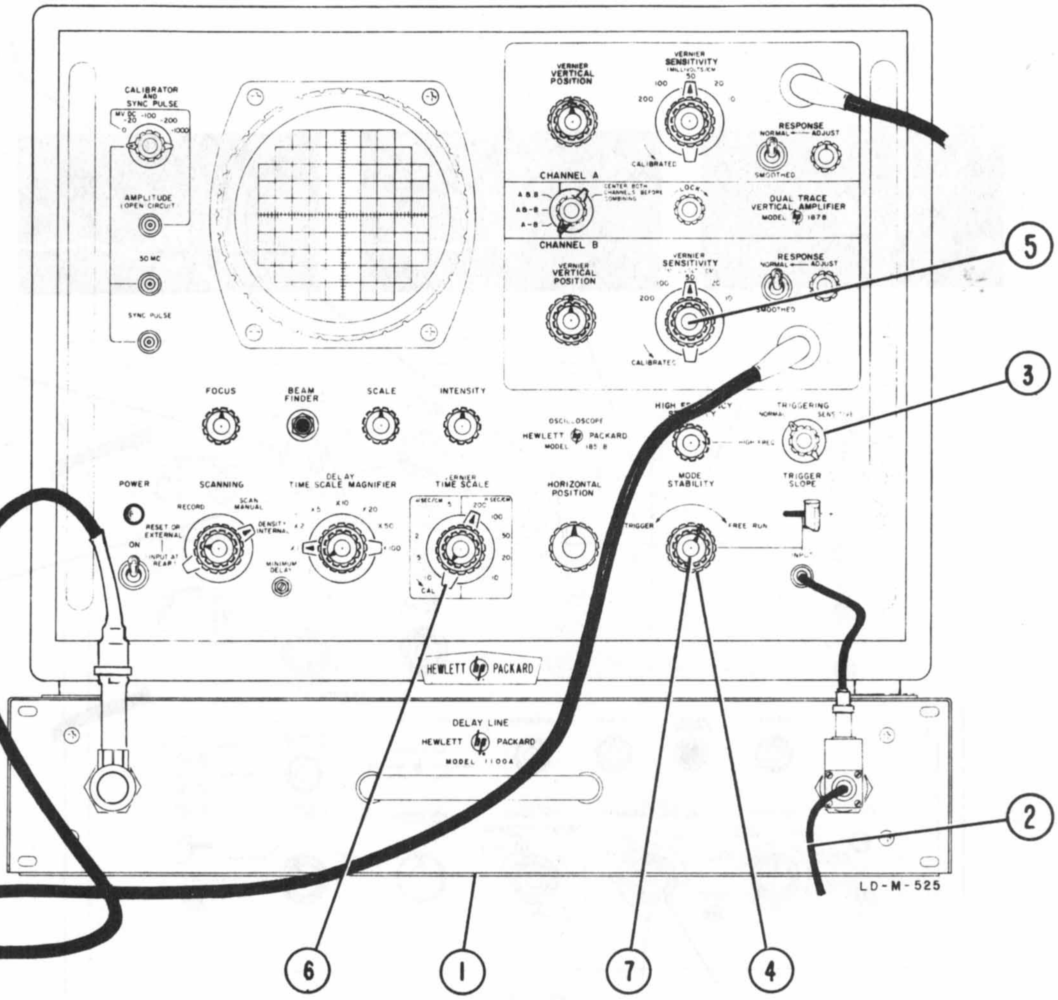
Figure 3-8. Unmagnified Trace



Follow instructions in figures 3-7 and 3-8.

1. Turn TIME SCALE MAGNIFIER clockwise about four ranges (depending on amount of magnification desired).
2. Rotate TIME SCALE MAGNIFIER and DELAY clockwise until the desired portion of the trace becomes visible. Adjust DELAY if necessary, to center the display.
3. Adjust SENSITIVITY and VERTICAL POSITION to amplify and center trace.
4. Finally, adjust TIME SCALE MAGNIFIER and DELAY to achieve desired magnification.

Figure 3-9. Magnified Trace



Follow instructions in figure 3-7.

1. Connect Model 185B to 1100A Delay Line system as illustrated above.

   Note: Be sure that system is properly terminated to prevent reflection which would result in misleading indications.

2. Connect resistive divider probe to signal to be viewed.

3. Set TRIGGERING as required depending on trigger frequency and amplitude.

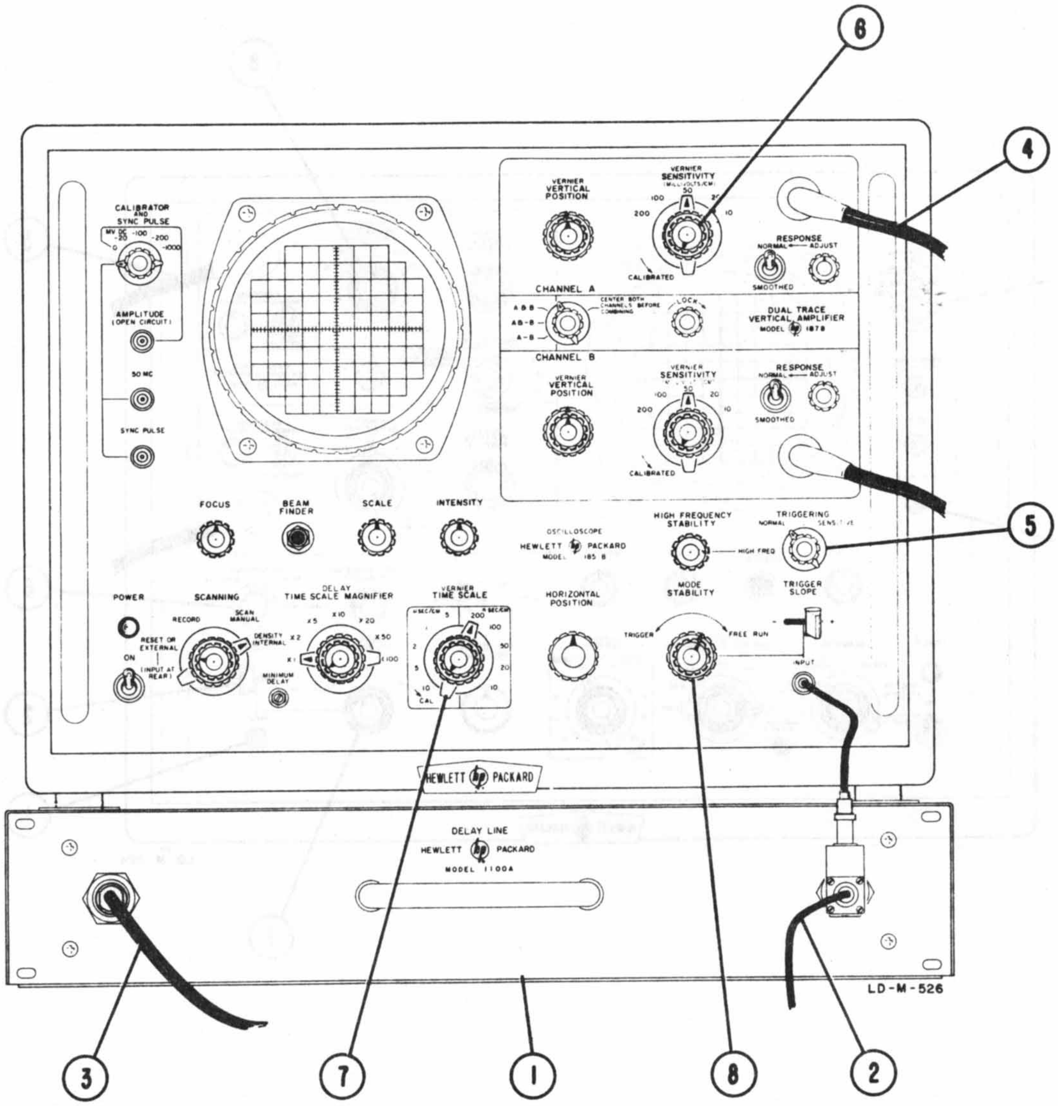
4. Set MODE as far counterclockwise as possible while maintaining reliable triggering.

5. Adjust SENSITIVITY as required. Note: Remember that signal will be attenuated by a factor of 1/2.

6. Set TIME SCALE as required.

7. Set STABILITY for stable presentation.

Figure 3-10. Viewing Delayed Signal



Follow instructions in figure 3-7.

1. Connect Model 185B to 1100A Delay Line system as illustrated above.

2. Connect input of sync take-off to trigger source.

3. Connect output of Model 1100A to test circuit to be triggered. Note: If test circuit itself has more than 120 ns delay, the delay line will not be needed.

4. Connect probe to signal to be viewed.

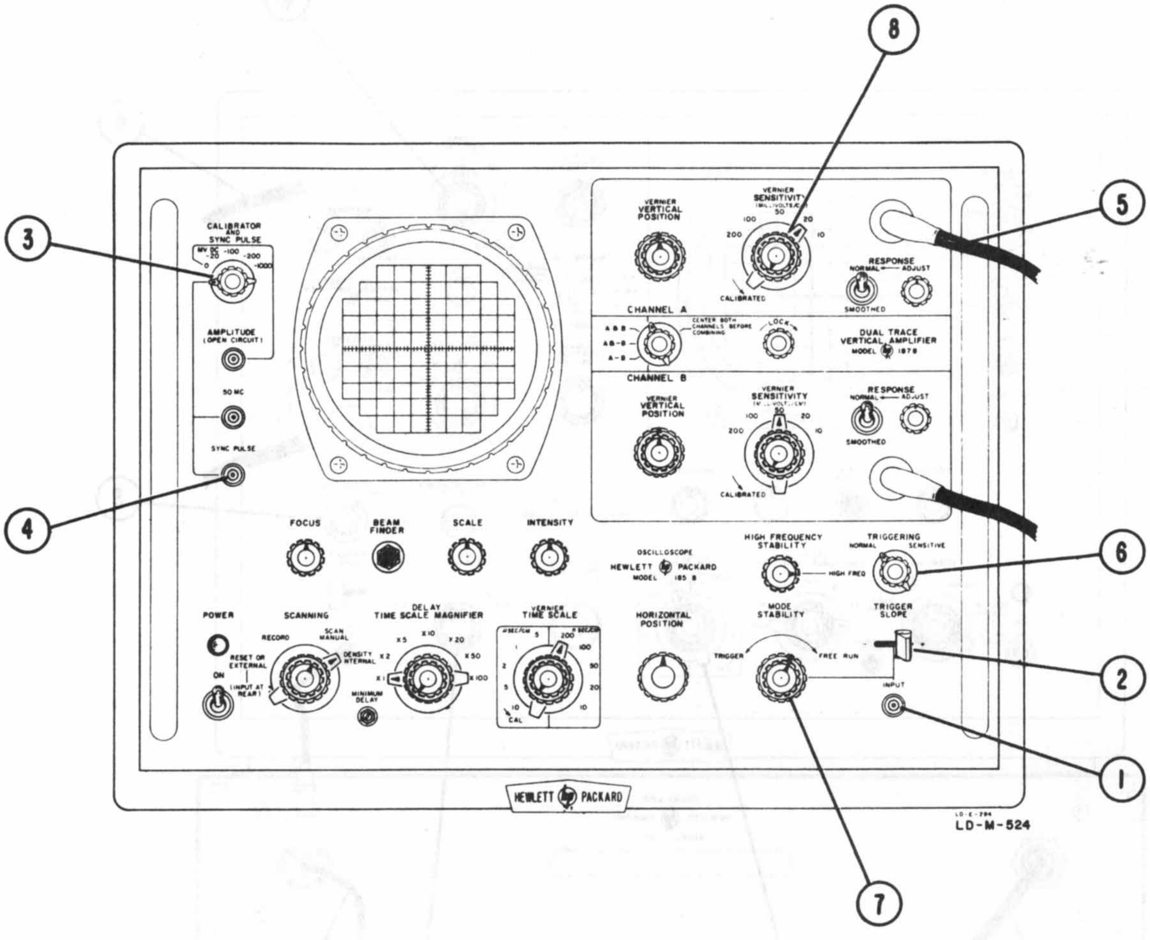
5. Set TRIGGERING as required depending on trigger frequency and amplitude.

6. Adjust SENSITIVITY as required.

7. Set TIME SCALE as required.

8. Adjust STABILITY for stable presentation.

Figure 3-11. Using Delayed Trigger



Follow instructions in figure 3-7.

1. If external triggering is desired connect trigger to INPUT.

2. Set TRIGGER SLOPE as appropriate.

3. Set CALIBRATOR AND SYNC PULSE full counterclockwise.

4. Obtain delayed sync pulse for triggering external circuit from SYNC PULSE output. Connect this pulse to trigger circuit under test.

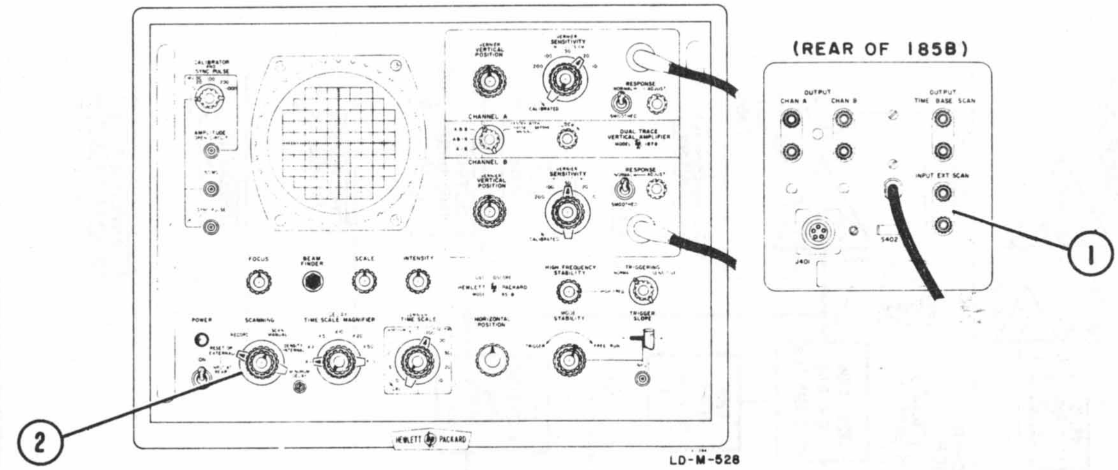
5. Connect probe to signal to be viewed.

6. If external triggering is used, set TRIGGERING as required depending on trigger frequency and amplitude.

7. If external triggering is used, set MODE as far counterclockwise as possible while maintaining reliable triggering; otherwise MODE should be full clockwise.

8. Adjust SENSITIVITY for desired signal amplitude.

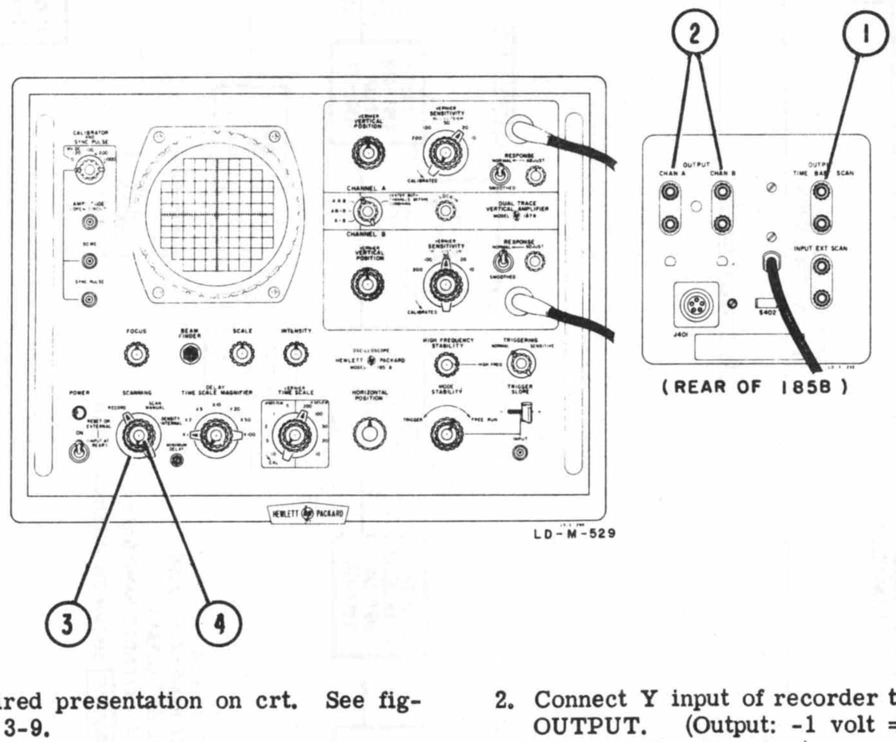
Figure 3-12. Delayed Sync Pulse



Obtain desired presentation on crt. See figures 3-7 to 3-9.

1. Connect external scanning signal to INPUT EXT SCAN. (Input: 0 volts places scan at left edge of crt; +12 volts at right edge.)
2. Set SCANNING to EXTERNAL.

Figure 3-13. External Scan



Obtain desired presentation on crt. See figures 3-7 to 3-9.

1. Connect X input of X-Y recorder to TIME BASE SCAN OUTPUT. (Output: 0 volts = left edge of crt; +12 volts = right edge.)
2. Connect Y input of recorder to CHAN A (or B) OUTPUT. (Output: -1 volt = bottom edge of crt; +1 volt = top edge.)
3. Set SCANNING to RECORD.
4. If it is desired to scan more slowly or rapidly, set SCANNING to MANUAL and scan signal with SCAN.

Figure 3-14. Recording the Signal

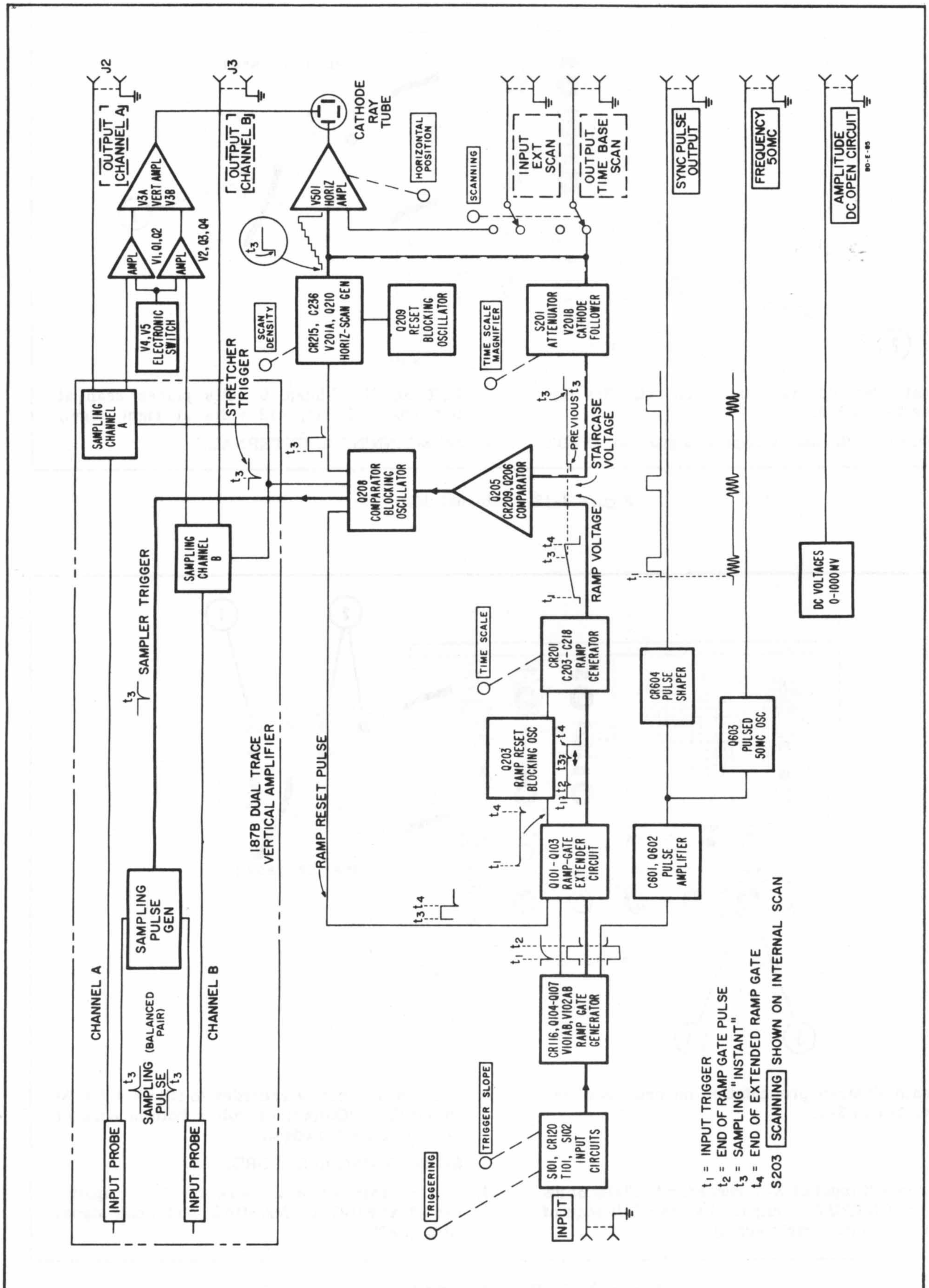


Figure 4-1. Overall Block Diagram

SECTION IV
PRINCIPLES OF OPERATION

4-1. INTRODUCTION.

4-2. GENERAL. The Model 185B oscilloscope and its vertical plug-in unit form a sampling unit for measuring fast repetitive signals. The circuit description is necessarily complex; a thorough reading of paragraphs 3-1 to 3-34 will prove helpful in understanding the information presented in this section.

4-3. This brief discussion of the relationship between the major functional groups is followed by a more detailed circuit description. An understanding of the following information should prove an aid in effectively troubleshooting Model 185B.

4-4. BLOCK DIAGRAM DESCRIPTION.

4-5. GENERAL.

4-6. Figure 4-1, a simplified block diagram of the Model 185B, shows functional relationships of each major section. For purposes of clarity in understanding the relationship between functional groups, the Model 187B Dual-Channel Vertical Amplifier has been shown as a part of figure 4-1.

4-7. INPUT CIRCUITS.

4-8. The input circuits accept the trigger signal. The controls provide for stable triggering from signals of various frequencies and amplitudes. The trigger circuits also select whether triggering will be on the positive or negative slope of the input signal.

4-9. RAMP-GATE GENERATOR.

4-10. RAMP GATE PULSE. The ramp-gate generator produces the basic timing pulse for Model 185B time base circuits (ramp generator, comparator and comparator blocking oscillator, and horizontal-scan generator). Usually the ramp-gate generator is energized by input trigger signal; however, it may be free run for certain applications. Maximum repetition rate for basic timing pulse is 100 kc for time scales 200 nsec/cm and faster, but decreases in proportion to selected time scale for time scales slower than 200 nsec/cm, becoming about 5 kc at 10 μsec/cm. Thus when trigger repetition rate is less than maximum timing pulse rate, one timing pulse is generated for each trigger pulse; when trigger repetition rate exceeds maximum timing pulse rate, trigger signal is counted down. In all cases, basic timing pulse (ramp-gate pulse) maintains a strict time relationship to input trigger frequency or to some submultiple of input trigger frequency.

4-11. USES OF RAMP-GATE PULSE. The ramp-gate pulse has four functions: 1) it initiates a ramp voltage in time-base circuits, 2) it is used in a feedback network to complete its own cycle (this feedback is not shown in figure 4-1), 3) it triggers the ramp-gate extender circuits, 4) it initiates delayed sync pulse and calibrator signals.

4-12. RAMP-GATE EXTENDER AND GENERATOR CIRCUIT. The ramp-gate extender circuit increases the duration of ramp-gate pulse, producing an extended pulse whose duration is dependent on time between input trigger, t_1, and moment just after sampling, t_4. Triggered by the ramp-gate pulse and under control of ramp-gate extender circuit (for TIME SCALE settings slower than 100 nsec/cm), the ramp generator produces a linearly-rising voltage whose slope is dependent on setting of TIME SCALE switch. This ramp voltage is fed to the comparator.

4-13. TIME-BASE CIRCUITS.

4-14. COMPARATOR. In the comparator circuit, the ramp voltage is compared to horizontal-scan voltage (a step level in staircase voltage generated by the horizontal-scan generator when SCANNING is at INTERNAL). When ramp voltage reaches coincidence with horizontal-scan voltage at time t_3, the comparator produces a pulse which triggers the comparator blocking oscillator.

4-15. COMPARATOR BLOCKING OSCILLATOR. At time t_3, the comparator blocking oscillator produces four pulses: two (the sampler trigger and stretcher trigger) initiate sampling action of plug-in, the third is used in horizontal-scan (staircase) generator, and the fourth is used to initiate the termination of ramp voltage.

4-16. HORIZONTAL-SCAN GENERATOR. The output of the horizontal-scan generator is applied to both the horizontal amplifier and, through TIME SCALE MAGNIFIER switch, to the comparator. The mode of horizontal operation is determined by the setting of SCANNING switch S203. There are four modes of operation:

a. INTERNAL: the scan voltage is derived from staircase-voltage generator. The beam is swept across crt and appears as a series of discrete points.

b. MANUAL: the scan voltage is derived by positioning potentiometer R255A (figure 5-17) which is brought out to front panel as SCAN control. The display appears as a spot which can be horizontally positioned at will by means of the SCAN control.

c. RECORD: the scan voltage is derived from charging voltage across capacitor C240. The beam is swept slowly across face of tube. (The horizontal output may be taken from OUTPUT TIME BASE SCAN connector J202, and vertical output from OUTPUT CHANNEL A connector J2 or OUTPUT CHANNEL B connector J3.)

d. RESET OR EXTERNAL: the scan voltage is derived from an external source, applied through INPUT EXT SCAN connector J201. The RESET OR EXTERNAL position also is used to reset trace when Model 185B is used on RECORD.

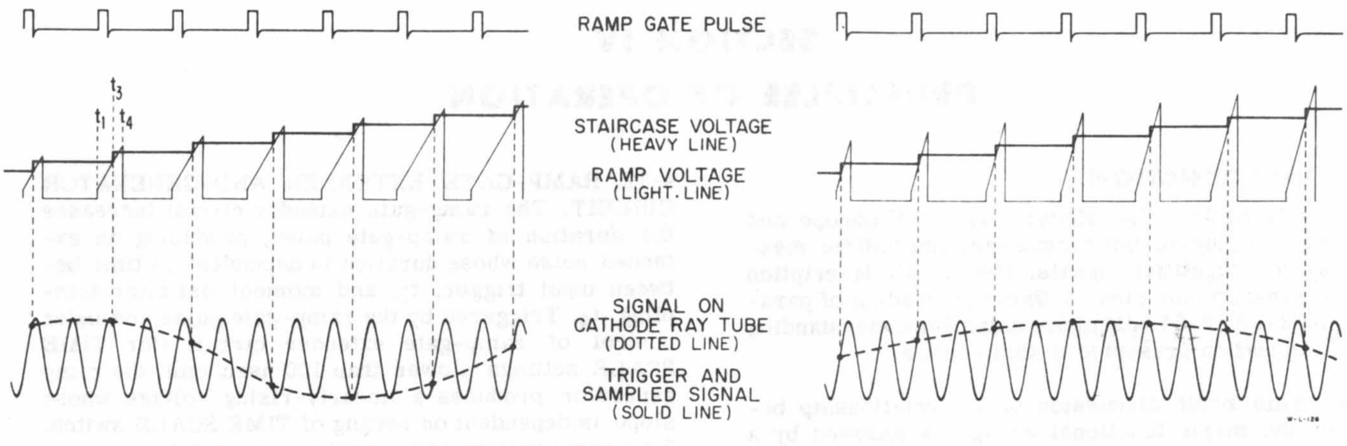


Figure 4-2. Time-Base Determination

4-17. CALIBRATOR.

4-18. The calibrator is made up of three circuits:

a. A pulse amplifier and pulse extender-shaper: a pulse from the ramp-gate blocking oscillator is amplified, extended, and shaped to a fast-rise pulse which is made available at SYNC PULSE OUTPUT connector. There is approximately a 120-nsec delay between signal applied to front panel TRIGGERING INPUT and signal available at SYNC PULSE OUTPUT.

b. A pulsed 50-mc oscillator: this circuit, triggered by amplified ramp-gate pulse, puts out a 50-mc sine wave for the duration of sync pulse.

c. A dc voltage divider: this circuit provides voltages from 0 volts dc to 1000 millivolts dc, the level depending on setting of CALIBRATOR AND SYNC PULSE switch.

4-19. VERTICAL AMPLIFIER AND ELECTRONIC SWITCH.

4-20. The vertical amplifier amplifies signal from vertical plug-in unit, and applies amplified signal to vertical deflection plates of cathode-ray tube (crt). The electronic switch provides switching action necessary for dual-trace operation of plug-in unit.

4-21. HORIZONTAL AMPLIFIER.

4-22. The horizontal amplifier amplifies the particular horizontal drive signal that has been selected by setting of SCANNING switch and applies it to horizontal deflection plates of the crt.

4-23. TIME-BASE DETERMINATION.

4-24. At this point, it should be emphasized that the actual speed of the horizontal beam across the face of the cathode-ray tube has no relation to the time base in sec/cm. The time base of Model 185B is dependent entirely upon time advance, between successive samples, as compared to some horizontal deflection voltage to the crt. In Model 185B two methods are used to vary this time advance: 1) by varying slope of ramp signal (TIME SCALE control), and 2) by varying amplitude of horizontal-scan voltage to comparator in relation to horizontal-scan voltage to horizontal amplifier (this ratio is determined by setting of TIME SCALE MAGNIFIER control).

4-25. Figure 4-2 shows the effect of varying TIME SCALE control (varying slope of ramp signal). Note that as slope decreases, more time elapses between ramp-gate pulse, t_1 and the time of voltage coincidence between ramp and horizontal-scan voltage, t_3 (t_3 = time at which input signal is sampled). The result is that a greater part of the input signal is covered between successive samples, giving more cycles per centimeter to the viewer. After basic operation of Model 185B is discussed, time-base determination will be discussed in more detail.

4-26. TUNNEL DIODE OPERATION.

4-27. GENERAL. Before detailed explanation of circuit operation is attempted, there will be a discussion of the operation of tunnel diodes in Model 185B triggering and time-base circuits. Tunnel diodes in the triggering and time-base circuits have two basic modes of operation: 1) free running (astable), where the diode oscillates at a frequency determined by associated circuitry, and 2) bistable, where the diode is triggered into one state where it stays until triggered back to the original state.

4-28. ASTABLE OPERATION. Figure 4-3A shows a typical circuit consisting of a low-voltage source which supplies bias current to the tunnel diode through an inductor which acts as a constant current source during switching times.

a. The external load is shown as R1; the diode junction capacity and stray capacity are indicated as a capacitor across the diode (the total of this capacity will be termed diode junction capacity in the following discussion). The diode is biased at point C on the E-I curve in figure 4-3A.

b. When power is applied to the circuit, current flows through the inductor and diode, in series, and diode voltage will rise from the origin toward point C, its operating point. As diode voltages passes point B on the knee of the E-I curve, the diode enters its negative resistance region and diode current begins to decrease. However, the energy stored in the inductor's magnetic field prevents its current from

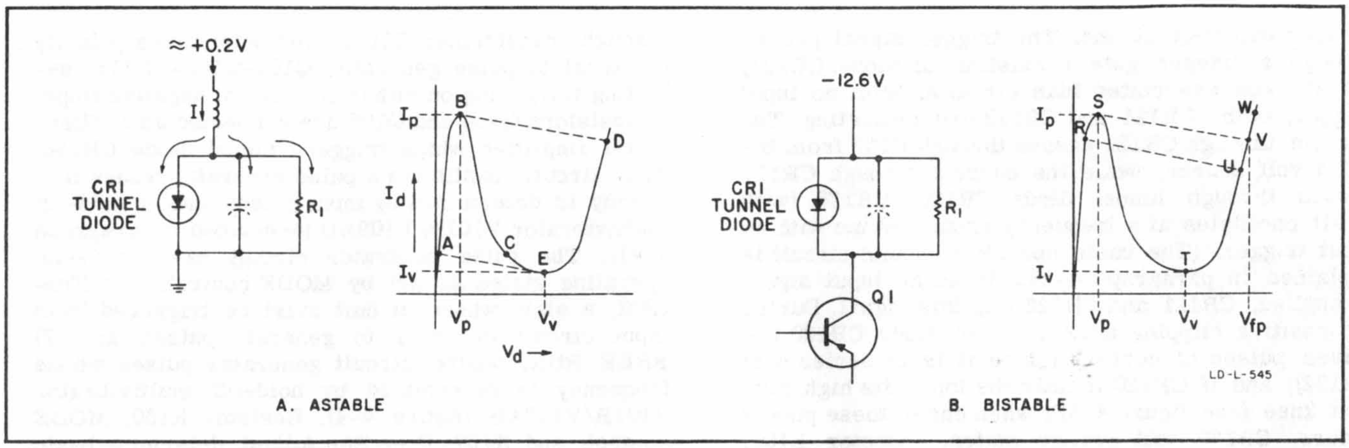


Figure 4-3. Tunnel-Diode Operation

decreasing, so the current difference between diode current and inductor current flows into diode junction capacity. Since diode junction capacitance is small, this difference current causes a sharp voltage rise across the junction capacity and hence across the diode. This voltage rises rapidly to point D on the E-I curve. At point D, diode conduction current equals the current supplied from the constant-current source, and so the voltage stops rising. At this time the voltage across the diode exceeds the supply voltage. Since current through the inductor is constant only during switching, current starts to decrease, and diode voltage starts to fall toward operating point C. When diode voltage reaches point E, tunnel diode CR1 again enters its negative resistance region. Inductor current is again held constant, and diode junction capacity is forced to discharge to point A. The process now begins over again.

c. For a large value of load resistance, pulse rise time (time BD) is determined by diode junction capacitance and peak current. Pulse width (time DE) and hold-off time (time AB) are determined by the inductor, diode resistance, and power source resistance. Assuming the inductor acts as a constant current source for the times involved, the size of the load resistance determines the slope of lines BD and EA.

4-29. BISTABLE OPERATION. Figure 4-3B shows a bistable circuit of the type used in Model 185B triggering circuit. In this case there is a PNP transistor with tunnel diode CR1 as part of its collector load. CR1 is biased at point R on the E-I curve, and is stable at this point. If a positive pulse is fed to the emitter of Q1 (or a negative pulse to the base), the current through Q1, and hence the tunnel diode current, will increase. As the current passes the high current knee of the curve, the tunnel diode enters its negative resistance region. Diode current therefore begins to decrease. Transistor Q1 acts as the constant current source, however, and prevents current from decreasing; the current difference flows into the junction capacity. As a result, diode voltage rises rapidly to point V, then when the input pulse falls again to zero, diode voltage falls to U where it remains until a negative reset pulse causes the current to drop below I_V.

4-30. The circuit described in paragraph 4-29 can be made monostable by increasing transistor current to a point where the tunnel diode is always receiving a current greater than its peak current. In this case, CR1 is stable at point W on the curve shown in figure 4-3B. Momentarily reducing tunnel diode current to less than that shown at point T in figure 4-3B will cause the tunnel diode to go through a cycle from T to R to S to V to W. The circuit will remain at point W until triggered by another pulse.

4-31. TRIGGERING CIRCUITS.

4-32. GENERAL.

4-33. The following discussion deals primarily with the synchronizing circuits in Model 185B. Unless otherwise noted, all reference to "signal" in the following circuit explanation will refer to the triggering pulse under discussion rather than the signal to be viewed. All reference to horizontal-scan voltage to the crt refers to the voltage at the input to the horizontal amplifier. Refer to the schematic diagram, figure 5-13 and figure 4-4 in the following discussion.

4-34. TRIGGER INPUT.

4-35. The trigger signal is connected to TRIGGERING INPUT connector J101. TRIGGERING switch S101 is adjusted to one of three positions, depending on frequency and amplitude of input trigger.

a. SENSITIVE: for small amplitude trigger signals (less than 150 mv) below 100 mc. In this position of TRIGGERING the input trigger is passed to the ramp gate generator.

b. NORMAL: for trigger signals of amplitude greater than 150 mv and frequency below 100 mc. In this position of TRIGGERING the input trigger passes through a 20-db attenuator consisting of R158, R159 before being passed to the ramp-gate generator.

c. HIGH FREQ: for trigger signals above 100 mc. In this position of TRIGGERING, trigger is applied to a count-down circuit before being passed to ramp-gate generator. A free-running tunnel diode oscillator consisting of diode CR120, inductor L101, and low-impedance bias voltage source R155, R156 (figure 4-5A) is used to count down the input frequency to approximately 10 mc. The trigger signal passes through a trigger gate consisting of diode CR121, CR122, and associated bias circuits. With no input trigger, both CR121 and CR122 are conducting. The current through CR121 passes through R152 from the +12.6 volt source, while the current through CR122 passes through tunnel diode CR120. CR120 (with L101) oscillates at a frequency around 10 mc with no input trigger. (The basic operation of this circuit is explained in paragraph 4-26.) When an input signal is applied, CR121 and CR122 clip this signal. During the positive clipping action, tunnel diode CR120 receives pulses of current (since it is in series with CR122), and if CR120 is near the top of its high current knee (see figure 4-5B) when one of these pulses occurs, CR120 will change states. Inductor L101, HIGH FREQUENCY STABILITY, adjusts frequency of CR120-L101 oscillator relative to input frequency so that an input pulse will always maintain the same time relationship to the oscillator. The result consists of count-down circuit output pulses with a frequency near 10 mc, but synchronized with input signal.

4-36. RAMP-GATE GENERATOR CIRCUITS.

4-37. PULSE GENERATOR. The output of trigger mode selected is fed to TRIGGER SLOPE switch S102 through transformer T101. S102 determines polarity of signal to pulse generator Q104-Q105-CR116, selecting triggering on either positive or negative slope. Transistors Q104 and Q105 are connected as a differential amplifier which triggers tunnel diode CR116. This circuit constitutes a pulse generator whose frequency is determined by input pulses and/or hold-off multivibrator V101B/V102AB (described in paragraph 4-41). The pulse generator circuit has two basic operating states as set by MODE control: 1) TRIGGER, a state where circuit must be triggered from input circuit in order to generate pulses, and 2) FREE RUN, where circuit generates pulses whose frequency is determined by hold-off multivibrator V101B/V102AB (figure 4-4). Resistor R160, MODE control, and R157, Free Run Adjust, determine basic operating state by adjusting current through Q104 which furnishes tunnel diode bias current; this is equivalent to adjusting point R, figure 4-3B.

