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465 SPECIFICATIONS

Introduction

The 465 Oscilloscope is a wide-band, portable oscilloscope designed to operate in a wide range of environmental conditions. The instrument is light in weight and compact of design for ease of transportaion, yet capable of performance necessary for accurate high-frequency measurements. The dual-channel, DC-to-100 megahertz vertical deflection system provides calibrated deflection factors from 5 millivolts to 5 volts/division. The bandwidth limiting switch reduces interference from signals above about 20 megahertz for viewing low-frequency, low-level signals.

The trigger circuits provide stable sweep triggering to beyond the bandwidth of the vertical deflection system. Separate controls are provided to select the desired mode of triggering for the A and B sweeps. The A sweep can be operated in one of three modes: automatic triggering, normal triggering, or single sweep. A variable trigger holdoff control provides the ability for A sweep to trigger stably on aperiodic signals or complex digital words. The horizontal deflection system has calibrated sweep rates from 0.5 second to 0.05 microsecond/division. A X10 magnifier increases each sweep rate by a factor of 10 to provide a maximum sweep rate of 5 nanoseconds/division in the 0.05 μs position. The delayed and mixed sweep features allow the start of the B sweep to be delayed a selected amount from the start of A sweep to provide accurate relative-time measurements. Calibrated X-Y measurements can be made with Channel 2 providing the vertical deflection and Channel 1 providing the horizontal deflection (TIME/DIV switch fully counterclockwise and VERT MODE switch to CH 2). The regulated DC power supplies ensure that instrument performance is not affected by variations in line voltage and frequency. Maximum power consumption of the instrument is approximately 75 watts.

The following instrument specifications apply over an ambient temperature range of −15°C to +55°C unless otherwise specified. Warm-up time for specified accuracies is 20 minutes. The calibration procedure given in section 5, if performed completely, will allow an instrument to meet the electrical characteristics listed below.

VERTICAL DEFLECTION SYSTEM

Deflection Factor

Calibrated range is from 5 millivolts to 5 volts per division in 10 steps in a 1-2-5 sequence. Accuracy is within 3%. Uncalibrated VAR control provides deflection factors continuously variable between the calibrated settings, and extends deflection factor to at least 12.5 volts per division in the 5 volts/div position.

Frequency Response

Bandwidth in both Channel 1 and Channel 2 is DC to at least 100 megahertz. Risetime is 3.5 nanoseconds or less. The AC-coupled lower −3 dB point is 10 hertz or less (1 hertz or less when using a 10X probe). Vertical system bandwidth with the BW LIMIT pushbutton pulled is approximately 20 megahertz.

Chopped Mode Repetition Rate

Approximately 250 kilohertz.

Input Resistance And Capacitance

One megohm within 2% paralleled by approximately 20 picofarads.

Maximum Input Voltage

DC coupled: 250 V (DC + Peak AC) or 500 V P-P AC at 1 kHz or less.

AC coupled: 500 V (DC + Peak AC) or 500 V P-P AC at 1 kHz or less.

Cascaded Operation (CH 1 VERT SIGNAL OUT Connected to CH 2 OR Y)

Bandwidth is DC to at least 50 MHz with a sensitivity of at least 1 mV/division.

TRIGGERING

Sensitivity

DC Coupled: 0.3 division internal or 50 millivolts external from DC to 25 megahertz, increasing to 1.5 divisions internal or 150 millivolts external at 100 megahertz.

AC Coupled: 0.3 division internal or 50 millivolts external from 60 hertz to 25 megahertz, increasing to 1.5 divisions internal or 150 millivolts external at 100 megahertz. Attenuates all signals below about 60 hertz.

LF REJ Coupled: 0.3 division internal or 100 millivolts external from 50 kilohertz to 25 megahertz, increasing to 1.5 divisions internal or 300 millivolts external at 100 megahertz. Blocks DC and attenuates all signals below about 50 kilohertz.

HF REJ Coupled: 0.3 division internal or 50 millivolts external from 60 hertz to 50 kilohertz. Blocks DC and attenuates all signals below about 60 hertz and above about 50 kilohertz.

Trigger Jitter

0.5 nanosecond or less at 5 nanoseconds/division with 100 megahertz applied (X10 MAG on).

External Trigger Input

Maximum input voltage is 250 V DC + peak AC or 250 V P-P AC (1 kilohertz or less). Input resistance is 1 megohm within 10%.

LEVEL Control Range

EXT: At least + and − 2 volts, 4 volts peak to peak.

EXT ÷10: At least + and − 20 volts, 40 volts peak to peak.

HORIZONTAL DEFLECTION SYSTEM

Calibrated Sweep Range

A Sweep: from 0.5 second/division to 0.05 microsecond/division in 22 steps in a 1-2-5 sequence. X10 MAG extends maximum sweep rate to 5 nanoseconds/division.

B Sweep: from 50 milliseconds/division to 0.05 microsecond/division in 19 steps in a 1-2-5 sequence. X10 MAG extends maximum sweep rate to 5 nanoseconds/division.

Calibrated Sweep Accuracy

Unmagnified sweep accuracy is ±2% from +20°C to +30°C (+68°F to +86°F) and ±3% from −15°C to +20°C and +30°C to +55°C (+5°F to +68°F and +86°F to +131°F). For the same temperature ranges, magnified sweep accuracy is ±3% and ±4% respectively. Exclude the first and last 50 ns of the 5 ns, 10 ns, and 20 ns magnified sweep rates. Accuracy specifications apply over full ten divisions unless otherwise specified.

Sweep accuracy, over any two or less division portion of the sweep, is ±5%. Exclude the first and last magnified divisions of the 5 ns and 10 ns/div magnified sweep rates. Also exclude the first and last 50 ns of the 5, 10, and 20 ns/div magnified sweep rates.

Mixed sweep accuracy is 2% plus the measured A sweep error when viewing the A sweep portion only. The B sweep portion retains its normal accuracy.

A Time/Division Variable Range

Provides continuously variable (uncalibrated) sweep rates between the calibrated settings of the A TIME/DIV switch. Extends the slowest A sweep rate to at least 1.25 seconds/division.

A Trigger Holdoff

Increases A sweep holdoff time by at least a factor of 10.

Delay Time And Differential Time Measurement Accuracy

	+15°C to +35°C (+60°F to +95°F)	−15°C to +55°C (+5°F to +131°F)
Over One Or More Major Dial Division	±1%	±2.5%
Over Less Than One Major Dial Division	±0.01 Major Dial Division	±0.03 Major Dial Division

Delay Time Jitter

Within 0.002% (less than one part in 50,000) of the maximum available delay time when operating on power line frequencies other than 50 Hz.

Within 0.005% (less than one part in 20,000) of the maximum available delay time when operating on 50 Hz power line frequency.

Maximum available delay time is ten times the setting of the A TIME/DIV switch.

Calibrated Delay Time (A VAR set to calibrated position)

Continuous from 5 seconds to 0.2 microsecond.

b. Adjust the CH 1 POSITION control for a 0 volt reading on the meter.

c. ADJUST—Vertical Output Centering adjustment, R429, (see Fig. 5-9) to position the trace to the center graticule line.

d. Remove the DC Voltmeter lead connections.

e. Position the trace off-screen with the CH 1 POSITION and horizontal POSITION controls.

f. Push the BEAM FIND button and hold it in.

g. CHECK—That the trace is brought into the CRT viewing area.

h. Release the BEAM FIND button.

11. Adjust CH 1 Step Attenuator Balance

a. Set the CH 1 VOLTS/DIV switch to 20 mV and the CH 1 INPUT COUPLING switch to GND.

b. Position the trace to the center horizontal graticule line.

c. CHECK—CRT display for 0.2 division or less of trace shift between adjacent switch positions when rotating the CH 1 VOLTS/DIV switch from 20 mV to 5 mV.

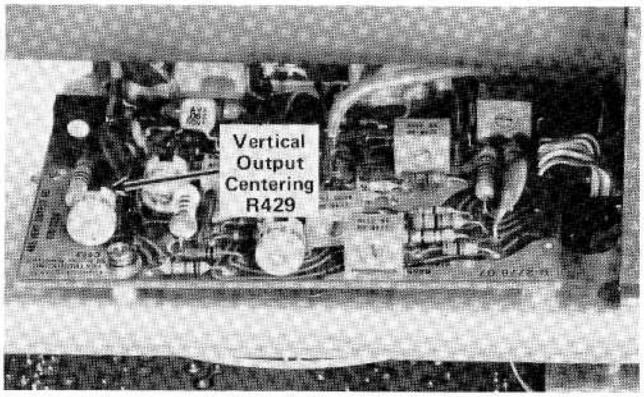


Fig. 5-9. Location of Vertical Output Centering adjustment.

d. ADJUST—CH 1 Step Atten Bal adjustment, R25, (see Fig. 5-10) for minimum trace shift when rotating the CH 1 VOLTS/DIV switch from 20 mV to 5 mV.

12. Adjust CH 1 Variable Volts/Division Balance

a. Position the trace to the center horizontal graticule line.

b. CHECK—That the CH 1 UNCAL light comes on when the VAR control is out of the detent position.

c. CHECK—CRT display for 1.0 division or less of trace shift when rotating the CH 1 VAR control through its range.

d. ADJUST—CH 1 Variable Balance adjustment, R120, (see Fig. 5-11) for minimum trace shift when rotating the CH 1 VAR control through its range.

e. Return the CH 1 VAR control to the detent position.

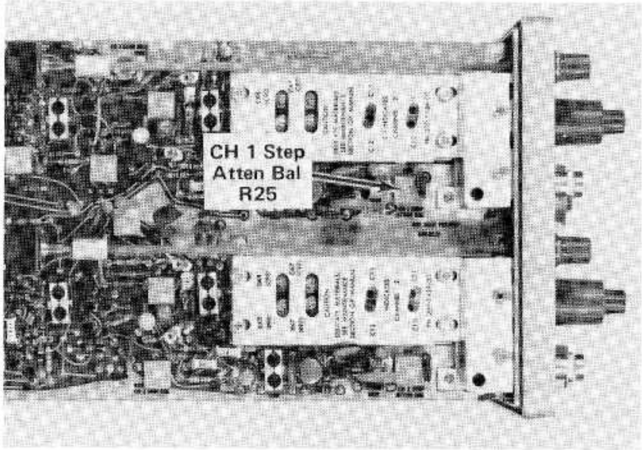


Fig. 5-10. Location of CH 1 Step Atten Bal adjustment.

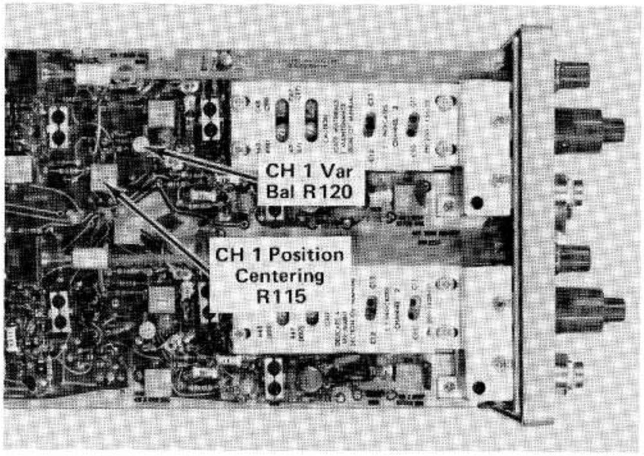
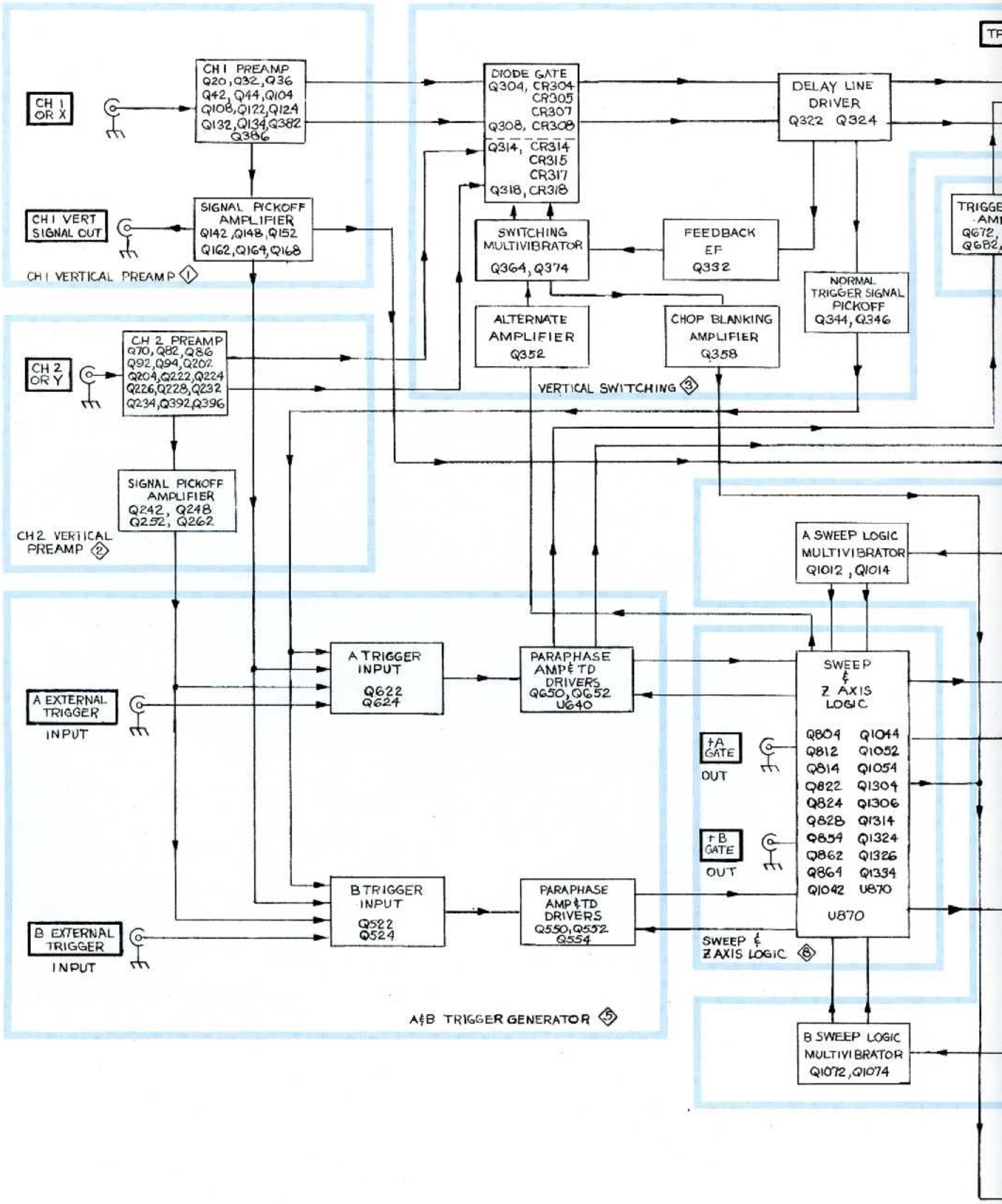
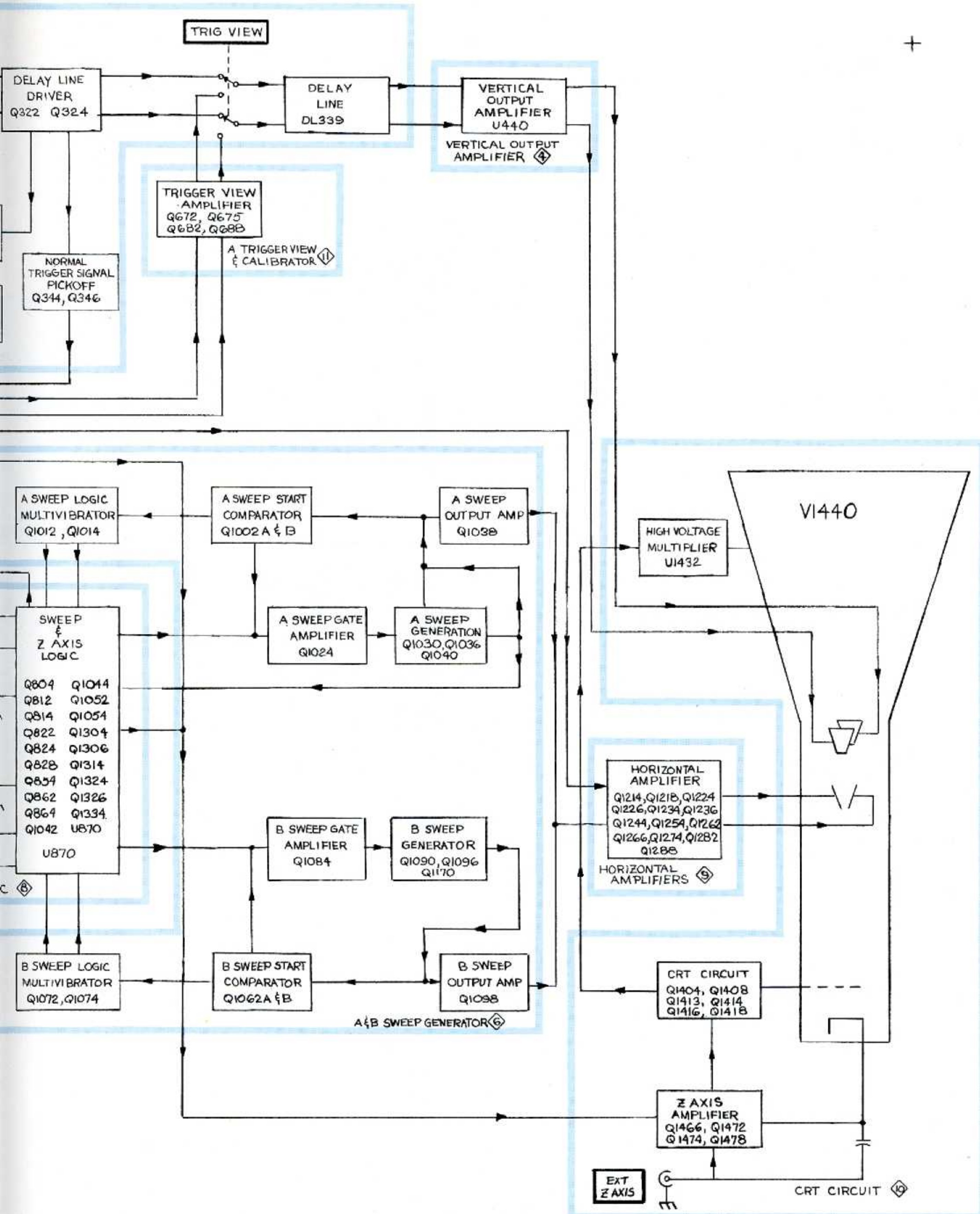