4-38. The circuit operates as follows (assuming MODE is set so that circuit must be triggered): Input trigger signal is applied to T101. If TRIGGER SLOPE switch S102 is in the + position, signal will be fed through T101 primary (since T101 secondary is shorted, primary presents a very low impedance to signal) to base of Q105. If S102 is set in the - position,

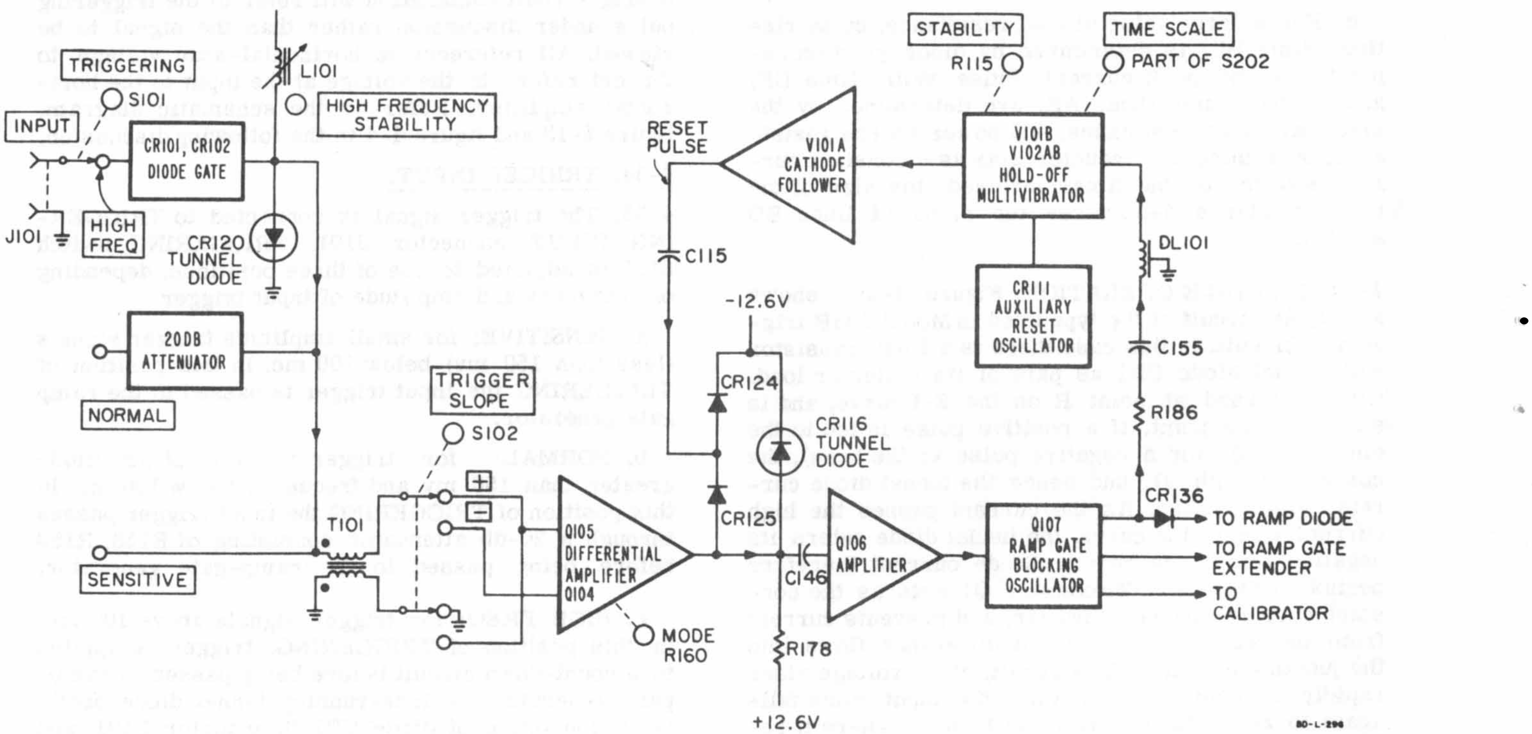


Figure 4-4. Triggering-Circuit Block Diagram

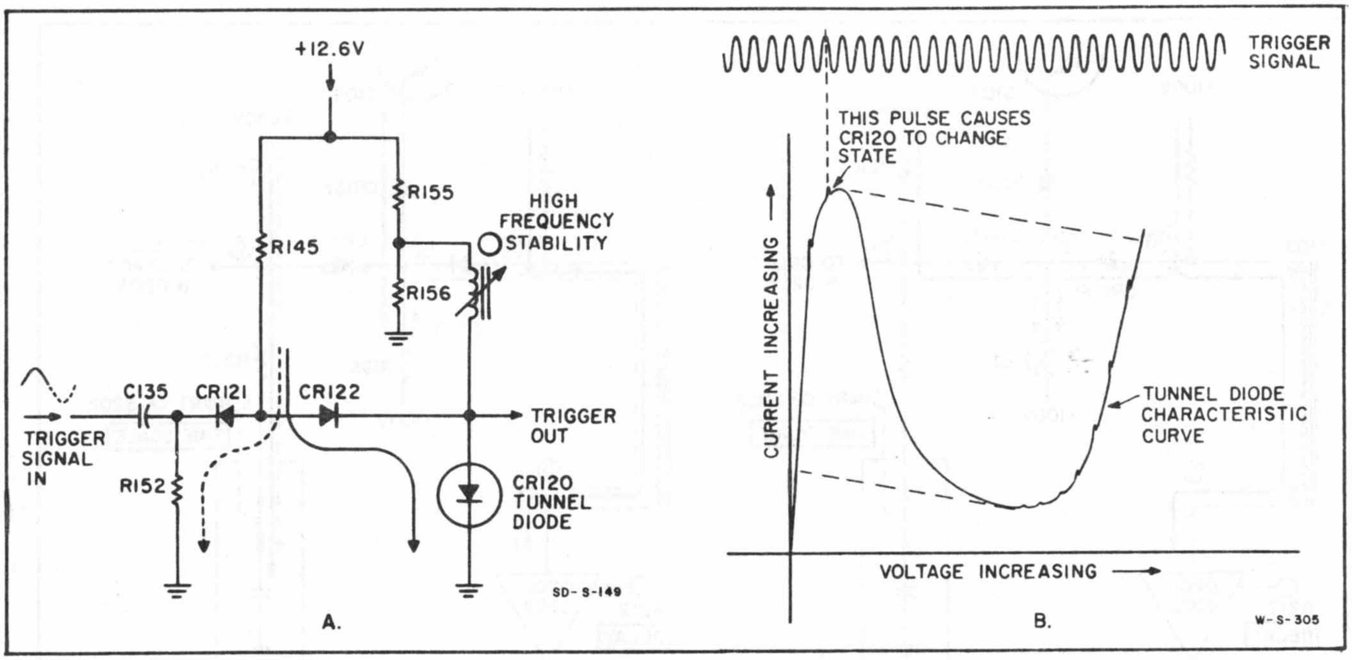


Figure 4-5. Tunnel-Diode Count-Down Circuit

operation depends on frequency of trigger signal. For high frequencies, signal is coupled through T101 to base of Q105. For low frequencies T101 becomes ineffective and signal is applied to base of Q104. In any case, this circuit must have either a positive pulse to base of Q105 or a negative pulse to base of Q104 to actuate triggering circuits.

4-39. If a positive pulse is applied to the base of Q105, its emitter becomes more positive. The resulting positive pulse is coupled to Q104 via common emitter coupling capacitor, C145. The increased positive voltage at emitter of Q104 increases conduction in that element. When Q104 current increases to I_p (figure 4-3B), tunnel diode CR116 switches to its high-voltage stable state (see paragraph 4-29), where it remains until reset by a pulse from hold-off multivibrator (paragraph 4-41). (Any further trigger pulses occurring before reset will have no effect on CR116.) The result is a positive voltage step which is differentiated by C146 and R178, amplified and inverted by Q106, and fed to ramp-gate blocking oscillator Q107 through CR131. CR131 limits signal at the base of Q107 to negative pulses.

4-40. RAMP-GATE BLOCKING OSCILLATOR. Transistor Q107 produces a typical blocking-oscillator pulse of about 1.5 μsec duration. This is the ramp-gate pulse and it has four functions:

a. To supply a gating signal to ramp-gate diode.

b. To supply trigger signal to ramp-gate extender circuit.

c. To provide trigger signal to calibrator.

d. To generate a reset pulse for tunnel diode CR116 in pulse generator circuit. This reset pulse completes cycle by which ramp-gate pulse is produced. In order to simplify the following discussion, generation of the reset pulse will be discussed first.

4-41. HOLD-OFF MULTIVIBRATOR. The ramp-gate pulse coupled by T103 is differentiated by C155 and R186, then delayed 1 μsec by DL101. The pulse is then fed through CR107 where the negative spike is clipped off and the positive spike is applied to the hold-off multivibrator (V101B/V102AB). With a positive spike on its grid, V102B conducts, cutting off V101B. Hold-off multivibrator V101B/V102B remains in this state until after sample has been taken and all circuits have had time to recover. The exact hold-off time is determined by setting of TIME SCALE switch S202 and by setting of STABILITY control.

4-42. When V101B/V102B switch back to their former states (V101B conducting, V102B cut off), the resulting negative voltage, coupled by capacitor C115, back-biases diode CR124 and forward-biases CR125. In this condition of the circuit, capacitor C115 now effectively in parallel with tunnel diode CR116, diverts current from the diode. Current through the diode drops below I_v (figure 4-3B) momentarily, returning CR116 to its low-voltage stable point where it remains until another input trigger is received.

4-43. There is a possibility that CR116 may not be reset to the low-voltage state when Model 185B is turned on. Also, under large signal conditions the reset pulse may be overcome by a large trigger. For these reasons, an auxiliary reset oscillator that assures resetting of CR116 to the low-voltage state is included in the triggering circuit.

4-44. Basically, the auxiliary reset oscillator circuit consists of a voltage-sensitive switch (four-layer diode CR111) with a small load, R135, that is capacitively coupled by C126 across the diode. Resistor R134 and the -100 volt supply constitute a current source for the circuit.

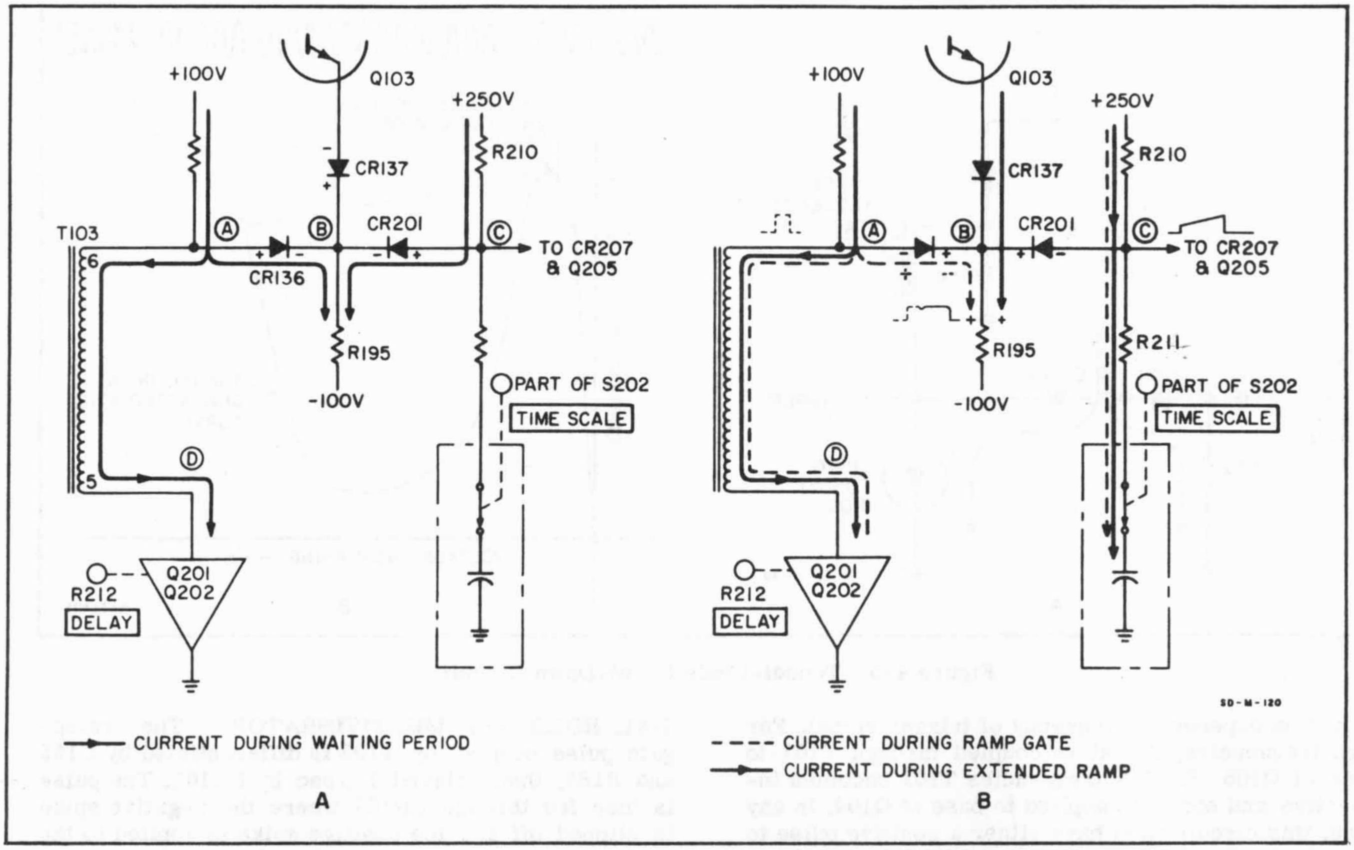


Figure 4-6. Ramp Generator

4-45. When Model 185B is turned on, C126 charges through R134. When voltage across C126, and therefore across the diode, reaches about 20 volts, CR111 conducts and quickly discharges C126. The circuit delivers a 20-volt pulse 2 μ seconds wide about once a second which is used to trigger hold-off multivibrator V101B/V102AB.

4-46. RAMP-GATE EXTENDER AND GENERATOR CIRCUITS.

4-47. The ramp-gate pulse is also used to trigger the ramp-gate extender circuit. Before this circuit is discussed, however, we should understand the various dc currents that flow in the T103 secondary circuit.

4-48. Figure 4-6 shows dc current paths during all phases of Model 185B operation. During the waiting period (after end of last sample and before occurrence of next trigger), current (figure 4-6A) flows from +100 volt and +250 volt sources into both delay reference-voltage source (Q201-Q202) and -100 volt supply. Since diodes CR136 and CR201 are conducting, points A, B, C, and D are all at the same potential (disregarding forward potential of the diodes). The voltage (point C) at which ramp starts is set by low-impedance reference-voltage source Q201-Q202, and DELAY control R212 adjusts bias on Q201-Q202. Adjusting DELAY control R212 therefore sets voltage at points A, B, C, and D. How this voltage affects the operation of ramp-gate extender and ramp-voltage generator circuits is discussed below.

4-49. Transistors Q101 and Q102 constitute ramp-gate extender multivibrator. This circuit is a monostable multivibrator with a period of approximately 500 ms; however, in actual operation its period is determined by length of time between input trigger and moment of sampling.

4-50. When ramp-gate pulse occurs, the resulting negative-going pulse from pin 7 of T103 causes Q102 to go to cutoff, forcing Q101 into conduction. When Q102 cuts off, its collector becomes more positive, increasing conduction in Q103, causing emitter of Q103, and therefore the anode of diode CR137 to become more positive.

4-51. At the same time, the positive-going ramp gate pulse at pin 6 of T103 (see paragraph 4-40, step b) causes the voltage at A and therefore at B (figure 4-6B) to become positive. (The cathode and anode of CR137 now are at very nearly the same potential.) Diode CR201, suddenly back-biased, cuts off, depriving point C of its path to -100 volts. When this happens, +250 volts and R210 form a current source for a capacitor in the TIME SCALE switch. The result is that the capacitor in the TIME SCALE switch begins to charge up toward +250 volts through R210 and R211, and the level at point C starts to rise. This rising voltage is the ramp signal.

Note

The ramp signal makes an initial jump at the outset due to the initial drop across R211 (see waveform at C, figure 4-6B). The starting voltage of the ramp signal depends on the output of delay reference-voltage generator Q201-Q202.

4-52. Meanwhile, the 1.5μsec ramp-gate pulse begins to decay. The ramp voltage at C, however, must continue to rise until after a sample of the input signal has been taken. Since the ramp must be as long as the longest time scale, for time scales longer than 100 μsec/cm the ramp-gate pulse must be extended. The circuit accomplishes this "extension" as follows: When ramp-gate signal at A drops to a more negative value than the anode of CR137, CR137 begins conduction, and the Q103 emitter voltage is coupled to point B. However, until ramp-gate extender multivibrator changes state, heavily-conducting Q103 will maintain a positive bias at point B, maintaining the back bias on CR201. (The ramp-gate extender multivibrator does not change state until, after the moment of sampling, the ramp reset pulse from comparator blocking oscillator Q208-T203 reaches the base of transistor Q101. The trailing edge of the ramp reset pulse causes transistor Q101 to cut off, biasing Q102 into conduction, which changes conduction through Q103.)

4-53. When the ramp-gate extender multivibrator changes state it does two things simultaneously: 1) It sends a pulse to trigger reset blocking oscillator Q203. The reset blocking oscillator then fires, discharging the capacitor in TIME SCALE switch, terminating the ramp. 2) It causes emitter of Q103 to go more negative, back-biasing CR137. The junction of CR201 and R195, deprived now of positive voltage through CR137, returns to a level determined by the setting of DELAY, and conduction begins again through CR201. The circuit is now at its "waiting period", where it remains until triggered again by the ramp-gate pulse from the ramp-gate blocking oscillator.

4-54. TIME-BASE CIRCUITS.

4-55. Up to this point we have discussed a pulse circuit that resets itself (the ramp-gate pulse generator), a circuit for extending this pulse and generating a linearly rising ramp voltage whose starting voltage may be varied by adjusting a control (DELAY) on the front panel. We will now discuss this ramp voltage and how it is compared with the horizontal-scan voltage to produce a gating (sampler) trigger for the vertical plug-in unit. Refer to figure 4-7 and figure 5-17 (schematic diagram) in the following discussion.

4-56. COMPARATOR.

4-57. THE RAMP. To understand the method of achieving changes in time base, it is essential to understand the ramp and its relation to the comparator and horizontal-scan circuits. Figure 4-8 shows the ramp voltage reaching coincidence with a dc horizontal-scan voltage at time t_3.

4-58. Referring to figure 4-8, if we call the start of the ramp t_1, then any voltage along the ramp can be assigned a time value, depending on how long it takes the ramp to reach that voltage. From this, then we can see that any voltage along a ramp of given slope corresponds to a specific time value.

4-59. Now to pick out a point in time along the ramp requires some kind of voltage-sensitive device. The comparator is just this. A voltage which corresponds to the desired point in time is fed to one side of the comparator, and when the ramp reaches that voltage (coincidence), the comparator fires. The resulting signal triggers the sequence which causes a sample of the input signal to be taken. In Model 185B, the voltage which corresponds to the desired point in time is the horizontal-scan voltage.

4-60. Note in figure 4-8, that when the ramp slope is steepened (dotted line) coincidence occurs sooner; that is, less time elapses between the start of the ramp (trigger time) and coincidence (sampling time). The cumulative effect of steepening the ramp is shown in figure 4-2. The relationship of the horizontal scan to the comparator circuit and the ramp is covered more thoroughly in paragraph 4-66.

4-61. COMPARATOR. The comparator is essentially a differential amplifier with a tunnel diode in series with its collector circuit. Any time the base voltage of Q205 exceeds the base voltage of Q206, which is the condition under which coincidence occurs, the comparator produces a voltage step having a very fast rise time. As soon as the base of Q205 again goes negative with respect to the Q206 base, the step is terminated. The duration of the resultant pulse is dependent on the length of time the base voltage of Q205 exceeds the base voltage of Q206; in other words, the resultant pulse lasts until the ramp is reset. The circuit operates as follows:

4-62. The particular horizontal-scan voltage being used, or a voltage proportional to the horizontal-scan voltage in use, is always present on the Q206 base. This Q206 base voltage, then is proportional to the horizontal position of the spot on the crt. For purposes of this explanation, assume the spot is on the extreme left of the crt about to start a sweep.

4-63. The horizontal-scan voltage for the comparator is brought through an attenuator, TIME SCALE MAGNIFIER switch S201. With DELAY set full counterclockwise and TIME SCALE MAGNIFIER set to X1 (the no attenuation setting), the voltage at the base of Q206 is approximately 0 volts, while its emitter(and therefore the emitter of Q205) is slightly more negative. Before generation of the ramp voltage, however, the base of Q205 is held at approximately -0.9 volts by delay reference-voltage generator Q201, Q202, and CR207. Negligible current flows through Q205 at this time, and no current flows through tunnel diode CR209.

4-64. When the ramp-gate pulse occurs, the ramp takes its initial voltage step, and the voltage on the Q205 base rises to -0.2 volt. After the initial spurt, the ramp voltage on the base of Q205 rises linearly until the Q205 base voltage exceeds the base voltage of Q206, and Q205 conducts. Conduction of Q205

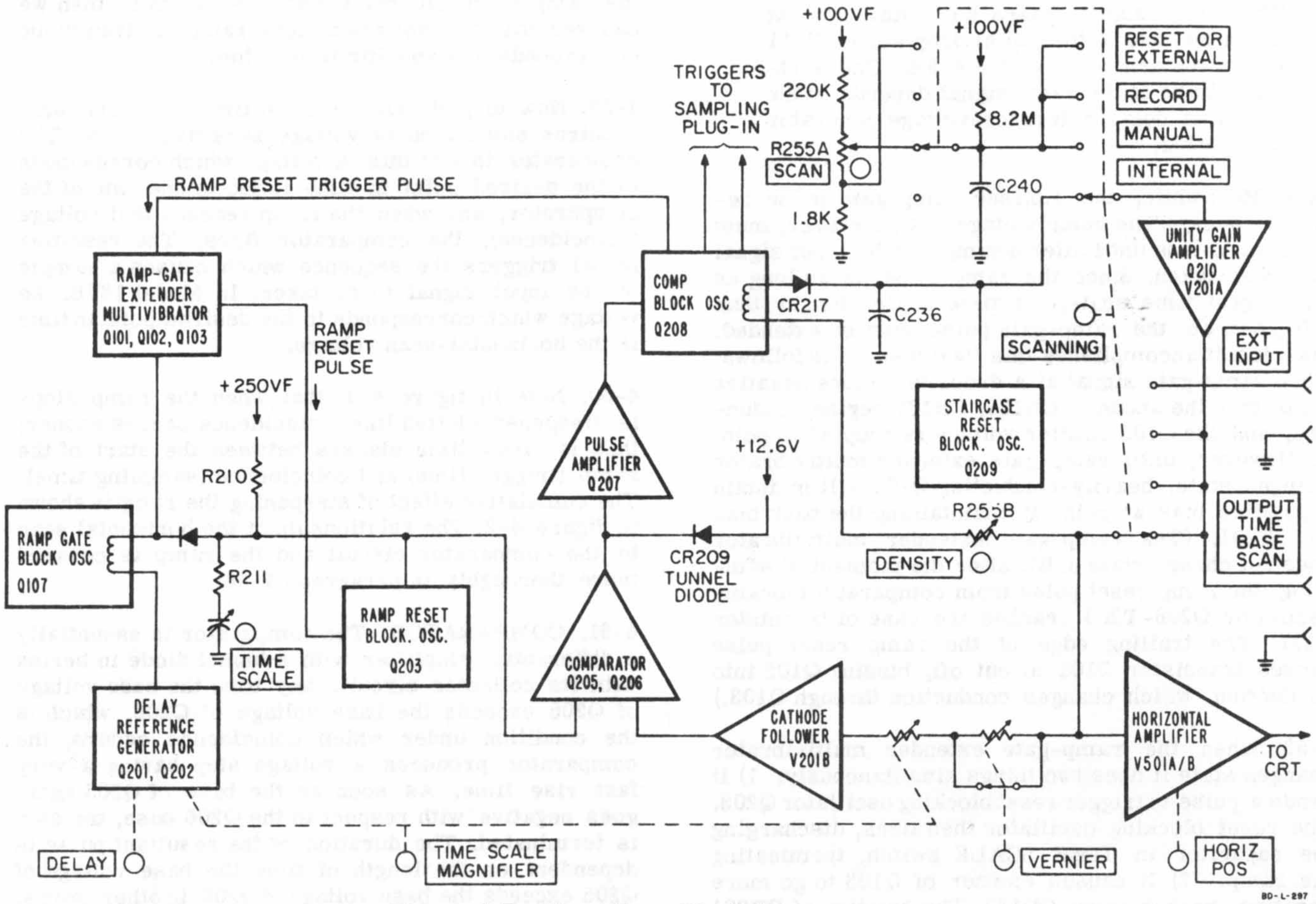


Figure 4-7. Time-Base Block Diagram

marks the time of coincidence. The resulting current through Q205 and CR209 exceeds I_p (figure 4-3), CR209 changes state (paragraph 4-29), and the voltage across CR209 rises.

4-65. As mentioned above (paragraph 4-61), this pulse from CR209 (the comparator pulse) lasts until ramp reset blocking oscillator Q203 resets the ramp. Meanwhile the horizontal-scan generator has stepped the Q206 base voltage to a slightly more positive value, the actual step amplitude depending on the setting of SCAN DENSITY. When the next trigger arrives the ramp again takes its initial voltage step to -0.2 volt and then rises linearly (this time a little farther) until the base voltage or Q205 again reaches coincidence with that of Q206. The comparator fires again, and the process continues until a horizontal sweep is completed.

4-66. TIME SCALE/MAGNIFIER RELATIONSHIP.

4-67. The following discusses why time scale is dependent only on the slope of the ramp (determined by the setting of TIME SCALE) and attenuation of the horizontal-scan voltage (determined by the setting of TIME SCALE MAGNIFIER). There are two important points to remember when thinking about the TIME SCALE/TIME SCALE MAGNIFIER relationship:

a. The time scale in sec/cm is the value selected by the TIME SCALE switch when no attenuation is

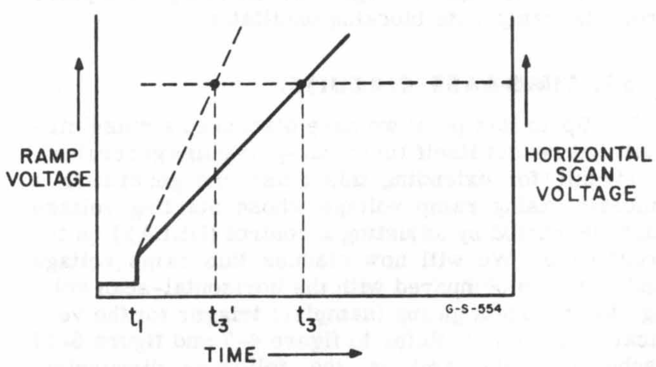


Figure 4-8. Ramp Voltage vs Time

inserted (by TIME SCALE MAGNIFIER and/or its VERNIER) between the scan voltage at the input to the horizontal amplifier and the scan voltage applied to the base of Q206 in the comparator.

b. Any particular level of voltage applied to the scan-voltage side (base of Q206) of the comparator represents a particular point in time (paragraph 4-58), as measured from the start of the ramp. Therefore any change in the voltage applied to the Q206 base will cause the ramp to reach coincidence sooner (or later) in time. Thus when the scan voltage applied to the comparator is attenuated (as it is when TIME SCALE MAGNIFIER is at any setting except X1 or its VERNIER is at any setting except CAL), time scale in sec/cm is no longer the value selected by the TIME SCALE switch.

4-68. A voltage change of say x volts to the horizontal amplifier causes the spot to shift a certain number of centimeters on the crt. Also, as described in paragraph 4-67, step b, this same voltage sent to the comparator represents a certain point in time.

4-69. Thus ANY method of making coincidence happen sooner so that from the start of the ramp to coincidence represents a shorter interval of time will also cause a change in time scale. This is what occurs when the ramp slope is made steeper (by adjusting TIME SCALE) or when horizontal-scan voltage to the comparator is further attenuated (by adjusting TIME SCALE MAGNIFIER).

4-70. Changing scan density, however, does not change time scale because the horizontal-scan voltage to the crt and the horizontal-scan voltage to the comparator are changed by the same ratio. A change in time scale can result only from a change in the slope of the ramp signal or a change in the horizontal-scan voltage applied to the comparator with respect to the horizontal-scan voltage applied to the crt. Scan voltage as such has absolutely no effect on time scale (to check this, switch SCANNING to MANUAL, and adjust SCAN). Time scale can be expressed mathematically as follows:

$$\text{time scale in sec/cm} = \left(\begin{matrix}\text{ramp slope,}\\ \text{sec/v}\end{matrix}\right)\left(\begin{matrix}\text{attenuation}\\ \text{factor}\end{matrix}\right)\left(\begin{matrix}\text{crt deflection}\\ \text{sensitivity, v/cm}\end{matrix}\right)$$

where

$$\text{attenuation factor} = \frac{\text{attenuated scan voltage (at comparator)}}{\text{scan voltage at horizontal amplifier input}}$$

crt deflection sensitivity =
v/cm deflection at input to horizontal amplifier

4-71. DELAY CIRCUITS.

4-72. As mentioned previously (paragraph 4-48), the DELAY potentiometer determines the starting voltage of the ramp signal by controlling the output voltage of delay reference-voltage generator Q201-Q202. A certain amount of delay is added even when DELAY is full counterclockwise (minimum delay position). This delay insures that the ramp voltage will have reached the linear portion of its characteristic before the first coincidence occurs. Minimum delay (the time between input trigger and first sample) is adjusted with MINIMUM DELAY, R213.

4-73. The following facts must be remembered when thinking about delay:

a. The ramp signal begins when the input trigger occurs (plus a delay inherent in the circuit).

b. Any time lapse between the input trigger and the first comparator coincidence is interpreted as delay.

c. Time scale is determined by ramp slope and the amplitude difference between the signal to the comparator and the signal to the horizontal amplifier. Differences in step-to-step amplitude of the staircase (horizontal-scan voltage), nonlinear scan voltages, etc, have no effect on the time scale.

4-74. Figure 4-9 shows the effect of varying the ramp starting voltage. Unless TIME SCALE MULTIPLIER is on X1, the ramp starting voltage is varied with DELAY control R212. When TIME SCALE MULTIPLIER is on X1, DELAY is inoperative, and the range of delay available is limited to that which can be obtained by adjustment of screwdriver-adjust MINIMUM DELAY, R213. Adjustment of either DELAY or MINIMUM DELAY varies the output delay reference-voltage generator Q201-Q202, and hence the ramp starting voltage. As explained in paragraph 4-72, a small amount of delay is built into the circuit to avoid possible nonlinearity in the start of the ramp. The exact amount of delay which will occur depends on two factors: 1) the degree to which the ramp starting voltage was made negative (by either R231, MINIMUM DELAY or R212, DELAY), and 2) the slope of the ramp.

4-75. DELAY/TIME SCALE MAGNIFIER RELATIONSHIP. When TIME SCALE MAGNIFIER is at any setting except X1, it inserts attenuation between the horizontal amplifier and the comparator. As attenuation is increased, the ratio between horizontal-signal-to-comparator and horizontal-signal-to-crt is decreased which decreases the time scale as viewed on the crt. For example, with TIME SCALE MAGNIFIER at X10, only 1/10 as much of the signal is displayed by the crt as when TIME SCALE MAGNIFIER is at X1.

Note

By means of the DELAY control, any desired fraction of the interval selected with TIME SCALE can be viewed at one time and, regardless of the degree of magnification selected, effectively the crt can be moved along the entire interval set by TIME SCALE by operating DELAY.

4-76. Note in figure 5-17 (time base schematic diagram), and figure 4-7, that a part of TIME SCALE MAGNIFIER is associated with the delay reference-voltage generator circuit (Q201-Q202). This assures that, regardless of the expansion used, the DELAY control will always have the range necessary to permit observation for the entire time selected by the TIME SCALE control.

4-77. COMPARATOR BLOCKING OSCILLATOR.

4-78. AMPLIFIER. The comparator pulse is differentiated and amplified by C228-R231/232 and amplifier Q207, respectively. The resulting negative spike is transformer-coupled to comparator blocking oscillator Q208-T203. Diode CR210 limits input to Q208 to negative pulses.

4-79. BLOCKING OSCILLATOR. These negative pulses trigger blocking oscillator Q208-T203 and a

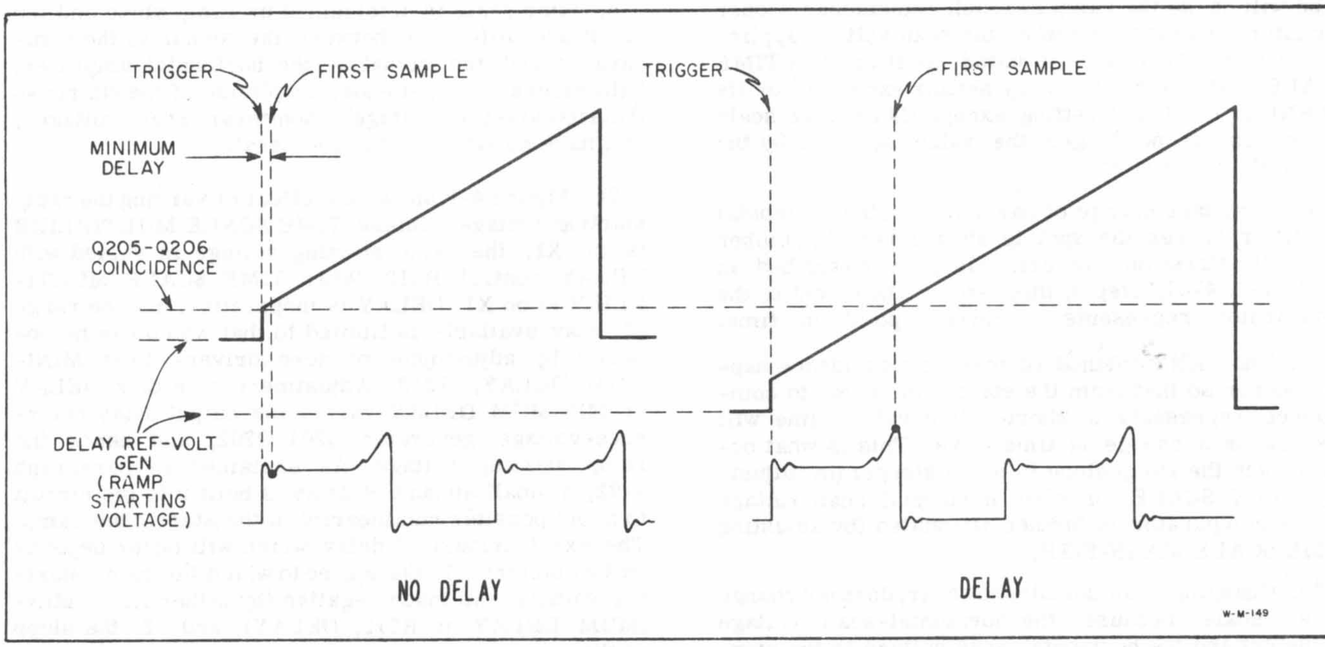


Figure 4-9. Effects of Delay

pulse of about 1.3 μseconds duration is produced. The leading edge of this comparator blocking oscillator pulse triggers three circuits:

a. A pulse, taken at pin 2 of T203, is differentiated and fed via J1 to the sampler unit where it is used to trigger sampling gate circuits in vertical plug-in unit.

b. Another pulse, taken at pin 4 of T203, is differentiated and fed via J1 to sampler unit where it initiates sampling action in the plug-in. When viewed on an oscilloscope, this pulse often appears double, but the second pulse is actually feeding back from the vertical plug-in unit.

c. Another output (pin 1) is used in the generation of the staircase voltage (paragraph 4-81).

4-80. In addition, the trailing edge of the comparator blocking oscillator pulse is used to reset the ramp-gate extender multivibrator, which in turn resets the ramp (paragraph 4-52).

4-81. HORIZONTAL-SCAN CIRCUITS.

4-82. The horizontal circuits in Model 185B are used both to deflect beam on the crt and to provide scanning potential for comparator circuit.

4-83. UNITY GAIN AMPLIFIER. V201A-Q210 constitute a unity gain amplifier. Tube V201A and transistor Q210 amplify the signal, while CR220 provides dc coupling between the two elements. R270, the Staircase Balance adjustment, sets the beginning of the horizontal-scan signal at 0 volts. The unity amplifier is used on all modes of operation of horizontal drive except EXTERNAL. The four types of horizontal drive selected by S203 (SCANNING) follow:

a. RECORD. In RECORD, S203 disconnects C240 from voltage divider R254, R255, R256, and connects it to the grid of V201A. C240 charges slowly toward +100 volts through R259 until voltage at junction of CR219 and R259 reaches +15 volts. When this occurs CR219 begins conduction, halting the sweep. The charge on capacitor C240 will remain at +15 volts until SCANNING (S203) is set to RESET OR EXTERNAL. With S203 at RESET OR EXTERNAL, capacitor C240 discharges through resistor R257.

b. RESET OR EXTERNAL. This position of S203 has two uses: 1) it is used to reset charging capacitor C240 as explained in RECORD, above, or 2) it connects J201, INPUT EXTERNAL SCAN connector, through S203B, to comparator and horizontal amplifier circuits, so that an external signal may be used to drive these circuits. The external signal should be between 0 and approximately + 12 volts. (With HORIZONTAL POSITION approximately centered, 0 volts puts spot on left-hand edge graticule, +12 volts puts spot on right-hand edge.)

c. MANUAL. Operation is similar to RECORD, except grid of V201A is connected to center arm of R255A, SCAN (MANUAL), so that the operator can manually control scanning.

d. INTERNAL. In INTERNAL, the output of unity amplifier V201A-Q210 is a staircase voltage which results from the following circuit action (see figures 4-10 and 5-20):

(1) Prior to start of circuit sequence (end of preceding staircase), staircase capacitor C236 is discharged, comparator blocking oscillator (Q208-T203 which generates sampler trigger) has not yet generated the next pulse, and diode CR215 is back-biased.

(2) When coincidence occurs, comparator blocking oscillator Q208-T203 fires, and the resulting pulse is coupled by transformer T203 to diode CR215. CR215, forward-biased now, conducts, and capacitor C236 begins to charge.

(3) The voltage across staircase capacitor C236 increases, and is applied, through SCANNING switch S203C/D, to unity amplifier V201A-Q210, increasing output of the generator by the same amount; this output is the horizontal-scan voltage.

(4) After comparator blocking oscillator pulse decays, diode CR215 becomes reverse-biased again, and prevents charge on capacitor C236 from leaking off.

(5) DENSITY control R255B is in the charge path of staircase capacitor C236. DENSITY permits limited adjustment of charge-path resistance, thereby determining amplitude of staircase steps by controlling amount of charge added to staircase capacitor each time blocking oscillator fires.

(6) The output of unity amplifier V201A-Q210 is applied to transformer T203 in such a way that a bootstrap action results. Thus for a given density, the same amount of charge is added to staircase capacitor C236 each time, which results in staircase steps of equal amplitude.

(7) When voltage across staircase capacitor C236 reaches about +15 volts, reset blocking oscillator Q209-T204 fires and discharges the capacitor. The staircase is thus reset and starts over again.

4-84. RESET BLOCKING OSCILLATOR. When the staircase voltage exceeds voltage on collector of Q209 (approximately 15 volts), diode CR217 becomes forward-biased, current begins to flow through collector winding of transformer T204, and capacitor C236 effectively becomes the voltage supply for blocking oscillator Q208-T204. The effect of this current flow is transformer-coupled to the base of Q209, which causes blocking oscillator to fire, essentially dropping collector of Q209 to ground. The resulting current-flow through CR217 and Q209 discharges capacitor C236, thereby resetting the staircase. It might be pointed out here that the amplitude of the staircase signal remains constant. The height of each individual step can be varied by adjusting R255B as mentioned in paragraph 4-83, step d (5). The result of varying the height of each step is to change the number of steps per staircase, which changes the number of samples per sweep on the crt.

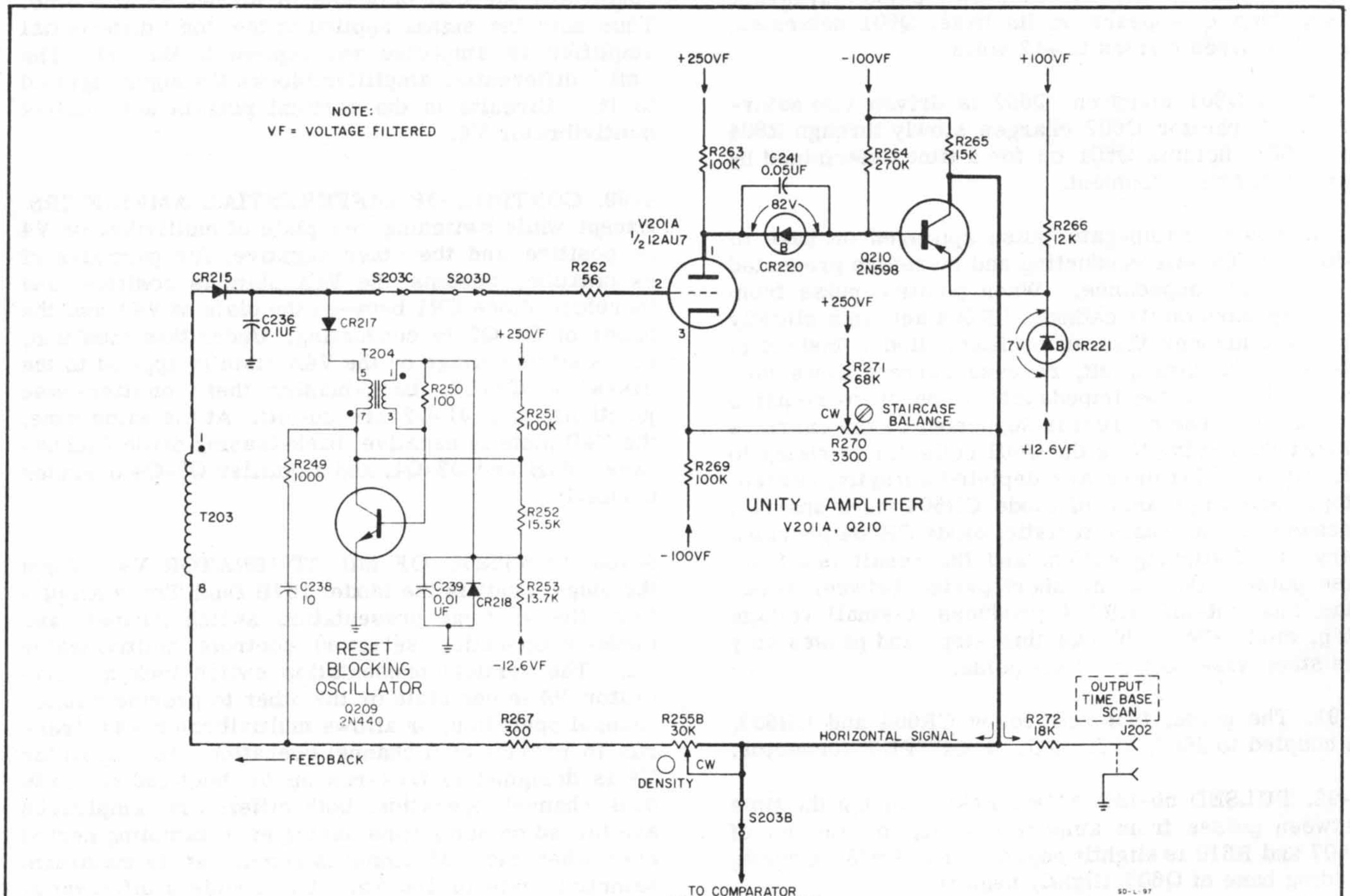


Figure 4-10. Staircase Generator

4-85. OUTPUT. The output of unity amplifier V201A-Q210 is fed:

a. To one side of the comparator (see paragraph 4-61). The path from unity amplifier is through R286, the time scale VERNIER (or, when TIME SCALE vernier is at CAL, through contacts on switch S204), through Sweep Calib adjustment R285, TIME SCALE MAGNIFIER switch S201 where the staircase voltage is attenuated if S201 is on any except the X1 setting, and cathode follower V201B.

b. To the grid of V501B in horizontal amplifier assembly A501.

4-86. HORIZONTAL AMPLIFIER. The horizontal amplifier is a conventional, single-stage differential amplifier. The scan voltage is applied to one half of the amplifier, the horizontal positioning voltage to the other. The level of the positioning voltage is set with R509, the HORIZONTAL POSITION control. The output of the amplifier is connected directly to the horizontal deflection plates of the crt.

4-87. CALIBRATOR.