Fig. 5-11. Location of CH 1 Variable Balance and Position Centering adjustment.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
DIODES (cont)				
CR825	152-0141-02			Silicon, 1N4152
CR826	152-0141-02			Silicon, 1N4152
CR831	152-0141-02			Silicon, 1N4152
CR832	152-0141-02			Silicon, 1N4152
CR838	152-0141-02			Silicon, 1N4152
CR851	152-0322-00			Silicon, A1108
CR859	152-0141-02			Silicon, 1N4152
CR863	152-0141-02	XB010600		Silicon, 1N4152
CR879	152-0141-02			Silicon, 1N4152
CR1001	152-0141-02			Silicon, 1N4152
CR1004	152-0141-02			Silicon, 1N4152
CR1011	152-0141-02			Silicon, 1N4152
CR1024	152-0141-02			Silicon, 1N4152
CR1035	152-0141-02			Silicon, 1N4152
CR1042	152-0141-02			Silicon, 1N4152
CR1043	152-0141-02			Silicon, 1N4152
CR1061	152-0141-02			Silicon, 1N4152
CR1064	152-0141-02			Silicon, 1N4152
CR1071	152-0141-02			Silicon, 1N4152
CR1095	152-0141-02			Silicon, 1N4152
CR1101	152-0141-02			Silicon, 1N4152
CR1102	152-0141-02			Silicon, 1N4152
CR1155	152-0333-00			Silicon, FDH6012
CR1201	152-0141-02			Silicon, 1N4152
CR1202	152-0141-02			Silicon, 1N4152
CR1216	152-0141-02			Silicon, 1N4152
CR1248	152-0141-02			Silicon, 1N4152
CR1251	152-0153-00			Silicon, FD7003 or CD5574
CR1252	152-0153-00			Silicon, FD7003 or CD5574
CR1253	152-0322-00			Silicon, A1108
CR1255	152-0141-02			Silicon, 1N4152
CR1273	152-0322-00			Silicon, A1108
CR1275	152-0141-02			Silicon, 1N4152
CR1286	152-0141-02			Silicon, 1N4152
CR1304	152-0141-02			Silicon, 1N4152
CR1306	152-0141-02			Silicon, 1N4152
CR1309	152-0141-02			Silicon, 1N4152
CR1315	152-0141-02			Silicon, 1N4152
CR1316	152-0141-02			Silicon, 1N4152
CR1325	152-0141-02			Silicon, 1N4152
CR1326	152-0141-02			Silicon, 1N4152
CR1327	152-0141-02			Silicon, 1N4152
CR1334	152-0141-02			Silicon, 1N4152
CR1335	152-0141-02			Silicon, 1N4152
CR1336	152-0141-02			Silicon, 1N4152


CH 1 OR X
CH 1 PREAMP Q20, Q32, Q36 Q42, Q44, Q104 Q108, Q122, Q124 Q132, Q134, Q382 Q386
CH 1 VERT SIGNAL OUT
SIGNAL PICKOFF AMPLIFIER Q142, Q148, Q152 Q162, Q164, Q168
CH 1 VERTICAL PREAMP 1
DIODE GATE Q304, CR304 CR305 CR307 Q308, CR308 Q314, CR314 CR315 CR317 Q318, CR318
DELAY LINE DRIVER Q322 Q324
SWITCHING MULTIVIBRATOR Q364, Q374
FEEDBACK EF Q332
NORMAL TRIGGER SIGNAL PICKOFF Q344, Q346
ALTERNATE AMPLIFIER Q352
CHOP BLANKING AMPLIFIER Q358
VERTICAL SWITCHING 3
CH 2 OR Y
CH 2 PREAMP Q70, Q82, Q86 Q92, Q94, Q202 Q204, Q222, Q224 Q226, Q228, Q232 Q234, Q392, Q396
SIGNAL PICKOFF AMPLIFIER Q242, Q248 Q252, Q262
CH2 VERTICAL PREAMP 2
A SWEEP LOGIC MULTIVIBRATOR Q1012, Q1014
A EXTERNAL TRIGGER INPUT
A TRIGGER INPUT Q622 Q624
PARAPHASE AMP & TD DRIVERS Q650, Q652 U640
SWEEP & Z AXIS LOGIC
Q804 Q1044 Q812 Q1052 Q814 Q1054 Q822 Q1304 Q824 Q1306 Q828 Q1314 Q854 Q1324 Q862 Q1326 Q864 Q1334 Q1042 U870
U870
+A GATE OUT
+B GATE OUT
B EXTERNAL TRIGGER INPUT
B TRIGGER INPUT Q522 Q524
PARAPHASE AMP & TD DRIVERS Q550, Q552 Q554
SWEEP & Z AXIS LOGIC 6
A&B TRIGGER GENERATOR 5
B SWEEP LOGIC MULTIVIBRATOR Q1072, Q1074



A

BLOCK DIAGRAM

1072
JEN

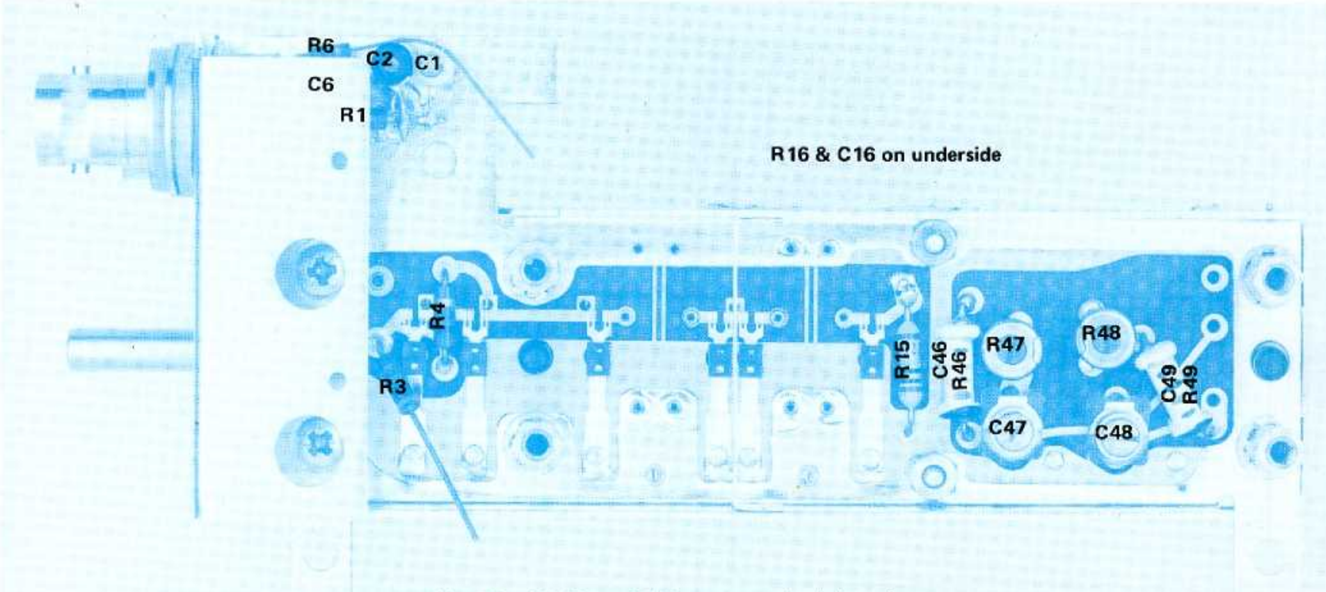


Fig. 7-3. A1. Channel 1 Attenuator circuit board.

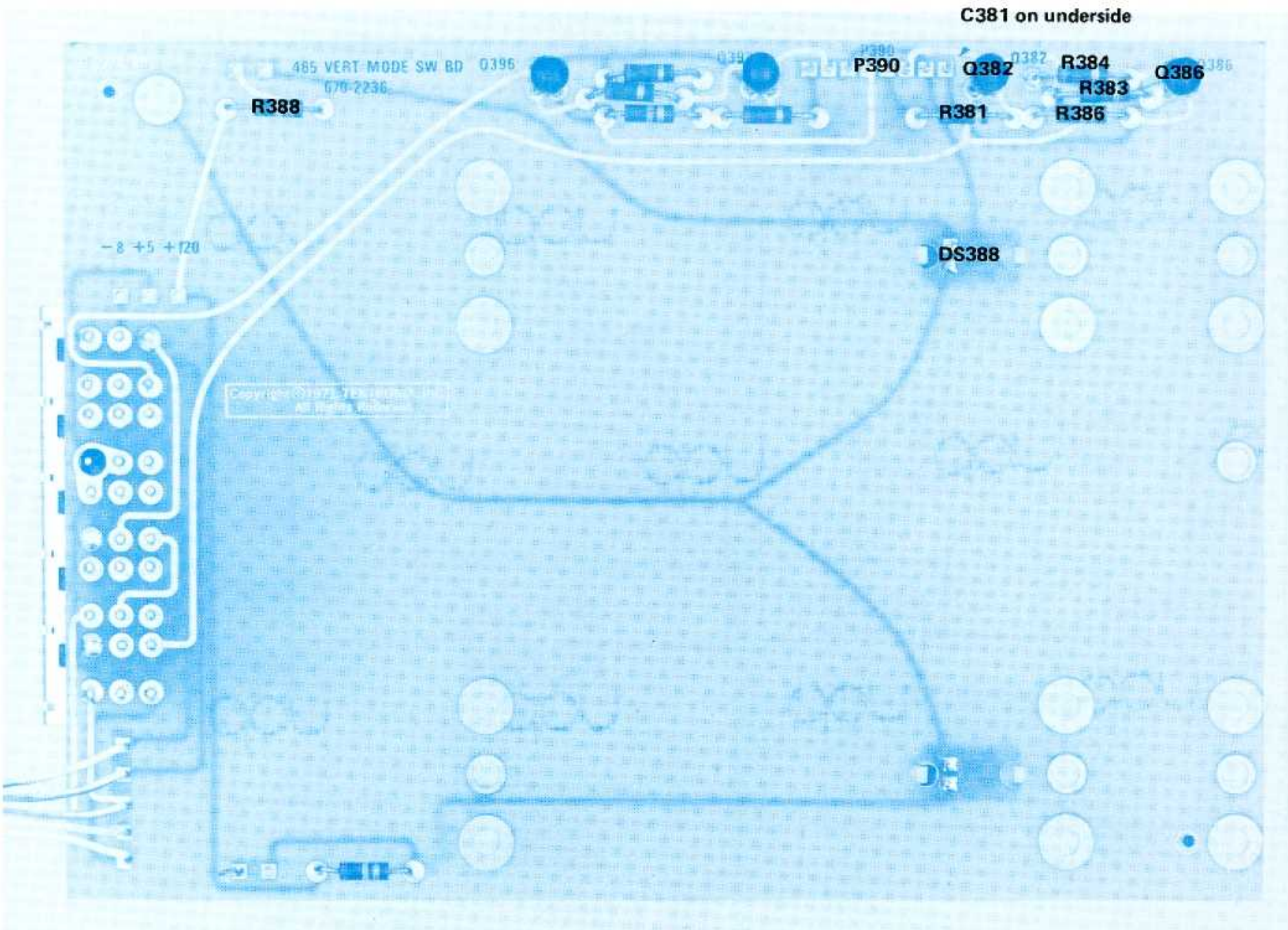


Fig. 7-4. P/O A4 Vertical Mode Switch circuit board.

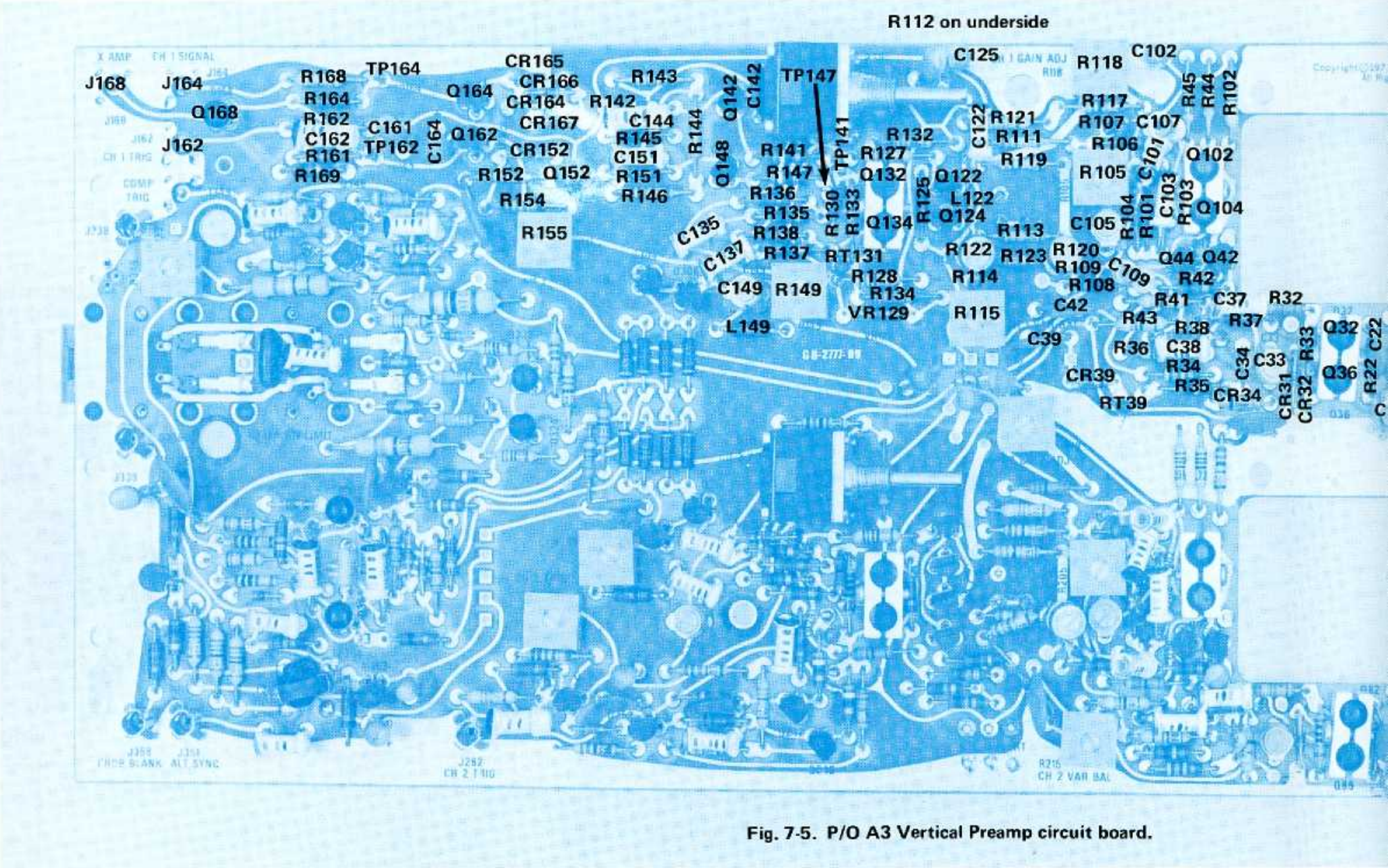
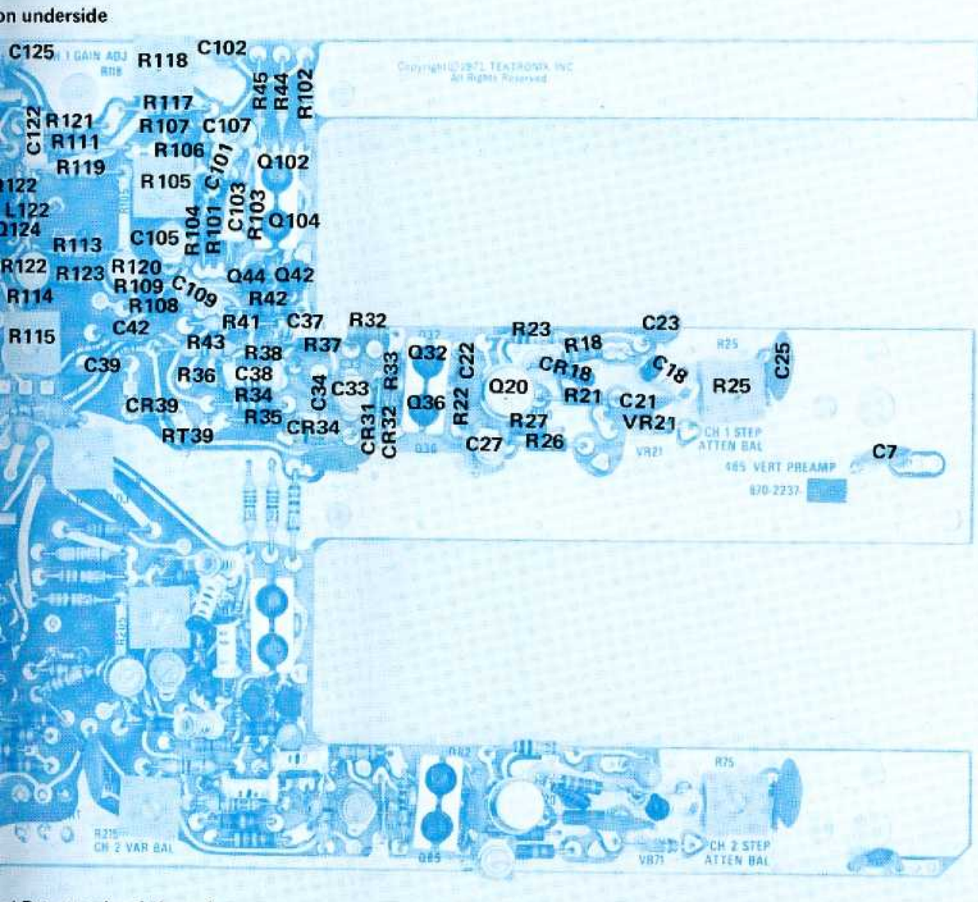


Fig. 7-5. P/O A3 Vertical Preamp circuit board.

on underside



al Preamp circuit board.

c. Adjust the A LEVEL control for a stable display.

d. Position the top of the display to the bottom graticule line.

e. CHECK - CRT display for less than 5% aberrations.

f. Set the Pulse Generator polarity to - and the 465 A SLOPE switch to -.

g. Position the bottom of the display to the top graticule line.

h. CHECK - CRT display for less than 7% aberrations.

31. Adjust CH 1 High-Frequency Compensation

a. Move the test signal from CH 2 to the CH 1 input.

b. Set the A TIME/DIV switch to 0.05 μs, the A SLOPE switch to +, and the VERT MODE switch to CH 1.

c. Set the Fast-Rise High-Amplitude Pulse Generator (Type 109) to + and adjust the Pulse Generator for five divisions of deflection. Remove or add attenuators as necessary to maintain a five division display throughout this step.

d. CHECK - CRT display for risetime of 3.5 nanoseconds or less.

e. CHECK - CRT display for flat-top waveform with 3% or less of aberrations.

f. ADJUST - C27, C33, C105, R105, R122, C122, C149, and R149 (see Fig. 5-23) with a low-capacitance screwdriver, for the best flat-top waveform.

g. Set the Pulse Generator polarity to - and the 465 A SLOPE switch to -.

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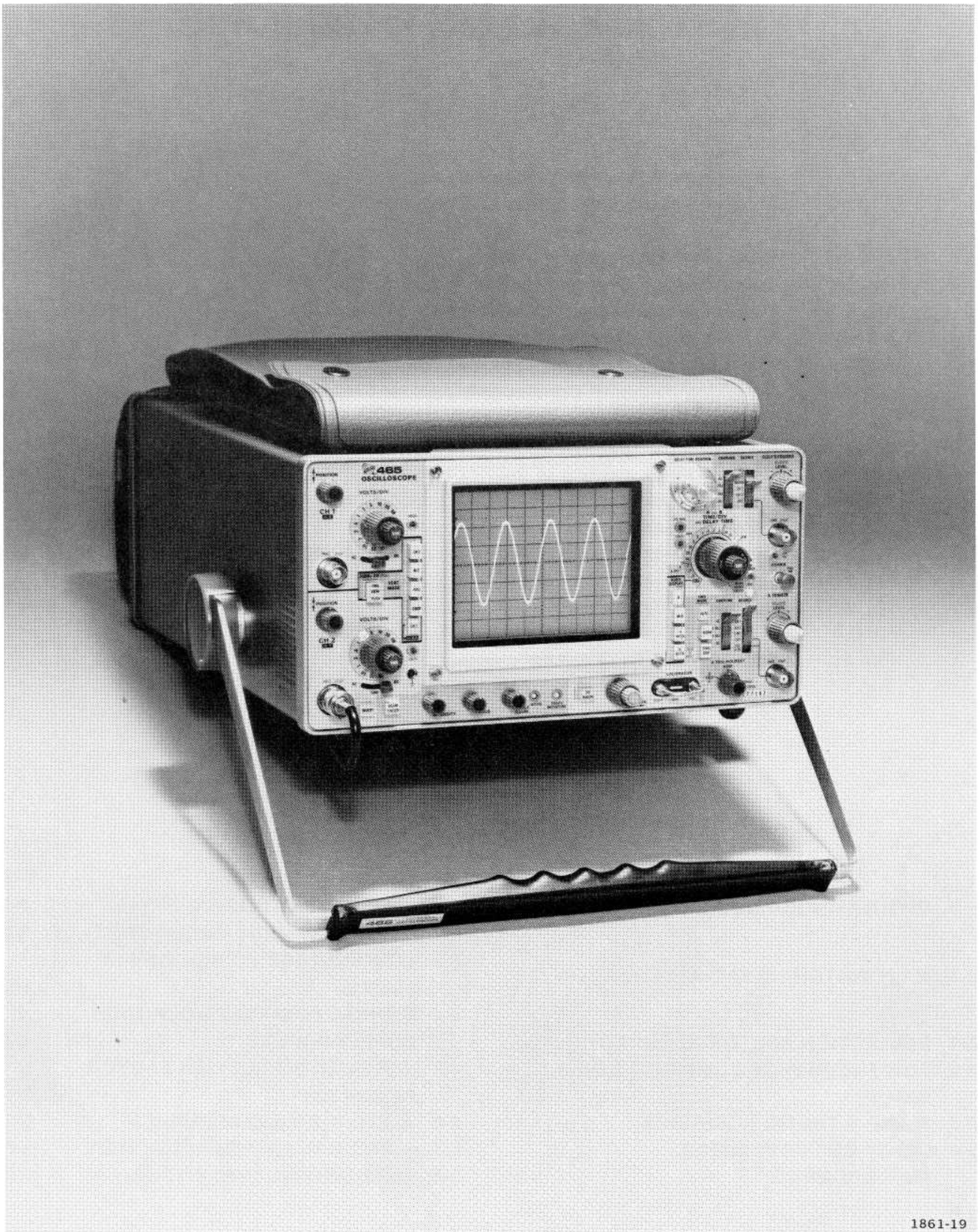


Fig. 1-1. 465 Oscilloscope.

SPECIFICATIONS

Introduction

The 465 Oscilloscope is a wide-band, portable oscilloscope designed to operate in a wide range of environmental conditions. The instrument is light in weight and compact of design for ease of transportation, yet capable of performance necessary for accurate high-frequency measurements. The dual-channel dc-to-100 megahertz vertical deflection system provides calibrated deflection factors from 5 millivolts to 5 volts/division. The bandwidth limiting switch reduces interference from signals above about 20 megahertz for viewing low-frequency, low-level signals.

The trigger circuits provide stable sweep triggering to beyond the bandwidth of the vertical deflection system. Separate controls are provided to select the desired mode of triggering for the A and B sweeps. The A sweep can be operated in one of three modes: automatic triggering, normal triggering, or single sweep. A variable trigger holdoff control provides the ability for A sweep to trigger stably on aperiodic signals or complex digital words. The horizontal deflection system has calibrated sweep rates from 0.5 second to 0.05 microsecond/division. A X10 magnifier increases each sweep rate by a factor of 10 to provide a maximum sweep rate of 5 nanoseconds/division in the 0.05 μs position. The delayed and mixed sweep features allow the start of the B sweep to be delayed a selected amount from the start of A sweep to provide accurate relative-time measurements. Calibrated X-Y measurements can be made with Channel 2 providing the vertical deflection and Channel 1 providing the horizontal deflection (TIME/DIV switch fully counterclockwise and VERT MODE switch to CH 2). The regulated dc power supplies ensure that instrument performance is not affected by variations in line voltage and frequency. Maximum power consumption of the instrument is approximately 75 watts.

The following instrument specifications apply over an ambient temperature range of −15°C to +55°C unless otherwise specified. Warm-up time for specified accuracies is 20 minutes. The calibration procedure given in section 6, if performed completely, will allow an instrument to meet the electrical characteristics listed below.

VERTICAL DEFLECTION SYSTEM

Deflection Factor

Calibrated range is from 5 millivolts to 5 volts/division in 10 steps in a 1-2-5 sequence. Accuracy is within 3%. Uncalibrated VAR control provides deflection factors continuously variable between the calibrated settings and extends deflection factor to at least 12.5 volts/division in the 5 VOLTS/DIV position.

Frequency Response

Bandwidth in both Channel 1 and Channel 2 is dc to at least 100 megahertz from −15°C to +40°C and dc to at least 85 megahertz from +40°C to +55°C. Risetime is 3.5 nanoseconds or less from 0°C to +40°C and 4.2 nanoseconds or less from +40°C to +55°C. The ac-coupled lower −3 dB point is 10 hertz or less (1 hertz or less when using a 10X probe). Vertical system bandwidth with the BW LIMIT pushbutton pulled is approximately 20 megahertz.

Chopped Mode Repetition Rate

Approximately 250 kilohertz.

Input Resistance And Capacitance

One megohm within 2% paralleled by approximately 20 picofarads.

Maximum Input Voltage

Dc coupled: 250 V (dc + peak ac) or 500 V p-p ac at 1 kHz or less.

Ac coupled: 500 V (dc + peak ac) or 500 V p-p ac at 1 kHz or less.

Cascaded Operation (CH 1 VERT SIGNAL OUT Connected to CH 2 OR Y)

Bandwidth is dc to at least 50 MHz with a sensitivity of at least 1 millivolt/division.