4-88. SYNC PULSE. When CALIBRATOR AND SYNC PULSE is full counterclockwise, pulse amplifier Q601 is biased so that it can conduct when triggered with a negative pulse. When the ramp-gate pulse (paragraph 4-40, step c) appears on its base, Q601 saturates, and its collector rises to +12 volts.

4-89. As Q601 turns on, Q602 is driven into saturation. Capacitor C602 charges slowly through R604 and Q601, holding Q601 on for a time determined by R604-C602 time constant.

4-90. Before ramp-gate pulse appeared on base of Q601, CR604 was conducting and therefore presented a very low impedance. When positive pulse from Q601 appears on its cathode, CR604 acts in a slightly different manner than an ordinary diode. Instead of immediately cutting off, reverse current flows momentarily, and the impedance of the diode remains low (the reverse current is supported by the carriers stored during the time the Q601 collector is rising to +12 volts). Carriers are depleted abruptly, current stops, and impedance of diode CR604 rises sharply; because of this characteristic, diode CR604 provides very fast switching action, and the result is a fast-rise pulse. During the short period between back-bias and cut-off, CR204 produces a small voltage step; diode CR603 blocks this step, and passes only the steep-rise portion of the pulse.

4-91. The pulse, thus shaped by CR604 and CR603, is coupled to J601, SYNC PULSE OUTPUT connector.

4-92. PULSED 50-MC AMPLIFIER. During the time between pulses from amplifier Q601, the junction of R607 and R610 is slightly negative and CR605 conducts, holding base of Q603 slightly negative.

4-93. When amplified ramp-gate pulse appears on Q601 collector, CR605 (a diode of the same type as described in paragraph 4-90) becomes back-biased. When it snaps off, resonant circuit T601-C610 is shock-excited into 50-mc oscillation. Q603 overcomes the tank-circuit losses, resulting in a constant-amplitude oscillation, and a 50-mc voltage is coupled to J602, the 50-mc connector. When the sync pulse ends, CR605 is again clamped to a negative voltage, terminating the 50-mc oscillation.

4-94. DC CALIBRATOR VOLTAGES. The rest of this circuit is simply a dc voltage divider, between -12.6 volts and ground. The level of the voltage fed to the AMPLITUDE DC OPEN CIRCUIT connector depends on the setting of S601, the CALIBRATOR AND SYNC PULSE switch.

4-95. VERTICAL AMPLIFIER.

4-96. GENERAL OPERATION.

4-97. Figure 4-11 is a block diagram of the vertical amplifier. The signal under investigation is applied to the input of the vertical plug-in unit, and is applied to Model 185B vertical amplifier via pins on connector J1 (not shown in figure 4-11).

4-98. In the Model 185B vertical amplifier, input signals are applied to cathode followers V1 and/or V2, and then to differential amplifiers Q1-Q2 and Q3-Q4. Multivibrator V4 controls the differential amplifiers so that only one is turned on at a time. Thus only the signal applied to the "on" differential amplifier is amplified and applied to the crt. The "off" differential amplifier blocks the signal applied to it. Circuits in the vertical plug-in unit control multivibrator V4.

4-99. CONTROL OF DIFFERENTIAL AMPLIFIERS. Except while switching, one plate of multivibrator V4 is positive and the other negative; for purposes of explanation, assume the V4A plate is positive, and therefore diode CR1 between the plate of V4A and the bases of Q1-Q2 is conducting. Under this condition, the positive voltage on the V4A plate is applied to the bases of Q1-Q2, back-biasing their emitter-base junctions, and Q1-Q2 are cut off. At the same time, the V4B plate is negative, back-biasing diode CR2 between V4B and Q3-Q4, and amplifier Q3-Q4 operates normally.

4-100. CONTROL OF MULTIVIBRATOR V4. When the plug-in unit is the Model 187B Dual Trace Amplifier, the vertical presentation switch (channel and mode-of-operation selector) controls multivibrator V4. The vertical presentation switch lock multivibrator V4 in one state or the other to provide single-channel operation, or allows multivibrator V4 to free-run to provide dual channel operation. Multivibrator V4 is designed to free-run up to about 180 kc, so in dual channel operation, both differential amplifiers are turned on some time during each sampling period even when the instrument is running at its maximum sampling rate of 100 kc. To provide a differential display, the Model 187B simultaneously applies the Channel A signal to the Model 185B amplifier V1A and the Channel B signal to amplifier V1B. Vertical deflection on the crt is then proportional to the difference between the signal voltages.

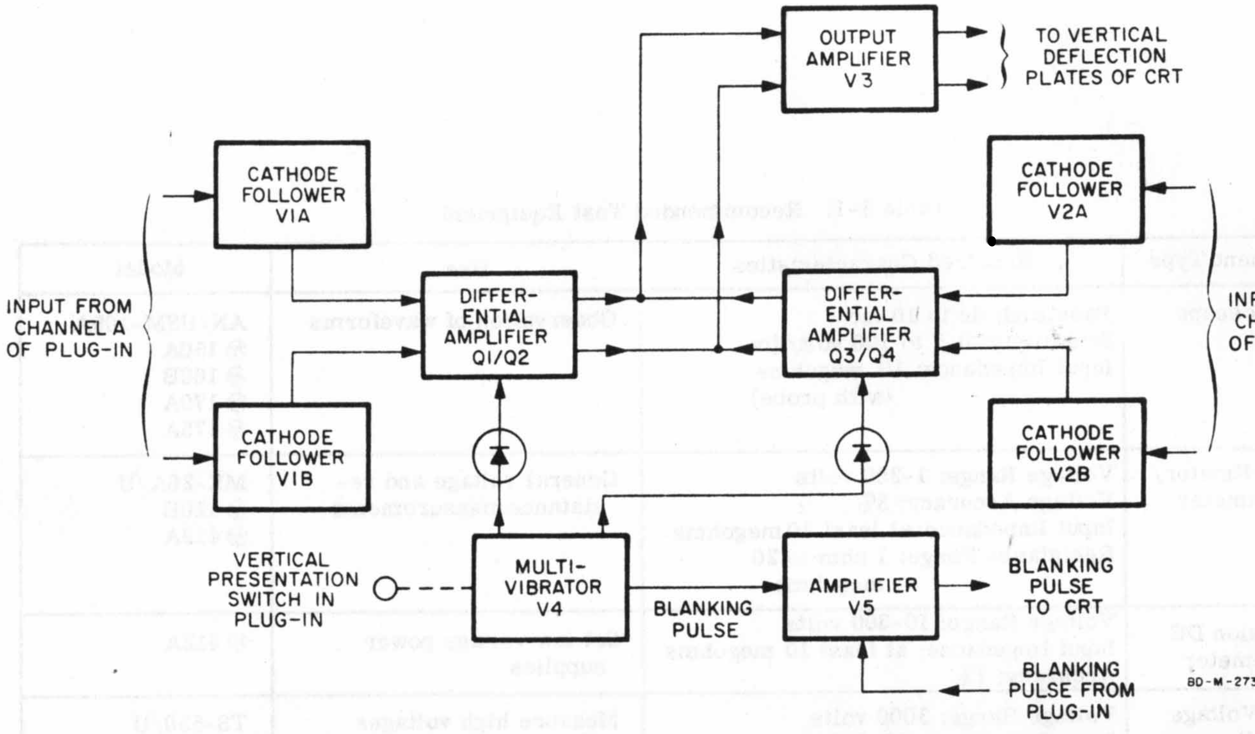


Figure 4-11. Vertical Amplifier Block Diagram

4-101. TRANSIENTS.

4-102. To prevent switching transients from appearing on the crt, a negative pulse generated by multivibrator V4 is applied to amplifier V5 and then to the crt to blank the crt during switching time. During sampling, the vertical plug-in unit sends a blanking pulse to amplifier V5; this pulse prevents sampling transients from appearing on the crt.

4-103. HIGH-VOLTAGE POWER SUPPLY.

4-104. The high-voltage power supply (figure 4-12) provides voltage (-2900 volts) required to operate the crt. An rf oscillator, V302, oscillates at approximately 80 kc. High-voltage transformer T301 steps up oscillator output to a high ac voltage which rectifies V303 and V304 and their associated rc filters convert to dc. The dc voltages are applied to the crt. Regulator V301 compares output of the crt cathode supply with +250 volts and changes amplitude of rf oscillations to oppose any high-voltage change relative to the 250 volts.

4-105. The crt is normally biased on. Blanking pulses from V5 (paragraph 4-102) blank the crt to prevent undesirable transients from appearing.

4-106. LOW-VOLTAGE POWER SUPPLIES.

4-107. The low-voltage power supplies include one independent supply and four dependent supplies. The -100 volt supply is the independent supply. It is a reference for the +100 volt and +250 volt supplies and is a supply voltage for the comparison amplifiers of the +12.6 volt and -12.6 volt supplies.

4-108. The series regulator in each supply acts as a variable resistor in series with the supply output. A comparison or differential amplifier senses any change in the output voltage by comparing the output against a fixed reference voltage. The amplifier then changes the resistance of the series regulator in a way that opposes the change in output voltage. The power supplies are transistorized. Emitter followers are required between amplifier and series regulator to amplify the current to the level required to drive the series regulator.

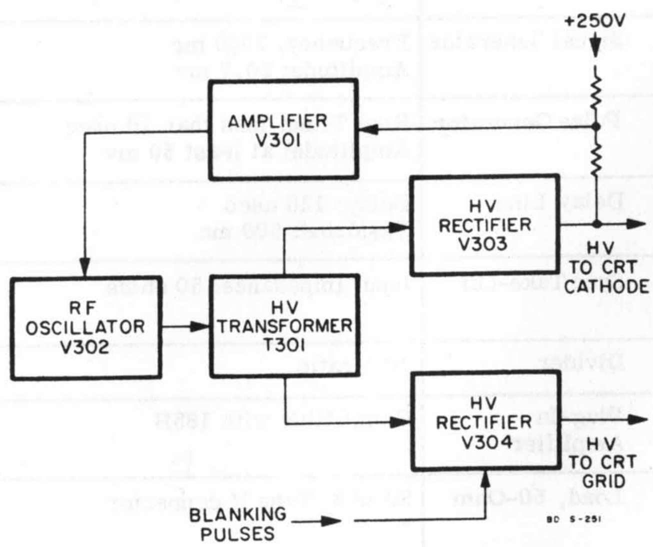


Figure 4-12. High-Voltage Power Supply Block Diagram

Table 5-1. Recommended Test Equipment

Instrument Type	Required Characteristics	Use	Model
Oscilloscope	Passband: dc to 10 mc Sensitivity: 0.5 to 100 volt/div Input Impedance: 10 megohms (with probe)	Observation of waveforms	AN/USM-105A hp 150A hp 160B hp 170A hp 175A
DC Voltmeter/ Ohmmeter	Voltage Range: 1-300 volts Voltage Accuracy: 3% Input Impedance: at least 10 megohms Resistance Range: 1 ohm to 20 megohms	General voltage and resistance measurements	ME-26A/U hp 410B hp 412A
Precision DC Voltmeter	Voltage Range: 10-300 volts Input Impedance: at least 10 megohms Accuracy: 1%	Set low voltage power supplies	hp 412A
High Voltage DC Voltmeter	Voltage Range: 3000 volts Input Impedance: 12,000 megohms Accuracy: 8%	Measure high voltages	TS-520/U hp 410B with hp 459A
AC Voltmeter	Voltage Range: 10 mv rms Input Impedance: at least 1 megohm Accuracy: 10%	Measure low voltage power supply ripple	ME-30A/U hp 400D
Variable Transformer	Output Voltage: 103-127 volts (206-254 volt if oscilloscope wired for 230-volt operation) Output Current: 5 amps (2.5 amps for 230-volt operation)	Vary line voltage	General Radio Type W10MT3A
Signal Generator	Frequency Range: 10-100 mc Output Amplitude: 15-500 mv Frequency Accuracy: 0.1%	Check frequency calibrator accuracy and trigger sensitivity	AN/USM-44A hp 608D
Signal Generator	Frequency: 1000 mc Amplitude: 20.7 mv	Trigger sensitivity	hp 612A
Pulse Generator	Rise Time: less than 10 nsec Amplitude: at least 50 mv	Set minimum delay	hp 213A
Delay Line	Delay: 120 nsec Passband: 500 mc	Provide fixed delay	hp 1100A
Sync Take-Off	Input Impedance: 50 ohms	Split input signal into two signals	hp 185A-76A
Divider	10:1 ratio	Attenuate sync pulse	hp 187B-76C
Plug-In Amplifier	Compatible with 185B	To complete vertical amplifier system	hp 187A/B
Load, 50-Ohm	50-ohm Type N connector	Terminate 50-ohm test signal	hp 908A
Tee Connector, 50-Ohm	Adapter to 187B Probe - 50-ohm Type N connectors	To insert probe in 50-ohm system	hp 187B-76E

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section provides maintenance and service information for Model 185B oscilloscope. Included in this section is a performance check which may be used to verify proper instrument operation. The section also includes recommended test equipment, troubleshooting, repair, and adjustment procedures.

5-3. TEST INSTRUMENTS REQUIRED.

5-4. Table 5-1 lists test equipment that is required to complete the maintenance instructions in this section. Instruments other than those recommended may be used, provided their performance meets the basic requirements given in table 5-1.

5-5. PERIODIC MAINTENANCE.

5-6. CLEANING THE AIR FILTER.

5-7. Inspect the air filter regularly, and clean it before it becomes dirty enough to restrict air flow.

a. Remove filter from instrument rear, and wash it in warm water and detergent.

b. Dry the filter thoroughly and coat it with filter adhesive. We recommended Filter Coat No.3 from Research Products Company, Inc. This adhesive comes in "Handi-Koter" sprayer cans and is available from most heating supply stores or from your authorized Hewlett-Packard sales representative.

5-8. GENERAL MAINTENANCE.

5-9. Other than periodic cleaning of the air filter as mentioned above, the Model 185B requires no special preventive maintenance. We do suggest, however, that low pressure air be used to blow any accumulated dust out of the instrument every six months or so.

5-10. CABINET REMOVAL.

5-11. To remove the Model 185B cabinet, proceed as follows:

a. Remove the plug-in unit.

b. Set instrument on its front-panel draw handles. Be careful of the probe clips.

c. Remove four screws at rear of cabinet.

d. Lift cabinet up and off the instrument.

5-12. TROUBLESHOOTING.

5-13. The troubleshooting procedure is divided into two categories: 1) system troubleshooting, in which the trouble is associated with a particular section of the instrument, and 2) sectional troubleshooting, in which trouble is located within a particular section.

5-14. Since Model 185B cannot function without a vertical plug-in unit, system troubleshooting is based on the assumption that a Model 187A or 187B Dual Trace Amplifier unit is installed. However, for sectional troubleshooting information on the plug-in unit, refer to the instruction manual for the plug-in unit.

5-15. SYSTEM TROUBLESHOOTING.

5-16. System troubleshooting consists of observing indications on the crt and associating the indications with a particular section or circuit. A number of indications are listed in table 5-2 along with any necessary steps for clarification. If the instrument is operating but does not meet all specifications, refer to the appropriate section of the performance check, paragraph 5-67, and check the particular instrument operation in question.

5-17. SECTIONAL TROUBLESHOOTING.

5-18. MAIN VERTICAL AMPLIFIER. Since the vertical amplifier consists of balanced amplifier circuits, trouble other than open tube heaters will usually cause an unbalance. If an unbalance is common to both channels, check circuit of V3. If unbalance is in one channel only, short input of faulty channel to ground and check voltages throughout the channel.

Note

Troubleshoot vertical amplifier with vertical plug-in unit installed. Otherwise multivibrator V4 will free run and make troubleshooting more difficult. However, if two traces appear on screen near center when vertical plug-in is removed, this is a good indication that trouble is in the plug-in unit.

5-19. TRIGGER CIRCUIT. Troubleshooting the sync circuit is best done by observing waveforms. Waveforms throughout the circuit are shown in figure 5-11 opposite the schematic.

5-20. The following will be helpful in troubleshooting Model 185B trigger circuit. First, of course, make sure that all diodes and transistors are mounted properly on etched circuit board and that all power supply voltages are within specifications (paragraph 5-47).

a. Measure voltage at collector of Q104. With MODE full counterclockwise, collector voltage should be approximately -12.5 volts, and should increase to -5 volts as MODE is rotated to full clockwise. This test indicates that bias current is being supplied to tunnel diode CR116.

b. Turn MODE full counterclockwise and measure voltage across CR116 with dc electronic voltmeter. The anode to cathode voltage should be about 10 mw.

Table 5-2. System Troubleshooting

Indication	Action
Nothing visible on crt with BEAM FINDER pressed	Check low voltage power supply, vertical amplifier output stage (V3), horizontal amplifier V501, high voltage power supply, and crt in that order.
Vertical unbalance, but trace on screen when BEAM FINDER is pressed	Short grids of V1 and V2 (pins 2 and 7 of each vertical amplifier input stage) to ground. If vertical unbalance remains, check vertical amplifier. If trace appears on screen check plug-in unit.
No vertical deflection from either channel but sweep is approximately centered	Check V3 and V4 in vertical amplifier, plug-in unit.
No vertical deflection from one channel, but operation of other channel is normal	Check input to Model 185B from faulty channel of plug-in with a signal applied to channel. If no signal is present check plug-in unit. If a signal is present, check vertical amplifier.
Same channel on screen regardless of channel selected	Check multivibrator V4 in vertical amplifier
Vertical troubles on per-sample basis (vertically elongated samples, etc)	Check plug-in unit Check Peaking Adj in V3
Hash on screen (no crt blanking during sampling or chopping)	Check amplifier V5 Check blanking circuitry
No trace but spot is on screen and VERTICAL POSITION and HORIZONTAL POSITION controls operate	Check reset blocking oscillator Q209, unity-gain amplifier V201A/Q210 in time base
No trace but spot is visible (BEAM FINDER may have to be pressed); HORIZONTAL POSITION control is effective but VERTICAL POSITION is not	Check sync circuit Check time base circuit.
Sweep free runs with MODE set to TRIGGER and no trigger signal applied	Check blocking oscillator Q106/Q107 in sync circuit, comparator blocking oscillator Q208 in time base. Check Q104, Q105
Operation normal on trigger repetition rates below 100 kc, faulty on trigger rates above 100 kc	Check hold-off multivibrator V101/V102 sync circuit
Horizontal unbalance	Check horizontal amplifier
Horizontal troubles on per-sample basis (horizontally elongated samples, etc)	Check time base circuits V201A and Q210, diodes CR215, CR217 and Q209
Excessive noise and jitter which appears sinusoidal at certain trigger repetition rates	Check low voltage power supply Be sure trigger is not overdriving input

c. Slowly rotate MODE clockwise. The anode to cathode voltage should increase to about 60 mv and then jump to about 470 mv when MODE is near "two o'clock". Continue turning MODE until it is full clockwise. The voltage should rise to about 500 mv.

d. Turn MODE full counterclockwise. The cathode to anode voltage should jump back to 10 mv. If the anode to cathode voltage is about 500 mv, and if the voltage does not change as MODE is rotated, turn MODE full counterclockwise and flip power switch off and on two or three times. If voltage still does not change to about 10 mv, CR116 is either defective or out of specifications, and should be replaced.

5-21. If, after completing the above procedure, the instrument will not free run, proceed as follows:

a. Open the circuit loop by lifting C146 at the junction of R175 and L112 (see figure 5-1).

b. Set controls on square wave generator as follows (use 75-ohm source):

(1) Attenuation at 0 db

(2) Amplitude at 1 volt

(3) Frequency to 30 kc

c. Using clip leads, connect square wave generator to capacitor and to ground as shown in figure 5-1.

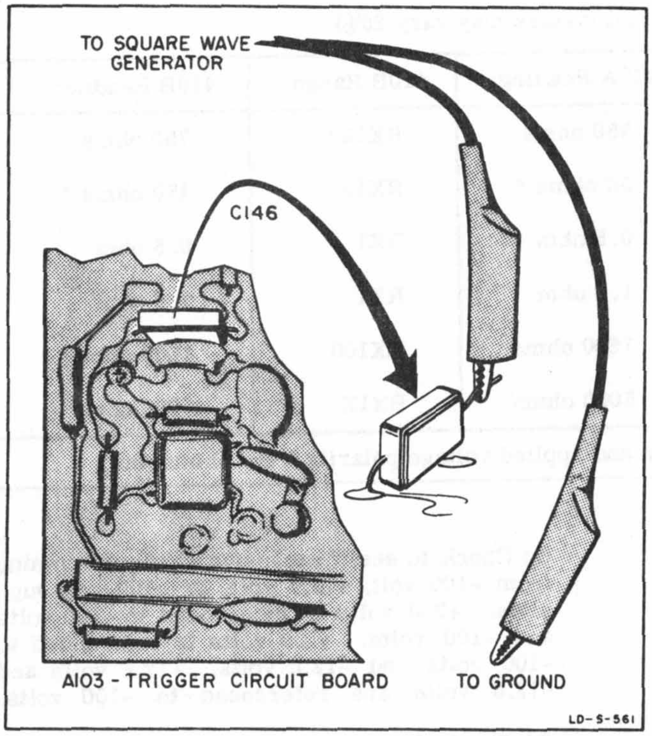


Figure 5-1. Driving the Trigger Circuit

The square wave cannot be traced through Q106 and Q107. The observed voltages should appear essentially as shown in figure 5-2. (The blocking oscillator and hold-off multivibrator should operate as described previously. If all parts of the trigger circuit function properly when driven from the square wave generator, but the tunnel diode will not reset, check CR104, CR124, and CR125 for continuity and proper polarity.)

5-22. Count Down Circuit. If the Model 185B will not trigger on the high frequency count down circuit, turn TRIGGERING to HIGH FREQUENCY and measure voltage at anode of CR120. This voltage should be about 200 mv. Observe signal at anode of CR120 with a Model 150A/151A or a Model 160A oscilloscope and an AC-21C probe. The waveform should be a 10-mc sine wave, approximately 300 mv peak-to-peak. If voltage is correct, and the sine wave cannot be observed, change CR120 (read paragraph 5-36 before attempting to replace tunnel diodes).

5-23. TIME BASE. Troubleshooting the time base is best done by observing waveforms (see figure 5-15).

5-24. If comparator blocking oscillator Q208 operates normally, but reset blocking oscillator Q209 is not triggered, V201A (excessive grid current) may be removing charge from staircase capacitor, C236, between samples. Set DENSITY full counterclockwise and carefully check waveform at Q210 collector for sag between samples.

5-25. If there is horizontal motion or elongation of individual samples, stop triggering of oscilloscope and note horizontal drift of spot. The drift rate should be less than about 1 cm/sec. If spot drifts left, check CR215; if spot drifts right, check CR217.

5-26. If time-base circuits are operating erratically on all ranges and the cause is not apparent, disable the ramp-gate extender multivibrator by lifting the emitter of Q103 and the emitter end of resistor R147 from circuit board (see paragraphs 5-34 and 5-37). The Model 185B should operate on the four fastest time-scale ranges. If it does, trouble in the ramp-gate extender is indicated.

5-27. TIME CALIBRATOR. The time calibrator and sync pulse circuit consists of a pulse extending amplifier Q601/Q602, a 50-mc oscillator Q603 and two shaping diodes CR604/605. The waveforms for this section are shown on figure 5-23. If both time calibrator and sync pulse are faulty, check Q601 and Q602. If only the sync pulse is faulty, check CR604. If the fault lies only in the time calibrator check CR605 and Q603.

5-28. HIGH-VOLTAGE POWER SUPPLY. Measure voltages supplied to the crt.

WARNING

Be very careful when measuring high voltages. Use equipment suited for high-voltage measurements.

a. If crt voltages are normal, and the crt is not receiving a faulty blanking signal, replace crt.

b. If high voltages are incorrect, check that rf oscillator V302 is oscillating. Note that a fault in the crt cathode supply causes a greater output from the rf oscillator and therefore a more negative output from the crt grid supply, whereas a fault in the crt grid supply has no effect on the cathode supply. If both crt supplies are excessively high, or both excessively low, check regulator V301.

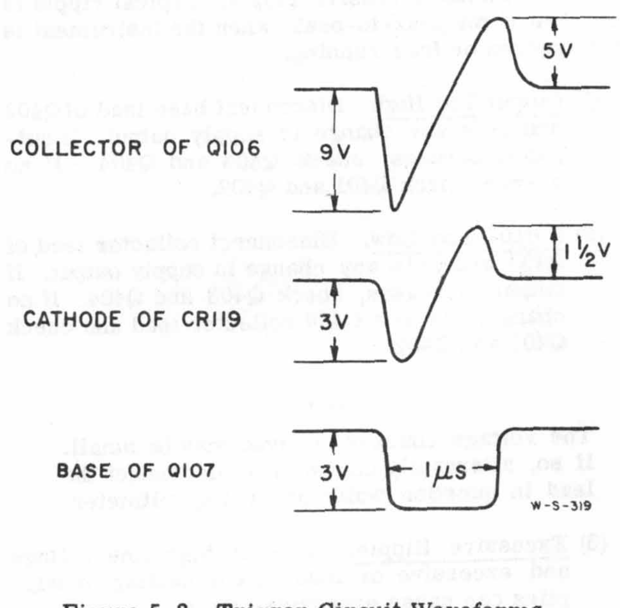


Figure 5-2. Trigger Circuit Waveforms

Table 5-3. Resistance to Ground (values may vary 25%)

Supply	Color Code	412A Range	412A Reading	410B Range	410B Reading
-100 volt	violet	RX1K	750 ohms	RX100	750 ohms
12.6 volt	vio/wht	RX100	50 ohms *	RX10	150 ohms *
+ 6.3 volt	brn/wht	RX1	0.5 ohm	RX1	0.5 ohm
+ 12.6 volt	brown	RX1	1.0 ohm	RX1	1.0 ohm
+ 100 volt	red/wht	RX1K	1600 ohms	RX100	1600 ohms
+ 250 volt	red	RX10K	5000 ohms	RX1K	5000 ohms
* Note: Readings differ due to diode, transistor action and applied voltage polarity from ohmmeter.					

Note

Do not reset High Voltage Adj R306 unless such adjustment is clearly indicated. The adjustment of high voltages affects the sensitivity of the crt and makes necessary the readjustment of vertical and horizontal gain, frequency response and time scales.

5-29. LOW-VOLTAGE POWER SUPPLIES. When checking low-voltage power supplies, check the -100 volt supply first, for it affects all supplies. Check the other supplies in the following order: -12.6 volt, +100 volt, +250 volt. The +12.6 volt supply may be checked in any order. The following describes a method of checking the +250 volt supply; a similar procedure may be used for the other supplies.

a. Check F402. If blown, check resistance from +250 volt line to ground (see table 5-3).

b. Check transformer output.

c. Check supply output. Note whether it is high, low, or contains excessive ripple. Typical ripple is less than 8 mv peak-to-peak, when the instrument is not triggered or free-running.

(1) Output Too High. Disconnect base lead of Q402 and note any change in supply output. If output decreases, check Q403 and Q404. If no change, check Q401 and Q402.

(2) Output Too Low. Disconnect collector lead of Q403 and note any change in supply output. If output increases, check Q403 and Q404. If no change, replace Q404 collector lead and check Q401 and Q402.

Note

The voltage changes involved may be small. If so, alternately connect and disconnect the lead in question while observing voltmeter.

(3) Excessive Ripple. Low or high line voltage and excessive or insufficient loading of supplies can cause excessive ripple.

(a) Check to see if excessive ripple is coming from -100 volt, -12.6 volt, or +100 volt supplies. +250 volts is referenced to +100 volts and -100 volts. +100 volts is referenced to -100 volts and -12.6 volts. +12.6 volts and -12.6 volts are referenced to -100 volts.

(b) Check for weak or defective transistors.

(c) Check capacitors throughout supply. Check C402, C403, and C404 first.

5-30. REPAIR.

5-31. ACCESS TO POWER TRANSISTORS AND FAN MOTOR.

5-32. Figure 5-3 shows necessary disassembly for replacement of power transistors or fan motor. Proceed as follows:

Note

Take care not to dislodge the vertical amplifier tubes from their sockets.

a. Remove cabinet.

b. Remove eight screws holding fan shroud to rear chassis.

c. Rotate shroud slightly to allow clearance for transistor, and remove shroud assembly from the instrument.

5-33. Replacement procedure is the reverse of the above. Install shroud with blank heat sink slot at 9 o'clock as viewed from rear of instrument.

5-34. REPLACEMENT OF SEMICONDUCTORS.

5-35. Excessive heat can destroy semiconductor devices. When soldering or unsoldering transistors or diodes, place a heat sink such as long-nose pliers on lead of component between its body and point to which heat is applied. In addition, isolate oscilloscope from ground or ground body of soldering iron to prevent leakage current from damaging component.

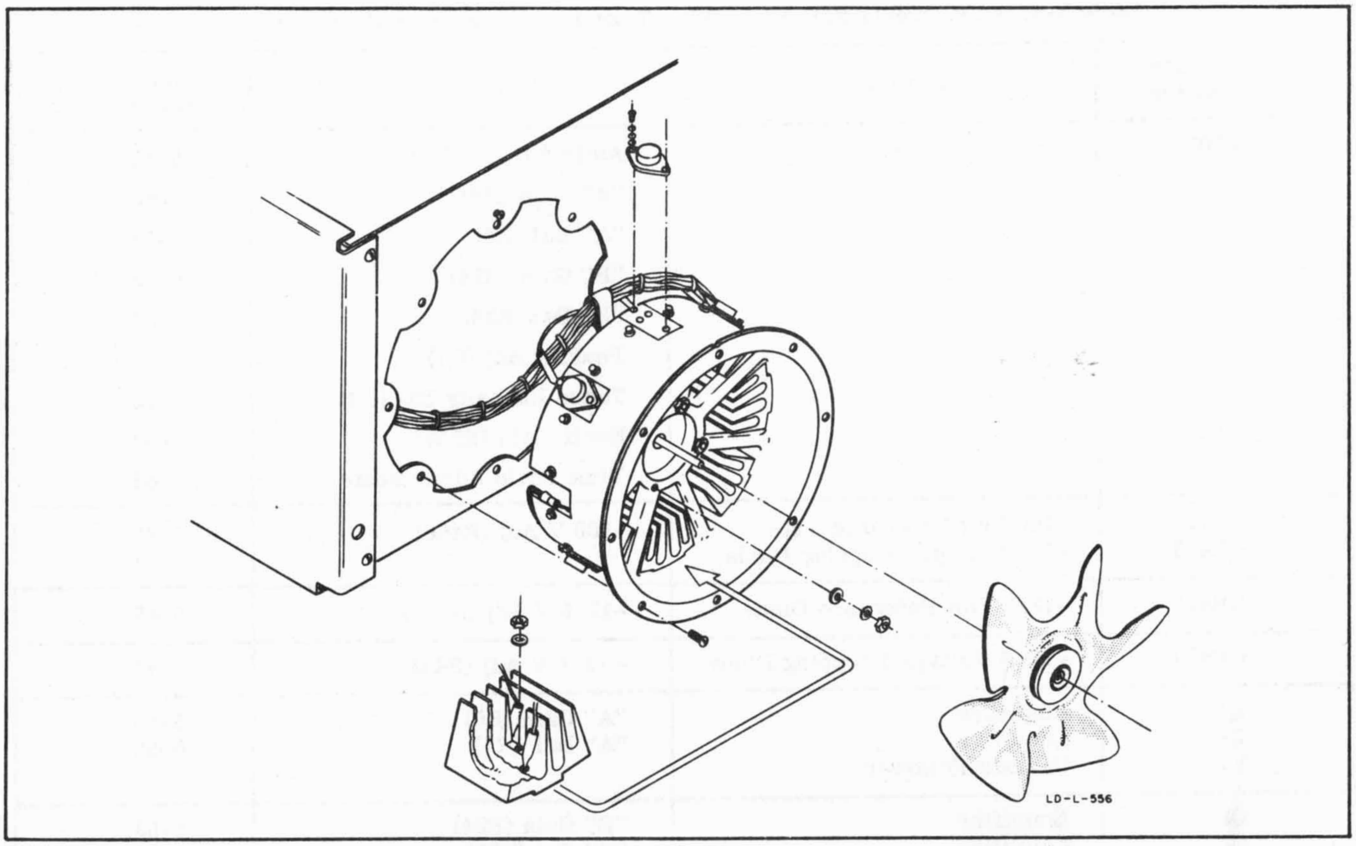


Figure 5-3. Disassembly for Power Transistor Replacement

5-36. TUNNEL DIODE REPLACEMENT. Tunnel diodes are more sensitive to heat than other semiconductors. Particular care is required in their replacement.

5-37. SERVICING ETCHED CIRCUIT BOARDS.

5-38. GENERAL. Component miniaturization in this instrument has resulted in the use of a board with conductor material on both sides. Good conductivity between sides has been assured by plating the inside of component mounting holes. This method of construction presents the need for new techniques in etched circuit board repair.

5-39. Proceed as follows:

a. Using a clean soldering iron, so that good heat transfer is obtained, apply heat (near circuit board) to one lead of component to be removed. Repeat for other leads.

CAUTION

AVOID EXCESSIVE HEAT. Use a 25- to 40-watt soldering iron. Excessive heat will cause copper circuit to lift from board. Use a heat sink (e.g., pair of long-nose pliers) between soldering iron and component. See paragraph 5-36 for special techniques in replacing tunnel diodes.

b. Reheat solder around holes and quickly insert a toothpick to clean holes in preparation for inserting new component. DO NOT use an awl or similar sharp metallic object to ream the hole. Doing so may remove plating from hole.

c. Preform new component leads to fit holes exactly. Insert new component carefully, without forcing it.

d. Resolder by applying heat to component lead on component side of board. Use just enough solder to assure a good connection. Clean off excess flux.

5-40. When heavy, multi-lead components such as tube or transformer sockets must be replaced, good practice is to remove component by clipping the component pins one by one and unsoldering the pins individually.

5-41. CRT REPLACEMENT.

WARNING

Handle crt with care. Wear gloves and plastic face mask or goggles.

a. Remove instrument cabinet.

b. Remove four mounting screws from bezel, and remove bezel and graticule.

Table 5-4. Adjustments Following Tube, Transistor, and Diode Replacement

Reference Designator	Function	Adjustment	Refer to Paragraph
V305	Cathode-Ray Tube	Astig Adj (R312) "A" Gain (R6) "A" Bal (R4) "B" Gain (R24) "B" Bal (R26) Peaking Adj (C7) Trace Intensity Bal (C8) Horiz Gain (R503) Time Scale Adjustments	5-51 5-53 5-53 5-53 5-53 5-56 5-62 5-63
V401 CR413	-100 Volt Reference Tube -100 Voltage-Dropping Diode	-100 V Adj (R468)	5-47
CR410	-12.6 Volt Reference Diode	-12.6 V Adj (R457)	5-47
CR407	+ 12.6 Voltage-Dropping Diode	+ 12.6 V Adj (R443)	5-47
Q1 Q2 V1	Amplifier Amplifier Cathode Follower	"A" Gain (R6) "A" Bal (R4)	5-53 5-53
Q3 Q4 V2	Amplifier Amplifier Cathode Follower	"B" Gain (R24) "B" Bal (R26)	5-53 5-53
Q601 CR604	Pulse Amplifier Pulse Shaper Diode	Pulse Delay (R611)	5-66
Note: Replacement of almost any component in the trigger or time-base circuits requires adjustment of Time Scales and Minimum Delay.			5-63 5-64

c. Loosen two screws holding clamp on crt base and socket. Do not remove screws or clamp.

d. Remove socket from crt base.

e. Slide crt forward out of instrument.

5-42. To install a replacement crt, reverse above procedure. When crt is installed, turn instrument on, obtain a free-running trace, and check trace alignment with horizontal lines on graticule. If necessary, loosen clamp on crt base and rotate crt by the tab on socket to align trace with graticule lines. If instrument has an internal-graticule crt, align trace with SCALE panel control.

5-43. ADJUSTMENT FOLLOWING REPAIR.

5-44. Table 5-4 lists adjustments required following replacement of a tube, transistor, or diode. Tubes, transistors, and diodes which can be replaced without a follow-up adjustment are not listed. If another component associated with an item listed in the table is replaced, check adjustment for listed item.

5-45. ADJUSTMENTS.

5-46. A condensed test and adjustment procedure (table 5-6) follows the detailed procedures. The table is for those who are thoroughly familiar with the adjustment procedures and no longer require the details of long procedures.

5-47. LOW-VOLTAGE POWER SUPPLIES.

5-48. The low-voltage power supplies are quite stable and seldom will require adjustment. If the voltages are regulated and within about 3% of their nominal values, avoid adjustment. Be sure to account for any possible inaccuracy in the voltmeter when measuring voltages.

5-49. The -12.6 volt supply is an exception to the above, for this supply determines accuracy of amplitude calibrator. Keep output of this supply within 1% of -12.6 volts.

Note

Following adjustment of any supply except the -12.6 volt supply, check adjustments listed in table 5-4 under V401.

5-50. When adjustment is necessary, adjust the supplies in the following order: -100, -12.6, +12.6, +100, and +250. You can measure voltages at any convenient point. Table 5-3 indicates the wire color code associated with each supply, and figure 5-12 indicates the location of each adjustment.

5-51. HIGH-VOLTAGE POWER SUPPLY.

5-52. Adjustment of the high voltage affects crt deflection sensitivity, intensity, and astigmatism. Check horizontal and vertical gain following any adjustment of high voltage. Intensity and astigmatism adjustments are included in this procedure.

WARNING

Be careful when measuring high voltage. Use equipment suited for high-voltage measurements. Use an insulated screwdriver to make adjustments in this procedure.

a. Connect voltmeter to either terminal of crt heater winding on power transformer (see figure 5-10).

b. Set High Voltage Adj R306 (figure 5-6) for -2900 volts as read on voltmeter.

c. Set MODE to FREE RUN, SCANNING to FINE, and position trace in center of crt.

d. Set INTENSITY to 9 o'clock and adjust Int. Limit R320 (figure 5-6) to just extinguish trace.

e. Set SCANNING to MANUAL, and increase INTENSITY to make spot visible.

f. Adjust FOCUS and Astig Adj R312 (figure 5-6) for small, round spot.

5-53. VERTICAL AMPLIFIER.

5-54. GAIN AND BALANCE.

a. Set MODE to FREE RUN, SCANNING to INTERNAL, DENSITY full clockwise, and CALIBRATOR to -200.

b. Remove Model 187A/B and connect junction of R61 and C1 (channel A input) and R63 and C5 (channel B input) to ground with a clip lead.

c. Adjust Channel A Balance, R4, (figure 5-6) and Channel B Balance, R26, to center both traces.

d. Remove ground from channel A input and connect junction to calibrator output.

e. Adjust Channel A Gain, R6, to obtain 4-cm deflection.

f. Disconnect channel A input from calibrator and jumper to ground.

g. Remove ground from channel B input and connect junction to calibrator input.

h. Adjust Channel B Gain, R24, to obtain 4-cm deflection.

5-55. PEAKING ADJUST (C7).

a. Set MODE to FREE RUN, SCANNING to INTERNAL and DENSITY full counterclockwise.

b. Place Model 187B channel selector in the A & B position, and adjust VERTICAL POSITION controls to separate traces approximately 10 cm.

c. Adjust C7 (figure 5-6) for minimum vertical tails on samples.

5-56. TRACE INTENSITY BALANCE (C8).

a. Set MODE to FREE RUN, SCANNING to INTERNAL, and DENSITY full clockwise.

b. Place Model 187B channel selector in A & B position, and separate traces slightly with VERTICAL POSITION controls.

c. Adjust C8 (figure 5-6) for equal intensity on both traces.

5-57. SYNC CIRCUIT.

5-58. FREE RUN ADJUST (R157).

a. Set SCANNING to INTERNAL, DENSITY full clockwise, and MODE to approximately 2 o'clock.

b. Adjust R157 (figure 5-9) so that horizontal trace just appears.

5-59. TIME BASE.

5-60. PULSE LENGTH (R236).

a. Set MODE to FREE RUN, SCANNING to INTERNAL, and DENSITY full clockwise.

b. Observe collector waveform of Q208 on the oscilloscope.

c. Adjust pulse length, R236, (figure 5-9) for a pulse width of 1.3 microseconds at the half amplitude points of positive-going pulse.

5-61. STAIRCASE BALANCE (R270).

a. Set SCANNING to EXTERNAL and adjust HORIZONTAL POSITION so spot is at left edge of graticule.

b. Set SCANNING to INTERNAL, DENSITY full counterclockwise, and adjust Staircase Balance R270 (figure 5-9) so first dot is at left edge of graticule.

5-62. HORIZONTAL AMPLIFIER GAIN (R503).

a. Set SCANNING to INTERNAL, MODE to FREE RUN, DENSITY full clockwise.

b. Adjust Horizontal Gain R503, (figure 5-6) for a trace length of approximately 11 cm.

5-63. TIME SCALE ADJUSTMENTS.

a. Connect either vertical probe to the 50-mc CALIBRATOR output and adjust vertical SENSITIVITY for convenient display.

Note

Precheck CALIBRATOR AND SYNC PULSE accuracy in paragraph 5-65.

b. Set MODE to FREE RUN, SCANNING to INTERNAL, DENSITY full clockwise, DELAY counterclockwise, Time Scale VERNIER to CAL.

c. Set TIME SCALE to 2 µSEC/CM, TIME SCALE MAGNIFIER to 100.

d. Set DELAY as far clockwise as possible, maintaining the 50-mc signal across the full screen.

e. Adjust R285 (figure 5-9) for 1 cycle/cm.

f. Set TIME SCALE MAGNIFIER to X20, TIME SCALE to 2 µSEC/CM, and adjust Time Scale VERNIER for 2 cycles/cm.

g. Change TIME SCALE MAGNIFIER to X50, SWEEP TIME to 5 µSEC/CM.

h. Display should show 20 cycles in 10 cm ±5 mm.

i. Change TIME SCALE MAGNIFIER to X100 and TIME SCALE to 10 µSEC/CM.

j. Display should show 20 cycles in 10 cm ±5 mm.

k. Set Time Scale VERNIER to CAL, DELAY to midrange, and adjust all other ranges following conditions of table 5-5.