TRIGGERING

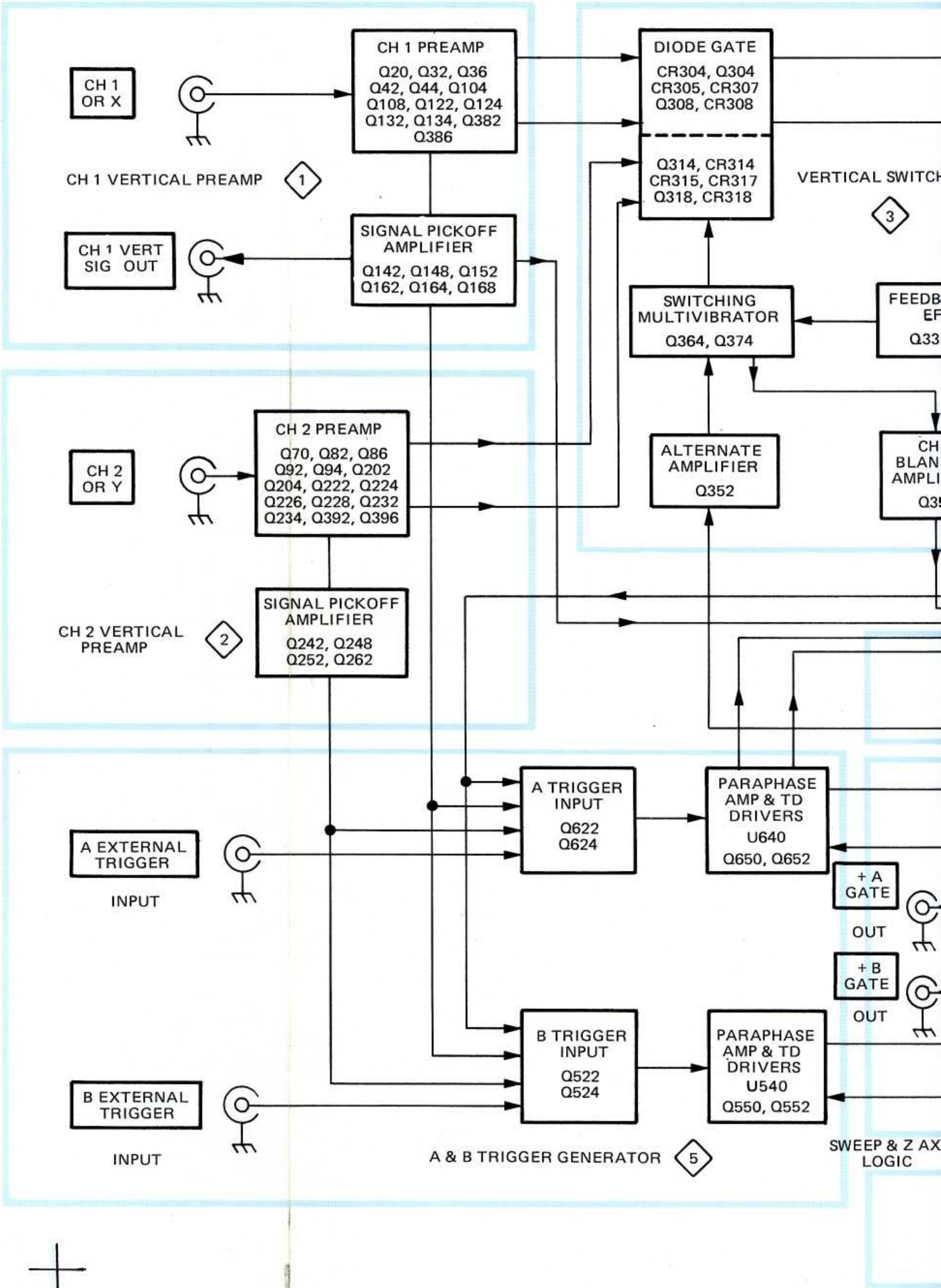
Sensitivity

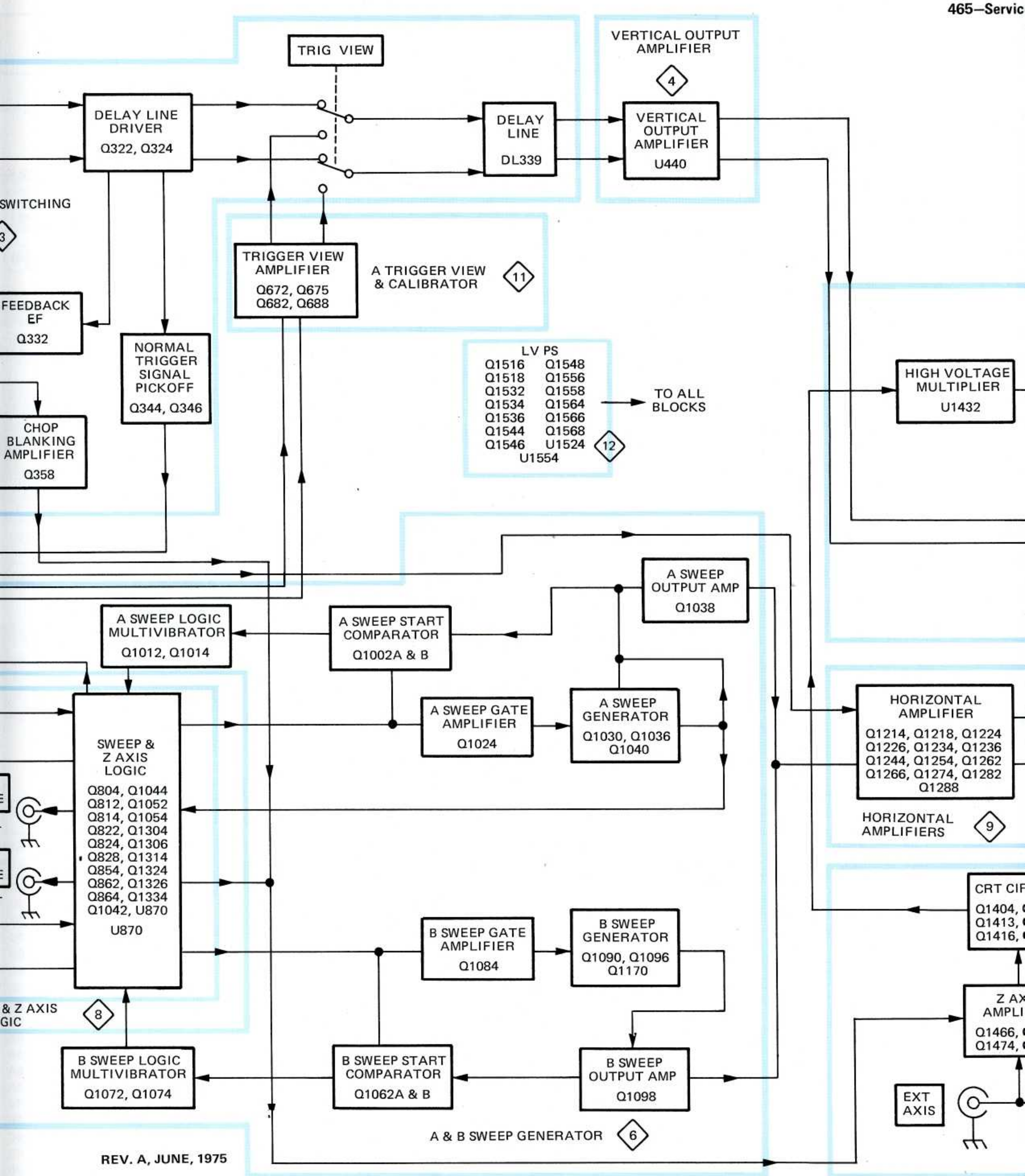
DC Coupled: 0.3 division internal or 50 millivolts external from dc to 25 megahertz, increasing to 1.5 divisions internal or 150 millivolts external at 100 megahertz.

AC Coupled: 0.3 division internal or 50 millivolts external from 60 hertz to 25 megahertz, increasing to 1.5 divisions internal or 150 millivolts external at 100 megahertz. Attenuates all signals below about 60 hertz.

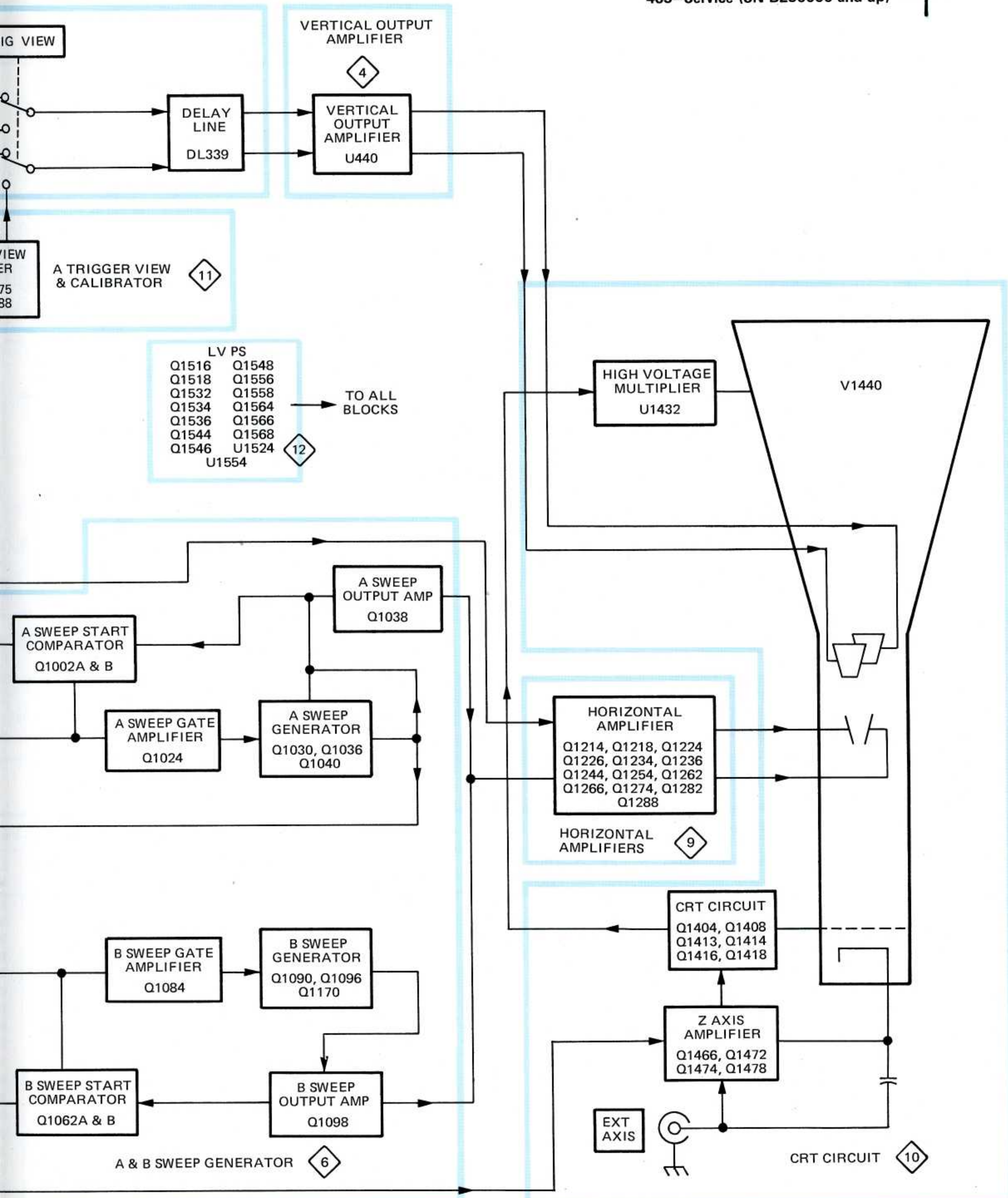
LF REJ Coupled: 0.5 division internal or 100 millivolts external from 50 kilohertz to 25 megahertz, increasing to 1.5 divisions internal or 300 millivolts external at

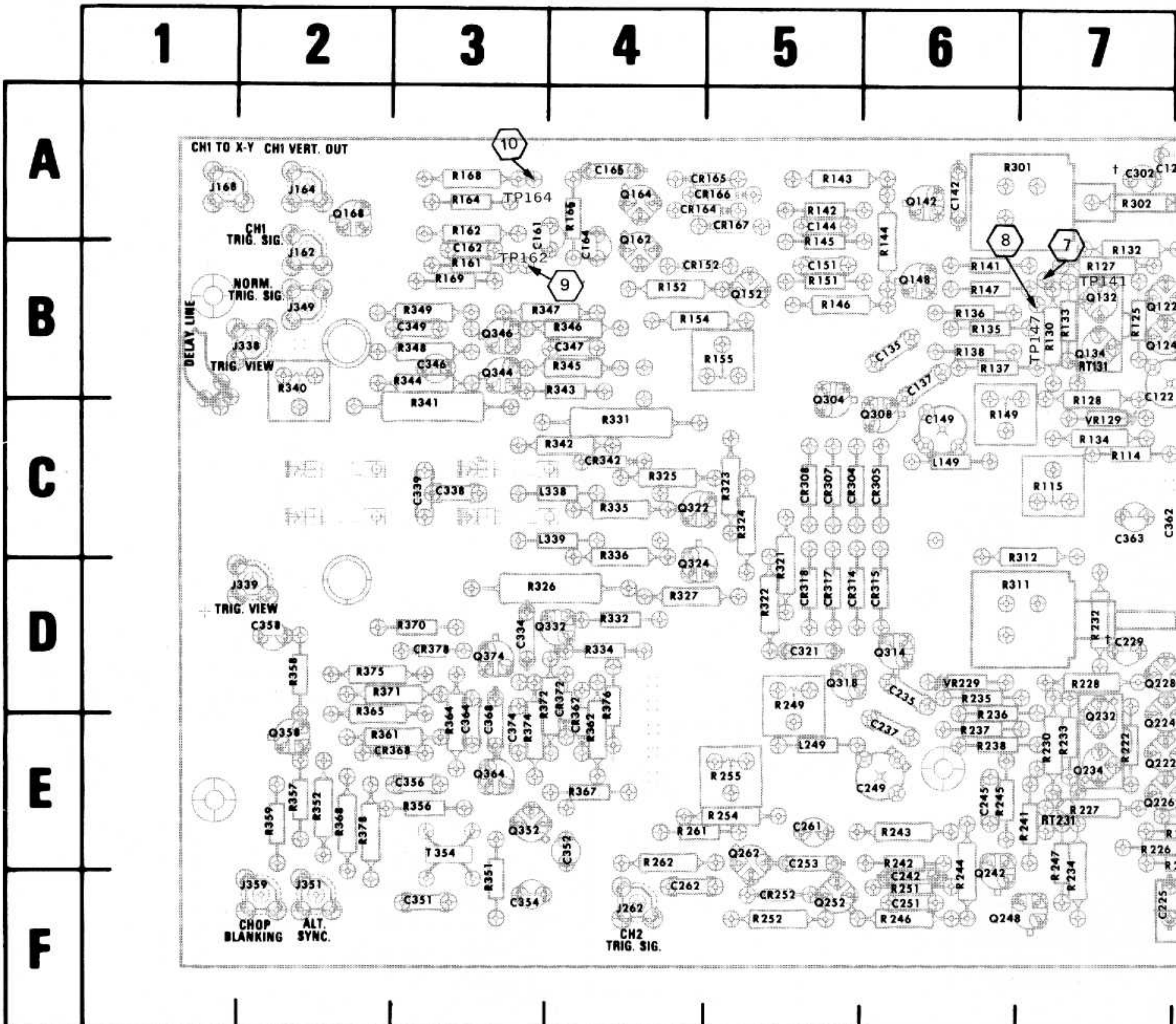
Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
CR68	152-0323-00			SEMICOND DEVICE:SILICON,35V,100MA	03508	SE365
CR81	152-0153-00			SEMICOND DEVICE:SILICON,15V,50MA	13715	FD7003
CR82	152-0153-00			SEMICOND DEVICE:SILICON,15V,50MA	13715	FD7003
CR84	152-0271-00			SEMICOND DEVICE:SILICON,10PF	01281	V10E
CR152	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR164	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR165	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR166	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR167	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR252	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR304	152-0153-00			SEMICOND DEVICE:SILICON,15V,50MA	13715	FD7003
CR305	152-0153-00			SEMICOND DEVICE:SILICON,15V,50MA	13715	FD7003
CR307	152-0153-00			SEMICOND DEVICE:SILICON,15V,50MA	13715	FD7003
CR308	152-0153-00			SEMICOND DEVICE:SILICON,15V,50MA	13715	FD7003
CR314	152-0153-00			SEMICOND DEVICE:SILICON,15V,50MA	13715	FD7003
CR315	152-0153-00			SEMICOND DEVICE:SILICON,15V,50MA	13715	FD7003
CR317	152-0153-00			SEMICOND DEVICE:SILICON,15V,50MA	13715	FD7003
CR318	152-0153-00			SEMICOND DEVICE:SILICON,15V,50MA	13715	FD7003
CR342	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR362	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR368	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR372	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR378	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR421	152-0269-00			SEMICOND DEVICE:SILICON,VAR VCAP.,4V,33PF	25403	1N3182
CR422	152-0269-00			SEMICOND DEVICE:SILICON,VAR VCAP.,4V,33PF	25403	1N3182
CR517	152-0246-00			SEMICOND DEVICE:SILICON,400PIV,200MA	07910	CD12676
CR550	152-0125-00	B250000	B256799	SEMICOND DEVICE:TUNNEL,15PF,4.7MA	03508	STD704
CR550	152-0125-01	B256800		SEMICOND DEVICE:TUNNEL,15PF,4.7MA		
CR552	152-0125-00	B256800	B256799	SEMICOND DEVICE:TUNNEL,15PF,4.7MA	03508	STD704
CR552	152-0125-01	B250000		SEMICOND DEVICE:TUNNEL15PF,4.7MA		
CR553	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR554	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR617	152-0246-00			SEMICOND DEVICE:SILICON,400PIV,200MA	07910	CD12676
CR650	152-0125-00	B250000	B256799	SEMICOND DEVICE:TUNNEL,15PF,4.7MA	03508	STD704
CR650	152-0125-01	B256800		SEMICOND DEVICE:TUNNEL,15PF,4.7MA		
CR652	152-0125-00	B250000	B257699	SEMICOND DEVICE:TUNNEL,15PF,4.7MA	03508	STD704
CR652	152-0125-01	B256800		SEMICOND DEVICE:TUNNEL,15PF,4.7MA		
CR801	152-0322-00			SEMICOND DEVICE:SILICON,15V	28480	5082-2672
CR809	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR818	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR822	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR825	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR826	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR831	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR832	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR838	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR851	152-0322-00			SEMICOND DEVICE:SILICON,15V	28480	5082-2672
CR859	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR862	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR863	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR877	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1001	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1004	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1011	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1024	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1035	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1042	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152


CH 1 OR X
CH 1 PREAMP
Q20, Q32, Q36
Q42, Q44, Q104
Q108, Q122, Q124
Q132, Q134, Q382
Q386
CH 1 VERTICAL PREAMP
1
CH 1 VERT SIG OUT
SIGNAL PICKOFF AMPLIFIER
Q142, Q148, Q152
Q162, Q164, Q168
DIODE GATE
CR304, Q304
CR305, CR307
Q308, CR308
Q314, CR314
CR315, CR317
Q318, CR318
VERTICAL SWITCH
3
SWITCHING MULTIVIBRATOR
Q364, Q374
ALTERNATE AMPLIFIER
Q352
CH 2 OR Y
CH 2 PREAMP
Q70, Q82, Q86
Q92, Q94, Q202
Q204, Q222, Q224
Q226, Q228, Q232
Q234, Q392, Q396
SIGNAL PICKOFF AMPLIFIER
Q242, Q248
Q252, Q262
CH 2 VERTICAL PREAMP
2
A EXTERNAL TRIGGER
INPUT
A TRIGGER INPUT
Q622
Q624
PARAPHASE AMP & TD DRIVERS
U640
Q650, Q652
+ A GATE
OUT
+ B GATE
OUT
B EXTERNAL TRIGGER
INPUT
B TRIGGER INPUT
Q522
Q524
PARAPHASE AMP & TD DRIVERS
U540
Q550, Q552
A & B TRIGGER GENERATOR
5
LOGIC