Table 5-5. Time Scale Adjustments

TIME SCALE	MAGNIFIER	Adjustments (see figure 5-9)	Display (cycles/cm)
2 µSEC/CM	X100	R285	1
5 µSEC/CM	X100	Check	1
10 µSEC/CM	X100	Check	1
1 µSEC/CM	X50	C207	1
0.5 µSEC/CM	X50	C209	1/2
200 NSEC/CM	X10	C211	1
100 NSEC/CM	X5	C213	1
50 NSEC/CM	X5	C215	1/2
20 NSEC/CM	X1	C217	1
10 NSEC/CM	X1	C219	1/2
10 NSEC/CM	X2	Check	1

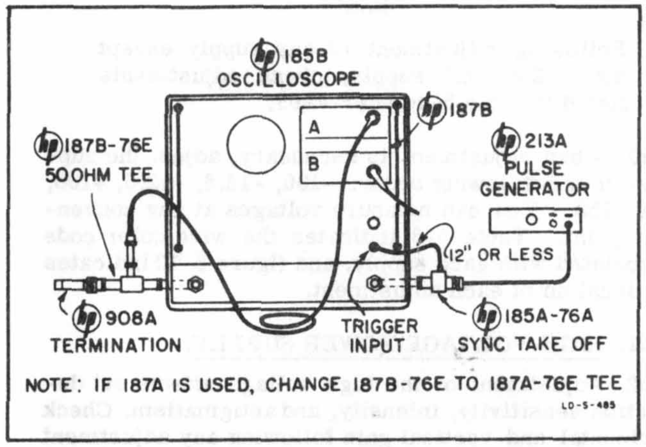


Figure 5-4. Minimum Delay Measurements

5-64. MINIMUM DELAY.

a. Connect equipment as shown in figure 5-4.

b. Set TIME SCALE to 100 NSEC/CM, TIME SCALE MAGNIFIER to X10, SCANNING to INTERNAL, DELAY full counterclockwise, TRIGGERING to NORMAL, vertical SENSITIVITY to 100 MILLIVOLTS/CM.

c. Adjust Model 213A sensitivity full clockwise and adjust Model 185B MODE and STABILITY for a stable pattern.

d. Adjust R213, Minimum Delay (figure 5-9) so pulse rise occurs 2 cm from start of trace.

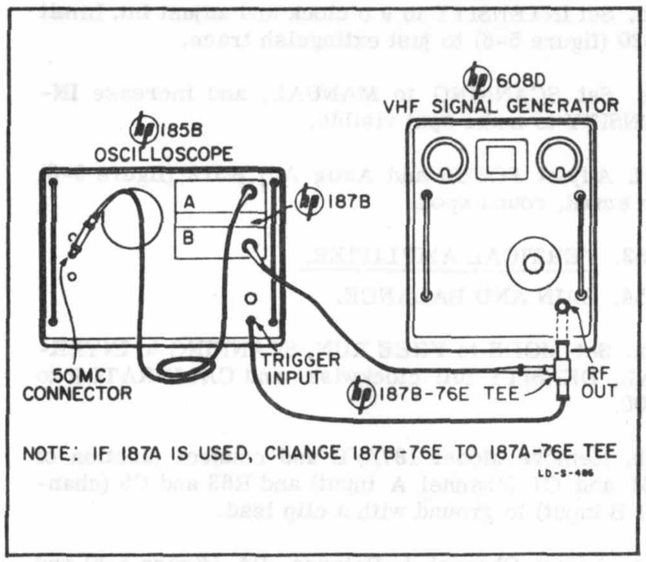


Figure 5-5. Calibrator Instrument Setup

5-65. CALIBRATOR AND SYNC PULSE.

a. Connect equipment as shown in figure 5-5.

b. Set CALIBRATOR full counterclockwise, SCANNING to INTERNAL, DENSITY full clockwise, TIME SCALE to 100 NSEC/CM, TIME SCALE MAGNIFIER to X5, DELAY full clockwise, TRIGGER to NORMAL, 187B channel selector to A & B, SENSITIVITY to 50 MILLIVOLTS/CM.

Table 5-6. Condensed Test and Adjustment Procedure

<table>
<tr><th>Test</th><th>Required Equipment</th><th>Procedure</th><th>Adjustment</th><th>Notes</th></tr>
<tr><td>Time Scale Adj</td><td>None</td><td colspan="2">Connect vertical amplifier probe to 50-mc connector and free run the 185B. Set controls as follows:
<table>
<tr><th>Time Scale</th><th>Magnifier</th><th>Adjust</th><th>For cy/cm</th></tr>
<tr><td>2 μSEC/CM</td><td>X100</td><td>R285</td><td>1</td></tr>
<tr><td>1 μSEC/CM</td><td>X50</td><td>C207</td><td>1</td></tr>
<tr><td>0.5 μSEC/CM</td><td>X50</td><td>C209</td><td>1/2</td></tr>
<tr><td>200 NSEC/CM</td><td>X10</td><td>C211</td><td>1</td></tr>
<tr><td>100 NSEC/CM</td><td>X5</td><td>C213</td><td>1</td></tr>
<tr><td>50 NSEC/CM</td><td>X5</td><td>C215</td><td>1/2</td></tr>
<tr><td>20 NSEC/CM</td><td>X1</td><td>C217</td><td>1</td></tr>
<tr><td>10 NSEC/CM</td><td>X1</td><td>C219</td><td>1/2</td></tr>
</table></td><td>Precheck 50 MC calibrator accuracy</td></tr>
<tr><td>Minimum Delay</td><td>Delay line 120ns, 50-ohm hp 1100A
Probe Tee 50-ohm hp 187B-76E
Termination 50-ohm hp 908A
Sync Take-Off 50-ohm hp 185A-76A
Pulse Generator 10-ns rise time hp 213A</td><td>Connect pulse generator to trigger INPUT and through delay line to vertical channel of 185B/187A/B. Set TIME SCALE to 100 NSEC/CM, TIME SCALE MAGNIFIER to X10, and DELAY full counterclockwise</td><td>Adjust MINIMUM DELAY (front panel) so pulse rise time occurs 2 cm after start of trace. For close approximation see note column. Use same TIME SCALE and MAGNIFIER settings.</td><td>A close approximation can be made by connecting the vertical probe to 50-mc connector and adjusting delay so nonlinear portion of 50-mc signal (first few cycles) is just off screen</td></tr>
<tr><td>Sync Pulse Position</td><td>10:1 Divider hp 187B-76C</td><td>Connect vertical probe through 10:1 divider to SYNC PULSE OUTPUT. Free run 185B, set TIME SCALE to 100 NSEC/CM, TIME SCALE MAGNIFIER to X10 and DELAY counterclockwise</td><td>Adjust R611 so rise of pulse is 3 cm after start of trace</td><td></td></tr>
<tr><td>50 MC Adjust</td><td>Signal Generator 50 mc hp 606A or 608D
Probe Tee Connector 187B-76E</td><td>Connect one channel at 187B to 50-mc connector and the other through tee connector to signal generator. Connect open end of tee to 185B trigger INPUT</td><td>Adjust C610 to make calibrator frequency the same as signal generator frequency</td><td>hp 606A and 608D have internal crystal calibrators ±1%</td></tr>
</table>

c. Set signal generator output for 350 mv at 50 mc (use calibrator on signal generator to insure exact frequency).

d. Adjust MODE and STABILITY for stable display.

e. Adjust C610 (figure 5-6) to make CALIBRATOR frequency within 1 mc of signal generator frequency.

Note

If CALIBRATOR is to be used as calibrating source for sweep times set CALIBRATOR to 50 mc ±250 kc.

5-66. SYNC PULSE POSITION (R611).

a. Connect either vertical amplifier probe to the SYNC PULSE output through a 187B-76C.

b. Set SENSITIVITY to 100 MILLIVOLTS/CM, MODE to FREE RUN, TIME SCALE to 100 NSEC/CM, TIME SCALE MAGNIFIER to X10, DELAY full counterclockwise, and SCANNING to INTERNAL full clockwise.

c. Adjust Pulse Position R611 (figure 5-2) so rise of sync pulse is 3 cm after start of trace.

5-67. PERFORMANCE CHECK.

5-68. TIME CALIBRATOR.

a. Connect equipment as shown in figure 5-5 and set signal generator to 50 mc ±250 kc.

b. Set channel selector on 187A/B to A & B.

c. Adjust MODE, STABILITY and time scales and vertical SENSITIVITY for convenient display.

d. Calibrator frequency must be within 1 mc of signal generator frequency.

5-69. SYNC PULSE.

a. Connect tee connector (187B-76E) and 50-ohm termination (908A) to SYNC PULSE output.

b. Connect one vertical probe to tee connector and check:

Amplitude - at least 1-1/2 volts
Rise Time - 2 ns or less
Width - approximately 5 μs

5-70. AMPLITUDE CALIBRATOR.

5-71. Connect voltmeter (412A) to CALIBRATOR output. Voltages measured on each range should be within the tolerances listed in table 5-7.

Table 5-7. Amplitude Calibrator Accuracy

CALIBRATOR range	20	100	200	1000	MV
Tolerance	0.6	3	6	30	mv

5-72. TIME SCALE.

a. Connect one vertical probe to 50-MC CALIBRATOR output.

b. Set TIME SCALE MAGNIFIER to X100, TIME SCALE to 2 μSEC/CM, and free run Model 185B and adjust DELAY as far clockwise as possible and still maintain 50-mc signal across full trace.

c. Display should show 10 cycles in 10 cm ±5 mm.

d. Adjust Time Scale VERNIER to make display 4 cycles in 10 cm.

e. Switch TIME SCALE to 5 μSEC/CM and adjust DELAY as in step b.

f. Display should show 10 cycles in 10 cm ±5 mm.

g. Switch TIME SCALE to 10 μSEC/CM and adjust DELAY as in step b.

h. Display should show 20 cycles in 10 cm ±5 mm.

i. Set Time Scale VERNIER to CAL and DELAY to midrange and following table 5-8, check balance of sweep time ranges for a 10-cm display ±5 mm.

5-73. MINIMUM DELAY.

5-74. Connect one vertical input to 50-MC CALIBRATOR output, set DELAY counterclockwise, and note that period of second cycle is equal to period of last cycle displayed.

5-75. TRIGGER SENSITIVITY.

a. Set TRIGGERING to NORMAL.

(1) Connect signal generator (608D) to trigger input and to vertical input probe as in figure 5-8. Apply a 300-mv peak-to-peak, 100-mc signal.

(2) Set TIME SCALE to 100 NSEC/CM.

(3) Trace should appear with proper adjustment of MODE and STABILITY controls.

b. Set TRIGGERING to SENSITIVE.

(1) Repeat paragraph 5-75, step a, using 30-mv peak-to-peak signal from generator.

c. Set TRIGGERING to HIGH FREQ.

(1) Connect signal generator (612A) to trigger input and to vertical input probe as in figure 5-5. Apply a 150-mv peak-to-peak, 1000-mc signal.

(2) Steady display should appear with proper adjustments of MODE, STABILITY and HIGH FREQUENCY STABILITY controls.

Table 5-8. Time Scale Calibration Check

TIME SCALE	MAGNIFIER	Cycles/10 cm
1 μSEC/CM	X50	10
0.5 μSEC/CM	X50	5
200 NSEC/CM	X10	10
100 NSEC/CM	X5	10
50 NSEC/CM	X5	5
20 NSEC/CM	X1	10
10 NSEC/CM	X1	5

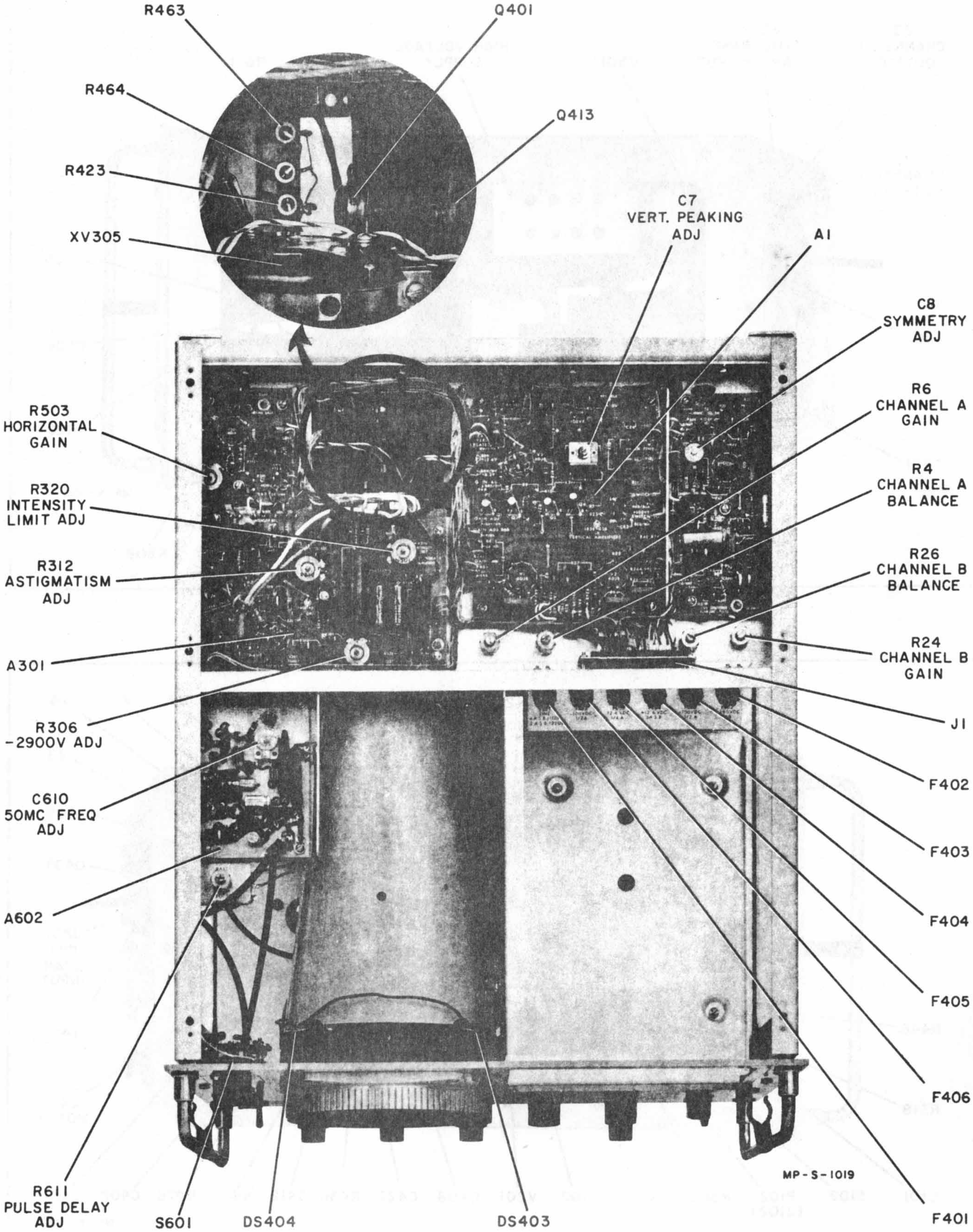


Figure 5-6. Top View, Model 185B

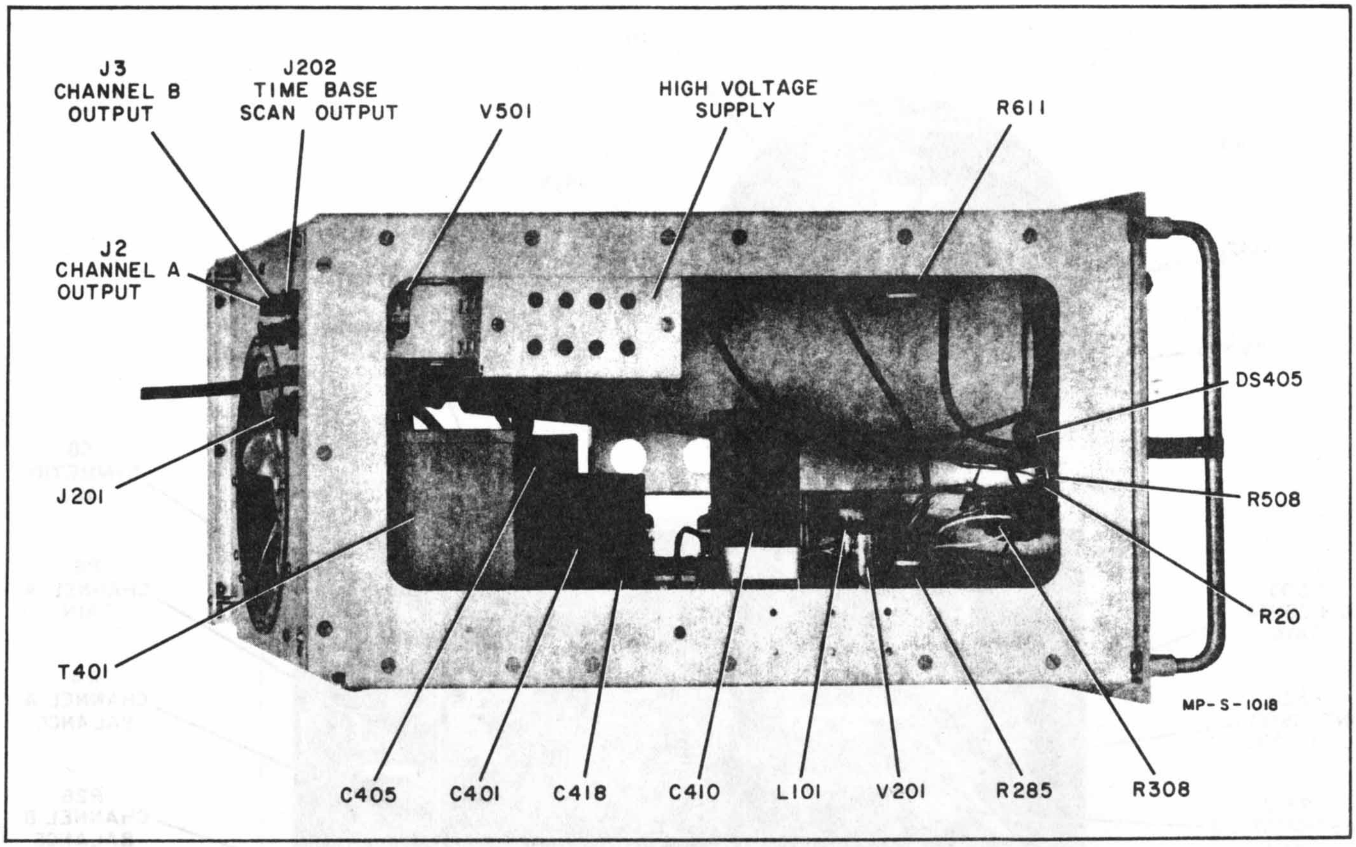


Figure 5-7. Left Side View, Model 185B

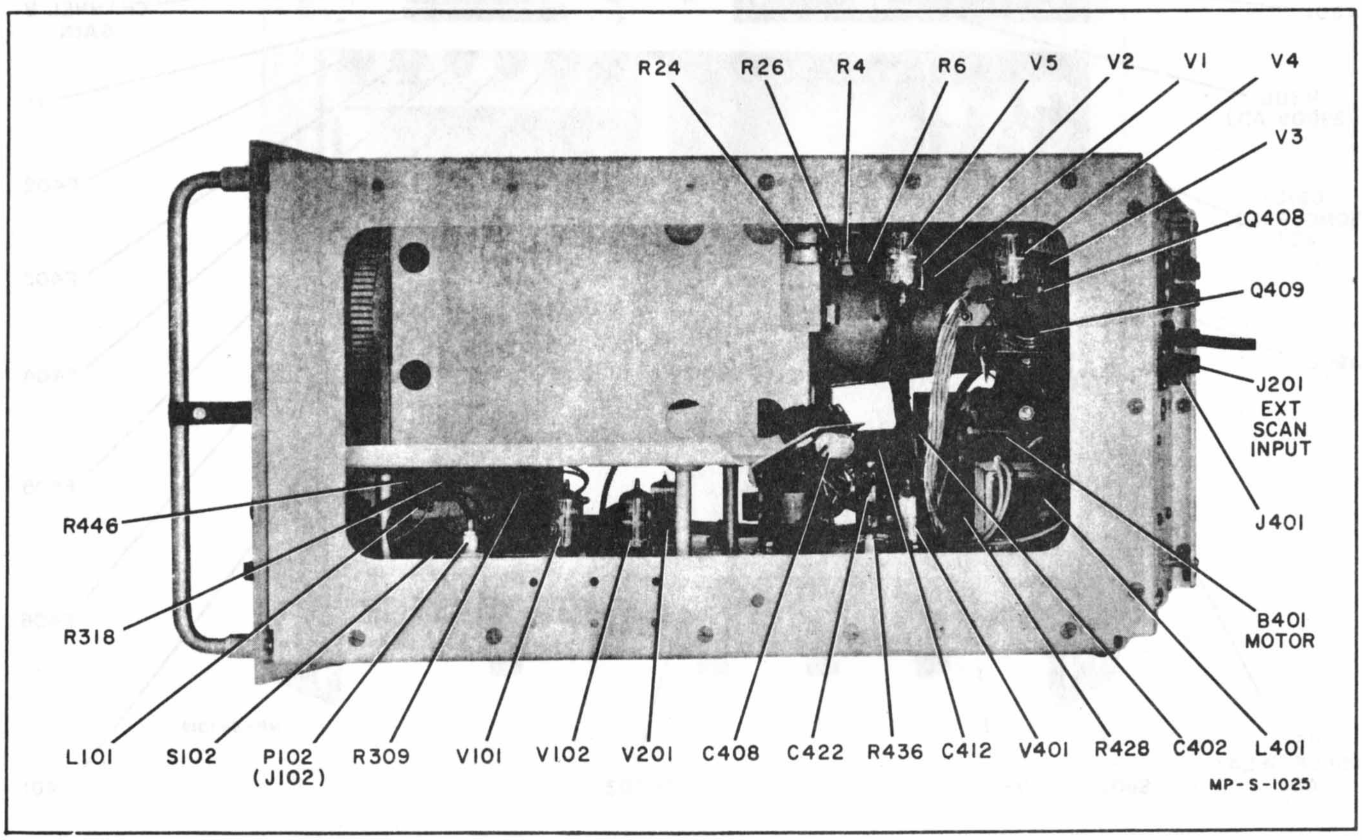


Figure 5-8. Right Side View, Model 185B

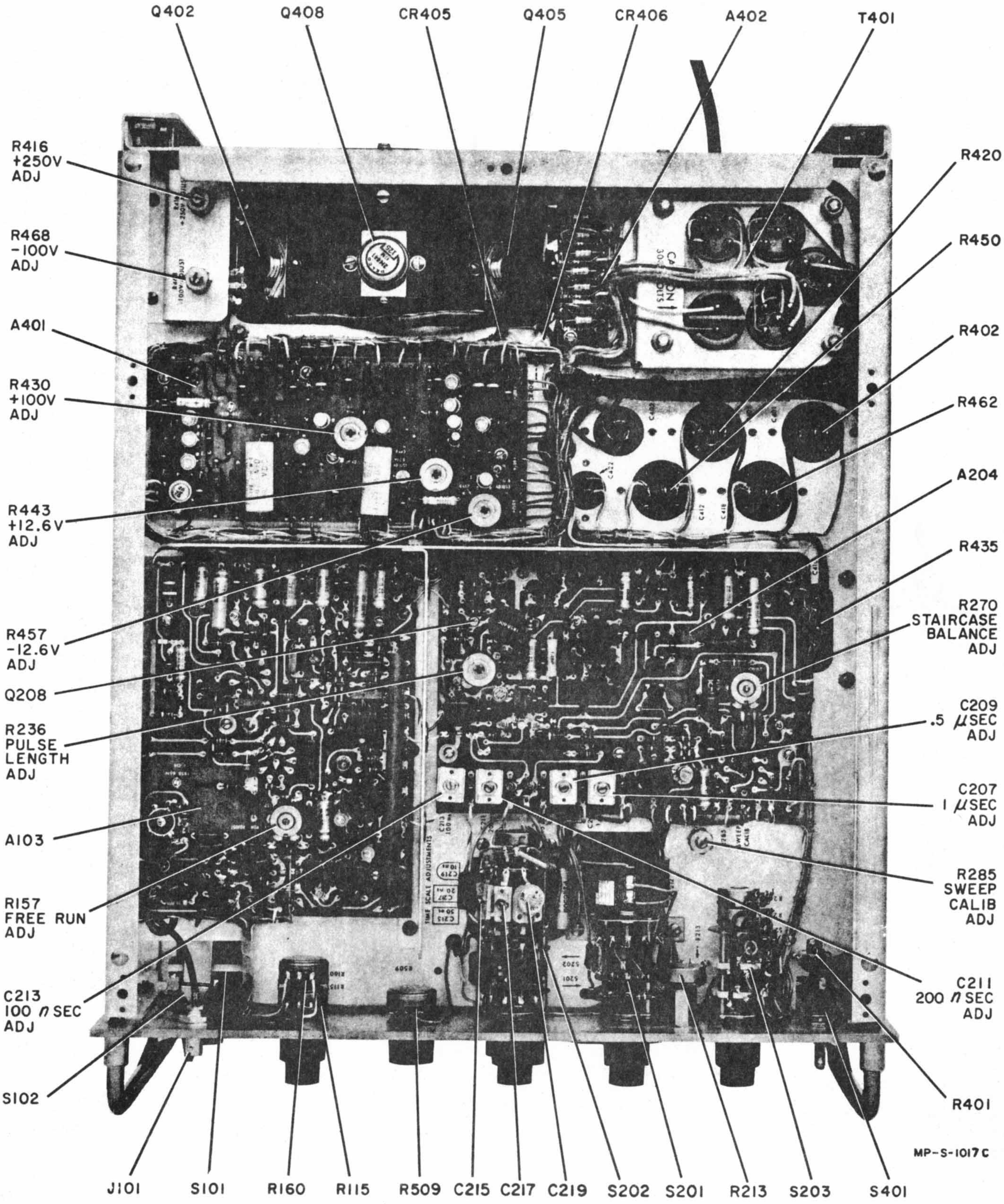


Figure 5-9. Bottom View, Model 185B

SCHEMATIC DIAGRAM NOTES

The following notes apply generally to all schematic diagrams. Individual schematics may have specific notes that apply to that schematic only.

a. All rotary switches are shown full clockwise as viewed from front panel, with the exception of the CALIBRATOR AND SYNC PULSE switch which is shown full counterclockwise.

b. Letters after the switch wafers (i.e., S202A) identify switch wafers (A = front side of first wafer, B = rear side, etc).

c. (1) 2 means that a waveform was taken at that point. The number in center refers to number under waveforms opposite schematic. See waveform notes.

(2) * means optimum value of component selected at the factory, average value shown.

d. DC voltages taken with electronic voltmeter having 10-megohm input resistance.

e. Resistance is in ohms, capacitance in picofarads unless otherwise noted.

f. "VF" means filtered voltage.

g. DC voltages in trigger circuit are taken with controls set as follows:

SCANNING	INTERNAL
DENSITY	clockwise
TIME SCALE MAGNIFIER	X1
TIME SCALE	10 μSEC/CM
MODE	TRIGGER
STABILITY	counterclockwise
TRIGGERING	NORMAL
HIGH FREQUENCY STABILITY	counterclockwise

WAVEFORM NOTES

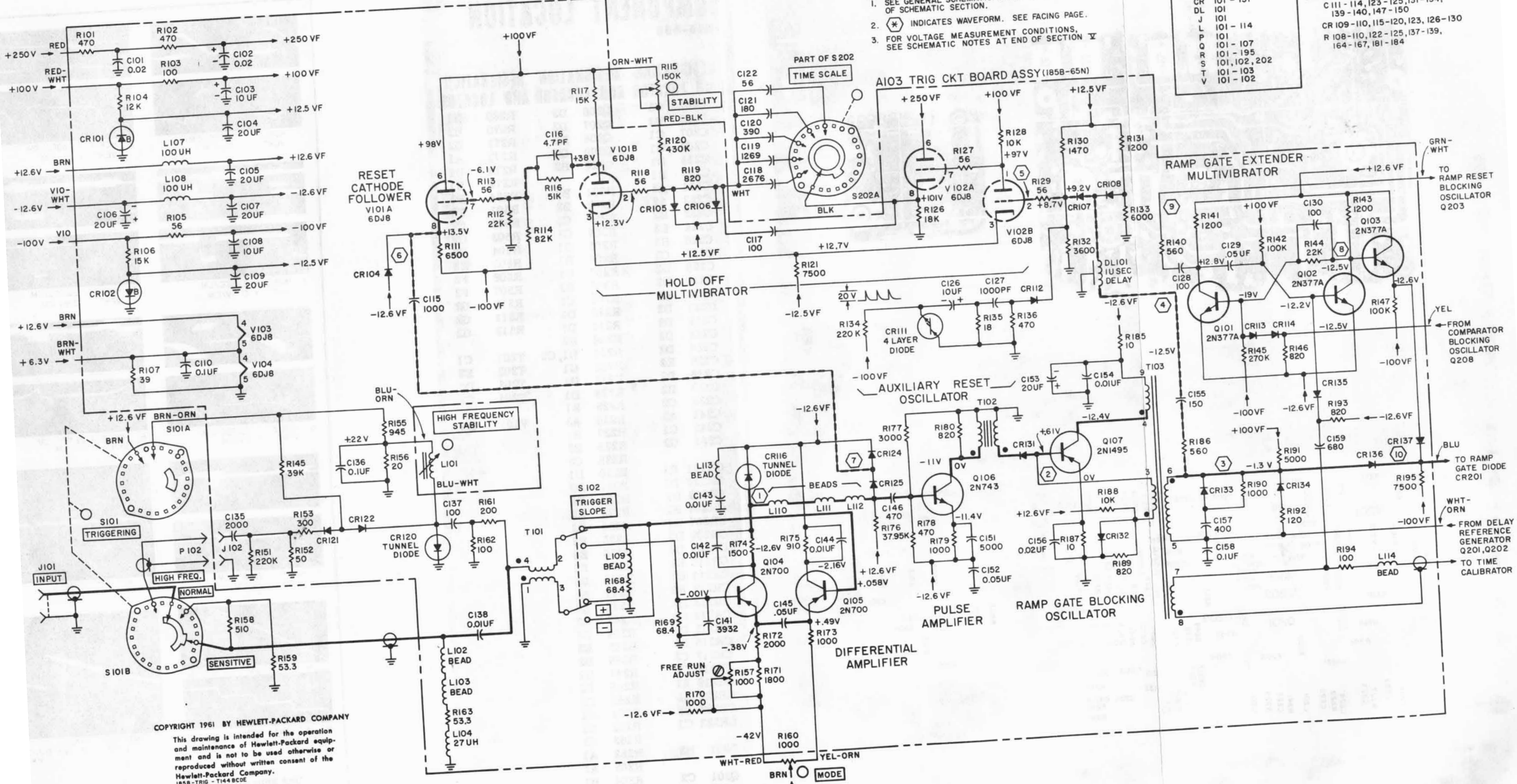
The following notes apply to all waveforms unless specifically contradicted on the waveform page. Waveforms are taken with 40-mc oscilloscope using a high-impedance probe.

a. Switch settings are as follows:

SCANNING	INTERNAL
DENSITY	counterclockwise
TIME SCALE MAGNIFIER	full counterclockwise
Time Scale VERNIER . .	full counterclockwise
TRIGGERING	HIGH FREQ
CALIBRATOR AND SYNC PULSE	full counterclockwise

b. Unless otherwise noted on the waveform page, where two waveforms are shown over one number, the upper one was taken with TIME SCALE set to 200 NSEC/CM, and the lower one was taken with TIME SCALE set to 10 NSEC/CM.

c. External sync from viewing oscilloscope was used unless otherwise noted by the word "internal" under the waveform.



NOTES

1. SEE GENERAL SCHEMATIC NOTES AT BEGINNING OF SCHEMATIC SECTION.
2. (*) INDICATES WAVEFORM. SEE FACING PAGE.
3. FOR VOLTAGE MEASUREMENT CONDITIONS, SEE SCHEMATIC NOTES AT END OF SECTION V

REFERENCE DESIGNATORS	
A	103
C	101 - 159
CR	101 - 137
DL	101
J	101
L	101 - 114
P	101
Q	101 - 107
R	101 - 195
S	101,102,202
T	101 - 103
V	101 - 102

UNASSIGNED:
C 111 - 114, 123 - 125, 131 - 134, 139 - 140, 147 - 150
CR 109 - 110, 115 - 120, 123, 126 - 130
R 108 - 110, 122 - 125, 137 - 139, 164 - 167, 181 - 184

Figure 5-13. Trigger Circuit

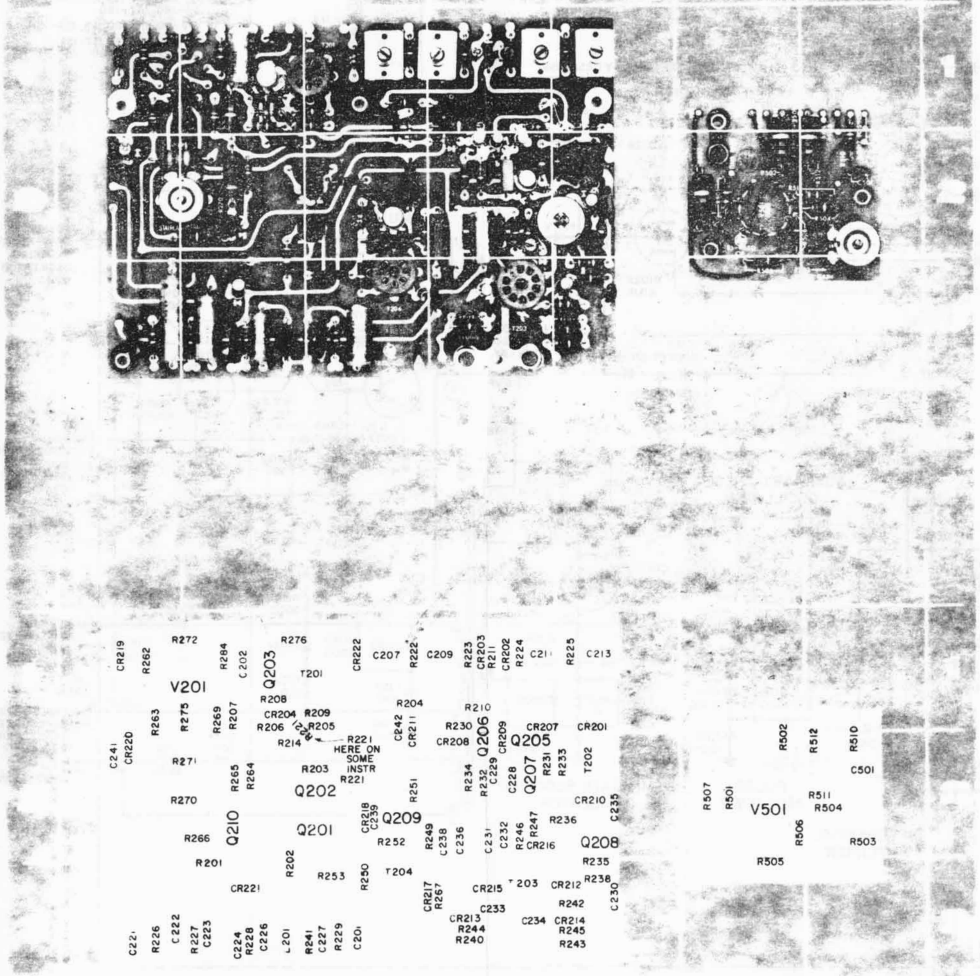


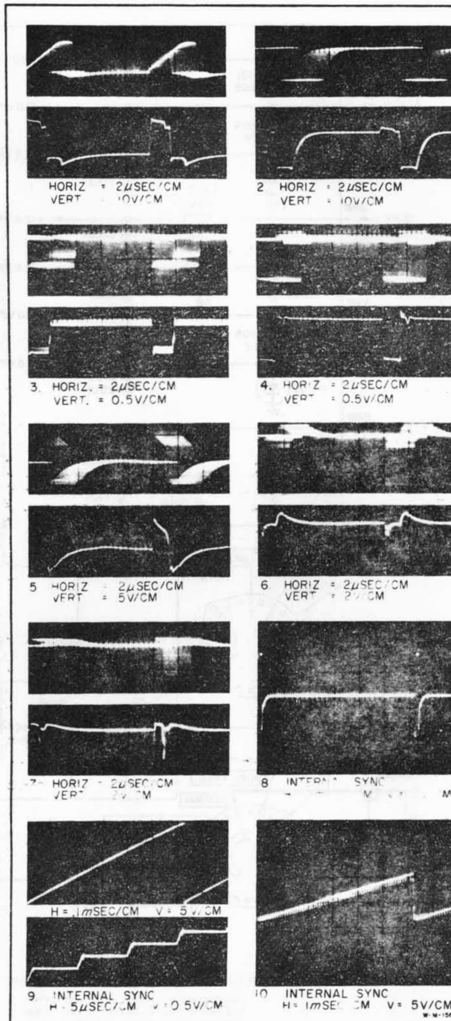
Figure 5-14. A204 Component Location

COMPONENT LOCATION

185B-65E

DESIGNATION AND LOCATOR		DESIGNATION AND LOCATOR		DESIGNATION AND LOCATOR	
C201	C3	Q206	D2	R269	B1
C202	B1	Q207	D2	R270	B2
C207	C1	Q208	E2	R271	B2
C209	D1	Q209	C2	R272	A1
C211	D1	Q210	B2	R275	B1
C213	E1			R276	B1
C221	A3	R201	B2	R284	B1
C222	A3	R202	B2	R501	F2
C223	B3	R203	C2	R502	F2
C224	B3	R204	C1	R503	G2
C226	B3	R205	C1	R504	G2
C227	C3	R206	B1	R505	E3
C228	D2	R207	B1	R506	F2
C229	D2	R208	B1	R507	F2
C230	E3	R209	C1	R510	G2
C231	D2	R210	D1	R511	G2
C232	D2	R211	D1	R512	G2
C233	D3	R214	B2		
C234	D3	R221	B1, C2	T201	C1
C235	E2	R222	C1	T202	E2
C236	D2	R223	D1	T203	D3
C238	D2	R224	D1	T204	C3
C239	C2	R225	E1		
C241	A2	R226	A3	V201	B1
C242	C1	R227	B3		
C501	G2	R228	B3		
		R229	C3		
CR201	E1	R230	D1		
CR202	D1	R231	D2		
CR203	D1	R232	D2		
CR204	B1	R233	E2		
CR207	D1	R234	D2		
CR208	D2	R235	E3		
CR209	D1	R236	E2		
CR210	E2	R238	E3		
CR211	C1	R240	D3		
CR212	E3	R241	B3		
CR213	D3	R242	E3		
CR214	E3	R243	E3		
CR215	D3	R244	C3		
CR216	D2	R245	E3		
CR217	C3	R246	D2		
CR218	C2	R247	D2		
CR219	A1	R249	C2		
CR220	A2	R250	C3		
CR221	B3	R251	C2		
CR222	C1	R252	C2		
		R253	C3		
L201	B3	R262	A1		
		R263	A1		
Q201	C2	R264	B2		
Q202	C2	R265	B2		
Q203	B1	R266	B2		
Q205	D2	R267	C3		

MP-M-70



See general waveform notes on page 5-15 for conditions of waveform measurement.

Waveforms 9 and 10 were taken with DENSITY full clockwise.

Figure 5-15. Waveforms

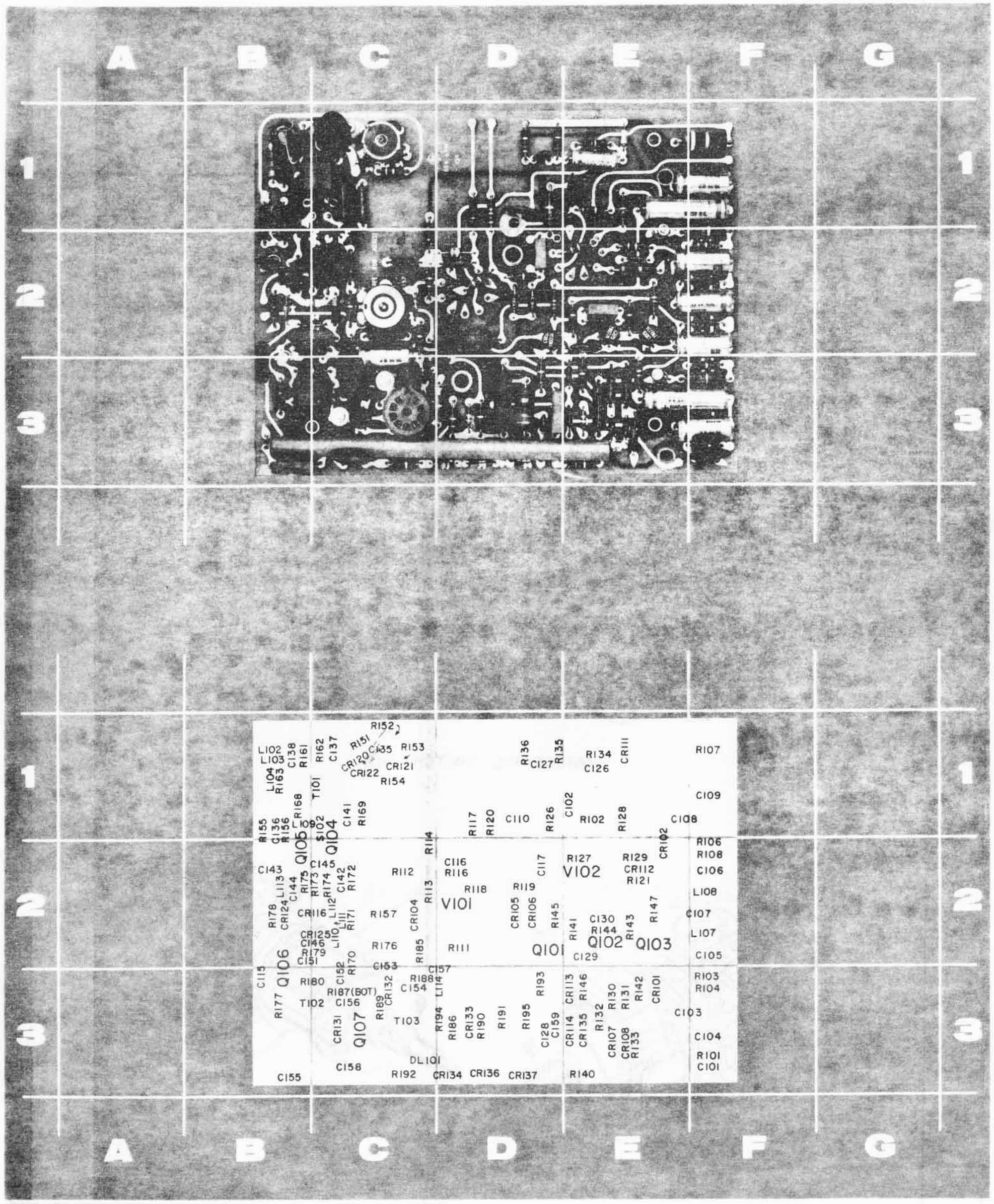


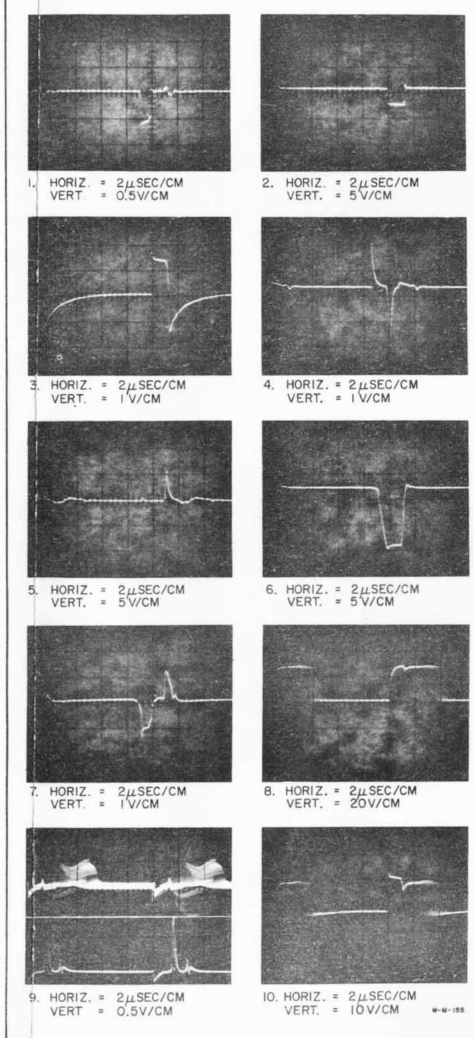
Figure 5-10. A103 Component Location

COMPONENT LOCATION

185B-65N

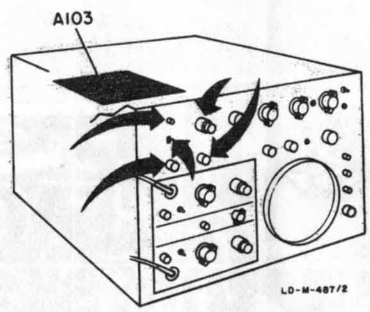
DESIGNATION AND LOCATOR		DESIGNATION AND LOCATOR		DESIGNATION AND LOCATOR	
C101	F3	CR124	B2	R133	E3
C102	E1	CR125	C2	R134	E1
C103	E3	CR131	C3	R135	D1
C104	F3	CR132	C3	R136	D1
C105	F2	CR133	D3	R140	E3
C106	F2	CR134	D3	R141	E2
C107	F2	CR135	E3	R142	E3
C108	E1	CR136	D3	R143	E2
C109	F1	CR137	D3	R144	E2
C110	D1	CR153	D3	R145	D2
C115	F2			R146	E3
C116	D2	L102	B1	R147	E2
C117	D2	L103	B1	R151	C1
C126	E1	L104	B1	R152	C1
C127	D1	L107	F2	R153	C1
C128	D3	L108	F2	R154	C1
C129	E2	L109	B1	R155	B1
C130	E2	L110	C2	R156	B1
C135	C1	L111	C2	R157	C2
C136	B1	L112	C2	R161	B1
C137	C1	L113	B2	R162	C1
C138	B1	L114	D3	R163	B1
C141	C1			R168	B1
C142	C2	Q101	D2	R169	C1
C143	B2	Q102	E2	R170	C2
C144	B2	Q103	E2	R171	C2
C145	C2	Q104	C2	R172	C2
C146	C2	Q105	B2	R173	C2
C151	B2	Q106	B3	R174	C2
C152	B3	Q107	C3	R175	B2
C153	C3			R176	C2
C154	C3	R101	F3	R177	B3
C155	B3	R102	E1	R178	B2
C156	C3	R103	F3	R179	B2
C157	D3	R104	F3	R180	B3
C158	C3	R106	F2	R185	C2
C159	D3	R107	F1	R186	D3
		R108	F2	R187	C3
CR101	E3	R111	D2	R188	C3
CR102	E2	R112	C2	R189	C3
CR104	C2	R113	C2	R190	D3
CR105	D2	R114	C2	R191	D3
CR106	D2	R116	D2	R192	C3
CR107	E3	R117	D1	R193	D3
CR108	E3	R118	D2	R194	D3
CR111	E1	R119	D2	R195	D3
CR112	E2	R120	D1		
CR113	E3	R121	E2	S102	C1
CR114	E3	R126	D1		
CR115	E3	R127	E2	T101	C1
CR116	C2	R128	E1	T102	B3
CR120	C1	R129	E2	T103	C3
CR121	C1	R130	E3		
CR122	C1	R131	E3	V101	D2
		R132	E3	V102	E2

MP-M-76
B-L-123

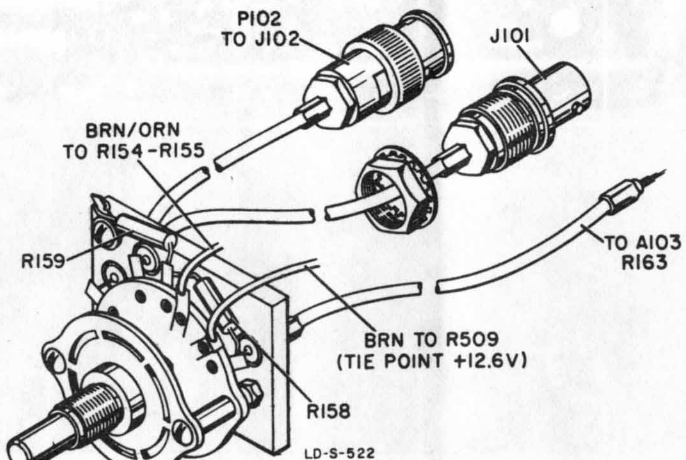


See general waveform notes on page 5-15 for conditions of waveform measurement.

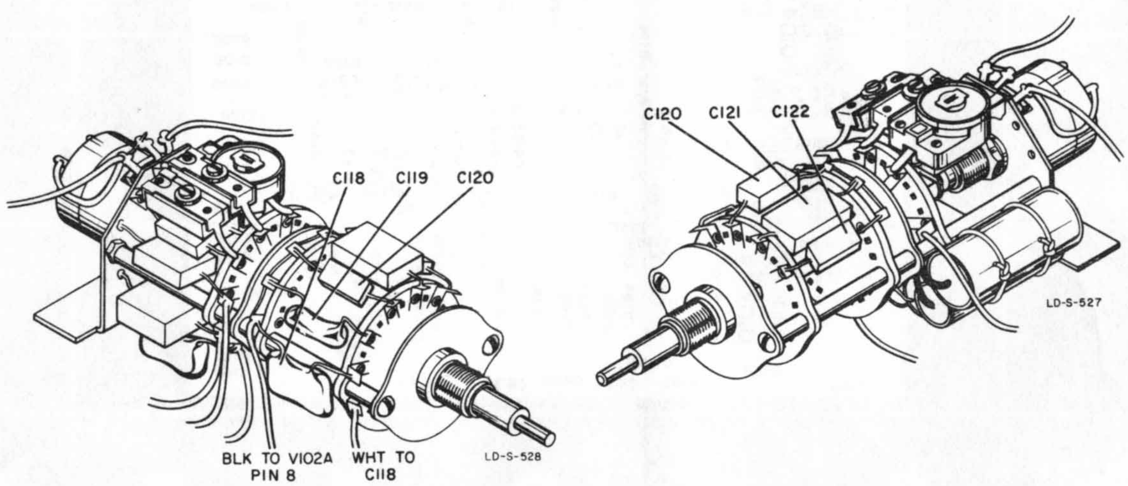
Figure 5-11. Waveforms



ASSEMBLY LOCATION



TRIGGERING SWITCH S101



TIME SCALE SWITCH S202

Figure 5-12. Parts Location, Switch Assemblies

NOTES

1. SEE GENERAL SCHEMATIC NOTES AT BEGINNING OF SCHEMATIC SECTION.
2. (*) INDICATES WAVEFORM. SEE FACING PAGE.
3. FOR VOLTAGE MEASUREMENT CONDITIONS, SEE SCHEMATIC NOTES AT END OF SECTION V

REFERENCE DESIGNATORS	
A	103
C	101 - 159
CR	101 - 137
DL	101
J	101
L	101 - 114
P	101
Q	101 - 107
R	101 - 195
S	101, 102, 202
T	101 - 103
V	101 - 102

UNASSIGNED:
C 111 - 114, 123 - 125, 131 - 134, 139 - 140, 147 - 150
CR 109 - 110, 115 - 120, 123, 126 - 130
R 108 - 110, 122 - 125, 137 - 139, 164 - 167, 181 - 184

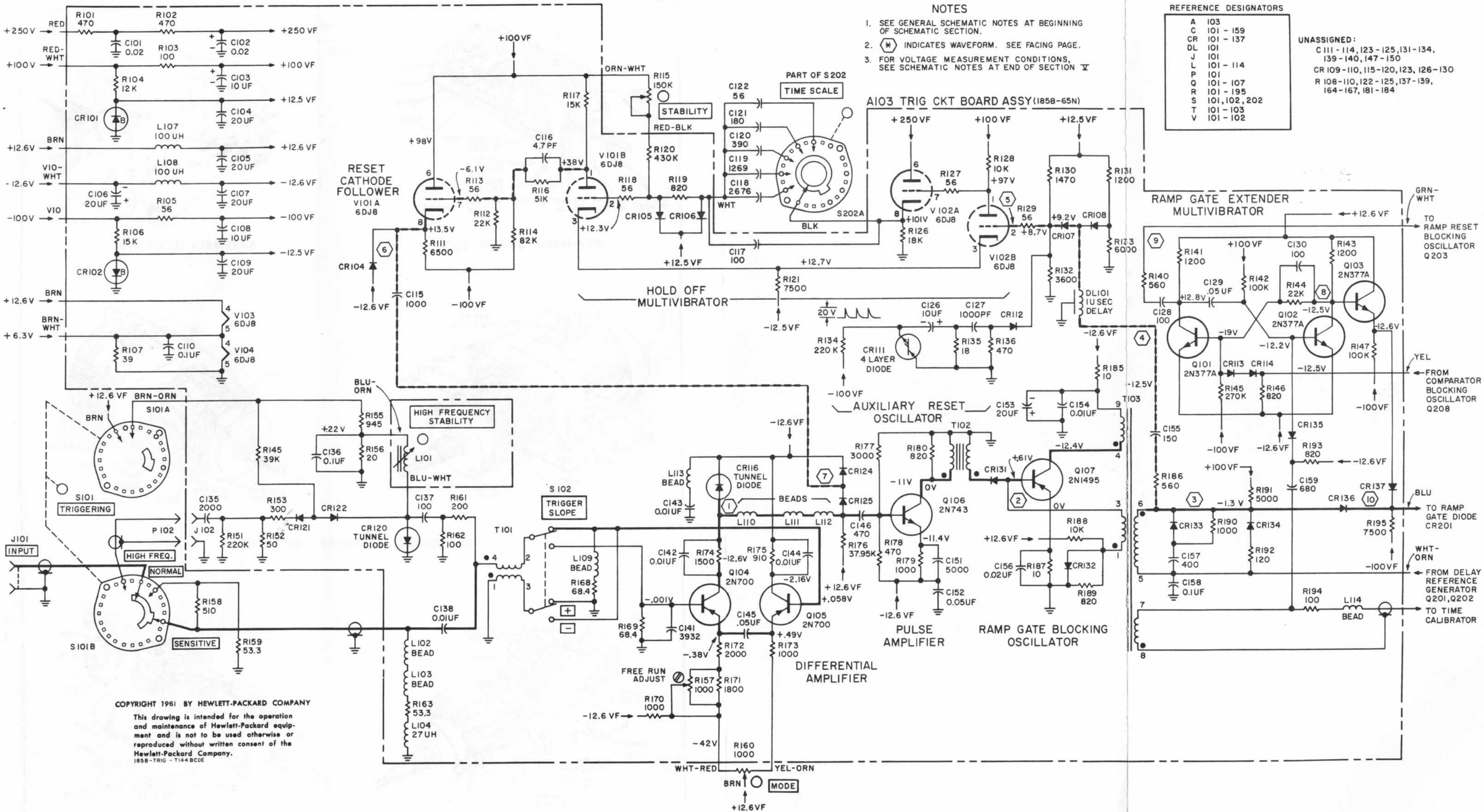
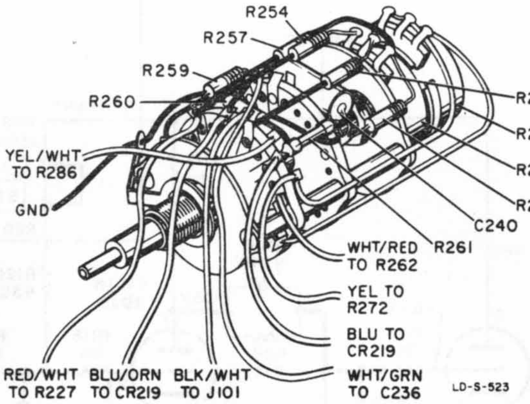
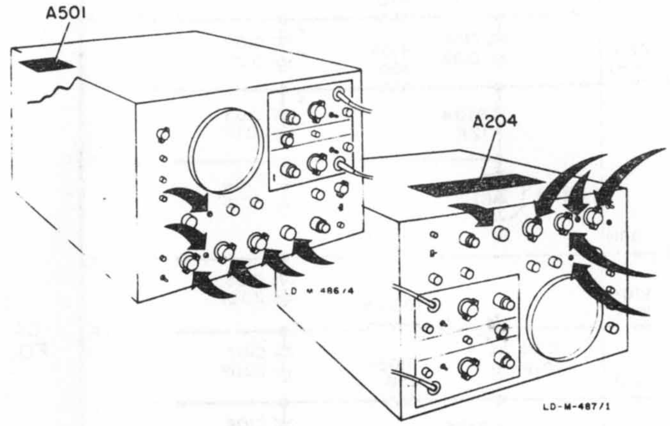


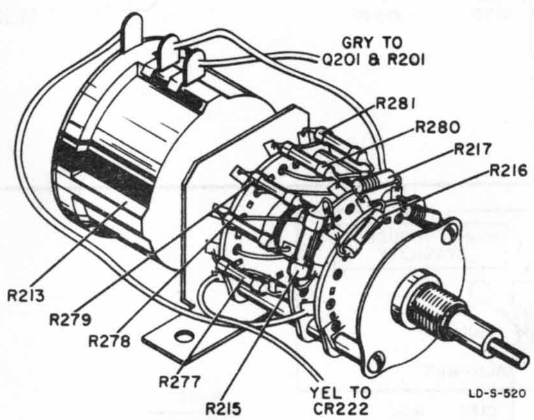
Figure 5-13. Trigger Circuit

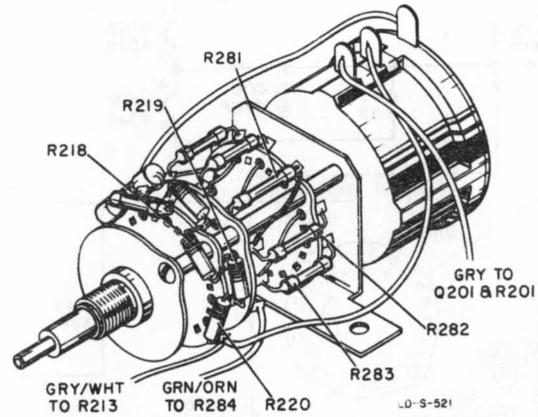


SCANNING SWITCH S203

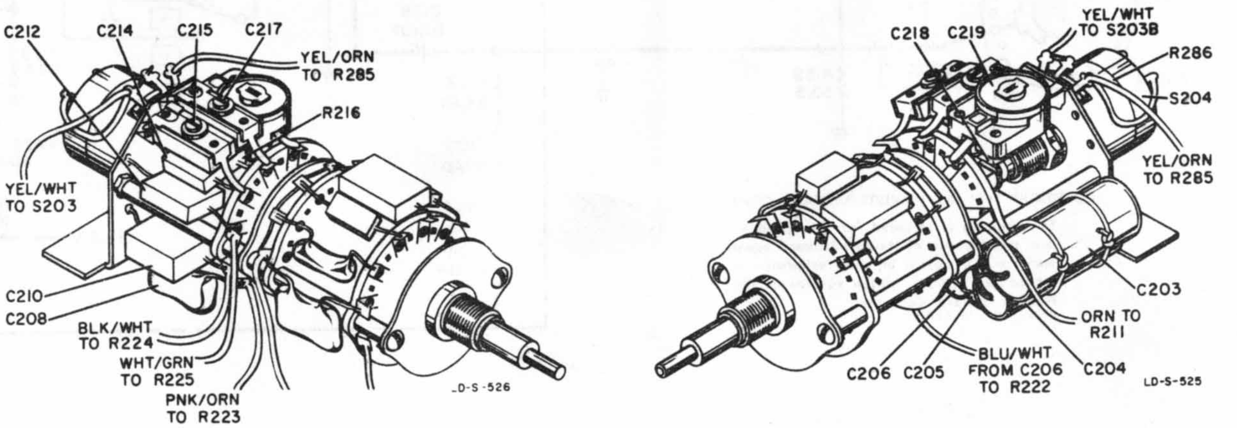


ASSEMBLY LOCATION





TIME SCALE MAGNIFIER SWITCH S201



TIME SCALE SWITCH S202

Figure 5-16. Parts Location, Switch Assemblies

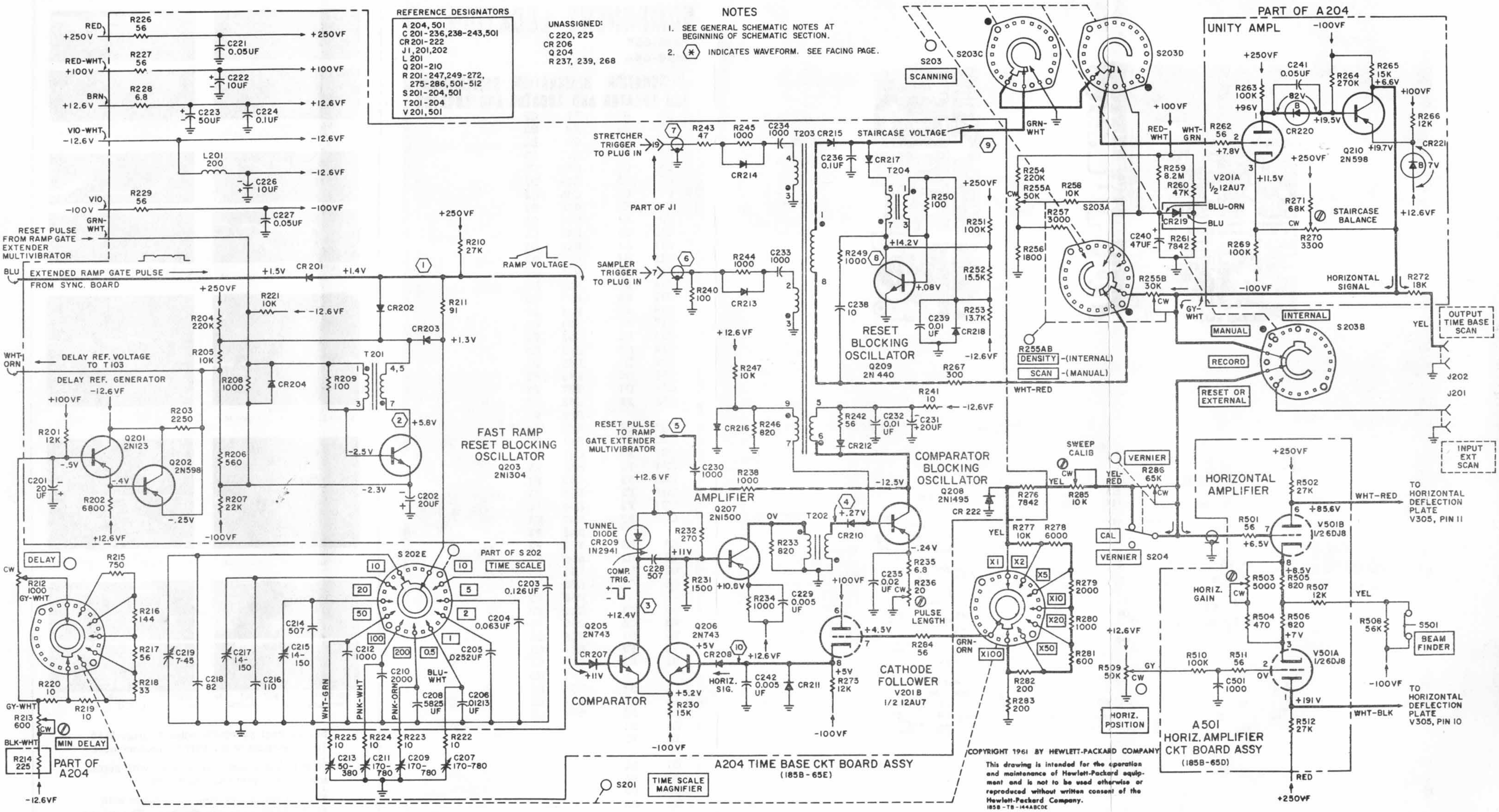


Figure 5-17. Time-Base Circuit

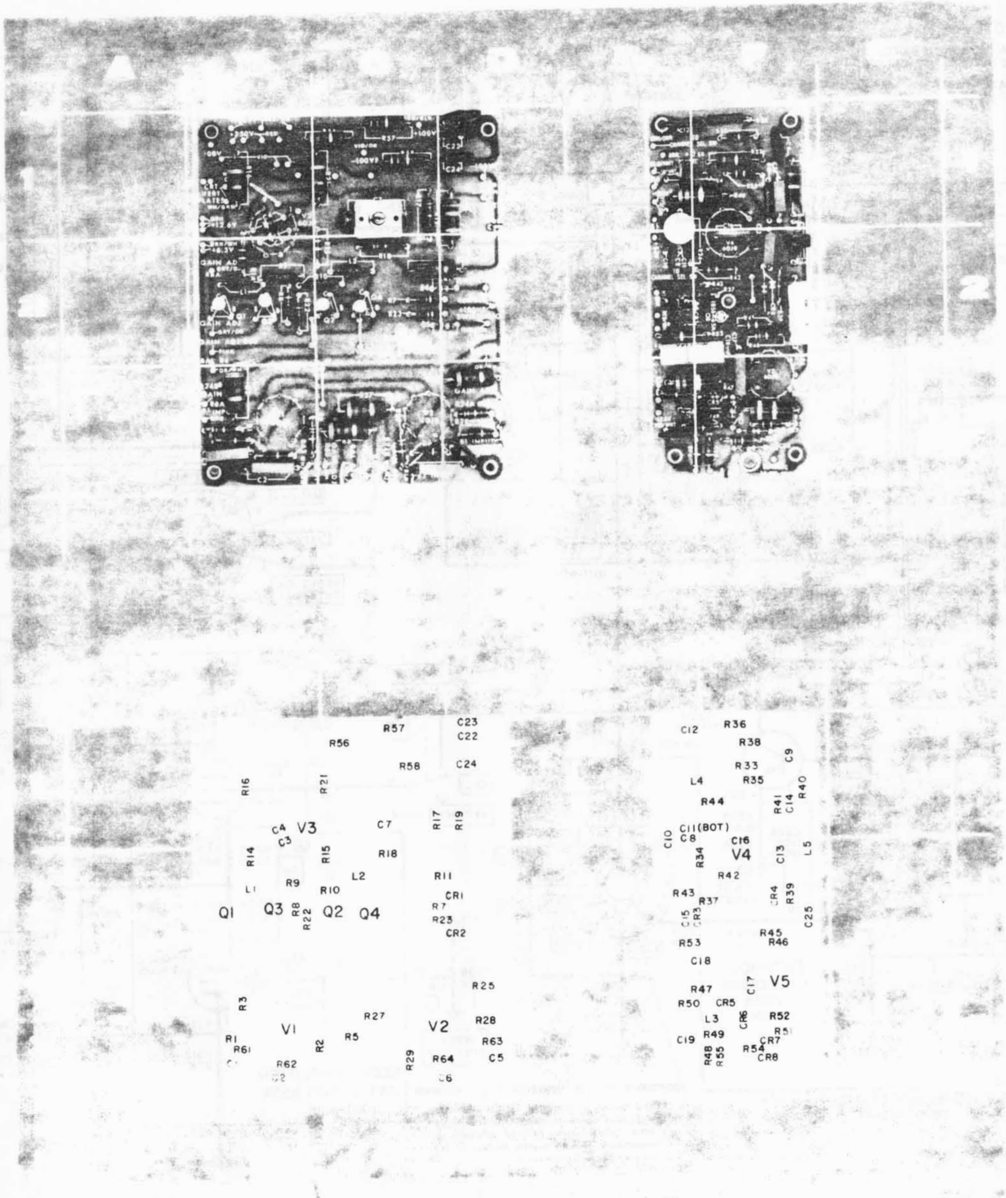


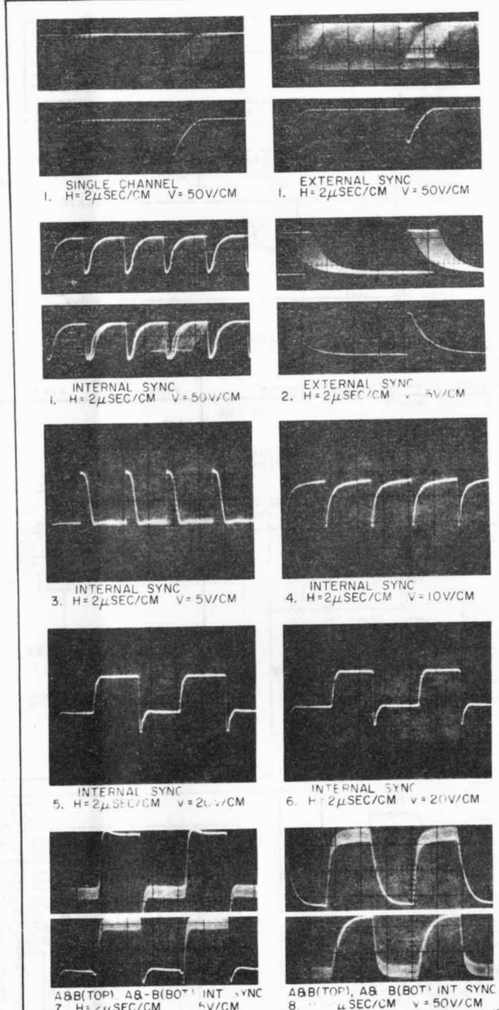
Figure 5-18. A1 and A2 Component Location

COMPONENT LOCATION

185B-65B
185B-65A

DESIGNATION AND LOCATOR		DESIGNATION AND LOCATOR		DESIGNATION AND LOCATOR	
C1	B3	R7	C2		
C2	B3	R8	B2		
C3	B1	R9	B2		
C4	B1	R10	C2		
C5	D3	R11	C2		
C6	C3	C14	B2		
C7	C1	C15	C2		
C8	E1	R16	B1		
C9	F1	R17	C1		
C10	E1	R18	C2		
C11	E1	R19	D1		
C12	E1	R22	B2		
C13	F2	R23	C2		
C14	F1	R26	D3		
C15	E2	R27	C3		
C16	F2	R28	D3		
C17	F3	R29	C3		
C18	E2	R33	F1		
C19	E3	R34	E2		
C22	D1	R35	F1		
C23	D1	R36	F1		
C24	D1	R37	F2		
C25	F2	R38	F1		
		R39	F2		
CR1	D2	R40	F1		
CR2	D2	R41	F1		
CR3	E2	R42	F2		
CR4	F2	R43	E2		
CR5	F3	R44	F1		
CR6	F3	R45	F2		
CR7	F3	R46	F2		
CR8	F3	R47	E3		
		R48	F3		
Q1	B2	R49	F3		
Q2	C2	R50	E3		
Q3	B2	R51	F3		
Q4	C2	R52	F3		
		R53	E2		
V1	B3	R54	F3		
V2	C3	R55	F3		
V3	B1	R56	C1		
V4	F2	R57	C1		
V5	F3	R58	C1		
		R61	B3		
L1	B2	R62	B3		
L2	C2	R63	D3		
L3	F2	R64	C3		
L4	E1				
L5	F2				
R1	B3				
R2	B3				
R3	B3				
R5	C3				

MP-M-77



See general waveform notes on page 5-15 for conditions of waveform measurement.

Waveforms 7 and 8 were taken with signal input to the vertical amplifiers.

The top two waveforms were taken with Model 187B on single channel. The others were on A & B.

Figure 5-19. Waveforms

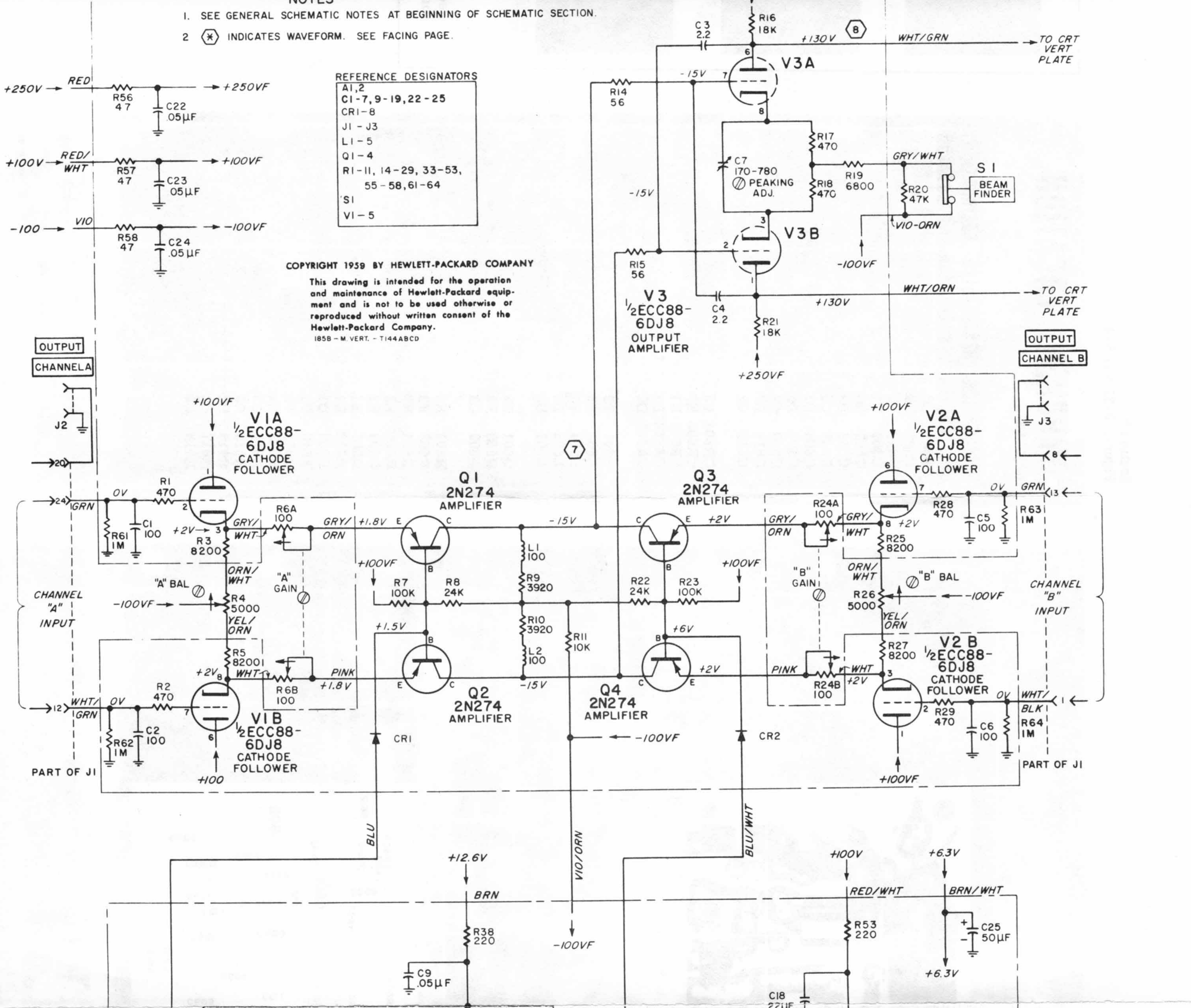
NOTES

1. SEE GENERAL SCHEMATIC NOTES AT BEGINNING OF SCHEMATIC SECTION.
2. (*) INDICATES WAVEFORM. SEE FACING PAGE.

REFERENCE DESIGNATORS

A1,2
C1-7, 9-19, 22-25
CR1-8
J1-J3
L1-5
Q1-4
R1-11, 14-29, 33-53, 55-58, 61-64
S1
V1-5

185B - M. VERT. - T144ABCD



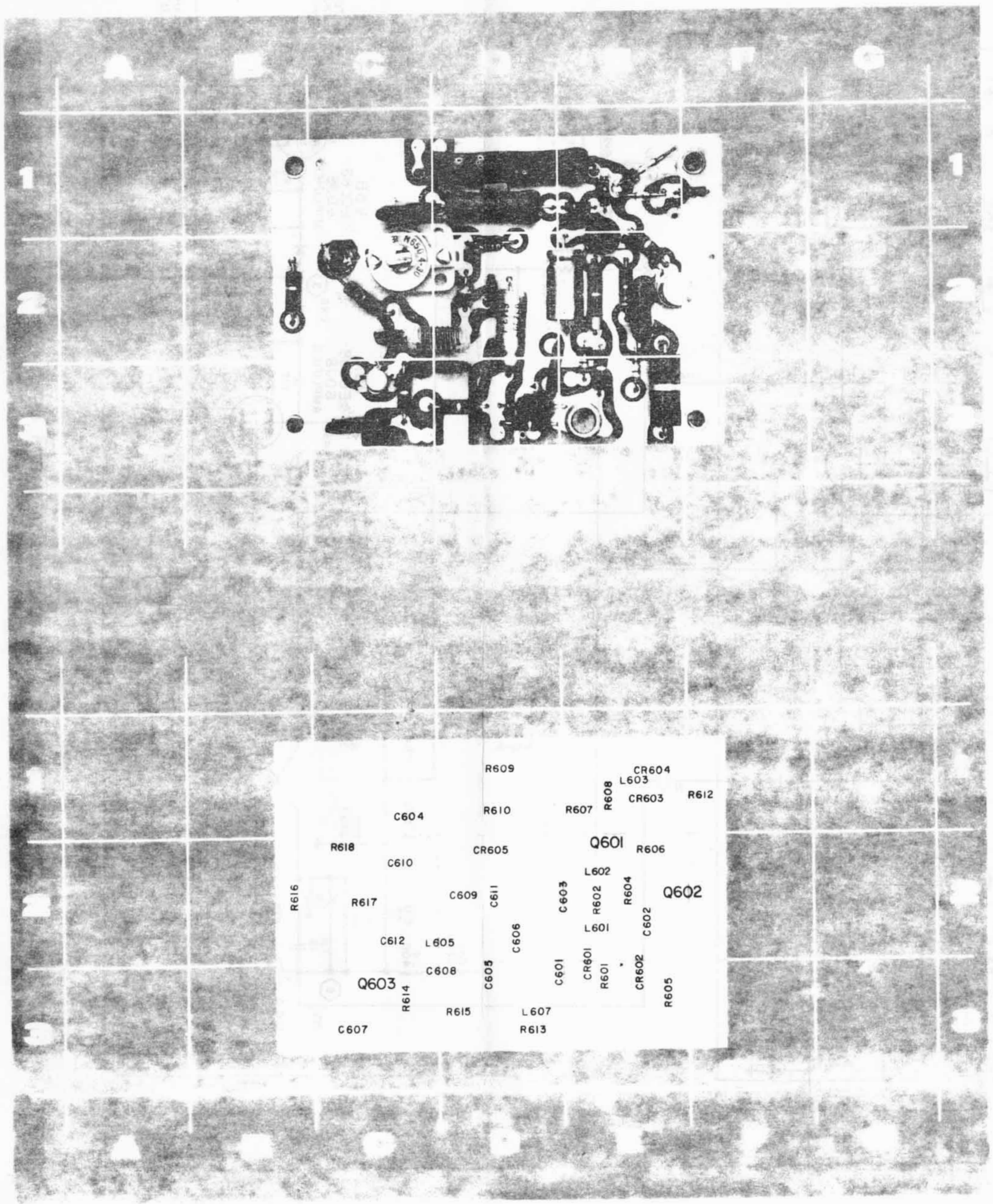


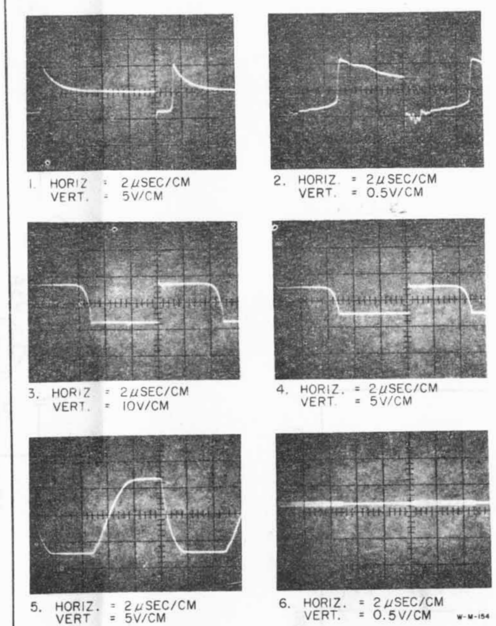
Figure 5-22. A602 Component Location

COMPONENT LOCATION

185B-65P

DESIGNATION AND LOCATOR	DESIGNATION AND LOCATOR	DESIGNATION AND LOCATOR
C601 D3		
C602 E2		
C603 E2		
C604 C1		
C605 D3		
C606 D2		
C607 C3		
C608 D3		
C609 D2		
C610 C2		
C611 D2		
C612 C2		
CR601 E3		
CR602 E3		
CR603 E1		
CR604 E1		
CR605 D2		
L601 E2		
L602 E2		
L603 E1		
L605 D2		
L607 D3		
Q601 E2		
Q602 E2		
Q603 C3		
R601 E3		
R602 E2		
R604 E2		
R605 E3		
R606 E2		
R607 E1		
R608 E1		
R609 D1		
R610 D1		
R612 F1		
R613 D3		
R614 C3		
R615 D3		
R616 B2		
R617 C2		
R618 C2		

MP-M-82



See general waveform notes on page 5-15 for conditions of waveform measurement.