REV. A, JUNE, 1975

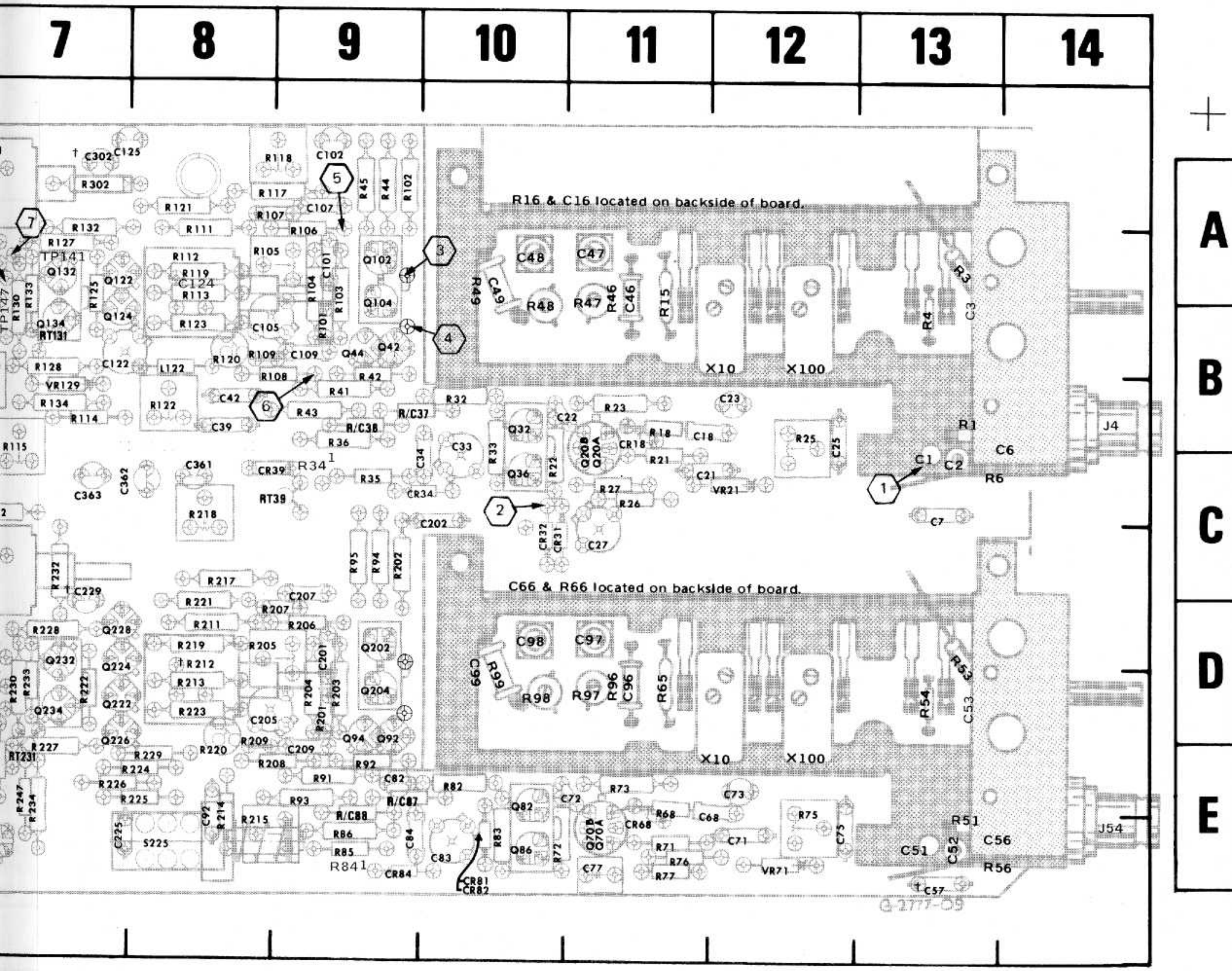

IG VIEW
VERTICAL OUTPUT AMPLIFIER
4
DELAY LINE
DL339
VERTICAL OUTPUT AMPLIFIER
U440
IEW
ER
75
88
A TRIGGER VIEW & CALIBRATOR
11
LV PS
Q1516 Q1548
Q1518 Q1556
Q1532 Q1558
Q1534 Q1564
Q1536 Q1566
Q1544 Q1568
Q1546 U1524
U1554
12
TO ALL BLOCKS
HIGH VOLTAGE MULTIPLIER
U1432
V1440
A SWEEP OUTPUT AMP
Q1038
A SWEEP START COMPARATOR
Q1002A & B
A SWEEP GATE AMPLIFIER
Q1024
A SWEEP GENERATOR
Q1030, Q1036
Q1040
HORIZONTAL AMPLIFIER
Q1214, Q1218, Q1224
Q1226, Q1234, Q1236
Q1244, Q1254, Q1262
Q1266, Q1274, Q1282
Q1288
HORIZONTAL AMPLIFIERS
9
CRT CIRCUIT
Q1404, Q1408
Q1413, Q1414
Q1416, Q1418
B SWEEP GATE AMPLIFIER
Q1084
B SWEEP GENERATOR
Q1090, Q1096
Q1170
Z AXIS AMPLIFIER
Q1466, Q1472
Q1474, Q1478
B SWEEP START COMPARATOR
Q1062A & B
B SWEEP OUTPUT AMP
Q1098
EXT AXIS
A & B SWEEP GENERATOR
6
CRT CIRCUIT
10



*See parts list for serial number ranges.
†Located on back of board.
1Not used with 670-3023 Vertical Output Board.

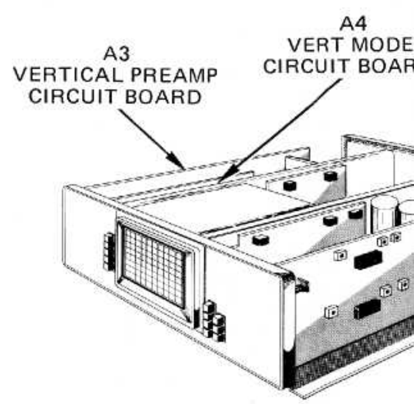
Fig. 8-2. A1 & A2—Attenuators and A

CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRI LOC
C1	13C	C47	11B	C164	4B	L122	8B	Q164	4A
C2	13C	C48	10B	C165	4A	L149	6C	Q168	2A
C3	13B	C49	10B					Q304	5B
C6	13C	C101	9B	CR18	11C	Q20A	11C	Q308	6C
C7	13C	C102	9A	CR31	10D	Q20B	11C		
C18	11C	C105	8B	CR32	10D	Q32	10C	R1	13C
C21	11C	C107	9A	CR34	10C	Q36	10C	R3	13B
C22	11C	C109	9B	CR39	8C	Q42	9B	R4	13B
C23	12C	C122	7B	CR152	4B	Q44	9B	R6	13C
C25	12C	C124	8B	CR164	4A	Q102	9B	R15	11B
C27	11D	C125	7A	CR165	5A	Q104	9B	R18	11C
C33	10C	C135	6B	CR166	5A	Q122	7B	R21	11C
C34	10C	C137	6B	CR167	5A	Q124	7B	R22	10C
C36	10C	C142	6A			Q132	7B	R23	11C
C37	9C	C144	5A	J4	14C	Q134	7B	R25	12C
C38	9C	C149	6C	J162	2B	Q142	6A	R26	11C
C39	8C	C151	5B	J164	2A	Q148	6B	R27	11C
C42	8C	C161	3A	J168	1A	Q152	5B	R32	10C
C46	11B	C162	3B			Q162	4A	R33	10C
								R34[1]	9C



—Attenuators and A3—Vertical Preamp circuit boards.

CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC
Q164	4A	R35	9C	R106	9B	R130	7B	R155	5B
Q168	2A	R36	9C	R107	8A	R132	7B	R161	3B
Q304	5B	R37	9C	R108	8C	R133	7B	R162	3A
Q308	6C	R38	9C	R109	8B	R134	7C	R164	3A
		R41	9C	R111	8B	R135	6B	R165	4A
R1	13C	R42	9C	R112	8B	R136	6B	R168	3A
R3	13B	R43	9C	R113	8B	R137	6B	R169	3B
R4	13B	R44	9A	R114	7C	R138	6B		
R6	13C	R45	9A	R115	7C	R141	6B	RT39	9C
R15	11B	R46	11B	R116	7C	R142	5A	RT131	7B
R18	11C	R47	11B	R117	8A	R143	5A		
R21	11C	R48	10B	R119	8E	R144	6A	VR21	12C
R22	10C	R49	10B	R120	8B	R145	5A	VR129	7C
R23	11C	R85	9F	R121	8A	R146	5B		
R25	12C	R101	9B	R122	8C	R147	6B		
R26	11C	R102	9A	R123	8B	R149	6C		
R27	11C	R103	9B	R125	7B	R151	5B		
R32	10C	R104	9E	R127	7B	R152	4B		
R33	10C	R105	8B	R128	7B	R154	4B		
R34[1]	9C								



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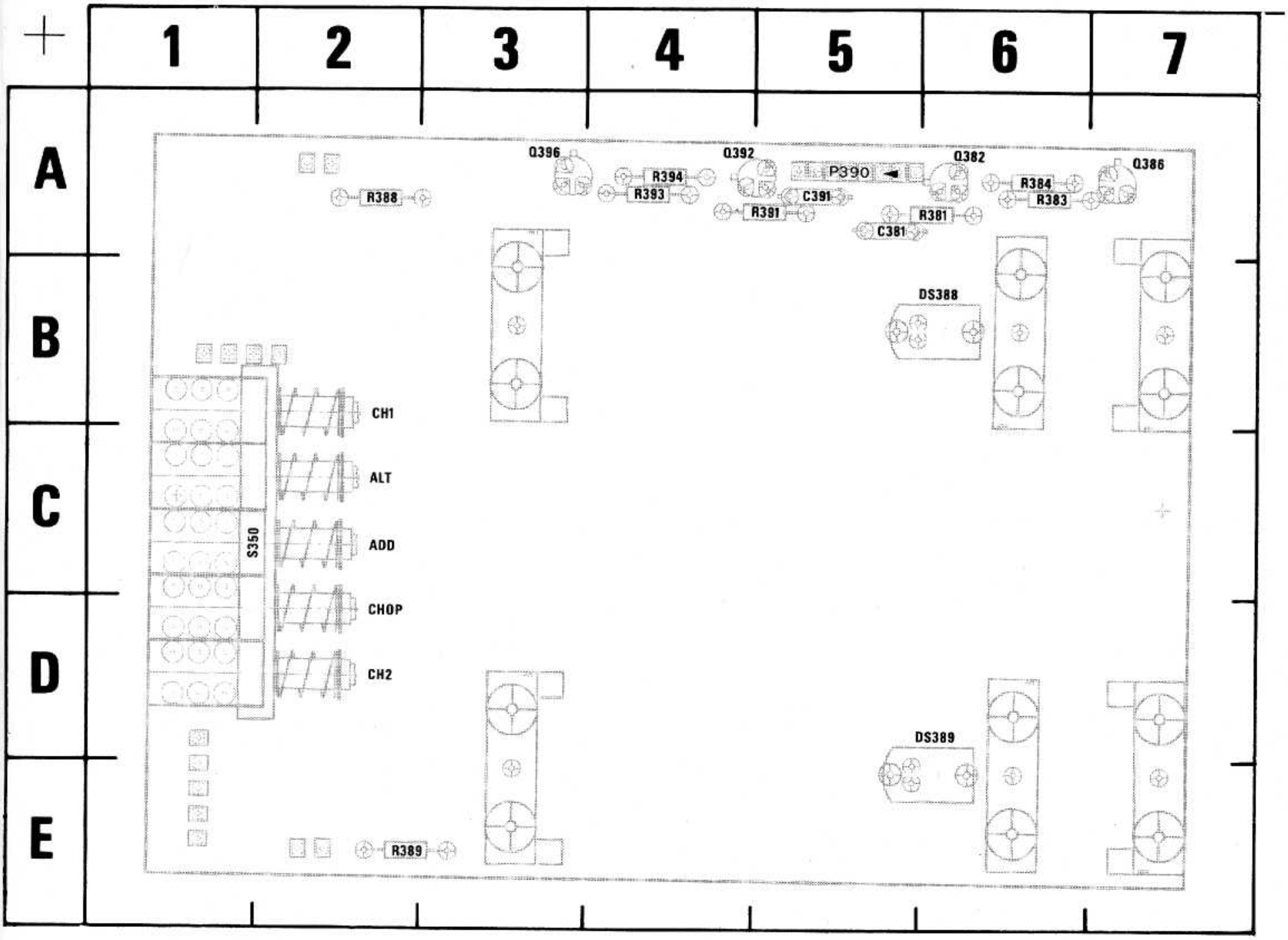
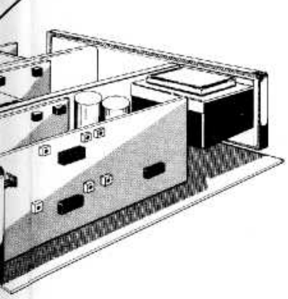


Fig. 8-3. A4—Vertical Mode Switch circuit board.

Located on back of board
R382

CKT NO	GRID LOC	CKT NO	GRID LOC
C381	5A	R381	6A
C391	5A	R383	6A
		R384	6A
DS388	6B	R388	2A
DS389	6D	R389	2E
P390	5A	R391	5A
Q382	6A	R393	4A
Q386	7A	R394	4A
Q392	4A		
Q396	3A	S350	1C

A4
VERT MODE
RCUIT BOARD



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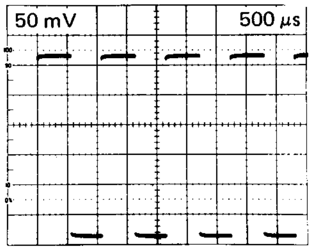

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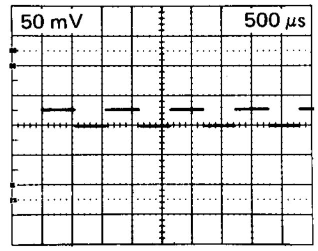

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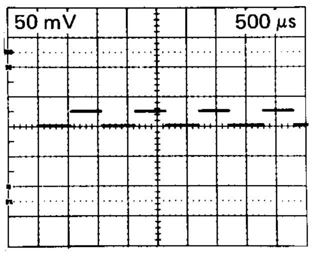

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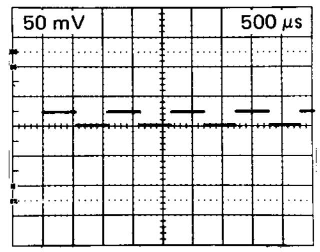

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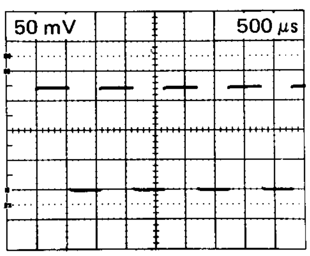

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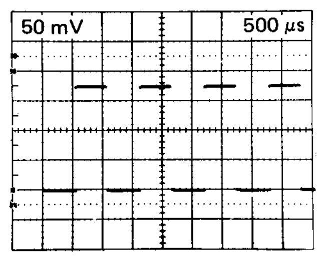

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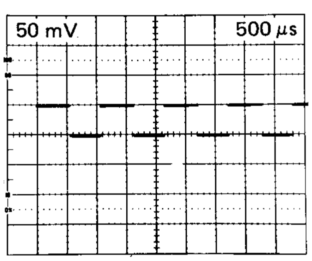

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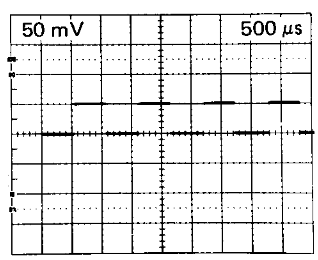

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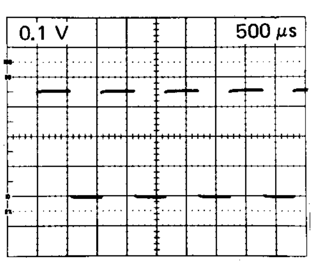

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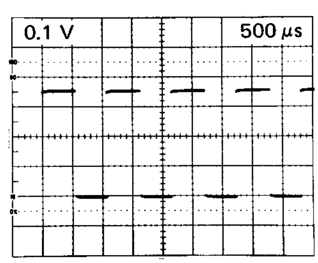
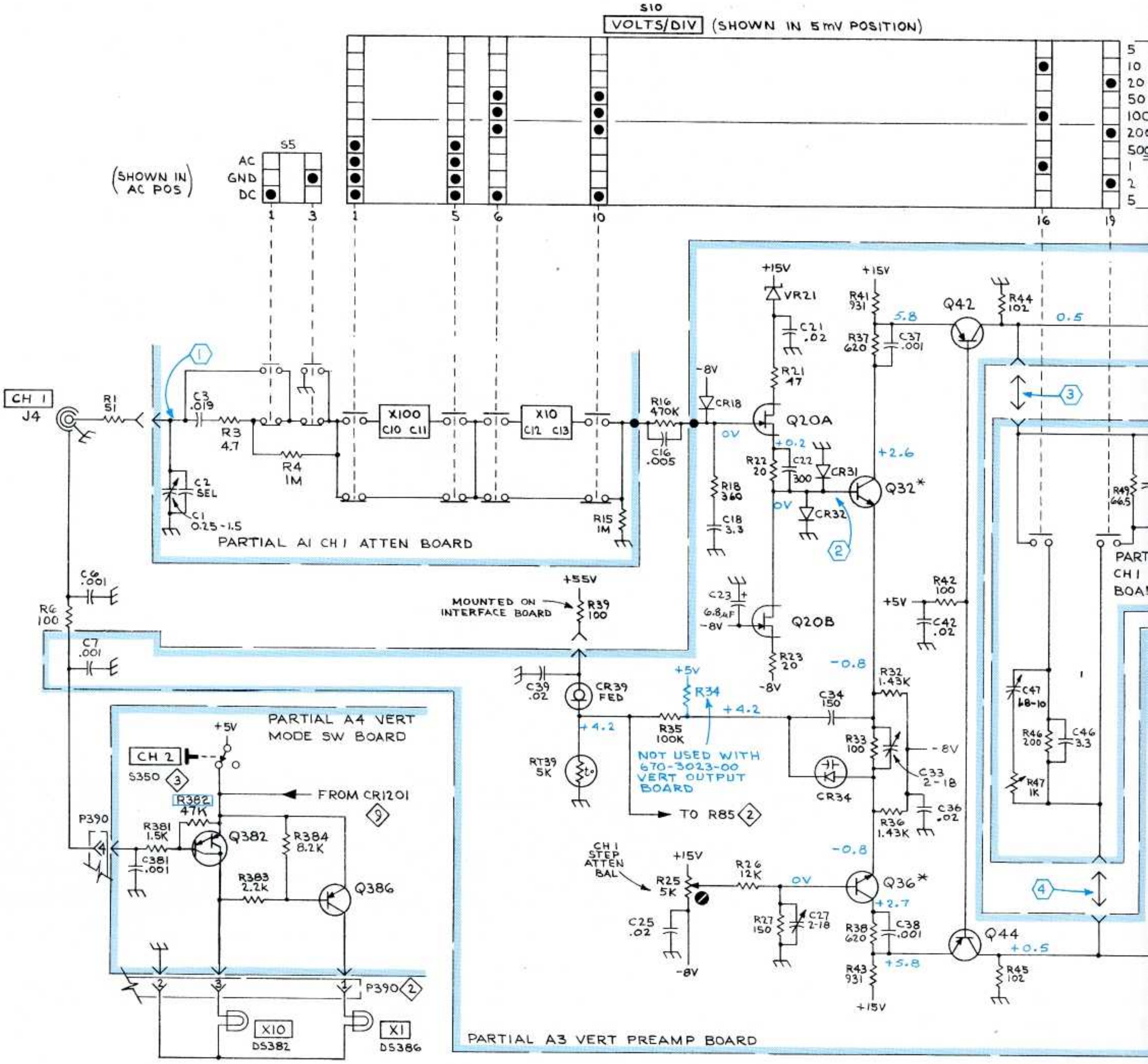