Figure 5-23. Waveforms

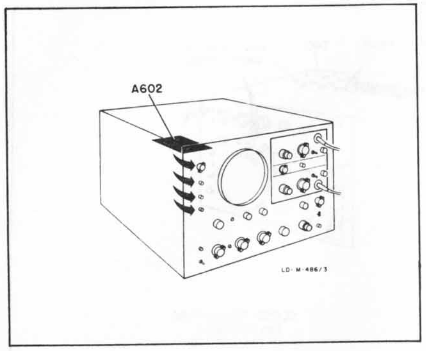


Figure 5-24. Assembly Location

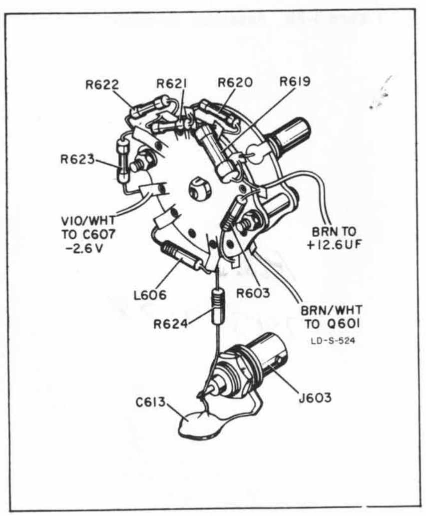
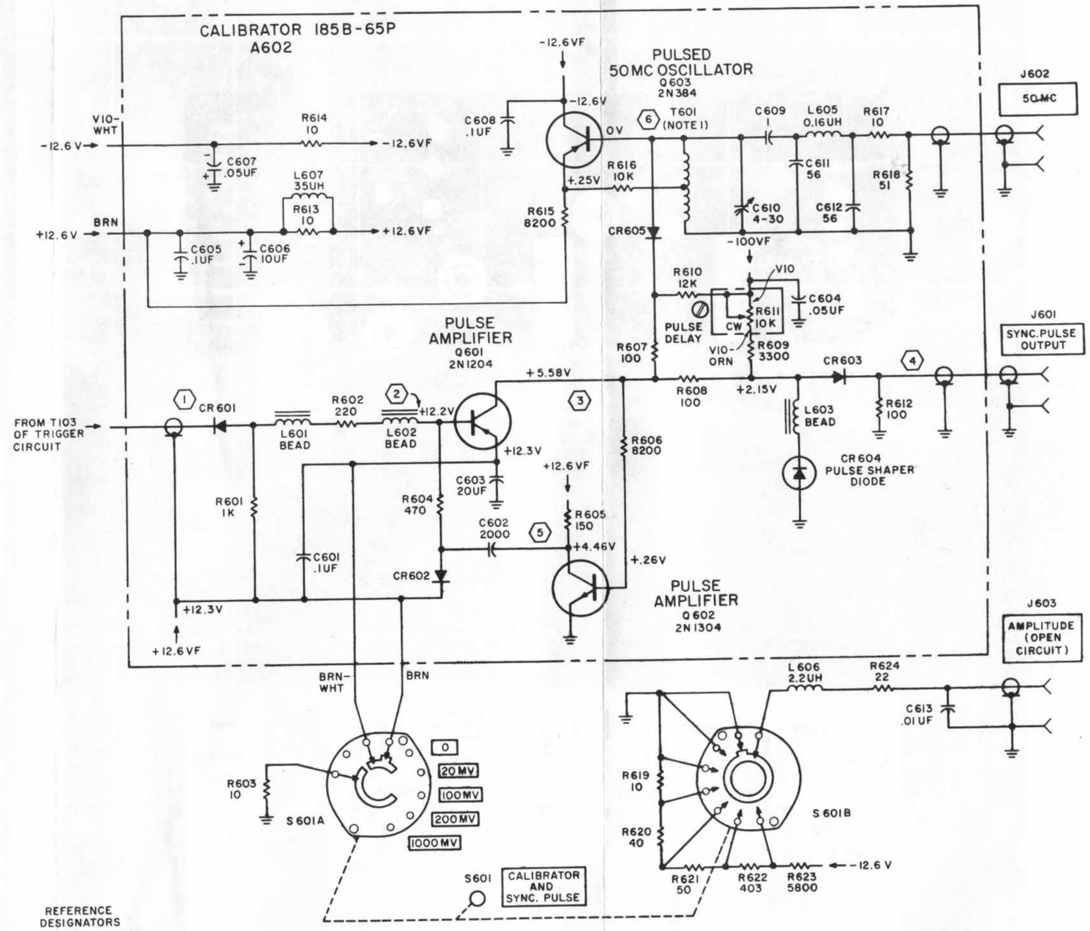


Figure 5-25. Parts Location, Calibrator and Sync Pulse Switch, S601, with Amplitude Connector, J603



REFERENCE DESIGNATORS

C	601 - 613
CR	601 - 605
J	601 - 603
L	601 - 607
Q	601 - 603
R	601 - 624
S	601
T	601

NOTES

1. T601 IS PRINTED ON REVERSED SIDE OF ETCHED CIRCUIT BOARD
2. (*) INDICATES WAVEFORM. SEE FACING PAGE.

Figure 5-26. Calibrator and Sync Pulse Generator

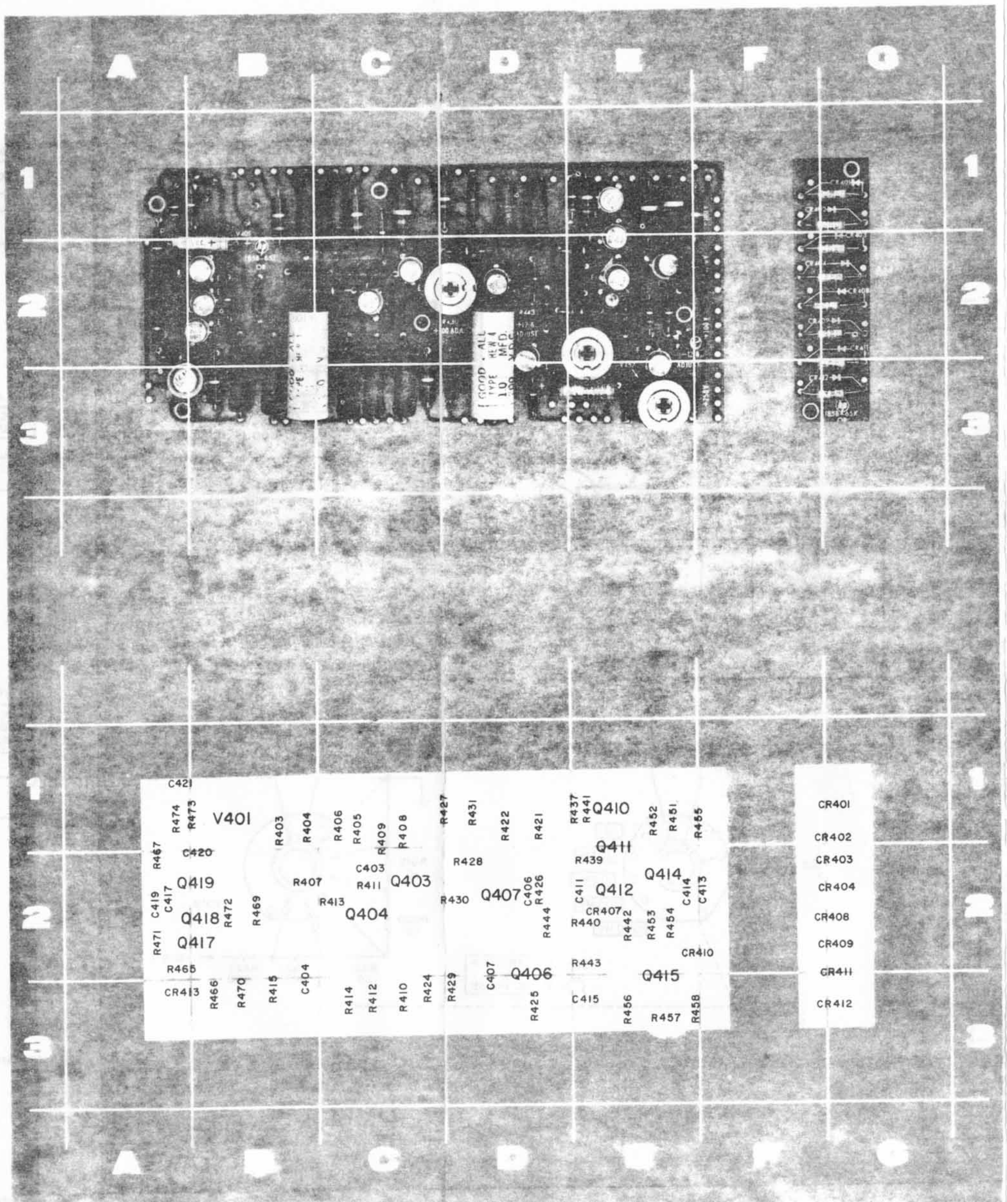


Figure 5-27. A401 and A402 Component Location

COMPONENT LOCATION

185B-65J
185B-65K

DESIGNATION AND LOCATOR		DESIGNATION AND LOCATOR		DESIGNATION AND LOCATOR	
C403	C2	R425	D3		
R404	B2	R426	D2		
R406	D2	R427	D1		
R407	D2	R428	D2		
R411	E2	R429	D3		
R413	F2	R430	D2		
R414	E2	R431	D1		
R415	E3	R437	E1		
R417	A2	R439	E2		
C419	A2	R440	E2		
C420	B2	R441	E1		
C421	A1	R442	E2		
		R443	E2		
CR401	G1	R444	D2		
CR402	G1	R451	E1		
CR403	G2	R452	E1		
CR404	G2	R453	E2		
CR407	E2	R454	E2		
CR408	G2	R455	F1		
CR409	G2	R456	E3		
CR410	E2	R457	E3		
CR411	G3	R458	E3		
CR412	G3	R465	A2		
CR413	A3	R466	B3		
		R467	A2		
Q403	C2	R469	B2		
Q404	C2	R470	B3		
Q406	D2	R471	A2		
Q407	D2	R472	B2		
Q410	E1	R473	B1		
Q411	E1	R474	A1		
Q412	E2				
Q414	E2	V401	B1		
Q415	E3				
Q417	B2				
Q418	B2				
Q419	B2				
R403	B1				
R404	B1				
R405	C1				
R406	C1				
R407	B2				
R408	C1				
R409	C1				
R410	C3				
R411	C2				
R412	C3				
R413	C2				
R414	C3				
R415	B3				
R421	D1				
R422	D1				
R424	C3				

MP-M-81

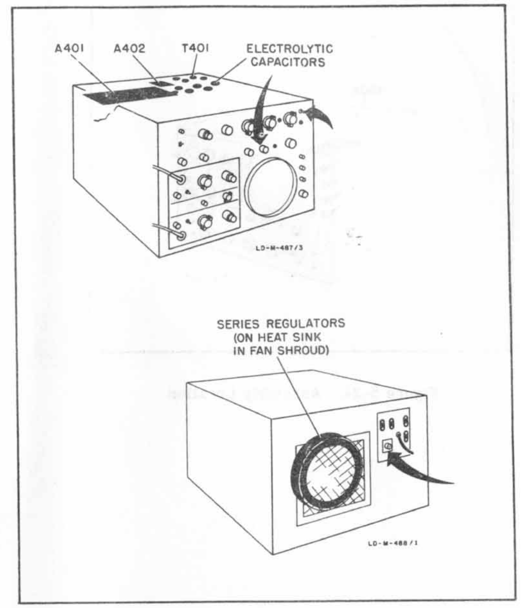


Figure 5-28. Assembly Location

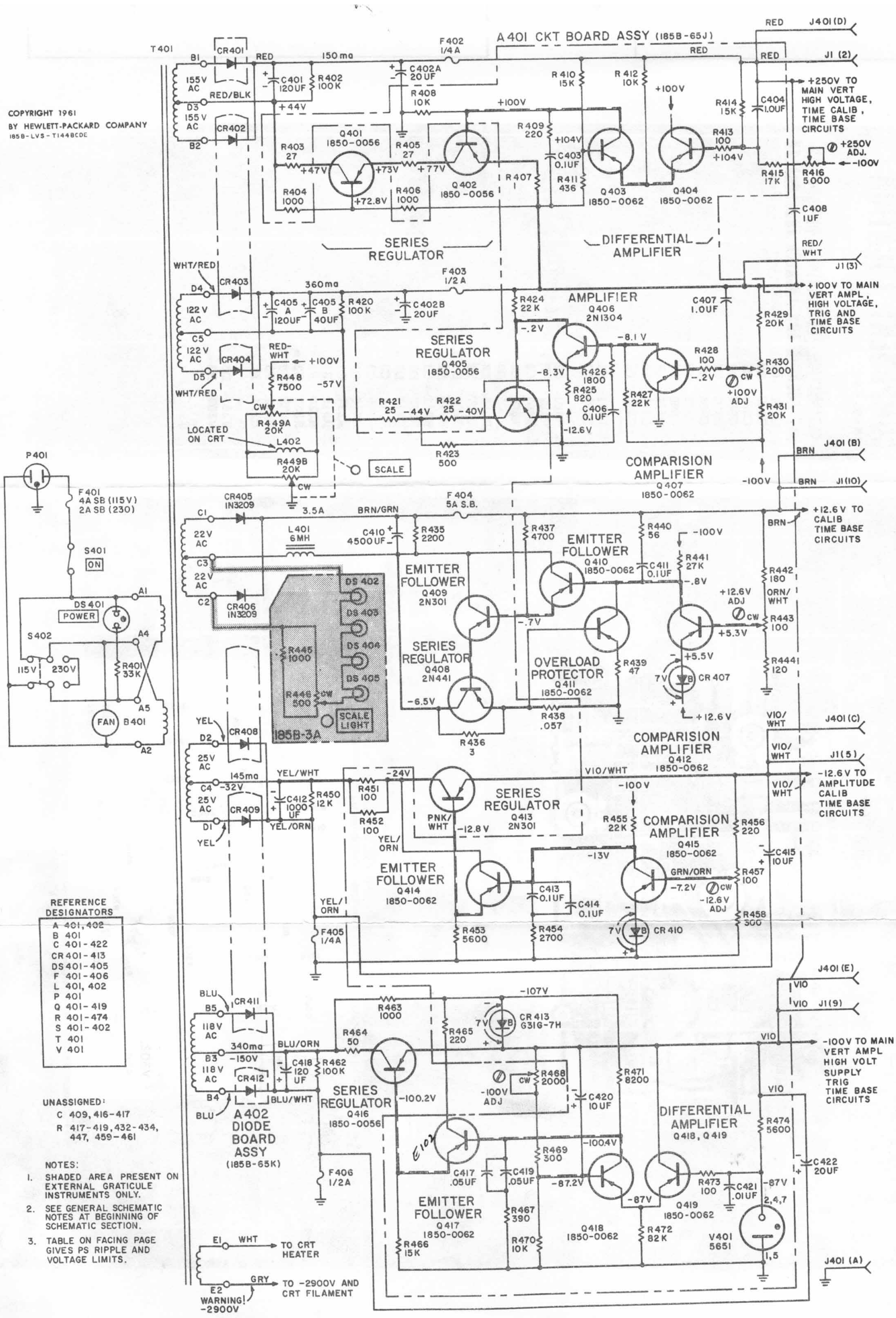


Figure 5-29. Low-Voltage Power Supply

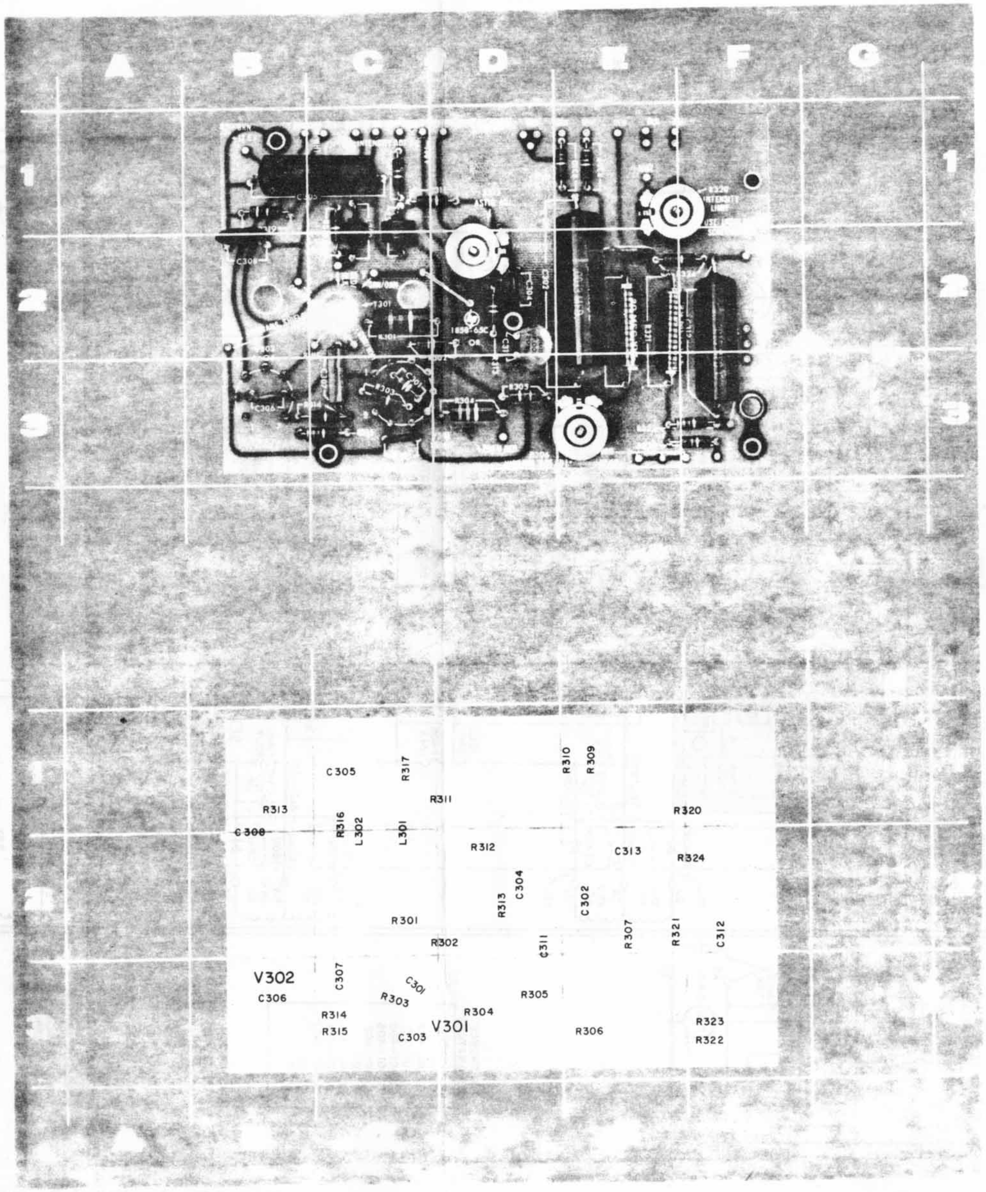


Figure 5-30. A301 Component Location

COMPONENT LOCATION

185B-65C

DESIGNATION AND LOCATOR		DESIGNATION AND LOCATOR	DESIGNATION AND LOCATOR
C301	C3		
C302	E2		
C303	C3		
C304	D2		
C305	C1		
C306	B3		
C307	C3		
C308	B1		
C311	D2		
C312	F2		
C313	E2		
L301	C1		
L302	C1		
R301	C2		
R302	D2		
R303	C3		
R304	D3		
R305	D3		
R306	E3		
R307	E2		
R309	E1		
R310	E1		
R311	D1		
R312	D2		
R313	D2		
R314	C3		
R315	C3		
R316	C1		
R317	C1		
R319	B1		
R320	F1		
R321	E2		
R322	F3		
R323	F3		
R324	F2		
V301	D3		
V302	B3		

MP-M-85

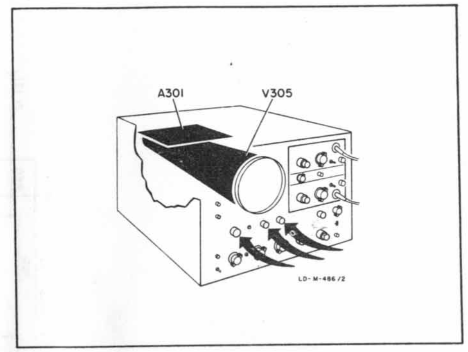


Figure 5-31. Assembly Location

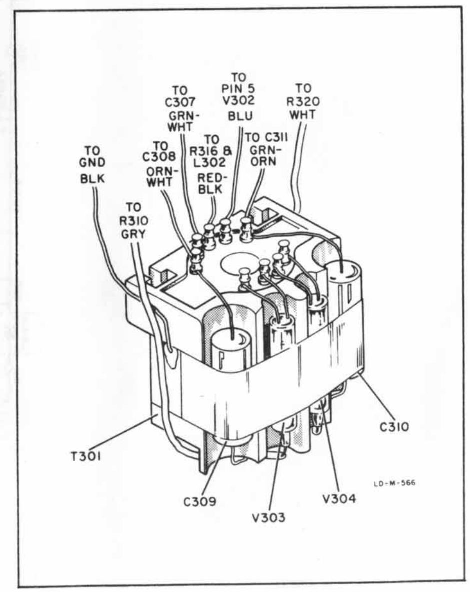


Figure 5-32. A302 High-Voltage Rectifier Assembly

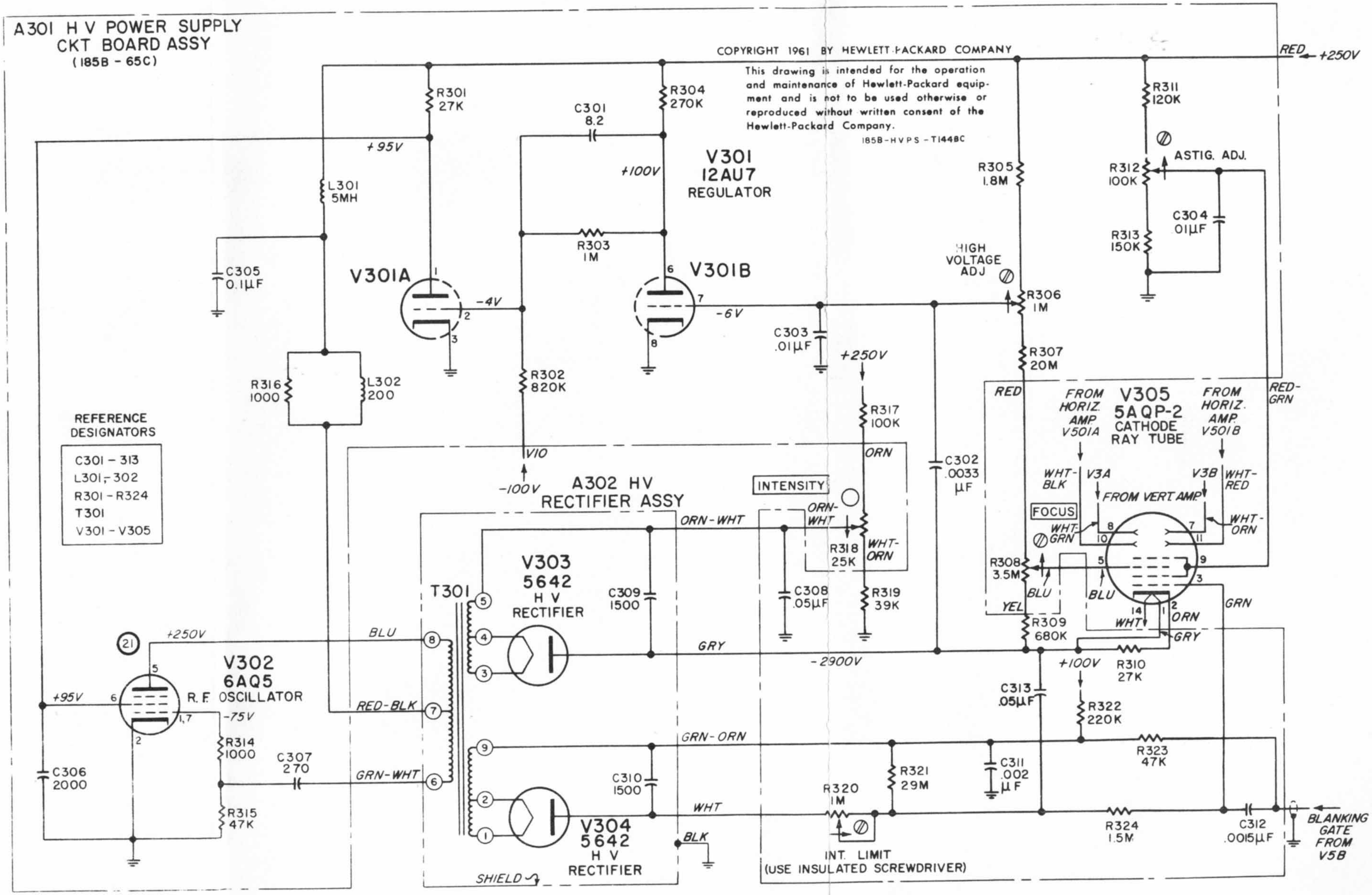


Figure 5-33. High-Voltage Power Supply

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alpha-numerical order of their reference designators and indicates the description and ⓗⓟ stock number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their ⓗⓟ stock numbers and provides the following information on each part:

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

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

c. Manufacturer's stock number.

d. Total quantity used in the instrument (TQ column).

e. Recommended spare part quantity for complete maintenance during one year of isolated service (RS column).

6-3. Miscellaneous parts not indexed in table 6-1 are listed at the end of table 6-2.

6-4. ORDERING INFORMATION.

6-5. To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales representative or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

or, in Western Europe, to

Hewlett-Packard S.A.
54-54bis Route des Acacias
Geneva, Switzerland

6-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

6-7. To order a part not listed in tables 6-1 and 6-2, give a complete description of the part and include its function and location.

REFERENCE DESIGNATORS

A = assembly
B = motor
C = capacitor
CR = diode
DL = delay line
DS = device signaling (lamp)
E = misc electronic part
F = fuse
FL = filter
J = jack
K = relay
L = inductor
M = meter
MP = mechanical part
P = plug
Q = transistor
R = resistor
RT = thermistor
S = switch
T = transformer
V = vacuum tube, neon bulb, photocell, etc.
W = cable
X = socket
XF = fuseholder
XDS = lampholder
Z = network

ABBREVIATIONS

a = amperes
bp = bandpass
bwo = backward wave oscillator
c = carbon
cer = ceramic
cmo = cabinet mount only
coef = coefficient
com = common
comp = composition
conn = connection
crt = cathode-ray tube
dep = deposited
EIA = Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by ⓗⓟ stock numbers.
elect = electrolytic
encap = encapsulated
f = farads
fxd = fixed
Ge = germanium
grd = ground (ed)
h = henries
Hg = mercury
impg = impregnated
incd = incandescent
ins = insulation (ed)
K = kilo = 1000
lin = linear taper
log = logarithmic taper
m = milli = 10^{-3}
M = megohms
ma = milliamperes
μ = micro = 10^{-6}
minat = miniature
mfgl = metal film on glass
mfr = manufacturer
mtg = mounting
my = mylar
NC = normally closed
Ne = neon
NO = normally open
NPO = negative positive zero (zero temperature coefficient)
nsr = not separately replaceable
obd = order by description
p = peak
pc = printed circuit board
pf = picofarads = 10^{-12} farads
pp = peak-to-peak
piv = peak inverse voltage
pos = position(s)
poly = polystyrene
pot = potentiometer
rect = rectifier
rot = rotary
rms = root-mean-square
rmo = rack mount only
s-b = slow-blow
Se = selenium
sect = section(s)
Si = silicon
sil = silver
sl = slide
td = time delay
TiO_2 = titanium dioxide
tog = toggle
tol = tolerance
trim = trimmer
twt = traveling wave tube
var = variable
w/ = with
W = watts
ww = wirewound
w/o = without
* = optimum value selected at factory, average value shown (part may be omitted)

01194-4

Table 6-1. Reference Designation Index

Circuit Reference	# Stock No.	Description	Note
A1	185B-65B	Assy, VERTICAL AMPLIFIER etched circuit: includes, C1 thru C7 R14 thru R19 C22 thru C24 R21 thru R23 CR1, 2 R25 L1, 2 R27 thru R29 Q1 thru Q4 R56 thru R58 R1 thru R3 R61 thru R64 R5 V1 thru V3 R7 thru R11 XV1 thru XV3	
A2	185B-65A	Assy, ELECTRONIC SWITCH etched circuit: includes, C8 thru C19 R33 thru R55 C25 V4, 5 CR2 thru CR8 XV4, 5 L3 thru L5	
A3 thru A100		Not assigned	
A101	185B-19F	Assy, TRIGGERING switch: includes, R158, R159, S101	
A102		Not assigned	
A103	185B-65N	Assy, SYNC etched circuit: includes, C101 thru C109 L102 thru L104 C115 thru C117 L107 thru L114 C126 thru C130 Q101 thru Q107 C135 thru C138 R101 thru R107 C141 thru C146 R111 thru R114 C151 thru C159 R116 thru R121 CR101, 102 R126 thru R136 CR104 thru CR108 R140 thru R147 CR111 thru CR114 R151 thru R157 CR116 R161 thru R163 CR120, 122 R168 thru R180 CR124, 125 R185 thru R195 CR131 thru CR137 T101 thru T103 DL101 V101, 102 J102	
A104 thru A200		Not assigned	
A201	185B-19C	Assy, TIME SCALE MAGNIFIER switch: includes, R212 R277 thru R283 R215 thru R220 S201	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
A202	185B-19B	Assy, TIME SCALE switch: includes, C118 thru C122 C212 C203 thru C206 C214 thru C219 C208 R286 C210 S202	
A203	185B-19A	Assy, SCANNING switch: includes, C240, R254 thru R261, S203	
A204	185B-65E	Assy, TIME BASE etched circuit: includes, C201, 202 CR207 thru CR222 C207 L201 C209 Q201 thru Q203 C211 R201 thru R211 C213 R214 C221 thru C224 R222 thru R236 C226 thru C236 R238 C238, 239 R240 thru R247 C241, 242 T201 thru T204 CR201 thru CR204 V201	
A205 thru A300		Not assigned	
A301	185B-65C	Assy, HV POWER SUPPLY etched circuit: includes, C301 thru C308 R309 thru R317 C311 thru C313 R319 thru R324 L301, 302 V301, 302 R301 thru R307 XV301, 302	
A302 thru A400		Not assigned	
A401	185B-65J	Assy, LV POWER SUPPLY etched circuit: includes C403, 404 Q414, 415 C406, 407 Q417 thru Q419 C411 R403 thru R415 C413 thru C415 R421, 422 C417 R424 thru R431 C419 thru C421 R437 CR407 R439 thru R444 CR410 R451 thru R458 CR413 R465 thru R467 Q403, 404 R469 thru R474 Q406, 407 V401 Q410 thru Q412 XV401	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	⊕ Stock No.	Description	Note
A402	185B-65K	Assy, RECTIFIER etched circuit: includes, CR401 thru CR404, CR408,409 CR411,412	
A403	1450-0045	Assy, SCALE LIGHT lampholder: includes, DS402 thru DS405	a
A404 thru 500		Not assigned	
A501	185B-65D	Assy, HORIZ. AMPLIFIER etched circuit: includes, C501, V501, R501 thru R507, XV501, R510 thru R512	
A502 thru A600		Not assigned	
A601	185B-19E	Assy, CALIBRATOR AND SYNC PULSE switch: includes, R619 thru R624, L606, S601, R603, T601	
A602	185B-65P	Assy, TIME CALIBRATOR etched circuit: includes, C601 thru C606, L607, C607 thru C612, Q601 thru Q603, CR601 thru CR605, R601,602, L601,602, R604 thru R610, L605, R612 thru R618	
B1 thru B400		Not assigned	
B401	3140-0020	Motor, ac	
C1,2	0140-0054	C: fxd, mica, 100 pf ±10%, 500 vdcw	
C3,4	0150-0015	C: fxd, TiO_2, 2.2 pf ±10%, 500 vdcw	
C5,6	0140-0054	C: fxd, mica, 100 pf ±10%, 500 vdcw	
C7	0131-0003	C: var, mica, 50-380 pf, 175 vdcw	
C8	0130-0017	C: var, cer, 8-50 pf, 500 vdcw	
C9	0150-0052	C: fxd, cer, dual tandem, 0.05 μf ±20%, 400 vdcw	
C10	0140-0116	C: fxd, mica, 39 pf ±2%, 500 vdcw	
C11	0140-0101	C: fxd, mica, 15 pf ±5%, 500 vdcw	
C12	0150-0052	C: fxd, cer, dual tandem, 0.05 μf ±20%, 400 vdcw	
C13,14	0140-0116	C: fxd, mica, 39 pf ±2%, 500 vdcw	
C15	0150-0052	C: fxd, cer, dual tandem, 0.05 μf ±20%, 400 vdcw	
C16	0150-0024	C: fxd, cer, 0.02 μf +80% -20%, 600 vdcw	
C17	0140-0054	C: fxd, mica, 100 pf ±10%, 500 vdcw	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	⊕ Stock No.	Description	Note
C18	0170-0038	C: fxd, my, 0.22 μf ±10%, 200 vdcw	
C19	0150-0052	C: fxd, cer, dual tandem, 0.05 μf ±20%, 400 vdcw	
C20, 21		Not assigned	
C22 thru C24	0150-0052	C: fxd, cer, dual tandem, 0.05 μf ±20%, 400 vdcw	
C25	0180-0058	C: fxd, elect, 50 μf -10% +100%, 25 vdcw	
C26 thru C100		Not assigned	
C101, 102	0150-0070	C: fxd, cer, 0.02 μf ±20%, 500 vdcw	
C103	0180-0089	C: fxd, elect, 10 μf -10% +100%, 150 vdcw	
C104 thru C107	0180-0076	C: fxd, elect, 20 μf, 25 vdcw	
C108	0180-0089	C: fxd, elect, 10 μf -10% +100%, 150 vdcw	
C109	0180-0076	C: fxd, elect, 20 μf, 25 vdcw	
C110	0150-0084	C: fxd, cer, 0.1 μf +80% -20%, 50 vdcw	
C111 thru C114		Not assigned	
C115	0140-0152	C: fxd, mica, 1000 pf ±5%, 300 vdcw	
C116	0150-0042	C: fxd, TiO_2, 4.7 pf ±5%, 500 vdcw	
C117	0140-0041	C: fxd, mica, 100 pf ±5%. 500 vdcw	
C118	0140-0158	C: fxd, mica, 2676 pf ±1%, 500 vdcw	
C119	0140-0153	C: fxd, mica, 1269 pf ±1%, 300 vdcw	
C120	0140-0037	C: fxd, mica, 390 pf ±5%, 500 vdcw	
C121	0140-0023	C: fxd, mica, 180 pf ±10%, 500 vdcw	
C122	0140-0081	C: fxd, mica, 56 pf ±1%, 500 vdcw	
C123 thru C125		Not assigned	
C126	0180-0059	C: fxd, elect, 10 μf -10% +100%, 25 vdcw	
C127	0150-0050	C: fxd, cer, 1000 pf, 600 vdcw	
C128	0150-0073	C: fxd, cer, 100 pf ±10%, 500 vdcw	
C129	0150-0096	C: fxd, cer, 0.05 μf +80% -20%, 100 vdcw	
C130	0140-0041	C: fxd, mica, 100 pf ±5%, 500 vdcw	
C131 thru C134		Not assigned	
C135	0140-0078	C: fxd, mica, 2000 pf ±200 pf	
C136	0150-0084	C: fxd, cer, 0.1 μf +80% -20%, 50 vdcw	
C137	0150-0037	C: fxd, cer, 100 pf ±1%, 500 vdcw	
C138	0150-0012	C: fxd, cer, 0.01 μf ±20%, 1000 vdcw	
C139, 140		Not assigned	
C141	0140-0161	C: fxd, mica, 3932 pf ±1%, 300 vdcw	
C142 thru C144	0150-0012	C: fxd, cer, 0.01 μf ±20%, 1000 vdcw	
C145	0150-0052	C: fxd, cer, dual tandem, 0.05 μf ±20%, 400 vdcw	
C146	0140-0085	C: fxd, mica, 470 pf ±5%, 500 vdcw	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description	Note
C147 thru C150		Not assigned	
C151	0150-0014	C: fxd, cer, 0.005 µf, 500 vdcw	
C152	0150-0052	C: fxd, cer, dual tandem, 0.05 µf ±20%, 400 vdcw	
C153	0180-0076	C: fxd, elect, 20 µf, 25 vdcw	
C154	0150-0012	C: fxd, cer, 0.01 µf ±20%, 1000 vdcw	
C155	0140-0055	C: fxd, mica, 150 pf ±10%, 500 vdcw	
C156	0150-0070	C: fxd, cer, 0.02 µf ±20%, 500 vdcw	
C157	0150-0071	C: fxd, cer, 400 pf ±5%, 500 vdcw	
C158	0150-0084	C: fxd, cer, 0.1 µf +80% -20%, 50 vdcw	
C159	0140-0007	C: fxd, mica, 680 pf ±10%, 500 vdcw	
C160 thru C200		Not assigned	
C201, 202	0180-0076	C: fxd, elect, 20 µf, 25 vdcw	
C203	0170-0088	C: fxd, poly, 0.126 µf ±1%, 500 vdcw	
C204	0170-0089	C: fxd, poly, 0.063 µf ±1%, 50 vdcw	
C205	0170-0090	C: fxd, poly, 0.0252 µf ±1%, 50 vdcw	
C206	0170-0091	C: fxd, poly, 0.01213 µf ±2%, 50 vdcw	
C207	0131-0003	C: var, mica, 170-780 pf, 175 vdcw	
C208	0140-0189	C: fxd, mica, 5825 pf ±2%, 300 vdcw	
C209	0131-0003	C: var, mica, 170-780 pf, 175 vdcw	
C210	0140-0086	C: fxd, mica, 2000 pf ±5%, 500 vdcw	
C211	0131-0003	C: var, mica, 170-780 pf, 175 vdcw	
C212	0140-0099	C: fxd, mica, 1000 pf ±1%, 500 vdcw	
C213	0131-0001	C: var, mica, 50-380 pf, 175 vdcw	
C214	0140-0107	C: fixd, mica, 507 pf ±2%, 500 vdcw	
C215	0131-0004	C: var, mica, 14-150 pf, 175 vdcw	
C216	0140-0036	C: fxd, mica, 110 pf ±5%, 500 vdcw	
C217	0131-0004	C: var, mica, 14-150 pf, 175 vdcw	
C218	0140-0006	C: fxd, mica, 82 pf ±10%, 500 vdcw	
C219	0130-0001	C: var, cer, 7-45 pf, 500 vdcw	
C220		Not assigned	
C221	0150-0052	C: fxd, cer, dual tandem, 0.05 µf ±20%, 400 vdcw	
C222	0180-0089	C: fxd, elect, 10 µf -10% +100%, 150 vdcw	
C223	0180-0058	C: fxd, elect, 5 µf -10% +100%, 25 vdcw	
C224	0150-0084	C: fxd, cer, 0.1 µf +80% -20%, 50 vdcw	
C225		Not assigned	
C226	0180-0059	C: fxd, elect, 10 µf -10% +100%, 25 vdcw	
C227	0150-0052	C: fxd, cer, dual tandem, 0.05 µf ±20%, 400 vdcw	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
C228	0140-0107	C: fxd, mica, 507 pf ±2%, 500 vdcw	
C229	0150-0014	C: fxd, cer, 0.005 μf, 500 vdcw	
C230	0150-0050	C: fxd, cer, 1000 pf, 600 vdcw	
C231	0180-0076	C: fxd, elect, 20 μf, 25 vdcw	
C232	0150-0012	C: fxd, cer, 0.01 μf ±20%, 1000 vdcw	
C233, 234	0150-0050	C: fxd, cer, 1000 pf, 600 vdcw	
C235	0150-0024	C: fxd, cer, 0.02 μf +80% -20%, 600 vdcw	
C236	0170-0055	C: fxd, my, 0.1 μf ±20%, 200 vdcw	
C237		Not assigned	
C238	0140-0002	C: fxd, mica, 10 pf ±10%, 500 vdcw	
C239	0150-0012	C: fxd, cer, 0.01 μf ±20%, 1000 vdcw	
C240	0180-0097	C: fxd, solid tantalum, 47 μf ±10%, 35 vdcw	
C241	0150-0052	C: fxd, cer, dual tandem, 0.05 μf ±20%, 400 vdcw	
C242	0150-0014	C: fxd, cer, 0.005 μf, 500 vdcw	
C243 thru C300		Not assigned	
C301	0150-0033	C: fxd, TiO_2, 8.2 pf ±10%, 500 vdcw	
C302	0160-0046	C: fxd, paper, 0.0033 pf ±20%, 6000 vdcw	
C303, 304	0150-0012	C: fxd, cer, 0.1 μf ±20%, 1000 vdcw	
C305	0160-0013	C: fxd, paper my, 0.1 pf ±10%, 400 vdcw	
C306	0150-0023	C: fxd, cer, 2000 pf ±20%, 1000 vdcw	
C307	0140-0015	C: fxd, mica, 270 pf ±10%, 500 vdcw	
C308	0150-0052	C: fxd, cer, dual tandem, 0.05 μf ±20%, 400 vdcw	
C309, 310		Not assigned	
C311	0150-0023	C: fxd, cer, 2000 pf ±20%, 1000 vdcw	
C312	0160-0061	C: fxd, paper, 0.0015 pf ±20%, 5000 vdcw	
C313	0150-0052	C: fxd, cer, dual tandem, 0.05 μf ±20%, 400 vdcw	
C314 thru C400		Not assigned	
C401	0180-0042	C: fxd, elect, 120 μf, 350 vdcw	
C402	0180-0012	C: fxd, elect, 2 sect, 20 μf / sect, 450 vdcw	
C403	0150-0084	C: fxd, cer, 0.1 μf +80% -20%, 50 vdcw	
C404	0170-0018	C: fxd, my, 1 μf ±5%, 200 vdcw	
C405	0180-0030	C: fxd, elect, 2 sect, 120x40 μf, 450 vdcw	
C406	0150-0084	C: fxd, cer, 0.1 μf +80% -20%, 50 vdcw	
C407, 408	0170-0018	C: fxd, my, 1 μf ±5%, 200 vdcw	
C409		Not assigned	
C410	0180-0077	C: fxd, elect, 4500 μf, 35 vdcw	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓗ Stock No.	Description	Note
C411	0150-0084	C: fxd, cer, 0.1 μf +80% -20%, 50 vdcw	
C412	0180-0056	C: fxd, elect, 1000 μf, 50 vdcw	
C413, 414	0150-0084	C: fxd, cer, 0.1 μf +80% -20%, 50 vdcw	
C415	0180-0059	C: fxd, elect, 10 μf -10% +100%, 25 vdcw	
C416		Not assigned	
C417	0150-0052	C: fxd, cer, dual tandem, 0.05 μf ±20%, 400 vdcw	
C418	0180-0042	C: fxd, elect, 120 μf, 350 vdcw	
C419	0150-0052	C: fxd, cer, dual tandem, 0.05 μf ±20%, 400 vdcw	
C420	0180-0059	C: fxd, elect, 10 μf -10% ±100%, 25 vdcw	
C421	0150-0012	C: fxd, cer, 0.01 μf ±20%, 1000 vdcw	
C422	0180-0004	C: fxd, elect, 20 μf -10% +100%, 150 vdcw	
C423 thru C500		Not assigned	
C501	0150-0050	C: fxd, cer, 1000 pf, 600 vdcw	
C502 thru C600		Not assigned	
C601	0150-0084	C: fxd, cer, 0.1 μf +80% -20%, 50 vdcw	
C602	0140-0213	C: fxd, mica, 2000 pf ±1%, 300 vdcw	
C603	0180-0045	C: fxd, elect, 20 μf, 25 vdcw	
C604	0150-0052	C: fxd, cer, dual tandem, 0.05 μf ±20%, 400 vdcw	
C605	0150-0084	C: fxd, cer, 0.1 μf +80% -20%, 50 vdcw	
C606	0180-0059	C: fxd, elect, 10 μf -10% +100%, 25 vdcw	
C607	0150-0052	C: fxd, cer, dual tandem, 0.05 μf ±20%, 400 vdcw	
C608	0150-0084	C: fxd, cer, 0.1 μf +80% -20%, 50 vdcw	
C609	0150-0029	C: fxd, TiO_2, 1 pf ±1%, 500 vdcw	
C610	0130-0019	C: var, cer, 4-30 pf, 500 vdcw	
C611, 612	0150-0078	C: fxd, cer, 56 pf ±10%, 1000 vdcw	
C613	0150-0012	C: fxd, cer, 0.01 μf ±20%, 1000 vdcw	
CR1 thru CR8	1910-0016	Diode, Ge	
CR9 thru CR100		Not assigned	
CR101, 102	1902-0031	Diode, avalanche	
CR103		Not assigned	
CR104	1910-0016	Diode, Ge	
CR105	G-29E-46	Diode	
CR106	G-29E-86	Diode	
CR107, 108	1901-0027	Diode, Si	
CR109, 110		Not assigned	
CR111	1903-0002	Diode, Si	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	⊕ Stock No.	Description	Note
CR112 thru 114	1901-0027	Diode, Si	
CR115		Not assigned	
CR116	1912-0005	Diode, Ge: tunnel	
CR117 thru 119		Not assigned	
CR120	1912-0004	Diode, Ge	
CR121, 122	1901-0027	Diode, Si	
CR123		Not assigned	
CR124, 125	G-29L-78	Diode	
CR126 thru 130		Not assigned	
CR131, 132	G-29M-8	Diode	
CR133 thru 135	1910-0016	Diode, Ge	
CR136, 137	G-29L-78	Diode	
C138 thru 200		Not assigned	
CR201	G-29L-78	Diode	
CR202, 203	G-29M-9	Diode	
CR204	1910-0016	Diode, Ge	
CR205, 206		Not assigned	
CR207, 208	1910-0016	Diode, Ge	
CR209	1912-0002	Diode, tunnel	
CR210	G-29M-8	Diode	
CR211	1910-0016	Diode, Ge	
CR212	G-29M-8	Diode	
CR213, 214	G-29E-12	Diode	
CR215	G-29M-9	Diode	
CR216	G-29M-8	Diode	
CR217	G-29M-9	Diode	
CR218	1910-0016	Diode, Ge	
CR219	G-29E-46	Diode	
CR220	G-31A-82L	Diode, Zener	
CR221	G-31A-7H	Diode, Zener	
CR222	1910-0016	Diode, Ge	
CR223 thru 400		Not assigned	
CR401 thru 404	1901-0029	Diode, Si	
CR405, 406	1901-0032	Diode, Si: 1N3209	
CR407	G-29A-74	Diode, Zener	
CR408, 409	1901-0026	Diode, Si	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
CR410	G-29A-74	Diode, Zener	
CR411, 412	1901-0029	Diode, Si	
CR413	G-31G-7H	Diode, Zener	
CR414 thru 600		Not assigned	
CR601, 602	1910-0016	Diode, Ge	
CR603	G-29L-49	Diode	
CR604	G-29J-38	Diode	
CR605	G-29J-48	Diode	
DL1 thru 100		Not assigned	
DL101	9190-0003	Line, delay: 1000 ohms, 1 microsecond	
DS1 thru DS400		Not assigned	
DS401	1450-0039	Lamp, neon: NE2H	a
DS402 thru 405	2140-0009	Lamp, indicating: 0.15 amp	a
F1 thru F400		Not assigned	
F401	2110-0014	Fuse, cartridge: 4 amp, s-b (for 115 v operation)	
	2110-0006	Fuse, cartridge: 2 amp, s-b (for 230 v operation)	
F402	2110-0004	Fuse, cartridge: 1/4 amp, 250 v	
F403	2110-0012	Fuse, cartridge: 1/2 amp, 250 v	
F404	2110-0030	Fuse: 5 amp, s-b	
F405	2110-0004	Fuse, cartridge: 1/4 amp, 250 v	
F406	2110-0012	Fuse, cartridge: 1/2 amp, 250 v	
J1	1251-0054	Connector: female	
J2, 3		Channel A output (J2), channel B output (J3): includes	
	AC-10C	Binding post: black	
	AC-10D	Binding post: red	
	AC-54D	Insulator, binding post: black, 1 hole	
	AC-54E	Insulator, binding post: black, 2 hole	
J4 thru J100		Not assigned	
J101	1250-0102	Connector, body	
J102	1250-0083	Connector, rf: 52 ohms, type UG-1094/U	
J103 thru J200		Not assigned	
J201, 202		Output time base scan (J202), input external scan (J201): includes,	
	AC-10C	Binding post: black	
	AC-10D	Binding post: red	
	AC-54D	Insulator, binding post: black, 1 hole	
	AC-54E	Insulator, binding post: black, 2 hole	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
J203 thru J400		Not assigned	
J401	1251-0130	Connector, rf: female	
J402 thru J600		Not assigned	
J601, 602	1250-0102	Connector, body: BNC	
J603	1250-0118	Connector, rf: BNC	
L1, 2	9140-0029	Inductor: 100 μh	
L3 thru L5	9140-0020	Inductor: 400 μh	
L6 thru L100		Not assigned	
L101	9140-0116	Inductor: var, 1.1 μh - 2.0 μh	
L102, 103	9170-0029	Core, ferrite bead	
L104	9140-0107	Inductor: fxd, 27 μh	
L105, 106		Not assigned	
L107, 108	9140-0029	Inductor: 100 μh	
L107 thru L113	9170-0029	Core, ferrite bead	
L114	9170-0016	Shielding bead: manganese zinc ferroxide	
L115 thru L200		Not assigned	
L201	9140-0019	Inductor: fxd, 200 μh	
L202 thru L300		Not assigned	
L301	9140-0037	Inductor: 5 mh	
L302	9140-0019	Inductor: fxd, 200 μh	
L303 thru L400		Not assigned	
L401	9110-0031	Reactor, filter choke: 6 mh	
L402	G-60A	Inductor, alignment	
L403 thru L600		Not assigned	
L601, 602	9170-0029	Core, ferrite bead	
L603, 604		Not assigned	
L605	185B-60G	Inductor: fxd, 0.16 μh	
L606	9140-0028	Inductor: 2.2 μh	
L607	9140-0027	Inductor: 35 μh	
P1 thru P101		Not assigned	
P102	1250-0052	Connector, plug	
P103 thru P400		Not assigned	
P401	8120-0015	Cord, power	
Q1 thru Q4	1850-0037	Transistor: 2N274	
Q5 thru Q100		Not assigned	
Q101 thru Q103	1851-0021	Transistor: 2N377A	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
Q104, 105	1850-0066	Transistor: 2N700	
Q106	1854-0004	Transistor: 2N743	
Q107	1850-0067	Transistor: 2N1495	
Q108 thru Q200		Not assigned	
Q201	1850-0012	Transistor: 2N123 (specially selected from ⓗ type 1850-0010, color coded blue)	
Q202	1850-0052	Transistor: 2N598	
Q203	1851-0017	Transistor: 2N1304	
Q204		Not assigned	
Q205, 206	1854-0004	Transistor: 2N743	
Q207	1850-0051	Transistor: 2N1500	
Q208	1850-0067	Transistor: 2N1495	
Q209	1851-0011	Transistor: 2N440	
Q210	1850-0052	Transistor: 2N598	
Q211 thru Q400		Not assigned	
Q401, 402	1850-0056	Transistor: 2N1159	
Q403, 404	1850-0062	Transistor: special 2N404	
Q405	1850-0056	Transistor: 2N1159	
Q406	1851-0017	Transistor: 2N1304	
Q407	1850-0062	Transistor: special 2N404	
Q408	1850-0021	Transistor: 2N441	
Q409	1850-0038	Transistor: 2N301	
Q410 thru Q412	1850-0062	Transistor: special 2N404	
Q413	1850-0038	Transistor: 2N301	
Q414, 415	1850-0062	Transistor: special 2N404	
Q416	1850-0056	Transistor: 2N1159	
Q417 thru Q419	1850-0062	Transistor: 2N404	
Q420 thru Q600		Not assigned	
Q601	1850-0073	Transistor: 2N1204	
Q602	1851-0017	Transistor: 2N1304	
Q603	1850-0018	Transistor: 2N384	
R1, 2	0687-4711	R: fxd, comp, 470 ohms ±10%, 1/2 w	
R3	0765-0005	R: fxd, mfgl, 8.2K ohms ±10%, 2 w	
R4	2100-0006	R: var, ww, 5K ohms ±10%, 3 w	
R5	0765-0005	R: fxd, mfgl, 8.2K ohms ±10 %, 2 w	
R6	2100-0231	R: var, comp, lin, 2 sect, 100 ohms ±20%, 1/2 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	⊕ Stock No.	Description	Note
R7	0687-1041	R: fxd, comp, 100K ohms ±10%, 1/2 w	
R8	0686-2435	R: fxd, comp, 24K ohms ±5%, 1/2 w	
R9,10	0727-0131	R: fxd, dep c, 3920 ohms ±1%, 1/2 w	
R11	0764-0005	R: fxd, mfgl, 10K ohms ±5%, 2 w	
R12,13		Not assigned	
R14,15	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R16	0764-0006	R: fxd, mfgl, 18K ohms ±5%, 2 w	
R17,18	0760-0008	R: fxd, mfgl, 470 ohms ±5%, 1 w	
R19	0765-0002	R: fxd, metallic oxide, 6.8K ohms ±10%, 2 w	
R20	0690-4731	R: fxd, comp, 47K ohms ±10%, 1 w	
R21	0764-0006	R: fxd, mfgl, 18K ohms ±5%, 2 w	
R22	0686-2435	R: fxd, comp, 24K ohms ±5%, 1/2 w	
R23	0687-1041	R: fxd, comp, 100K ohms ±10%, 1/2 w	
R24	2100-0231	R: var, comp lin, 2 sect, 100 ohms ±20%, 1/2 w	
R25	0765-0005	R: fxd, mfgl, 8.2K ohms ±10%, 2 w	
R26	2100-0006	R: var, ww, 5K ohms ±10%, 3 w	
R27	0765-0005	R: fxd, mfgl, 8.2K ohms ±10%, 2 w	
R28, 29	0687-4711	R: fxd, comp, 470 ohms ±10%, 1/2 w	
R30 thru R32		Not assigned	
R33	0690-2721	R: fxd, comp, 2.7K ohms ±10%, 1 w	
R34	0727-0218	R: fxd, dep c, 180K ohms ±1%, 1/2 w	
R35	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R36	0727-0202	R: fxd, dep c, 83K ohms ±1%, 1/2 w	
R37	0686-3325	R: fxd, comp, 3.3K ohms ±5%, 1/2 w	
R38	0687-2211	R: fxd, 220 ohms ±10%, 1/2 w	
R39	0686-3325	R: fxd, comp, 3.3K ohms ±5%, 1/2 w	
R40	0690-2721	R: fxd, comp, 2.7K ohms ±10%, 1 w	
R41	0727-0218	R: fxd, dep c, 180K ohms ±1%, 1/2 w	
R42	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R43	0727-0202	R: fxd, dep c, 83K ohms ±1%, 1/2 w	
R44	0693-4721	R: fxd, comp, 4.7K ohms ±10%, 2 w	
R45	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R46	0687-4731	R: fxd, comp, 47K ohms ±10%, 1/2 w	
R47	0693-4721	R: fxd, comp, 4.7K ohms ±10%, 2 w	
R48	0687-1021	R: fxd, comp, 1K ohm ±10%, 1/2 w	
R49	0687-1031	R: fxd, comp, 10K ohms ±10%, 1/2 w	
R50	0687-8211	R: fxd, comp, 820 ohms ±10%, 1/2 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	⊕ Stock No.	Description	Note
R51	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R52	0693-3921	R: fxd, comp, 3.9K ohms ±10%, 2 w	
R53	0690-2211	R: fxd, comp, 220 ohms ±10%, 1 w	
R54	0687-4731	R: fxd, comp, 47K ohms ±10%, 1/2 w	
R55	0687-1031	R: fxd, comp, 10K ohms ±10%, 1/2 w	
R56 thru R58	0690-4701	R: fxd, comp, 47 ohms ±10%, 1 w	
R59, 60		Not assigned	
R61 thru R64	0687-1051	R: fxd, comp, 1M ±10%, 1/2 w	
R65 thru R100		Not assigned	
R101, 102	0687-4711	R: fxd, comp, 470 ohms ±10%, 1/2 w	
R103	0687-1011	R: fxd, comp, 100 ohms ±10%, 1/2 w	
R104	0690-1231	R: fxd, comp, 12K ohms ±10%, 1 w	
R105	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R106	0670-1531	R: fxd, comp, 15K ohms ±10%, 1 w	
R107	0693-3901	R: fxd, comp, 39 ohms ±10%, 1 w	
R108 thru R110		Not assigned	
R111	0767-0006	R: fxd, mfgl, 6.5K ohms ±5%, 3 w	
R112	0758-0020	R: fxd, mfgl, 22K ohms ±5%, 1/2 w	
R113	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R114	0758-0022	R: fxd, mfgl, 82K ohms ±5%, 1/2 w	
R115	2100-0305	R: var, comp, 2 sect (includes R160) 20 C log, 150K ohms ±20%, 1-1/4 w	
R116	0758-0021	R: fxd, mfgl, 51K ohms ±5%, 1/2 w	
R117	0758-0018	R: fxd, mfgl, 15K ohms ±5%, 1/2 w	
R118	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R119	0687-8211	R: fxd, comp, 820 ohms ±10%, 1/2 w	
R120	0686-4345	R: fxd, comp, 430K ohms ±5%, 1/2 w	
R121	0687-7525	R: fxd, comp, 7.5K ohms ±5%, 1 w	
R122 thru R125		Not assigned	
R126	0690-1831	R: fxd, comp, 18K ohms ±10%, 1 w	
R127	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R128	0687-1031	R: fxd, comp, 10K ohms ±10%, 1/2 w	
R129	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R130	0727-0109	R: fxd, dep c, 1470 ohms ±1%, 1/2 w	
R131	0727-0352	R: fxd, dep c, 1.2K ohms ±1/2%, 1/2 w	
R132	0727-0128	R: fxd, dep c, 3.60K ohms ±1%, 1/2 w	
R133	0727-0140	R: fxd, dep c, 6K ohms ±1%, 1/2 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
R134	0687-2241	R: fxd, comp, 220K ohms ±10%, 1/2 w	
R135	0687-1801	R: fxd, comp, 18 ohms ±10%, 1/2 w	
R136	0687-4711	R: fxd, comp, 470 ohms ±10%, 1/2 w	
R137 thru R139		Not assigned	
R140	0687-5611	R: fxd, comp, 560 ohms ±10%, 1/2w	
R141	0687-1221	R: fxd, comp, 1.2K ohms ±10%, 1/2 w	
R142	0687-1041	R: fxd, comp, 100K ohms ±10%, 1/2 w	
R143	0687-1221	R: fxd, comp, 1.2K ohms ±10%, 1/2 w	
R144	0686-2235	R: fxd, comp, 22K ohms ±5%, 1/2 w	
R145	0686-2745	R: fxd, comp, 270K ohms ±5%, 1/2 w	
R146	0687-8211	R: fxd, comp, 820 ohms ±10%, 1/2 w	
R147	0687-1041	R: fxd, comp, 100K ohms ±10%, 1/2 w	
R148 thru R150		Not assigned	
R151	0683-2245	R: fxd, comp, 220K ohms ±5%, 1/4 w	
R152	0727-0023	R: fxd, dep c, 50 ohms ±1%, 1/2 w	
R153	0683-3015	R: fxd, comp, 300 ohms ±5%, 1/4 w	
R154	0687-3931	R: fxd, comp, 39K ohms ±10%, 1/2 w	
R155	0727-0098	R: fxd, dep c, 945 ohms ±1%, 1/2 w	
R156	0727-0012	R: fxd, dep c, 20 ohms ±1%, 1/2 w	
R157	2100-0154	R: var, comp, lin, 1K ohms ±30%, 3/10 w	
R158	0757-0062	R: fxd, mfgl, 510 ohms ±2%, 1/2 w	
R159	0727-0027	R: fxd, dep c, 53.3 ohms ±1%, 1/2 w	
R160	2100-0305	R: var, comp, 2 sect (includes R115), 10 CC log, 1K ohm ±10%, 1-49 w	
R161	0686-2015	R: fxd, comp, 200 ohms ±5%, 1/2 w	
R162	0687-1071	R: fxd, comp, 100 ohms ±10%, 1/2 w	
R163	0727-0027	R: fxd, dep c, 53.3 ohms ±1%, 1/2 w	
R164 thru R167		Not assigned	
R168, 169	0727-0035	R: fxd, dep c, 68.4 ohms ±1/2%, 1/2 w	
R170	0686-1025	R: fxd, comp, 1K ohm ±5%, 1/2 w	
R171	0687-1821	R: fxd, comp, 1.8K ohms ±10%, 1/2 w	
R172	0686-2025	R: fxd, comp, 2K ohms ±5%, 1/2 w	
R173	0686-1025	R: fxd, comp, 1K ohm ±5%, 1/2 w	
R174	0686-1525	R: fxd, comp, 1.5K ohms ±5%, 1/2 w	
R175	0686-9115	R: fxd, comp, 910 ohms ±5%, 1/2 w	
R176	0727-0354	R: fxd, dep c, 37.95K ±1/2%, 1/2 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
R177	0686-3025	R: fxd, comp, 3K ohms ±5%, 1/2 w	
R178	0686-4715	R: fxd, comp, 470 ohms ±5%, 1/2 W	
R179	0687-1021	R: fxd, comp, 1K ohm ±10%, 1/2 w	
R180	0687-8211	R: fxd, comp, 820 ohms ±10%, 1/2 w	
R181 thru R184		Not assigned	
R185	0687-1001	R: fxd, comp, 10 ohms ±10%, 1/2 w	
R186	0687-5611	R: fxd, comp, 560 ohms ±10%, 1/2 w	
R187	0687-1001	R: fxd, comp, 10 ohms ±10%, 1/2 w	
R188	0684-1031	R: fxd, comp, 10K ohms ±10%, 1/4 w	
R189	0687-8211	R: fxd, comp, 820 ohms ±10%, 1/2 w	
R190	0687-1021	R: fxd, comp, 1K ohms ±10%, 1/2 w	
R191	0767-0004	R: fxd, mfgl, 5K ohms ±5%, 3 w	
R192	0687-1211	R: fxd, comp, 120 ohms ±10%, 1/2 w	
R193	0687-8211	R: fxd, comp, 820 ohms ±10%, 1/2 w	
R194	0687-1011	R: fxd, comp, 100 ohms ±10%, 1/2 w	
R195	0764-0002	R: fxd, mfgl, 7.5K ohms ±5%, 2 w	
R196 thru R200		Not assigned	
R201	0767-0009	R: fxd, mfgl, 12K ohms ±5%, 3 w	
R202	0687-6821	R: fxd, comp, 6.8K ohms ±10%, 1/2 w	
R203	0727-0120	R: fxd, dep c, 2.25K ohms ±1%, 1/2 w	
R204	0687-2241	R: fxd, comp, 220K ohms ±10%, 1/2 w	
R205	0687-1031	R: fxd, comp, 10K ohms ±10%, 1/2w	
R206	0687-5611	R: fxd, comp, 560 ohms ±10%, 1/2 w	
R207	0690-2231	R: fxd, comp, 22K ohms ±10%, 1 w	
R208	0687-1021	R: fxd, comp, 1K ohms ±10%, 1/2 w	
R209	0687-1011	R: fxd, comp, 100 ohms ±10%, 1/2 w	
R210	0763-0006	R: fxd, mfgl, 27K ohms ±20%, 4 w	
R211	0686-9105	R: fxd, comp, 91 ohms ±5%, 1/2 w	
R212	2100-0293	R: var, ww, lin, 1K ohms ±5%, 3 w	
R213	2100-0223	R: var, comp, lin, 600 ohms ±10%, 1/2 w	
R214	0727-0060	R: fxd, dep c, 225 ohms ±1%, 1/2 w	
R215	0727-0090	R: fxd, dep c, 750 ohms ±1%, 1/2 w	
R216	0727-0047	R: fxd, dep c, 144 ohms ±1%, 1/2 w	
R217	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R218	0686-3305	R: fxd, comp, 33 ohms ±5%, 1/2 w	
R219, 220	0686-1005	R: fxd, comp, 10 ohms ±5%, 1/2 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	# Stock No.	Description	Note
R221	0687-1031	R: fxd, comp, 10K ohms ±10%, 1/2 w	
R222 thru R225	0687-1001	R: fxd, comp, 10 ohms ±10%, 1/2 w	
R226, 227	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R228	0699-0002	R: fxd, comp, 6.8 ohms ±10%, 1/2 w	
R229	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R230	0690-1531	R: fxd, comp, 15K ohms ±10%, 1 w	
R231	0687-1521	R: fxd, comp, 1.5K ohms ±10%, 1/2 w	
R232	0687-2711	R: fxd, comp, 270 ohms ±10%, 1/2 w	
R233	0687-8211	R: fxd, comp, 820 ohms ±10%, 1/2 w	
R234	0687-1021	R: fxd, comp, 1K ohm ±10%, 1/2 w	
R235	0699-0002	R: fxd, comp, 6.8 ohms ±10%, 1/2 w	
R236	2100-0227	R: var, ww, lin, 20 ohms ±10%, 1 w	
R237		Not assigned	
R238	0687-1021	R: fxd, comp, 1K ohm ±10%, 1/2 w	
R239		Not assigned	
R240	0727-0043	R: fxd, dep c, 100 ohms ±1%, 1/2 w	
R241	0687-1001	R: fxd, comp, 10 ohms ±10%, 1/2 w	
R242	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R243	0687-4701	R: fxd, comp, 47 ohms ±10%, 1/2 w	
R244, 245	0687-1021	R: fxd, comp, 1K ohm ±10%, 1/2 w	
R246	0687-8211	R: fxd, comp, 820 ohms ±10%, 1/2 w	
R247	0687-1031	R: fxd, comp, 10K ohms ±10%, 1/2 w	
R248		Not assigned	
R249	0687-1021	R: fxd, comp, 1K ohm ±10%, 1/2 w	
R250	0687-1011	R: fxd, comp, 100 ohms ±10%, 1/2 w	
R251	0760-0009	R: fxd, mfgl, 100K ohms ±2%, 1 w	
R252	0727-0169	R: fxd, dep c, 15.5K ohms ±10%, 1/2 w	
R253	0727-0167	R: fxd, dep c, 13.7K ohms ±1%, 1/2 w	
R254	0687-2241	R: fxd, comp, 220K ohms ±10%, 1/2 w	
R255	2100-0280	R: var, comp, lin, dual ganged, 1st sect: 50K ohms ±20%, 1/3 w 2nd sect: 10 c log, 30K ohms ±10%, 1/3 w	
R256	0687-1821	R: fxd, comp, 1.8K ohms ±10%, 1/2 w	
R257	0686-3025	R: fxd, comp, 3K ohms ±5%, 1/2 w	
R258	0687-1031	R: fxd, comp, 10K ohms ±10%, 1/2 w	
R259	0686-8255	R: fxd, comp, 8.2M ±5%, 1/2 w	
R260	0686-4735	R: fxd, comp, 47K ohms ±5%, 1/2 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
R261	0727-0148	R: fxd, dep c, 7,842 ohms ±1%, 1/2 w	
R262	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R263	0687-1041	R: fxd, comp, 100K ohms ±10%, 1/2 w	
R264	0687-2741	R: fxd, comp, 270K ohms ±10%, 1/2 w	
R265	0765-0007	R: fxd, mfgl, 15K ohms ±10%, 2 w	
R266	0690-1231	R: fxd, comp, 12K ohms ±10%, 1 w	
R267	0758-0016	R: fxd, mfgl, 300 ohms ±5%, 1/2 w	
R268		Not assigned	
R269	0687-1041	R: fxd, comp, 100K ohms ±10%, 1/2 w	
R270	2100-0182	R: var, comp, lin, 3.3K ohms ±10%, 1/3 w	
R271	0765-0008	R: fxd, mfgl, 68K ohms ±10%, 2 w	
R272	0758-0019	R: fxd, mfgl, 18K ohms ±5%, 1/2 w	
R273, 274		Not assigned	
R275	0767-0009	R: fxd, mfgl, 12K ohms ±5%, 3 w	
R276	0727-0148	R: fxd, dep c, 7,842 ohms ±1%, 1/2 w	
R277	0727-0158	R: fxd, dep c, 10.1K ohms ±1%, 1/2 w	
R278	0727-0140	R: fxd, dep c, 6K ohms ±1%, 1/2 w	
R279	0727-0115	R: fxd, dep c, 2K ohms ±1%, 1/2 w	
R280	0727-0100	R: fxd, dep c, 1K ohm ±1%, 1/2 w	
R281	0727-0081	R: fxd, dep c, 600 ohms ±1%, 1/2 w	
R282, 283	0727-0054	R: fxd, dep c, 200 ohms ±1%, 1/2 w	
R284	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R285	2100-0053	R: var, ww, 10K ohms	
R286	2100-0230	R: var, comp, 65K ohms ±20%, 1/4 w	
R287 thru R300		Not assigned	
R301	0699-0012	R: fxd, comp, 27K ohms ±10%, 500 v, 2 w	
R302	0687-8241	R: fxd, comp, 820K ohms ±10%, 1/2 w	
R303	0687-1051	R: fxd, comp, 1M ±10%, 1/2 w	
R304	0690-2741	R: fxd, comp, 270K ohms ±10%, 1 w	
R305	0699-0011	R: fxd, comp, 1.8M ±1%, 1/2 w	
R306	2100-0096	R: var, comp, lin, 1M ±30%, 1/4 w	
R307	0836-0002	R: fxd, dep c, 20M ±10%, 1 w	
R308	2100-0105	R: var, comp, 3.5M ±30%, 1/2 w	
R309	0687-6841	R: fxd, comp, 680K ohms ±10%, 1/2 w	
R310	0687-2731	R: fxd, comp, 27K ohms ±10%, 1/2 w	
R311	0687-1241	R: fxd, comp, 120K ohms ±10%, 1/2 w	
R312	2100-0095	R: var, comp, lin, 100K ohms ±30%, 1/4 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
R313	0687-1541	R: fxd, comp, 150K ohms ±10%, 1/2 w	
R314	0687-1021	R: fxd, comp, 1K ohm ±10%, 1/2 w	
R315	0687-4731	R: fxd, comp, 47K ohms ±10%, 1/2 w	
R316	0687-1021	R: fxd, comp, 1K ohm ±10%, 1/2 w	
R317	0687-1041	R: fxd, comp, 100K ohms ±10%, 1/2 w	
R318	2100-0009	R: var, comp, 25K ohms ±20%, 1/3 w	
R319	0687-3931	R: fxd, comp, 39K ohms ±10%, 1/2 w	
R320	2100-0096	R: var, comp, lin, 1M ±30%, 1/4 w	
R321	0836-0003	R: fxd, dep c, 29M ±10%, 1 w	
R322	0687-2241	R: fxd, comp, 220K ohms ±10%, 1/2 w	
R323	0687-4731	R: fxd, comp, 47K ohms ±10%, 1/2 w	
R324	0687-1551	R: fxd, comp, 1.5M ±10%, 1/2 w	
R425 thru R400		Not assigned	
R401	0687-3331	R: fxd, comp, 33K ohms ±10%, 1/2 w	
R402	0687-1041	R: fxd, comp, 100K ohms ±10%, 1/2 w	
R403	0690-2701	R: fxd, comp, 27 ohms ±10%, 1 w	
R404	0768-0001	R: fxd, mfgl, 1K ohm ±10%, 3 w	
R405	0690-2701	R: fxd, comp, 27 ohms ±10%, 1 w	
R406	0768-0001	R: fxd, mfgl, 1K ohm ±10%, 3 w	
R407	0813-0028	R: fxd, ww, 1 ohm ±10%, 1 w	
R408	0693-1031	R: fxd, comp, 10K ohms ±10%, 2 w	
R409	0687-2211	R: fxd, comp, 220 ohms ±10%, 1/2 w	
R410	0767-0010	R: fxd, mfgl, 15K ohms ±5%, 3 w	
R411	0727-0074	R: fxd, dep c, 436 ohms ±1/2%, 1/2 w	
R412	0767-0008	R: fxd, mfgl, 10K ohms ±5%, 3 w	
R413	0687-1011	R: fxd, comp, 100 ohms ±10%, 1/2 w	
R414	0767-0010	R: fxd, mfgl, 15K ohms ±5%, 3 w	
R415	0767-0017	R: fxd, mfgl, 17K ohms ±5%, 3 w	
R416	2100-0006	R: var, ww, 5K ohms ±10%, 3 w	
R417 thru R419		Not assigned	
R420	0687-1041	R: fxd, comp, 100K ohms ±10%, 1/2 w	
R421,422	0812-0016	R: fxd, ww, 25 ohms ±3%, 5 w	
R423	0816-0003	R: fxd, ww, 500 ohms ±10%, 10 w	
R424	0690-2231	R: fxd, comp, 22K ohms ±10%, 1 w	
R425	0687-8211	R: fxd, comp, 820 ohms ±10%, 1/2 w	
R426	0687-1821	R: fxd, comp, 1.8K ohms ±10%, 1/2 w	
R427	0690-2231	R: fxd, comp, 22K ohms ±10%, 1 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
R428	0687-1011	R: fxd, comp, 100 ohms ±10%, 1/2 w	
R429	0761-0004	R: fxd, mfgl, 20K ohms ±5%, 1 w	
R430	2100-0282	R: var, ww, lin, 2K ohms ±20%, 1-1/2 w	
R431	0761-0004	R: fxd, mfgl, 20K ohms ±5%, 1 w	
R432 thru R434		Not assigned	
R435	0687-2221	R: fxd, comp, 2.2K ohms ±10%, 1/2 w	
R436	0819-0021	R: fxd, ww, 3 ohms ±20%, 55 w	
R437	0687-4721	R: fxd, comp, 4.7K ohms ±10%, 1/2 w	
R438	185A-26A	R: fxd, 0.057 ohm	
R439	0687-4701	R: fxd, comp, 47 ohms ±10%, 1/2 w	
R440	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R441	0690-2731	R: fxd, comp, 27K ohms ±10%, 1 w	
R442	0758-0014	R: fxd, mfgl, 180 ohms ±5%, 1/2 w	
R443	2100-0281	R: var, ww, lin, 100 ohms ±20%, 1-1/2 w	
R444	0758-0013	R: fxd, mfgl, 120 ohms ±5%, 1/2 w	
R445	0687-1021	R: fxd, comp, 1K ohm ±10%, 1/2 w	a
R446,447		Not assigned	
R448	0764-0002	R: fxd, mfgl, 7.5K ohms ±5%, 2 w	b
R449	2100-0049	R: var, lin, 20K ohms ±20%, 1/3 w	b
	2100-0054	R: var, ww, 500 ohms, 2 w	a
R450	0687-1231	R: fxd, comp, 12K ohms ±10%, 1/2 w	
R451,452	0693-1011	R: fxd, comp, 100 ohms ±10%, 2 w	
R453	0687-5621	R: fxd, comp, 5.6K ohms ±10%, 1/2 w	
R454	0687-2721	R: fxd, comp, 2.7K ohms ±10%, 1/2 w	
R455	0690-2231	R: fxd, comp, 22K ohms ±10%, 1 w	
R456	0758-0015	R: fxd, mfgl, 220 ohms ±5%, 1/2 w	
R457	2100-0281	R: var, ww, lin, 100 ohms ±20%, 1-1/2 w	
R458	0758-0016	R: fxd, mfgl, 300 ohms ±5%, 1/2 w	
R459 thru R461		Not assigned	
R462	0687-1041	R: fxd, comp, 100K ohms ±10%, 1/2 w	
R463	0816-0011	R: fxd, ww, 1K ohm ±10%, 10 w	
R464	0816-0015	R: fxd, ww, 50 ohms ±10%, 10 w	
R465	0687-2211	R: fxd, comp, 220 ohms ±10%, 1/2 w	
R466	0690-1531	R: fxd, comp, 15K ohms ±10%, 1 w	
R467	0687-3911	R: fxd, comp, 390 ohms ±10%, 1/2 w	
R468	2100-0005	R: var, ww, lin, 2K ohms ±10%, 2 w	
R469	0758-0016	R: fxd, mfgl, 300 ohms ±5%, 1/2 w	
R470	0767-0008	R: fxd, mfgl, 10K ohms ±5%, 3 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	⊕ Stock No.	Description	Note
R471	0687-8221	R: fxd, comp, 8.2K ohms ±10%, 1/2 w	
R472	0687-8231	R: fxd, comp, 82K ohms ±10%, 1/2 w	
R473	0687-1011	R: fxd, comp, 100 ohms ±10%, 1/2 w	
R474	0687-5621	R: fxd, comp, 5.6K ohms ±10%, 1/2 w	
R475 thru R500		Not assigned	
R501	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R502	0764-0007	R: fxd, mfgl, 27K ohms ±5%, 2 w	
R503	2100-0091	R: var, comp, 5K ohms ±30%, 1/2 w	
R504	0687-4711	R: fxd, comp, 470 ohms ±10%, 1/2 w	
R505, 506	0687-8211	R: fxd, comp, 820 ohms ±10%, 1/2 w	
R507	0765-0006	R: fxd, mfgl, 12K ohms ±10%, 2 w	
R508	0690-5631	R: fxd, comp, 56K ohms ±10%, 1 w	
R509	2100-0044	R: var, comp, lin, 50K ohms ±10%	
R510	0687-1041	R: fxd, comp, 100K ohms ±10%, 1/2 w	
R511	0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 w	
R512	0764-0007	R: fxd, mfgl, 27K ohms ±5%, 2 w	
R513 thru R600		Not assigned	
R601	0687-1021	R: fxd, comp, 1K ohm ±10%, 1/2 w	
R602	0687-2211	R: fxd, comp, 220 ohms ±10%, 1/2 w	
R603	0687-1001	R: fxd, comp, 10 ohms ±10%, 1/2 w	
R604	0686-4715	R: fxd, comp, 470 ohms ±5%, 1/2 w	
R605	0693-1511	R: fxd, comp, 150 ohms ±10%, 2 w	
R606	0687-8221	R: fxd, comp, 8.2K ohms ±10%, 1/2 w	
R607, 608	0683-1015	R: fxd, comp, 100 ohms ±5%, 1/4 w	
R609	0770-0003	R: fxd, mfgl, 3.3K ohms ±5%, 4 w	
R610	0767-0009	R: fxd, mfgl, 12K ohms ±5%, 3 w	
R611	2100-0053	R: var, ww, 10K ohms	
R612	0683-1015	R: fxd, comp, 100 ohms ±5%, 1/4 w	
R613, 614	0687-1001	R: fxd, comp, 10 ohms ±10%, 1/2 w	
R615	0687-8221	R: fxd, comp, 8.2K ohms ±10%, 1/2 w	
R616	0687-1031	R: fxd, comp, 10K ohms ±10%, 1/2 w	
R617	0687-1001	R: fxd, comp, 10 ohms ±10%, 1/2 w	
R618	0683-5105	R: fxd, comp, 51 ohms ±5%, 1/4 w	
R619	0727-0335	R: fxd, dep c, 10 ohms ±1%, 1/2 w	
R620	0727-0018	R: fxd, dep c, 40 ohms ±1%, 1/2 w	
R621	0727-0023	R: fxd, dep c, 50 ohms ±1%, 1/2 w	
R622	0727-0072	R: fxd, dep c, 403 ohms ±1%, 1/2 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	⊕ Stock No.	Description	Note
R623	0727-0356	R: fxd, dep c, 5.8K ohms ±1%, 1/2 w	
R624	0687-2201	R: fxd, comp, 22 ohms ±10%, 1/2 w	
S1	3101-0010	Switch, push: DPDT	
S2 thru S100		Not assigned	
S101		nsr; part of A101 assy	
S102	3101-0011	Switch, wafer	
S103 thru S200		Not assigned	
S201		nsr; part of A201 assy	
S202		nsr; part of A202 assy	
S203		nsr; part of A203 assy	
S204		Not assigned	
S401	3101-0030	Switch, tog: 15 amp, SPST	
S402	3101-0033	Switch, sl: DPDT	
S403 thru S600		Not assigned	
S601		nsr; part of A601 assy	
T1 thru T100		Not assigned	
T101	185B-60D	Transformer, trigger slope	
T102	185B-60A	Transformer, oscillator amplifier	
T103	185B-60E	Transformer, sync blocking oscillator	
T104 thru T200		Not assigned	
T201	185A-60B	Transformer, sweep pulse	
T202	185B-60A	Transformer, oscillator amplifier	
T203	185B-60C	Transformer, sweep oscillator	
T204	185A-60B	Transformer, sweep pulse	
T205 thru T400		Not assigned	
T401	9100-0154	Transformer, power	
T402 thru T600		Not assigned	
T601		nsr; part of A601	
V1 thru V5	1932-0022	Tube, electron: 6DJ8	
V6 thru V100		Not assigned	
V101,102	1932-0022	Tube, electron: 6DJ8	
V103 thru V200		Not assigned	
V201	1932-0029	Tube, electron: 12AU7	
V202 thru V300		Not assigned	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	⊕ Stock No.	Description	Note
V301	1932-0029	Tube, electron: 12AU7	
V302	1923-0018	Tube, electron: 6AQ5	
V303,304		Not assigned	
V305	G-200B	Cathode Ray Tube: 5AQP2A	
	G-200B-2	Cathode Ray Tube: 5AQP2	b
V306 thru V400		Not assigned	
V401	1940-0001	Tube, electron: 5651	
V402 thru V500		Not assigned	
V501	1932-0022	Tube, electron: 6DJ8	
XV1 thru XV5	1200-0048	Socket, tube: 9 pin, minat (for pc)	
XV6 thru 300		Not assigned	
XV301	1200-0048	Socket, tube: 9 pin, minat (for pc)	
XV302	1200-0047	Socket, tube: 7 pin, minat (for pc)	
XV303 thru 400		Not assigned	
XV401	1200-0047	Socket, tube: 7 pin, minat (for pc)	
XV402 thru 500		Not assigned	
XV501	1200-0048	Socket, tube: 9 pin, minat (for pc)	
		a. external CRT only	
		b. internal CRT only; see option 3	

See introduction to this section

Table 6-2. Replaceable Parts

ℏ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
AC-10C	Binding post: black	28480	AC-10C	4	1		
AC-10D	Binding post: red	28480	AC-10D				
AC-54D	Insulator, binding post: black, 1 hole	28480	AC-54D	4	0		
AC-54E	Insulator, binding post: black, 2 hole	28480	AC-54E	4	0		
G-60A	Inductor, alignment	28480	G-60A	1	1		
G-29A-74	Diode, zener	28480	G-29A-74	2	2		
G-29E-12	Diode	28480	G-29E-12	2	2		
G-29E-46	Diode	28480	G-29E-46	2	2		
G-29E-86	Diode	28480	G-29E-86	1	1		
G-29J-38	Diode	28480	G-29J-38	1	1		
G-29J-48	Diode	28480	G-29J-48	1	1		
G-29L-49	Diode	28480	G-29L-49	1	1		
G-29L-78	Diode	28480	G-29L-78	5	5		
G-29M-8	Diode	28480	G-29M-8	5	5		
G-29M-9	Diode	28480	G-29M-9	4	4		
G-31A-7H	Diode, zener	28480	G-31A-7H	1	1		
G-31A-82L	Diode, zener	28480	G-31A-82L	1	1		
G-31G-7H	Diode, zener	28480	G-31G-7H	1	1		
G-200B	Cathode ray tube: 5AQP2A	28480	G-200B				
G-200B-2	Cathode ray tube: 5AQP2 (standard tube with option 3)	28480	G-200B-2				
185A-26A	R: fxd, 0.057 ohms	28480	185A-26A	1	1		
185A-60B	Transformer, sweep pulse	28480	185A-60B	2	1		
185B-19A	Assy, SCANNING SWITCH: includes, C240; R254 - R261; S203	28480	185B-19A	1	1		
185B-19B	Assy, TIME SCALE SWITCH: includes, C118 - C122; C203 - C206; C208; C210; C212; C214 - C219; R286; S202	28480	185B-19B	1	1		