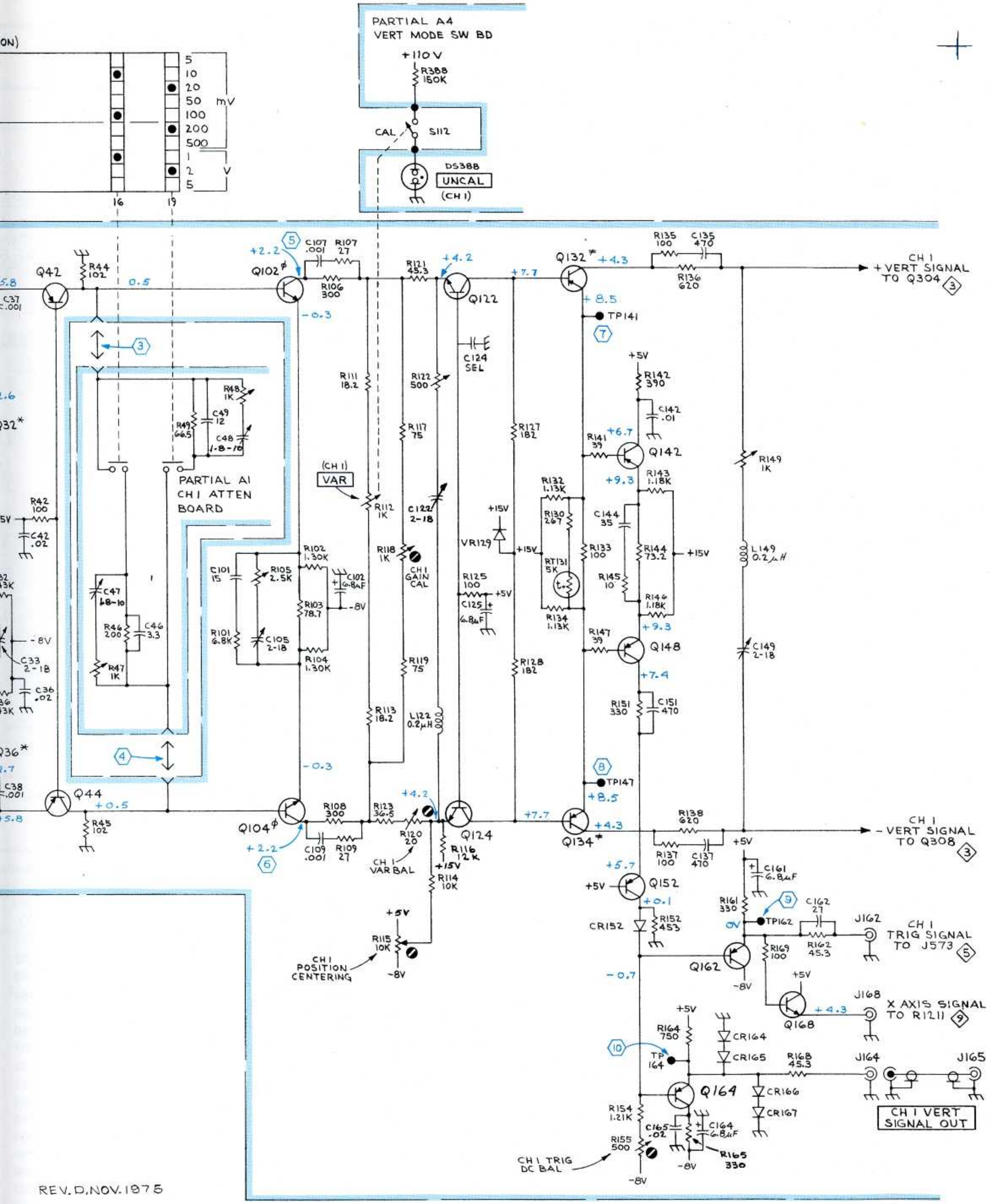


NOTE:
*, ϕ, ≠ THERMAL COUPLED

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

SEE PARTS LIST FOR SEMICONDUCTOR TYPES.

REV. D, NOV. 1975



REV. D. NOV. 1975

CH 1 VERTICAL PREAMP ⟨1⟩

SN B250000 and up

mgf 874

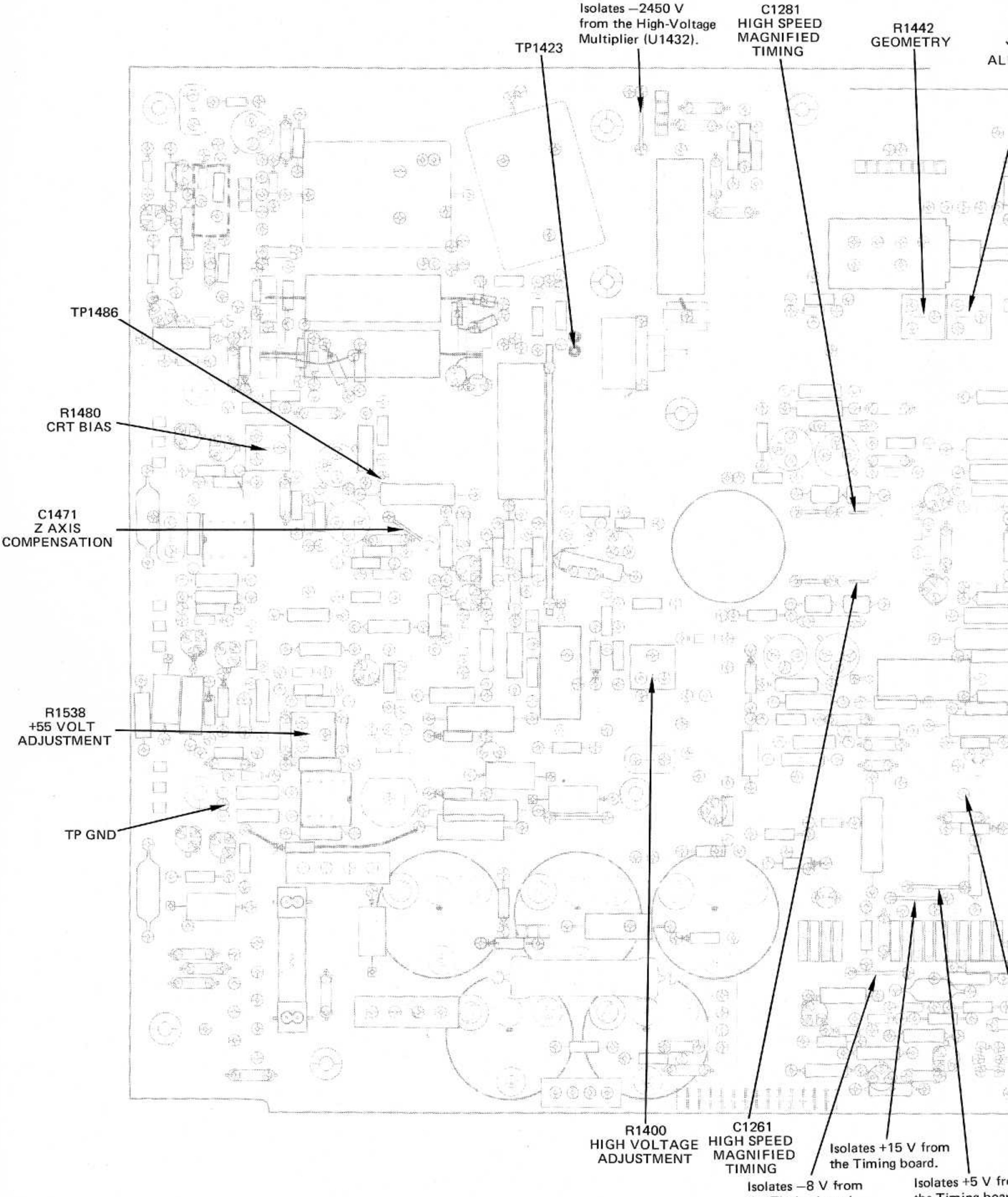
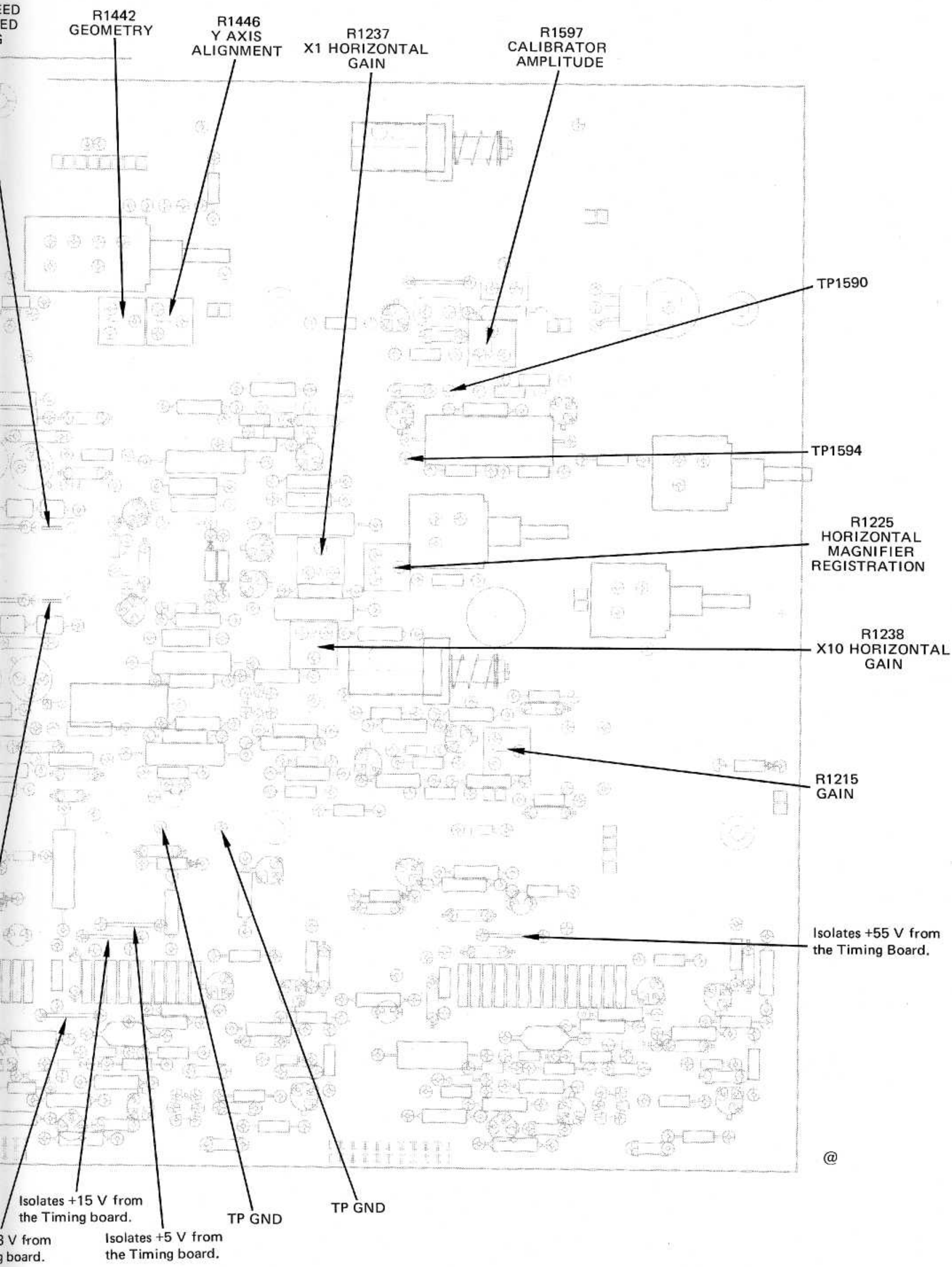
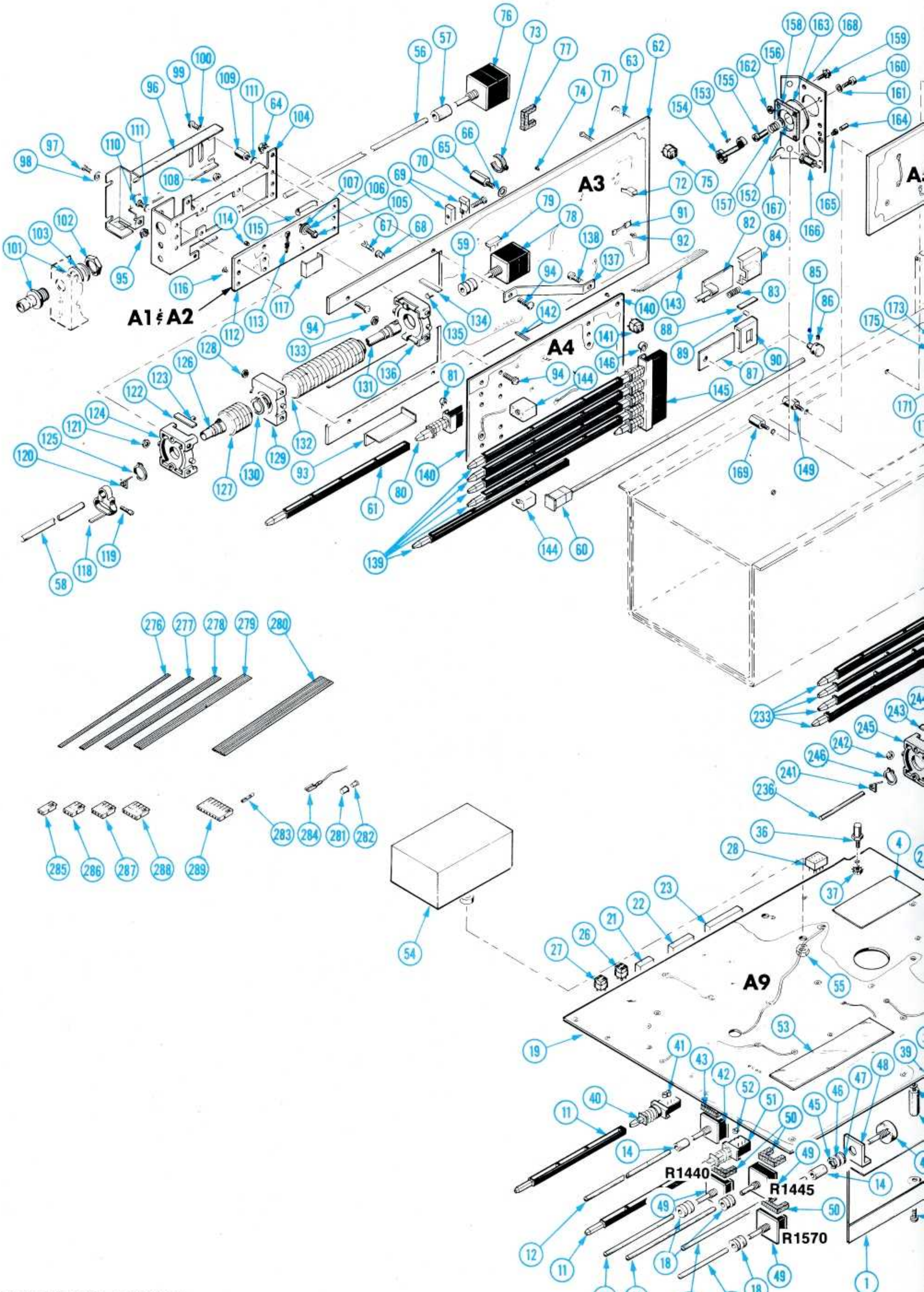