#See introduction to this section

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

℗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS
185B-19C	Assy, TIME SCALE MAG. SWITCH: includes, R212 R277 - R283 R215 - R220 S201	28480	185B-19C	1	1
185B-19E	Assy, CALIBRATOR AND SYNC PULSE switch: includes, L606 R619 - R624 R603 S601	28480	185B-19E	1	1
185B-19F	Assy, TRIGGERING switch: includes, R158, R159 S101	28480	185B-19F	1	1
185B-60A	Transformer, oscillator amp.	28480	185B-60A	2	1
185B-60C	Transformer, sweep oscillator	28480	185B-60C	1	1
185B-60D	Transformer, trigger slope	28480	185B-60D	1	1
185B-60E	Transformer, sync blocking oscillator	28480	185B-60E	1	1
185B-60G	Inductor: fxd, 0.16 mh	28480	185B-60G	1	1
185B-65A	Assy, ELECTRONIC SWITCH etched circuit: includes, C8 - C19 L3 - L5 C25 R33 - R55 CR2 - CR8 V4, V5 XV4, XV5	28480	185B-65A	1	0
185B-65B	Assy, VERTICAL AMPLIFIER ETCHED CIRCUIT: includes, C1 - C7 R7 - R11 C22 - C24 R14 - R19 CR1, CR2 R21 - R23 L1, L2 R25 Q1 - Q4 R27 - R29 R1 - R3 R56 - R58 R5 R61 - R64 V1 - V3 XV1 - XV3	28480	185B-65B	1	0
185B-65C	Assy, HV SUPPLY ETCHED CIRCUIT: includes, C301 - C308 R309 - R317 C311 - C313 R319 - R324 L301, L302 V301, V302 R301 - R307 XV301, XV302	28480	185B-65C	1	0

#See introduction to this section

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

ⓗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS
185B-65D	Assy, HORIZ. AMP. ETCHED CIRCUIT: includes, C501 R510- R512 R501 - R507 V501 XV501	28480	185B-65D	1	0
185B-65E	Assy, TIME BASE ETCHED CIRCUIT: includes, C201, C202 Q201, Q203 C207 R201 - R211 C209 R214 C211 R222 - R236 C213 R238 C221 - C224 R240 - R247 C226 - C236 R249 - R253 C238, C239 R262 - R267 C241, C242 R269 - R272 CR201 - CR204 R275, R276 CR207 - CR222 R284 L201 T202	28480	185B-65E	1	0
185B-65J	Assy, LV SUPPLY ETCHED CIRCUIT: includes, C403, C404 Q410 - Q412 C406, C407 Q414, Q415 C411 Q417 - Q419 C413 - C415 R403 - R415 C417 R421, R422 C419 - C421 R424 - R431 CR407 R437 CR410 R439 - R444 CR413 R451 - R458 Q403, Q404 R465 - R467 Q406, Q407 R469 - R474 XV401	28480	185B-65J	1	0
185B-65K	Assy, RECTIFIER ETCHED CIRCUIT: includes, CR401 - CR404 CR411, CR412 CR408, CR409	28480	185B-65K	1	0

#See introduction to this section

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

ⓗⓟ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
185B-65N	Assy, SYNC ETCHED CIRCUIT: includes, C101 - C109, C115 - C117, C126 - C130, C135 - C138, C141 - C146, C151 - C159, CR101, CR102, CR104 - CR108, CR111 - CR114, CR120 - CR125, CR131 - CR137, DL101, J102, L102 - L104, L107 - L114, Q101 - Q107, R101 - R107, R111 - R114, R116 - R121, R126 - R136, R140 - R147, R151 - R157, R161 - R163, R168 - R180, R185 - R195, T101, T102	28480	185B-65N	1	0		
185B-65P	Assy, TIME CALIB. ETCHED CIRCUIT: includes, C601 - C606, C607 - C612, CR601 - CR605, L601, L602, L605, L607, Q601 - Q603, R601, R602, R604 - R610, R612 - R618	28480	185B-65P	1	0		
0130-0001	C: var, cer, 7-45 pf, 500 vdcw	72982	503-000-D2PO-33R	1	1		
0130-0017	C: var, cer, 8-50 pf, 500 vdcw	72982	557-019-U2PO-34R	1	1		
0130-0019	C: var, cer, 4-30 pf, 500 vdcw	72982	503-015-N650	1	1		
0131-0001	C: var, mica, 50-380 pf, 175 vdcw	72136	obd#	1	1		
0131-0003	C: var, mica, 170 -780 pf, 175 vdcw	72136	T52910	4	1		
0131-0004	C: var, mica, 14-150 pf, 175 vdcw	72136	T51410-3	2	1		
0140-0002	C: fxd, mica, 10 pf ±10%, 500 vdcw	76433	RCM20B100K	1	1		
0140-0006	C: fxd, mica, 82 pf ±10%, 500 vdcw	76433	RCM15B820K	1	1		
0140-0007	C: fxd, mica, 680 pf ±10%, 500 vdcw	76433	RCM20B681K	1	1		
0140-0015	C: fxd, mica, 270 pf ±10%, 500 vdcw	76433	RCM20B271K	1	1		
0140-0023	C: fxd, mica, 180 pf ±10%, 500 vdcw	72136	CM20E18K	1	1		
0140-0036	C: fxd, mica, 110 pf ±5%, 500 vdcw	76433	RCM15E111J	1	1		
0140-0037	C: fxd, mica, 390 pf ±5%, 500 vdcw	76433	RCM15E391J	1	1		
0140-0041	C: fxd, mica, 100 pf ±5%, 500 vdcw	76433	RCM15E101J	2	1		

#See introduction to this section

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

℗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0140-0054	C: fxd, mica, 100 pf ±10%, 500 vdcw	76433	RCM20B101K	5	2		
0140-0055	C: fxd, mica, 150 pf ±10%, 500 vdcw	76433	RCM20B151K	1	1		
0140-0078	C: fxd, mica, 2000 pf ±200 pf	72982	609-013-01AU-202K	1	1		
0140-0081	C: fxd, mica, 56 pf ±1%, 500 vdcw	72136	15E560F	1	1		
0140-0085	C: fxd, mica, 470 pf ±5%, 500 vdcw	76433	RCM20C471J	1	1		
0140-0086	C: fxd, mica, 2000 pf ±5%, 500 vdcw	00853	CR1220-E5	1	1		
0140-0099	C: fxd, mica, 1000 pf ±1%, 500 vdcw	00853	KR1210E1	1	1		
0140-0101	C: fxd, mica, 15 pf ±5%, 500 vdcw	76433	RCM15E150J	1	1		
0140-0107	C: fxd, mica, 507 pf ±2%, 500 vdcw	76433	RCM15E(507)G	2	1		
0140-0116	C: fxd, mica, 39 pf ±2%, 500 vdcw	76433	RCM15E390G	3	1		
0140-0152	C: fxd, mica, 1000 pf ±5%, 300 vdcw	72136	DM16F102J	1	1		
0140-0153	C: fxd, mica, 1269 pf ±1%, 300 vdcw	72136	DM16F1269F	1	1		
0140-0158	C: fxd, mica, 2676 pf ±1%, 500 vdcw	72136	DM20F2676F	1	1		
0140-0161	C: fxd, mica, 3932 pf ±1%, 300 vdcw	72136	DM20F3932F	1	1		
0140-0189	C: fxd, mica, 5825 pf ±2%, 300 vdcw	72136	DM20F5825G	1	1		
0140-0213	C: fxd, mica, 2000 pf ±1%, 300 vdcw	72136	DM19F202F-300 vdc	1	1		
0150-0012	C: fxd, cer, 0.01 μf ±20%, 1000 vdcw	56289	29C214A3-H-1038	11	3		
0150-0014	C: fxd, cer, 0.005 μf, 500 vdcw	96095	D1-4	3	1		
0150-0015	C: fxd, TiO_2, 2.2 pf ±10%, 500 vdcw	78488	Type GA, obd#	2	1		
0150-0023	C: fxd, cer, 2000 pf ±20%, 1000 vdcw	91418	JF.002-20%	2	1		
0150-0024	C: fxd, cer, 0.02 μf +80% -20%, 600 vdcw	91418	B.02GMV	2	1		
0150-0029	C: fxd, TiO_2, 1 pf ±1%, 500 vdcw	78488	GA obd#	1	1		
0150-0033	C: fxd, TiO_2, 8.2 pf ±10%, 500 vdcw	78488	Type GA obd#	1	1		
0150-0037	C: fxd, cer, 100 pf ±1%, 500 vdcw	72982	821	1	1		
0150-0042	C: fxd, TiO_2, 4.7 pf ±5%, 500 vdcw	82142	JM obd#	1	1		
0150-0050	C: fxd, cer, 1000 pf, 600 vdcw	84411	Type E obd#	5	2		
0150-0052	C: fxd, cer, dual tandem, 0.05 μf ±20%, 400 vdcw	05729	20X503MC4	18	4		
0150-0070	C: fxd, cer, 0.02 μf ±20%, 500 vdcw	72982	821010X5120203M	3	1		
0150-0071	C: fxd, cer, 400 pf ±5%, 500 vdcw	56289	19C formulation 28, obd#	1	1		
0150-0073	C: fxd, cer, 100 pf ±10%, 500 vdcw	56289	40C200A2	1	1		

#See introduction to this section

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

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0150-0078	C: fxd, cer, 56 pf ±10%, 1000 vdcw	56289	Formulation, obd#	2	1		
0150-0084	C: fxd, cer, 0.1 μf +80% -20%, 50 vdcw	56289	33C41	12	3		
0150-0096	C: fxd, cer, 0.05 pf +80% -20%, 100 vdcw	91418	TA obd#	1	1		
0160-0013	C: fxd, my, 0.1μf ±10%, 400 vdcw	56289	160P10494	1	1		
0160-0046	C: fxd, paper, 0.0033 μf ±20%, 6000 vdcw	56289	184P332060	1	1		
0160-0061	C: fxd, paper, 0.0015 μf ±20%, 5000 vdcw	56289	184P152050	1	1		
0170-0018	C: fxd, my, 1 μf ±5%, 200 vdcw	84411	HEW-4	3	1		
0170-0038	C: fxd, my, 0.22 μf ±10%, 200 vdcw	56289	148P22492	1	1		
0170-0055	C: fxd, my, 0.1 μf ±20%, 200 vdcw	56289	192P10402	1	1		
0170-0088	C: fxd, poly, 0.126 μf ±1%, 500 vdcw	56289	114P-IR5S3	1	1		
0170-0089	C: fxd, poly, 0.063 μf ±1%, 50 vdcw	56289	114P6331R5S3 obd#	1	1		
0170-0090	C: fxd, poly, 0.0252 μf ±1%, 50 vdcw	56289	114P-IR5S3, obd#	1	1		
0170-0091	C: fxd, poly, 0.01213 μf ±2%, 50 vdcw	56289	114P2R5S3	1	1		
0180-0004	C: fxd, elect, 20 μf -10% +100%, 150 vdcw	37942	203624	1	1		
0180-0012	C: fxd, elect, 2 sect, 20 μf/sect, 450 vdcw	00853	PL1 obd#	1	1		
0180-0030	C: fxd, elect, 2 sect, 120 x 40 μf, 450 vdcw	56289	D32352	1	1		
0180-0042	C: fxd, elect, 120 μf, 350 vdcw	56289	D32353	2	1		
0180-0045	C: fxd, elect, 20 μf, 25 vdcw	56289	Type 30D obd#	1	1		
0180-0056	C: fxd, elect, 1000 μf, 50 vdcw	56289	D32429	1	1		
0180-0058	C: fxd, elect, 50 μf -10% +100%, 25 vdcw	56289	30D186A1	2	1		
0180-0059	C: fxd, elect, 10 μf -10% +100%, 25 vdcw	56289	30D182A1	5	2		
0180-0076	C: fxd, elect, 20 μf, 25 vdcw	56289	40D-181-A2	9	2		
0180-0077	C: fxd, elect, 4500 μf, 35 vdcw	56289	32D314	1	1		
0180-0089	C: fxd, elect, 10 μf -10% +100%, 150 vdcw	56289	30D218A1	3	1		
0180-0097	C: fxd, solid tantalum, 47 μf ±10%, 35 vdcw	56289	150D476X9035S2	1	1		

#See introduction to this section

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

ⓗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0683-1015	R: fxd, comp, 100 ohms ±5%, 1/4 W	01121	CB1015	3	1		
0683-2245	R: fxd, comp, 220K ohms ±5%, 1/4 W	01121	CB2245	1	1		
0683-3015	R: fxd, comp, 300 ohms ±5%, 1/4 W	01121	CB3015	1	1		
0683-5105	R: fxd, comp, 51 ohms ±5%, 1/4 W	01121	CB5105	1	1		
0684-1031	R: fxd, comp, 10K ohms ±10%, 1/4W	01121	CB1031	1	1		
0686-1005	R: fxd, comp, 10 ohms ±5%, 1/2 W	01121	EB1005	2	1		
0686-1025	R: fxd, comp, 1K ohms ±5%, 1/2 W	01121	EB1025	2	1		
0686-1525	R: fxd, comp, 1.5K ohms ±5%, 1/2 W	01121	EB1525	1	1		
0686-2015	R: fxd, comp, 200 ohms±5%, 1/2 W	01121	EB2015	1	1		
0686-2025	R: fxd, comp, 2K ohms ±5%, 1/2 W	01121	EB2025	1	1		
0686-2235	R: fxd, comp, 22K ohms ±5%, 1/2 W	01121	EB2235	1	1		
0686-2435	R: fxd, comp, 24K ohms ±5%, 1/2 W	01121	EB2435	2	1		
0686-2745	R: fxd, comp, 270K ohms±5%, 1/2 W	01121	EB2745	1	1		
0686-3025	R: fxd, comp, 3K ohms ±5%, 1/2 W	01121	EB3025	2	1		
0686-3305	R: fxd, comp, 33 ohms ±5%, 1/2 W	01121	EB3305	1	1		
0686-3325	R: fxd, comp, 3.3K ohms ±5%, 1/2 W	01121	EB3325	2	1		
0686-4345	R: fxd, comp, 430K ohms ±5%, 1/2 W	01121	EB4345	1	1		
0686-4715	R: fxd, comp, 470 ohms ±5%, 1/2 W	01121	EB4715	2	1		
0686-4735	R: fxd, comp, 47K ohms ±5%, 1/2 W	01121	EB4735	1	1		
0686-8255	R: fxd, comp, 8.2M ±5%, 1/2 W	01121	EB8255	1	1		
0686-9105	R: fxd, comp, 91 ohms ±5%, 1/2 W	01121	EB9105	1	1		
0686-9115	R: fxd, comp, 910 ohms ±5%, 1/2 W	01121	EB9115	1	1		
0687-1001	R: fxd, comp, 10 ohms ±10%, 1/2 W	01121	EB1001	11	3		
0687-1011	R: fxd, comp, 100 ohms ±10%, 1/2 W	01121	EB1011	8	2		
0687-1021	R: fxd, comp, 1K ohms ±10%, 1/2 W	01121	EB1021	13	3		
0687-1031	R: fxd, comp, 10K ohms ±10%, 1/2 W	01121	EB1031	9	2		
0687-1041	R: fxd, comp, 100K ohms ±10%, 1/2 W	01121	EB1041	11	3		
0687-1051	R: fxd, comp, 1M ±10%, 1/2 W	01121	EB1051	5	2		
0687-1211	R: fxd, comp, 120 ohms ±10%, 1/2 W	01121	EB1211	1	1		
0687-1221	R: fxd, comp, 1.2K ohms ±10%, 1/2 W	01121	EB1221	2	1		
0687-1231	R: fxd, comp, 12K ohms ±10%, 1/2 W	01121	EB1231	1	1		
0687-1241	R: fxd, comp, 120K ohms ±10%, 1/2 W	01121	EB1241	1	1		
0687-1521	R: fxd, comp, 1.5K ohms ±10%, 1/2 W	01121	EB1521	1	1		
0687-1541	R: fxd, comp, 150K ohms ±10%, 1/2 W	01121	EB1541	1	1		
0687-1551	R: fxd, comp, 1.5M ±10%, 1/2 W	01121	EB1551	1	1		

#See introduction to this section

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

ⓗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0687-1801	R: fxd, comp, 18 ohms ±10%, 1/2 W	01121	EB1801	1	1		
0687-1821	R: fxd, comp, 1.8K ohms ±10%, 1/2 W	01121	EB1821	3	1		
0687-2201	R: fxd, comp, 22 ohms ±10%, 1/2 W	01121	EB2201	1	1		
0687-2211	R: fxd, comp, 220 ohms ±10%, 1/2 W	01121	EB2211	4	1		
0687-2221	R: fxd, comp, 2.2K ohms ±10%, 1/2 W	01121	EB2221	1	1		
0687-2241	R: fxd, comp, 220K ohms ±10%, 1/2 W	01121	EB2241	4	1		
0687-2711	R: fxd, comp, 270 ohms ±10%, 1/2 W	01121	EB2711	1	1		
0687-2721	R: fxd, comp, 2.7K ohms ±10%, 1/2 W	01121	EB2721	1	1		
0687-2731	R: fxd, comp, 27K ohms ±10%, 1/2 W	01121	EB2731	1	1		
0687-2741	R: fxd, comp, 270K ohms ±10%, 1/2 W	01121	EB2741	1	1		
0687-3331	R: fxd, comp, 33K ohms ±10%, 1/2 W	01121	EB3331	1	1		
0687-3911	R: fxd, comp, 390 ohms ±10%, 1/2 W	01121	EB3911	1	1		
0687-3931	R: fxd, comp, 39K ohms ±10%, 1/2 W	01121	EB3931	2	1		
0687-4701	R: fxd, comp, 47 ohms ±10%, 1/2 W	01121	EB4701	2	1		
0687-4711	R: fxd, comp, 470 ohms ±10%, 1/2 W	01121	EB4711	8	2		
0687-4721	R: fxd, comp, 4.7K ohms ±10%, 1/2 W	01121	EB4721	1	1		
0687-4731	R: fxd, comp, 47K ohms ±10%, 1/2 W	01121	EB4731	4	1		
0687-5601	R: fxd, comp, 56 ohms ±10%, 1/2 W	01121	EB5601	21	5		
0687-5611	R: fxd, comp, 560 ohms ±10%, 1/2 W	01121	EB5611	3	1		
0687-5621	R: fxd, comp, 5.6K ohms ±10%, 1/2 W	01121	EB5621	2	1		
0687-6821	R: fxd, comp, 6.8K ohms ±10%, 1/2 W	01121	EB6821	1	1		
0687-6841	R: fxd, comp, 680K ohms ±10%, 1/2 W	01121	EB6841	1	1		
0687-8211	R: fxd, comp, 820 ohms ±10%, 1/2 W	01121	EB8211	11	3		
0687-8221	R: fxd, comp, 8.2K ohms ±10%, 1/2 W	01121	EB8221	3	1		
0687-8231	R: fxd, comp, 82K ohms ±10%, 1/2 W	01121	EB8231	1	1		
0687-8241	R: fxd, comp, 820K ohms ±10%, 1/2 W.	01121	EB8241	1	1		
0689-7525	R: fxd, comp, 7.5K ohms ±5%, 1 W	01121	GB7525	1	1		
0690-1231	R: fxd, comp, 12K ohms ±10%, 1 W	01121	GB1231	2	1		
0690-1531	R: fxd, comp, 15K ohms ±10%, 1 W	01121	GB1531	3	1		
0690-1831	R: fxd, comp, 18K ohms ±10%, 1 W	01121	GB1831	1	1		
0690-2211	R: fxd, comp, 220 ohms ±10%, 1 W	01121	GB2211	1	1		
0690-2231	R: fxd, comp, 22K ohms ±10%, 1 W	01121	GB2231	4	1		
0690-2701	R: fxd, comp, 27 ohms ±10%, 1 W	01121	GB2701	2	1		
0690-2721	R: fxd, comp, 2.7K ohms ±10%, 1 W	01121	GB2211	2	1		
0690-2731	R: fxd, comp, 27K ohms ±10%, 1 W	01121	GB2731	1	1		

#See introduction to this section

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

℗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0690-2741	R: fxd, comp, 270K ohms ±10%, 1 W	01121	GB2741	1	1		
0690-4701	R: fxd, comp, 47 ohms ±10%, 1 W	01121	GB4701	3	1		
0690-4731	R: fxd, comp, 47K ohms ±10%, 1 W	01121	GB4731	1	1		
0690-5631	R: fxd, comp, 56K ohms ±10%, 1 W	01121	GB5631	1	1		
0693-1011	R: fxd, comp, 100 ohms ±10%, 2W	01121	HB1011	2	1		
0693-1031	R: fxd, comp, 10K ohms ±10%, 2 W	01121	HB1031	1	1		
0693-1511	R: fxd, comp, 150 ohms ±10%, 2 W	01121	HB1511	1	1		
0693-3901	R: fxd, comp, 39 ohms ±10%, 2 W	01121	HB3901	1	1		
0693-3921	R: fxd, comp, 3.9K ohms ±10%, 2 W	01121	HB3921	1	1		
0693-4721	R: fxd, comp, 4.7K ohms ±10%, 2 W	01121	HB4721	2	1		
0699-0002	R: fxd, comp, 5.8 ohms ±10%, 1/2 W	01121	EB68G1	2	1		
0699-0011	R: fxd, comp, 1.8M ±1%, 1/2 W	75042	GBT-1/2	1	1		
0699-0012	R: fxd, comp, 27K ohms ±10%, 2 W	75042	SR2	1	1		
0727-0012	R: fxd, dep c, 20 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0018	R: fxd, dep c, 40 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0023	R: fxd, dep c, 50 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	2	1		
0727-0027	R: fxd, dep c, 53.3 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	2	1		
0727-0035	R: fxd, dep c, 68.4 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	2	1		
0727-0043	R: fxd, dep c, 100 ohms ±1%, 1/2 W	19701	DC1/2BR5 obd#	1	1		
0727-0047	R: fxd, dep c, 144 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0054	R: fxd, dep c, 200 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	2	1		
0727-0060	R: fxd, dep c, 225 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0072	R: fxd, dep c, 403 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0074	R: fxd, dep c, 436 ohms ±1/2%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0081	R: fxd, dep c, 600 ohms ±1%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0090	R: fxd, dep c, 750 ohms ±1%, 1/2 W	19701	DC1/2BR5 obd#	1	1		
0727-0098	R: fxd, dep c, 945 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0100	R: fxd, dep c, 1K ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0109	R: fxd, dep c, 1470 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0115	R: fxd, dep c, 2K ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0120	R: fxd, dep c, 2.25K ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0128	R: fxd, dep c, 3.60K ohms ±1%, 1/2 W	19701	DC1/2BR5 obd#	1	1		
0727-0131	R: fxd, dep c, 3920 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	2	1		
0727-0140	R: fxd, dep c, 6K ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	2	1		

#See introduction to this section

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

℗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0727-0148	R: fxd, dep c, 7.842K ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	2	1		
0727-0158	R: fxd, dep c, 10.1K ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0167	R: fxd, dep c, 13.7K ohms ±1%, 1/2 W	19701	DC1/2PR obd#	1	1		
0727-0169	R: fxd, dep c, 15.5K ohms ±1%, 1/2 W	19701	DC1/2BR5 obd#	1	1		
0727-0202	R: fxd, dep c, 83K ohms ±1%, 1/2 W	19701	DC1/2AR5 obd#	2	1		
0727-0218	R: fxd, dep c, 180K ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	2	1		
0727-0335	R: fxd, dep c, 10 ohms ±1%, 1/2 W	19701	CF1/2 obd#	1	1		
0727-0352	R: fxd, dep c, 1.2K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0354	R: fxd, dep c, 37.95K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0356	R: fxd, dep c, 5.8K ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0757-0062	R: fxd, mfgl, 510 ohms ±2%, 1/2 W	07115	C20 obd#	1	1		
0758-0013	R: fxd, mfgl, 120 ohms ±5%, 1/2 W	07115	C20 obd#	1	1		
0758-0014	R: fxd, mfgl, 180 ohms ±5%, 1/2 W	07115	C20 obd#	1	1		
0758-0015	R: fxd, mfgl, 220 ohms ±5%, 1/2 W	07115	C20 obd#	1	1		
0758-0016	R: fxd, mfgl, 300 ohms ±5%, 1/2 W	07115	C20 obd#	3	1		
0758-0018	R: fxd, mfgl, 15K ohms ±5%, 1/2 W	07115	C20 obd#	1	1		
0758-0019	R: fxd, mfgl, 18K ohms ±5%, 1/2 W	07115	C20 obd#	1	1		
0758-0020	R: fxd, mfgl, 22K ohms ±5%, 1/2 W	07115	C20 obd#	1	1		
0758-0021	R: fxd, mfgl, 51K ohms ±5%, 1/2 W	07115	C20 obd#	1	1		
0758-0022	R: fxd, mfgl, 82K ohms ±5%, 1/2 W	07115	C20 obd#	1	1		
0760-0008	R: fxd, mfgl, 470 ohms ±5%, 1 W	07115	C32 obd#	2	1		
0760-0009	R: fxd, mfgl, 100K ohms ±2%, 1 W	07115	C32 obd#	1	1		
0761-0004	R: fxd, mfgl, 20K ohms ±5%, 1 W	07115	C32 obd#	2	1		
0763-0006	R: fxd, mfgl, 27K ohms ±20%, 4 W	07115	LP1-4 obd#	1	1		
0764-0002	R: fxd, mfgl, 7.5K ohms ±5%, 2 W	07115	C-42 obd#	2	1		
0764-0005	R: fxd, mfgl, 10K ohms ±5%, 2 W	07115	C42S obd#	1	1		
0764-0006	R: fxd, mfgl, 18K ohms ±5%, 2 W	07115	C24S obd#	2	1		
0764-0007	R: fxd, mfgl, 27K ohms ±5%, 2 W	07115	C42S obd#	3	1		
0765-0002	R: fxd, metallic oxide, 6.8K ohms, ±10%, 2 W	07115	C42S obd#	1	1		
0765-0005	R: fxd, mfgl, 8.2K ohms ±10%, 2 W	07115	C42S obd#	4	1		
0765-0006	R: fxd, mfgl, 12K ohms ±10%, 2 W	07115	C42S obd#	2	1		
0765-0007	R: fxd, mfgl, 15K ohms ±10%, 2 W	07115	C42S obd#	1	1		
0765-0008	R: fxd, mfgl, 68K ohms ±10%, 2 W	07115	C42S obd#	1	1		
0767-0004	R: fxd, mfgl, 5K ohms ±5%, 3 W	07115	LP1-3	1	1		

#See introduction to this section

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

ⓗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS
0767-0006	R: fxd, mfgl, 6.5K ohms ±5%, 3 W	07115	LP1-3 obd#	1	1
0767-0008	R: fxd, mfgl, 10K ohms ±5%, 3 W	07115	LP1-3 obd#	2	1
0767-0009	R: fxd, mfgl, 12K ohms ±5%, 3 W	07115	LP1-3 obd#	3	1
0767-0010	R: fxd, mfgl, 15K ohms ±5%, 3 W	07115	LP1-3 obd#	2	1
0767-0017	R: fxd, mfgl, 17K ohms ±5%, 3W	07115	LP1-3 obd#	1	1
0768-0001	R: fxd, mfgl, 1K ohms ±10%, 3 W	07115	LP1-3 obd#	2	1
0770-0003	R: fxd, mfgl, 3.3K ohms ±5%, 4 W	07115	LP1-4 obd#	1	1
0812-0016	R: fxd, ww, 25 ohms ±3%, 5 W	91637	RLS-5-5W	2	1
0813-0028	R: fxd, ww, 1 ohm ±10%, 1 W	91637	CS-1A obd#	1	1
0816-0003	R: fxd, ww, 500 ohms ±10%, 10 W	35434	C-10 obd#	1	1
0816-0011	R: fxd, ww, 1K ohms ±10%, 10 W	35434	C-10 obd#	1	1
0816-0015	R: fxd, ww, 50 ohms ±10%, 10 W	35434	GC10-50	1	1
0819-0021	R: fxd, ww, 3 ohms ±20%, 55 W	94310	OR-55	1	1
0836-0002	R: fxd, dep c, 20M ±10%, 1 W	77764	Type BBF obd#	1	1
0836-0003	R: fxd, dep c, 29M ±10%, 1 W	77764	Type BBF obd#	1	1
1200-0047	Socket, tube: 7 pin, minat (for pc)	91662	3708-2-4	2	1
1200-0048	Socket, tube: 9 pin, minat (for pc)	91662	3908-2-4	7	1
1250-0052	Connector, plug	91737	obd#	1	1
1250-0083	Connector, RF: 52 ohms type UG-1094/U	91737	UG-1094/U	1	1
1250-0102	Connector, body: BNC	91737	obd#	3	1
1250-0118	Connector, RF: BNC	91737	8427	1	1
1251-0054	Connector: female	71785	26-4100-24P	1	1
1251-0130	Connector, RF: female	71468	MS3102P148-5S	1	1
1450-0039	Lamp, neon: NE2H	08717	859-R-5	1	1
1450-0045	Assy, lampholder: SCALE LIGHT	95263	2-40XP74(4)	1	1
1850-0012	Transistor: 2N123 (specially slected from ⓗ type 1850-0010, color coded blue)	28480	obd#	1	1
1850-0018	Transistor: 2N384	02735	obd#	1	1
1850-0021	Transistor: 2N441	16758	2N441	1	1
1850-0037	Transistor: 2N274	02735	2N274	4	4

#See introduction to this section

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

ⓗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
1850-0038	Transistor: 2N301	02735	2N301	2	2		
1850-0051	Transistor: 2N1500	87216	2N1500	1	1		
1850-0052	Transistor: 2N598	87216	2N598	2	2		
1850-0056	Transistor: 2N1159	16758	special 2N1159	4	4		
1850-0062	Transistor: special 2N404	02735	34146	11	11		
1850-0066	Transistor: 2N700	04713	2N700	2	2		
1850-0067	Transistor: 2N1495	87216	2N1495	2	2		
1850-0073	Transistor: 2N1204	87216	2N1204	1	1		
1851-0011	Transistor: 2N440	11711	2N440	1	1		
1851-0017	Transistor: 2N1304	11711	2N1304	3	3		
1851-0021	Transistor: 2N377A	93332	2N377A	3	3		
1854-0004	Transistor: 2N743	01295	2N743	3	3		
1901-0026	Diode, Si	02735	obd#	2	2		
1901-0027	Diode, Si	73293	HD5004	7	7		
1901-0029	Diode, Si	02735	obd#	6	6		
1901-0032	Diode, Si: 1N3209	04713	1N3209	2	2		
1902-0031	Diode, avalanche	73293	HZ8818	2	2		
1903-0002	Diode, Si	07966	4E20-28	1	1		
1910-0016	Diode, Ge	98925	CGD1003	20	20		
1912-0002	Diode, tunnel	03508	1N2941	1	1		
1912-0004	Diode, Ge	02735	34301	1	1		
1912-0005	Diode, Ge: tunnel	02735	38302	1	1		
1923-0018	Tube, electron: 6AQ5	04651	6AQ5	1	1		
1932-0022	Tube, electron: 6DJ8	0000I	6DJ8	8	8		
1932-0029	Tube, electron: 12AU7	33173	12AU7	2	2		
1940-0001	Tube, electron: 5651	86684	5651	1	1		
2100-0005	R: var, ww, lin, 2K ohms ±10%, 2 W	11237	252	1	1		
2100-0006	R: var, ww, 5K ohms ±10%, 3 W	71590	21-010-357	3	1		
2100-0009	R: var, comp, 25K ohms ±20%, 1/3 W	11237	Type 45 obd#	1	1		
2100-0044	R: var, comp, lin, 50K ohms ±10%	01121	JA1N056S503UA	1	1		
2100-0049	R: var, lin, 20K ohms ±20%, 1/3 W	11237	2-45 obd#	1	1		
2100-0053	R: var, ww, 10K ohms	11237	252 obd#	2	1		
2100-0054	R: var, ww, 500 ohms, 2 W	11237	252 obd#	1	1		
2100-0091	R: var, comp, 5K ohms ±30%, 1/2 W	11237	UPE70 special obd#	1	1		

#See introduction to this section

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

ⓗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
2100-0095	R: var, comp, lin, 100K ohms ±30%, 1/4 W	11237	UPE 70 special obd#	1	1		
2100-0096	R: var, comp, lin, 1M ±30%, 1/4 W	11237	UPE 70 special obd#	2	1		
2100-0105	R: var, comp, 3.5M ±30%, 1/2 W	12697	obd#	1	1		
2100-0154	R: var, comp, lin, 1K ohms ±30%, 3/10 W	11237	UPE 70 obd#	1	1		
2100-0182	R: var, comp, lin, 3.3K ohms ±10%, 1/3 W	11237	UPE 70 obd#	1	1		
2100-0223	R: var, comp, lin, 600 ohm ±10%, 1/2 W	11237	45, obd#	1	1		
2100-0227	R: var, ww, lin, 20 ohms ±10%, 1 W	71450	110, obd#	1	1		
2100-0230	R: var, comp, 65K ohms ±20%, 1/4 W	11237	VF45, obd#	1	1		
2100-0231	R: var, comp, lin, 2 sect, 100 ohms ±20%, 1/2 W	11237	2-45-LT	2	1		
2100-0280	R: var, comp, lin, dual ganged, 1st sect: 50K ohms ±20%, 1/3 W 2nd sect: 10C log, 30K ohms ±10%, 1/3 W	11237	2-45 obd#	1	1		
2100-0281	R: var, ww, lin, 100 ohms ±20%, 1-1/2 W	71450	110, obd#	2	1		
2100-0282	R: var, ww, lin, 2K ohms ±20%, 1-1/2 W	71450	110, obd#	1	1		
2100-0293	R: var, ww, lin, 1K ohms ±5%, 3 W	11534	Model 3605, obd#	1	1		
2100-0305	R: var, comp, 2 sect (includes R115 and R160) Front sect: 20C log, 150K ohms ±20%, 1-1/4 W Rear sect: 10CC log, 1K ohms ±10%, 1.49 W	01121	22C, obd#	2	1		
2110-0004	Fuse, cartridge: 1/4 amp, 250 V	75915	3AG/CAT.312 250	2	20		
2110-0006	Fuse, cartridge: 2 amp, s-b (for 230 V operation)	75915	obd#	0	0		
2110-0012	Fuse, cartridge: 1/2 amp, 250 V	75915	312.500	2	20		
2110-0014	Fuse, cartridge: 4 amp (for 115 V operation)	71400	MDX-4	1	10		
2110-0030	Fuse: 5 amp, 125 V	75915	313005	1	10		

#See introduction to this section

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

ⓗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
2140-0009	Lamp, indicating: 0.15 amp	24455	47	4	4		
3101-0010	Switch, push: DPDT	82389	3S-1407	1	1		
3101-0011	Switch, wafer	76854	133866-H4 sect 4	1	1		
3101-0030	Switch, tog: 15 amp, SPST	04009	82601	1	1		
3101-0033	Switch, sl: DPDT	42190	4633	1	1		
3140-0020	Motor, AC	000JJ	103-2453	1	1		
8120-0015	Cord, power	70903	KH3981/PH70/ 7.5 ft.	1	1		
9100-0154	Transformer, power	98734	obd#	1	1		
9110-0031	Reactor, filter choke: 6 mh	98734	1630	1	1		
9140-0019	Inductor: fxd, 200 μh	99848	1200-15-201	2	1		
9140-0020	Inductor: 400 μh	99848	1400-15-401	3	1		
9140-0027	Inductor: 35 μh	99848	1035-15-350	1	1		
9140-0028	Inductor: 2.2 μh	99848	209-11-22	1	1		
9140-0029	Inductor: 100 μh	99848	3100-15-101	4	1		
9140-0037	Inductor: 5 mh	99848	35000-15-502	1	1		
9140-0107	Inductor: fxd, 27 μh	99800	1840-38	1	1		
9140-0116	Inductor: var, 1.1 μh-2.0 μh	09250	200-1-GC	1	1		
9170-0016	Shielding bead: mangonese zinc ferroxide	02114	56-590-65/3B	1	1		
9170-0029	Core, ferrite bead	02114	56-590-65/4A	7	1		
9190-0003	Line, delay: 1000 ohms 1 microsecond	98734	6302	1	1		

#See introduction to this section

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

ⓗp Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
	MISCELLANEOUS						
G-74C	Knob: HIGH FREQUENCY STABILITY (3/4", black)	28480	G-74C	1	0		
G-74D	Knob: FOCUS, SCALE and INTENSITY (3/4", black with arrow)	28480	G-74D	3	0		
G-74G	Knob: HORIZONTAL POSITION (1", black with arrow)	28480	G-74G	1	0		
G-74Q	Knob: SCANNING, TIME SCALE MAGNIFIER and TIME SCALE (1" bar, concentric shaft)	28480	G-74Q	3	0		
G-74AA	Knob: TRIGGER SLOPE lever	28480	G-74AA	1	0		
G-74AV	Knob: SCAN, DELAY and time scale VERNIER (3/4", red with arrow)	28480	G-74AV	3	0		
G-74BS	Knob: TRIGGERING and CALIBRATOR AND SYNC PULSE (3/4", bar)	28480	G-74BS	2	0		
G-74CF	Knob: STABILITY (1", concentric with arrow)	28480	G-74CF	1	0		
120A-83A	Filter, amber (external CRT only)	28480	120A-83A	1	0		
130B-20G	Assy, green bezel(external CRT only)	28480	130B-20G	1	0		
150A-83A	Assy, scale light holder (part of A403)	28480	150A-83A	1	0		
160B-17A	Bushing (rmo)	28480	160B-17A	2	0		
160B-110C	Pin guide (rmo)	28480	160B-110C	1	0		
185A-12G	Holder, probe	28480	185A-12G	1	0		
185B1B	Gusset, back	28480	185B-1B	1	0		
185B-21A	Assy, sync probe: includes	28480	185B-21A		1		
	Ground lead	28480	AC-21A-2	1	0		
	Probe jaw	28480	AC-21A-31	1	0		
	Sync probe cable	28480	185A-21A-2	1	0		
	Sync probe body	28480	185B-21A-2	1	0		
1200-0088	Insulator, diode	76530	293201	4	1		
1400-0084	Fuseholder	75915	342014	6	1		
3150-0014	Filter, air	82866	808876	1	1		
3160-0019	Blade, fan	06812	OUH-731-5	1	1		

#See introduction to this section

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

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
	OPTIONS						
	Option 1:						
G-200A	Tube, cathode ray: 5AQP1A	28480	G-200A				
	Option 3:						
185B-95A	Internal graticule kit: includes, R448, R449 (Note! This kit does not include the cathode ray tube. The cathode ray tube must be ordered separately. Either the internal graticule tube (P2) or options 7, 11, or 31 may be ordered.	28480	185B-95A				
	Option 7:						
G-200C	Tube, cathode ray: 5AQP7A	28480	G-200C				
G-200C-3	Tube, cathode ray: 5AQP7, internal graticule (may be ordered with option 3).	28480	G-200C-3				
	Option 11:						
G-200D-1	Tube, cathode ray: 5AQP11B, aluminized, external graticule	28480	G-200D-1				
G-200D-2	Tube, cathode ray: 5AQP11, aluminized, internal graticule (may be ordered with option 3).	28480	G-200D-2				
	Option 31:						
G-200E-3	Tube, cathode ray: 5AQP31, internal graticule (may be ordered with option 3).	28480	G-200E-3				

#See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire & Cable Company	Redwood City, Calif.
04870	P M Motor Co.	Chicago, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronics, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronics, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71528	Standard-Thomson Corp., Clifford Mfg. Co. Div.	Waltham, Mass.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Products Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio

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H4-1 Dated January 1962
H4-2 Dated January 1962

00015-22
Revised: 3 March 1962

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91921	Minneapolis-Honeywell Regulator Co., Micro-Switch Division	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000F	Malco Tool and Die	Los Angeles, Calif.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CC	Computer Diode Corp.	Lodi, N.J.
000EE	A. Williams Manufacturing Co.	San Jose, Calif.
000FF	Carmichael Corrugated Specialties	Richmond, Calif.
000GG	Goshen Die Cutting Service	Goshen, Ind.
000HH	Rubbercraft Corp.	Torrance, Calif.
000II	Birtcher Corporation, Industrial Division	Monterey Park, Calif.
000KK	Amatom	New Rochelle, N.Y.
000LL	Avery Label	Monrovia, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.

00015-22
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H4-1 Dated January 1962
H4-2 Dated January 1962

CATHODE RAY TUBE WARRANTY

The cathode ray tube supplied in your Hewlett-Packard Oscilloscope and replacement cathode ray tubes purchased from hp, are guaranteed against electrical failure for one year from the date of sale by the Hewlett-Packard Company. Broken tubes or tubes with burned phosphor are not included in this guarantee.

Your local Hewlett-Packard representative maintains a stock of replacement tubes and will be glad to process your warranty claim for you. Please consult him.

Whenever a tube is returned for a warranty claim, the reverse side of this sheet must be filled out in full and returned with the tube. Follow shipping instructions carefully to insure safe arrival, since no credit can be allowed on broken tubes.

SHIPPING INSTRUCTIONS

1) Carefully wrap the tube in 1/4" thick cotton batting or other soft padding material.

2) Wrap the above in heavy kraft paper.

3) Pack in a rigid container which is at least 4 inches larger than the tube in each dimension.

4) Surround the tube with at least four inches of packed excelsior or similar shock absorbing material. Be certain that the packing is tight all around the tube.

5) Tubes returned from outside the continental United States should be packed in a wooden box.

6) Ship prepaid preferably by AIR FREIGHT or RAILWAY EXPRESS. We do not recommend parcel post or air parcel post shipment.

CRT WARRANTY CLAIM

FROM: DATE: ________

NAME: ______________________________

COMPANY: ______________________________

ADDRESS: ______________________________

____

____

Person to contact for further information:

NAME: ______________________________

TITLE: ______________________________

COMPANY: ______________________________

ADDRESS: ______________________________

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To process your claim quickly please enter the information indicated below:

1) hp INSTRUMENT MODEL ______________ SERIAL ______________

2) TUBE TYPE ______________ SERIAL ______________

3) ORIGINAL TUBE ______________ REPLACEMENT TUBE ______________

4) YOUR PURCHASE ORDER NO. ______________________________

5) DATE PURCHASED ______________________________

6) PURCHASED FROM ______________________________

7) COMPLAINT: (Please describe nature of trouble) ______________

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8) OPERATING CONDITIONS: (Please describe conditions prior to and at time of failure ______

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SIGNATURE ______________

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