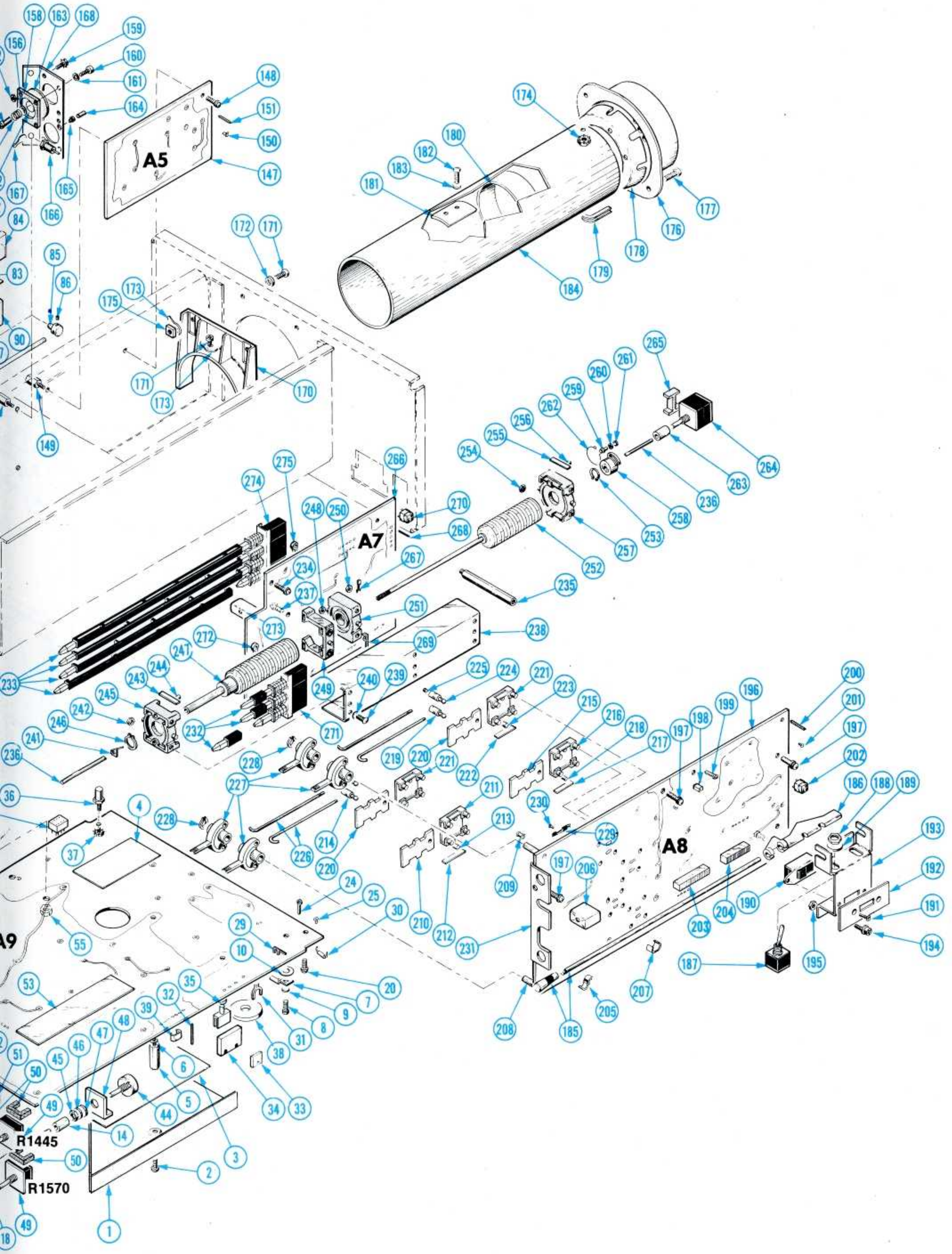
Fig. 8-19. Interface circuit board adjustment locati



e circuit board adjustment locations.



465 OSCILLOSCOPE SN B250000


A5
A7
A8
A9
R1445
R1570

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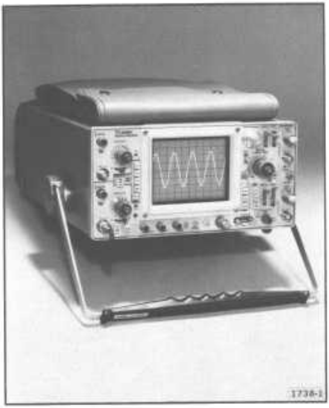
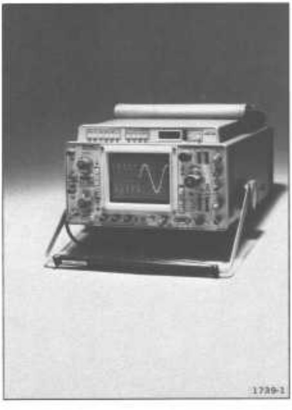


Basic 465 Oscilloscope.

465 Oscilloscope with DM 43 digital multimeter.



475 Oscilloscope with DM 43 digital multimeter.

Basic 475 Oscilloscope.

BEFORE OPERATING

INTRODUCTION

The Tektronix 465 Oscilloscope is a dual-channel, portable instrument. The dual-channel dc-to-100 MHz vertical system provides calibrated deflection factors from 5 millivolts to 5 volts/division. The sweep trigger circuits are capable of stable triggering over the full bandwidth capabilities of the vertical deflection system. The horizontal deflection system provides calibrated sweep rates from 0.5 second to 0.05 microsecond/division along with delayed sweep features for accurate relative-time measurements. A X10 magnifier extends the calibrated sweep rate to 5 nanoseconds/division. The instrument operates over a wide variation of line voltages and frequencies. Maximum power consumption is about 100 watts.

The Tektronix DM43 Digital Mulitmeter measures 0 ohms to 20 megohms, 0 dc volts to 1200 dc volts (+ or −) or −55° C to +150° C and displays the measurement on a digital display while the oscilloscope operates normally.

The digital multimeter and oscilloscope combine to provide a digital readout of the time between any two points on the oscilloscope display.

The DM40 is identical to the DM43, except that the DM40 lacks temperature measurement capability.

SAFETY INFORMATION

The instrument is designed to operate from a single-phase power source with one of the current-carrying conductors (the Neutral Conductor) at ground (earth) potential. Operation from power sources where both current-carrying conductors are live with respect to ground (such as phase-to-phase on a three-wire system) is not recommended, since only the Line Conductor has over-current (fuse) protection within the instrument.

The instrument has a three-wire power cord with a three-terminal polarized plug for connection to the power source and safety-earth. The ground (earth) terminal of the plug is directly connected to the instrument frame. For electric-shock protection, insert this plug only in a mating outlet with a safety-earth contact.

BEFORE OPERATING

INTRODUCTION

The Tektronix 475 Oscilloscope is a dual-channel, portable instrument. The dual-channel dc-to-200 MHz vertical system provides calibrated deflection factors from 2 millivolts to 5 volts/division. The sweep trigger circuits are capable of stable triggering over the full bandwidth capabilities of the vertical deflection system. The horizontal deflection system provides calibrated sweep rates from 0.5 second to 0.01 microsecond/division along with delayed sweep features for accurate relative-time measurements. A X10 magnifier extends the calibrated sweep rate to 1 nanosecond/division. The instrument operates over a wide variation of line voltages and frequencies. Maximum power consumption is about 100 watts.

The Tektronix DM43 Digital Mulitmeter measures 0 ohms to 20 megohms, 0 dc volts to 1200 dc volts (+ or −) or −55° C to +150° C and displays the measurement on a digital display while the oscilloscope operates normally.

The digital multimeter and oscilloscope combine to provide a digital readout of the time between any two points on the oscilloscope display.

The DM40 is identical to the DM43, except that the DM40 lacks temperature measurement capability.

SAFETY INFORMATION

The instrument is designed to operate from a single-phase power source with one of the current-carrying conductors (the Neutral Conductor) at ground (earth) potential. Operation from power sources where both current-carrying conductors are live with respect to ground (such as phase-to-phase on a three-wire system) is not recommended, since only the Line Conductor has over-current (fuse) protection within the instrument.

The instrument has a three-wire power cord with a three-terminal polarized plug for connection to the power source and safety-earth. The ground (earth) terminal of the plug is directly connected to the instrument frame. For electric-shock protection, insert this plug only in a mating outlet with a safety-earth contact.

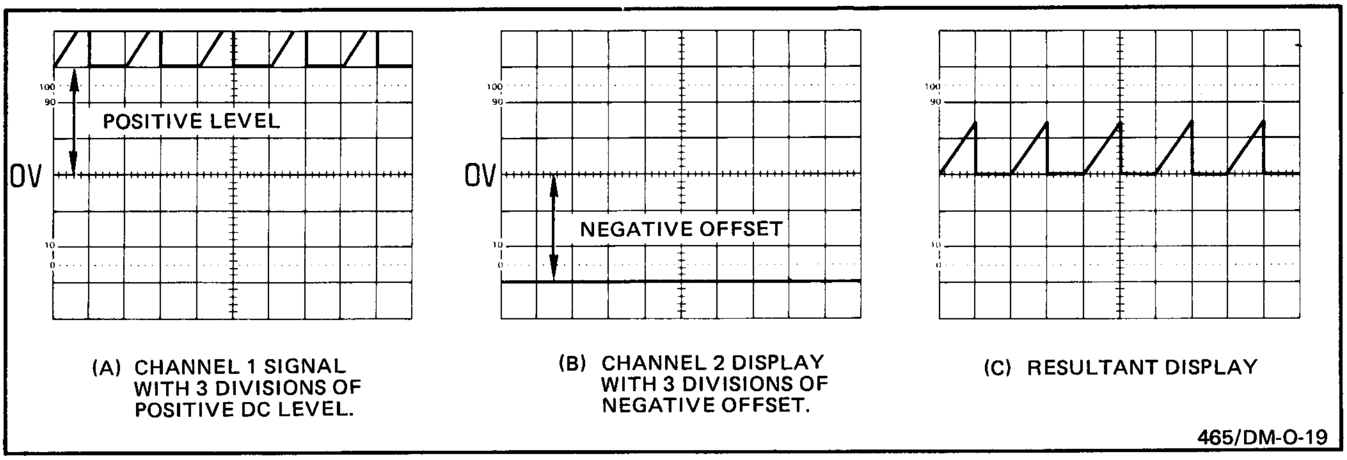


Fig. 16. Algebraic addition.

COMMON-MODE REJECTION

The ADD mode can be used to display signals that contain undesirable components. These undesirable components can be eliminated through common mode rejection. The precautions given under algebraic addition should be observed.

EXAMPLE: The signal applied to the CH 1 input contains unwanted line frequency components (see Fig. 17A.). To remove the undesired components use the following procedure.

1. Connect a line frequency signal to the CH 2 input.

2. Set the VERT MODE switch to ALT and the CH 2 INVERT switch to on (button in). Adjust the CH 2

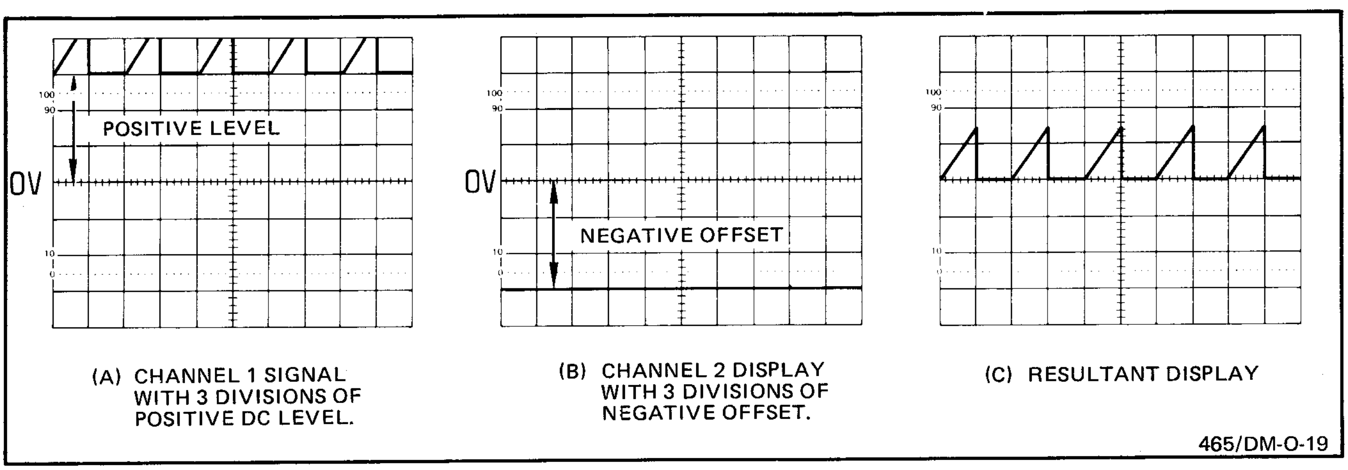


Fig. 16. Algebraic addition.

COMMON-MODE REJECTION

The ADD mode can be used to display signals that contain undesirable components. These undesirable components can be eliminated through common mode rejection. The precautions given under algebraic addition should be observed.

EXAMPLE: The signal applied to the CH 1 input contains unwanted line frequency components (see Fig. 17A.). To remove the undesired components use the following procedure.

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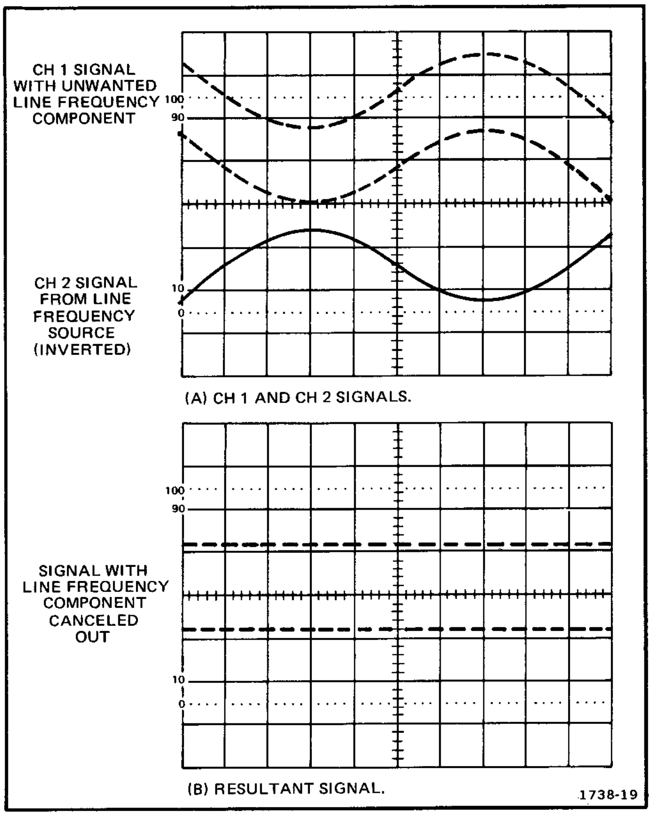

Fig. 17. Common-mode rejection.

VOLTS/DIV and VAR VOLTS/DIV controls so the CH 2 display is about the same amplitude as the undesired portion of the CH 1 display (see Fig. 17A).

3. Set the VERT MODE switch to ADD. Slightly readjust the CH 2 VAR VOLTS/DIV control for maximum cancellation of the undesired signal component (see Fig. 17B).

AMPLITUDE COMPARISON MEASUREMENTS

If comparisons of an unknown signal with a reference signal are repetitious (e.g., on an assembly line test) it is possible to obtain more accurate easily read measurements if the VAR VOLTS/DIV control is adjusted to set the reference signal to an exact number of divisions. The unknown signal can then be quickly and easily compared with or adjusted to an exact number of divisions.

Other unknown signals may be measured without disturbing the setting of the VAR VOLTS/DIV control by establishing a vertical conversion factor and an arbitrary deflection factor. The amplitude of the reference signal must be known before a vertical conversion factor can be established.

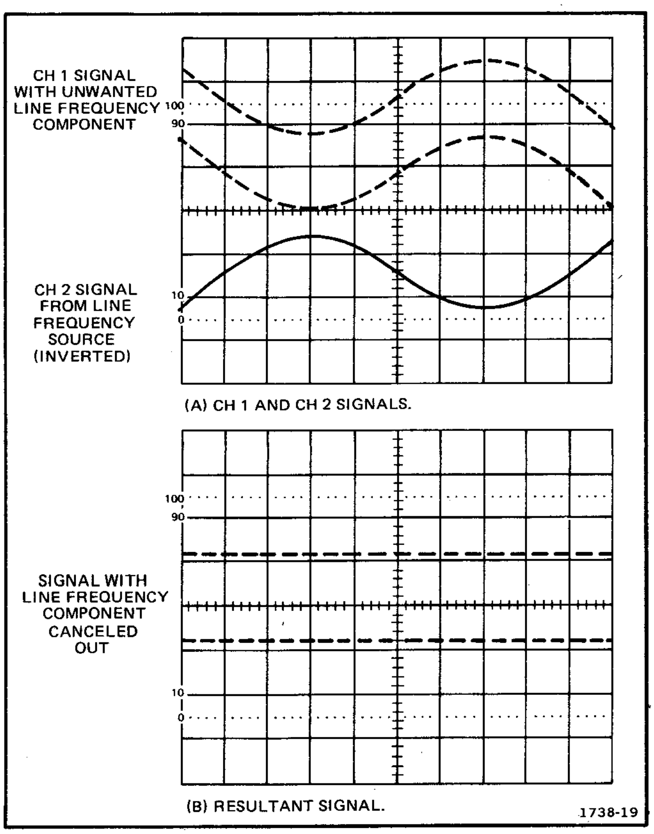

Fig. 17. Common-mode rejection.

VOLTS/DIV and VAR VOLTS/DIV controls so the CH 2 display is about the same amplitude as the undesired portion of the CH 1 display (see Fig. 17A).

3. Set the VERT MODE switch to ADD. Slightly readjust the CH 2 VAR VOLTS/DIV control for maximum cancellation of the undesired signal component (see Fig. 17B).

AMPLITUDE COMPARISON MEASUREMENTS

If comparisons of an unknown signal with a reference signal are repetitious (e.g., on an assembly line test) it is possible to obtain more accurate easily read measurements if the VAR VOLTS/DIV control is adjusted to set the reference signal to an exact number of divisions. The unknown signal can then be quickly and easily compared with or adjusted to an exact number of divisions.

Other unknown signals may be measured without disturbing the setting of the VAR VOLTS/DIV control by establishing a vertical conversion factor and an arbitrary deflection factor. The amplitude of the reference signal must be known before a vertical conversion factor can be established.

EXAMPLE: The apparent magnification of a display with an A TIME/DIV switch setting of .1 ms and a B TIME/DIV switch setting of 1 μs is:

$$\text{Apparent Magnification (Delayed Sweep)} = \frac{\text{A TIME/DIV setting}}{\text{B TIME/DIV setting}}$$

Substituting the given values:

$$\text{Apparent Magnification} = \frac{1 \times 10^{-4}}{1 \times 10^{-6}}$$

The apparent magnification is 100 times.

Triggered Delayed Sweep Magnification

The delayed sweep magnification method just described may produce too much jitter at high apparent magnification ranges. Operating the B Sweep in a triggered mode provides a more stable display since the delayed display is triggered at the same point each time.

1. Set up the display as given in steps 1 through 6 under "Magnified Sweep Starts After Delay".

2. Set the B Trigger SOURCE switch to the same position as the A Trigger SOURCE switch.

3. Adjust the B LEVEL control so the intensified zone on the trace is stable. (If an intensified zone cannot be obtained, see step 4.)

4. Inability to intensify the desired portion indicates that the signal does not meet the triggering requirements. If the condition cannot be remedied with the B Triggering controls or by increasing the display amplitude (lower VOLTS/DIV setting), trigger B Sweep externally.

5. When the correct portion is intensified, set the HORIZ DISPLAY switch to B DLY'D. Slight readjustment of the B LEVEL control may be necessary for a stable display.

6. Measurements are made and magnification factors are calculated as in the STARTS AFTER DELAY mode previously given.

EXAMPLE: The apparent magnification of a display with an A TIME/DIV switch setting of .1 ms and a B TIME/DIV switch setting of 1 μs is:

$$\text{Apparent Magnification (Delayed Sweep)} = \frac{\text{A TIME/DIV setting}}{\text{B TIME/DIV setting}}$$

Substituting the given values:

$$\text{Apparent Magnification} = \frac{1 \times 10^{-4}}{1 \times 10^{-6}}$$

The apparent magnification is 100 times.

Triggered Delayed Sweep Magnification

The delayed sweep magnification method just described may produce too much jitter at high apparent magnification ranges. Operating the B Sweep in a triggered mode provides a more stable display since the delayed display is triggered at the same point each time.

1. Set up the display as given in steps 1 through 6 under "Magnified Sweep Starts After Delay".

2. Set the B Trigger SOURCE switch to the same position as the A Trigger SOURCE switch.

3. Adjust the B LEVEL control so the intensified zone on the trace is stable. (If an intensified zone cannot be obtained, see step 4.)

4. Inability to intensify the desired portion indicates that the signal does not meet the triggering requirements. If the condition cannot be remedied with the B Triggering controls or by increasing the display amplitude (lower VOLTS/DIV setting), trigger B Sweep externally.

5. When the correct portion is intensified, set the HORIZ DISPLAY switch to B DLY'D. Slight readjustment of the B LEVEL control may be necessary for a stable display.

6. Measurements are made and magnification factors are calculated as in the STARTS AFTER DELAY mode previously given.

PHASE DIFFERENCE MEASUREMENTS

Use either the CHOP or ALT mode. Set the A Trigger SOURCE switch to CH 1. The reference signal should precede the comparison signal in time. Use coaxial cables or probes that have equal time delay to connect the signals to the input connectors.

If the signals are of opposite polarity, set the INVERT pushbutton to invert the Channel 2 display (signals may be of opposite polarity due to 180° phase difference; if so, take this into account in the final calculation). Set the CH 1 and CH 2 VOLTS/DIV switches and the CH 1 and CH 2 VAR controls so the displays are equal in amplitude.

Set the TIME/DIV switch for about a one-cycle waveform. Position the display and turn the A VAR TIME/DIV control for 1 reference signal cycle in exactly eight divisions (see Fig. 30). Each division of the graticule represents 45° of the cycle (360° ÷ 8 divisions = 45°/division). The sweep rate can be stated in terms of degrees as 45°/division.

Measure the horizontal difference between corresponding points on the waveforms and multiply the distance measured (in divisions) by 45°/division (sweep rate) to obtain the amount of phase difference.

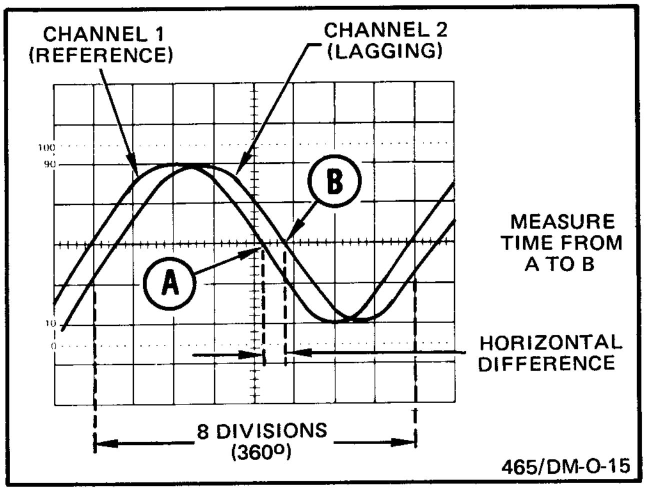

Fig. 30. Phase difference.

EXAMPLE: The horizontal difference is 0.6 division with a sweep rate of 45°/division as shown in Fig. 30.

Using the formula:

$$\text{Phase Difference} = \frac{\text{horizontal difference}}{\text{divisions}} \times \frac{\text{sweep}}{\text{(degrees/div)}}$$

PHASE DIFFERENCE MEASUREMENTS

Use either the CHOP or ALT mode. Set the A Trigger SOURCE switch to CH 1. The reference signal should precede the comparison signal in time. Use coaxial cables or probes that have equal time delay to connect the signals to the input connectors.

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Set the TIME/DIV switch for about a one-cycle waveform. Position the display and turn the A VAR TIME/DIV control for 1 reference signal cycle in exactly eight divisions (see Fig. 30). Each division of the graticule represents 45° of the cycle (360° ÷ 8 divisions = 45°/division). The sweep rate can be stated in terms of degrees as 45°/division.

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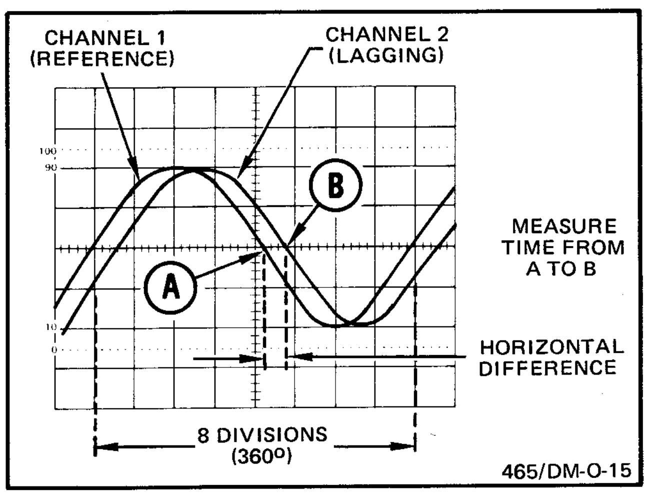

Fig. 30. Phase difference.

EXAMPLE: The horizontal difference is 0.6 division with a sweep rate of 45°/division as shown in Fig. 30.

Using the formula:

$$\text{Phase Difference} = \frac{\text{horizontal difference}}{\text{divisions}} \times \frac{\text{sweep}}{\text{(degrees/div)}}$$

Substituting the given values:

Phase Difference = 0.6 X 45° = 27°.

HIGH RESOLUTION PHASE DIFFERENCE MEASUREMENTS

Make more accurate phase measurements by increasing the sweep rate (without changing the A VAR TIME/DIV control) by using the X10 MAG mode. Delayed sweep magnification may also be used (see Fig. 31).

EXAMPLE: If the sweep rate were increased 10 times with the magnifier, the magnified sweep rate would be 45° ÷ 10 = 4.5°/division. Fig. 31 shows the same signals as used in Fig. 30 but with the X10 MAG switch set to X10. With a horizontal difference of 6 divisions, the phase difference is:

$$\text{Phase Difference} = \begin{matrix}\text{horizontal}\\ \text{difference}\\ \text{(divisions)}\end{matrix} \times \begin{matrix}\text{magnified}\\ \text{sweep rate}\\ \text{(degrees/div)}\end{matrix}$$

Substituting the given values:

Phase Difference = 6 X 4.5° = 27°.

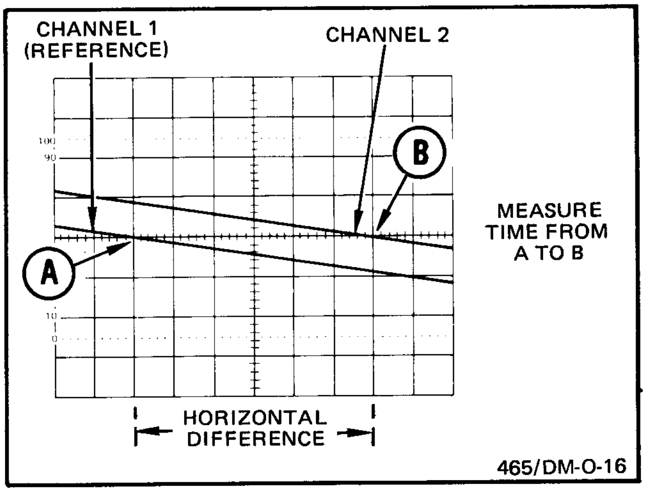

Fig. 31. High resolution phase difference.

Substituting the given values:

Phase Difference = 0.6 X 45° = 27°.

HIGH RESOLUTION PHASE DIFFERENCE MEASUREMENTS

Make more accurate phase measurements by increasing the sweep rate (without changing the A VAR TIME/DIV control) by using the X10 MAG mode. Delayed sweep magnification may also be used (see Fig. 31).

EXAMPLE: If the sweep rate were increased 10 times with the magnifier, the magnified sweep rate would be 45° ÷ 10 = 4.5°/division. Fig. 31 shows the same signals as used in Fig. 30 but with the X10 MAG switch set to X10. With a horizontal difference of 6 divisions, the phase difference is:

Phase Difference = horizontal difference (divisions) X magnified sweep rate (degrees/div)

Substituting the given values:

Phase Difference = 6 X 4.5° = 27°.

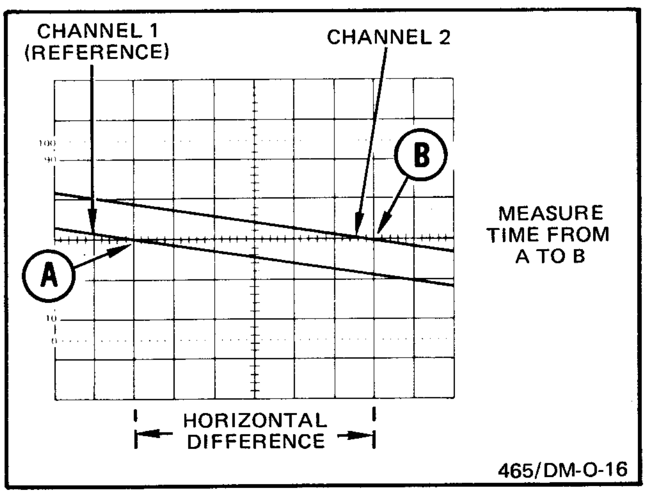

Fig. 31. High resolution phase difference.

PULSE JITTER MEASUREMENTS

Be sure the VAR TIME/DIV switch is in the calibrated detent. Set the B TIME/DIV switch to intensify the full rising portion of the pulse. Set the HORIZ DISPLAY switch to B DLY'D.

Pulse jitter is shown by horizontal movement of the pulse and includes the inherent jitter of the Delayed Sweep (see Fig. 32). Multiply the distance by the B TIME/DIV switch setting to obtain pulse jitter time.

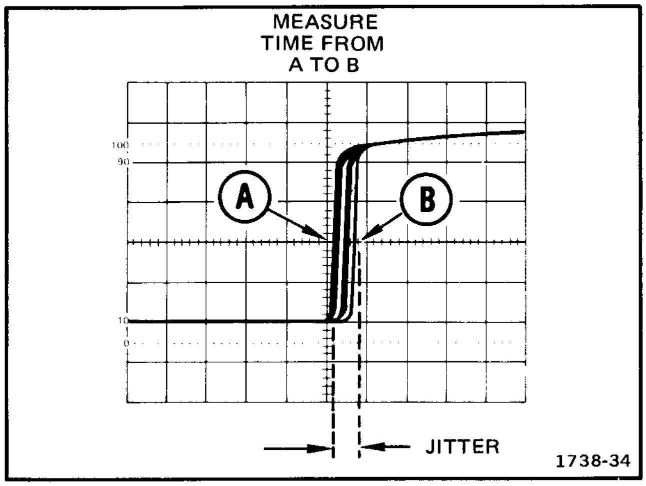

Fig. 32. Pulse jitter.

PULSE JITTER MEASUREMENTS

Be sure the VAR TIME/DIV switch is in the calibrated detent. Set the B TIME/DIV switch to intensify the full rising portion of the pulse. Set the HORIZ DISPLAY switch to B DLY'D.

Pulse jitter is shown by horizontal movement of the pulse and includes the inherent jitter of the Delayed Sweep (see Fig. 32). Multiply the distance by the B TIME/DIV switch setting to obtain pulse jitter time.

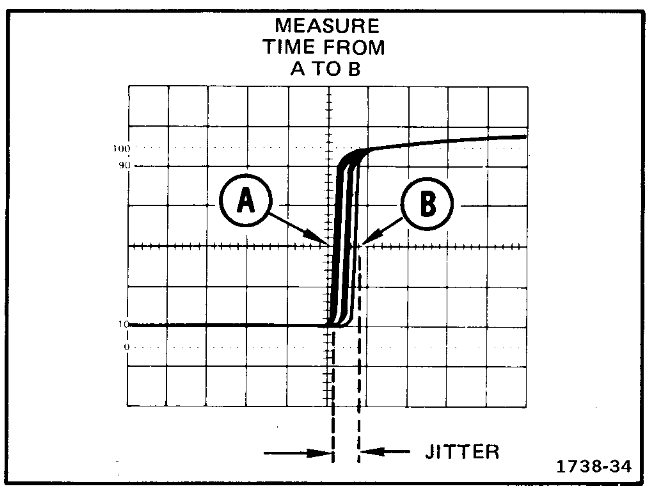

Fig. 32. Pulse jitter.