

**TECHNICAL MANUAL**

**OPERATOR'S, ORGANIZATIONAL,  
DIRECT SUPPORT AND GENERAL  
SUPPORT MAINTENANCE MANUAL**

**FOR**

**OSCILLOSCOPE OS-261B(V)1/U**

**(NSN 6625-01-101-1318)**

**(TEKTRONIX MODEL 475 WITH OPTION 04)**

This copy is a reprint which includes current  
pages from Change 1.

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**HEADQUARTERS, DEPARTMENT OF THE ARMY**

**JUNE 1982**



CHANGE

HEADQUARTERS  
DEPARTMENT OF THE ARMY  
Washington, DC, 10 September 1984

No. 1

**OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT, AND  
GENERAL SUPPORT MAINTENANCE MANUAL  
OSCILLOSCOPE OS-261B(V)1/U  
(TEKTRONIX MODEL 475 WITH OPTION 04)  
(NSN 6625-01-101-1318)  
AND  
OSCILLOSCOPE OS-261C(V)1/U  
(TEKTRONIX MODEL 475 WITH OPTION 04  
AND OPTION 07)  
(NSN 6625-01-119-7314)**

TM 11-6625-2735-14-1, 17 June 1982, is changed as follows:

1. Title of manual is changed as shown above.
2. New or changed material is indicated by a vertical bar in the margin of the page. Added or revised illustrations are indicated by a vertical bar in front of the figure caption.
3. Remove old pages and insert new pages as indicated below:

*Remove pages*

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By Order of the Secretary of the Army:

JOHN A. WICKHAM JR.  
*General, United States Army*  
*Chief of Staff*

Official:

ROBERT M. JOYCE  
*Major General, United States Army*  
*The Adjutant General*

To be distributed in accordance with DA Form 12-36B requirements for OS-261.

## SAFETY SUMMARY

This manual contains safety information which the user must follow to ensure safe operation of this instrument. WARNING information is intended to protect the operator; CAUTION information is intended to protect the instrument. The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument.

Warning statements precede potentially dangerous procedures throughout this manual. The instructions contained in the warnings must be followed. The following warning statements are found in this manual:

### WARNING

**Use a proper power source.** This instrument is intended to be operated from a single-phase power source. A suitable power source is one where both current-carrying conductors are ungrounded, since over-current protection (fuse) is provided in both conductors. Operation from a grounded power source is not recommended. If the fuse in the grounded conductor opens, the power-source voltage appears on the internal primary wiring causing a possible shock hazard during troubleshooting.

### WARNING

**Ground the instrument.** This instrument has a three-wire power cord with a three-terminal polarized plug for connection to the power source and safety-earth. The safety-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 or otherwise connect the frame to a safety-earth system. Failure to complete the ground system may allow the chassis of this instrument to be elevated above ground potential and pose a shock hazard.

### WARNING

**Avoid live circuits.** Dangerous voltages exist at several points throughout this instrument. When the instrument is operated with the covers removed, do not touch exposed connections or components. Some transistors have voltages present on their cases. Disconnect power before cleaning the instrument or replacing parts.

### WARNING

**Avoid contact with chemicals.** Handle silicone grease with care. Avoid getting silicone grease in eyes. Wash hands thoroughly after use.

### WARNING

**Use care when handling the crt.** Protective clothing and safety glasses should be worn when handling a crt. Avoid striking it on any object which might cause it to crack or implode. When storing a crt, place it in a protective carton or set it facedown in a protected location on a smooth surface with a soft mat under the faceplate to protect it from scratches.

## SAFETY SUMMARY (CONT.)

### WARNING

Adequate ventilation should be provided while using TRICHLOROTRIFLUOROETHANE. Prolonged breathing of vapor should be avoided. The solvent should not be used near heat or open flames; the products of decomposition are toxic and irritating. Since TRICHLOROTRIFLUOROETHANE dissolves natural oils, prolonged contact with skin should be avoided. When necessary, use gloves which the solvent cannot penetrate. If the solvent is taken internally, consult a physician immediately.

### WARNING

Compressed air shall not be used for cleaning purposes except where reduced to less than 29 pounds per square inch (psi) and then only with effective chip guarding and personnel protective equipment. Do not use compressed air to dry parts when TRICHLOROTRIFLUOROETHANE has been used. Compressed air is dangerous and can cause serious bodily harm if protective means or methods are not observed to prevent chip or particle (of whatever size) from being blown into the eyes or unbroken skin of the operator or other personnel.

### CAUTION

**Avoid crt phosphor damage.** Crt phosphor damage can occur under adverse conditions. Avoid any condition where an extremely bright, sharply focused spot exists on the crt.



**5** SAFETY STEPS TO FOLLOW IF SOMEONE IS THE VICTIM OF ELECTRICAL SHOCK

**1** DO NOT TRY TO PULL OR GRAB THE INDIVIDUAL

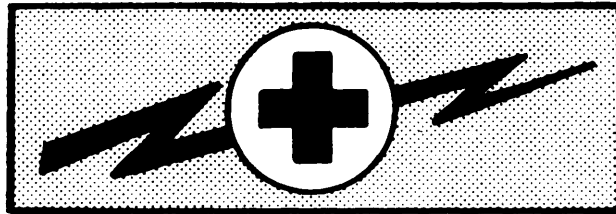
**2** IF POSSIBLE, TURN OFF THE ELECTRICAL

**3** IF YOU CANNOT TURN OFF THE ELECTRICAL POWER, PULL, PUSH, OR LIFT THE PERSON TO SAFETY USING A WOODEN POLE OR A ROPE OR SOME OTHER INSULATING MATERIAL

**4** SEND FOR HELP AS SOON AS POSSIBLE

**5** AFTER THE INJURED PERSON IS FREE OF CONTACT WITH THE SOURCE OF ELECTRICAL SHOCK, MOVE THE PERSON A SHORT DISTANCE AWAY AND IMMEDIATELY START ARTIFICIAL RESUSCITATION

## WARNING



## HIGH VOLTAGE

is used in the operation of this equipment

## DEATH ON CONTACT

may result if personnel fail to observe safety precautions

Never work on electronic equipment unless there is another person nearby who is familiar with the operation and hazards of the equipment and who is competent in administering first aid. When the technician is aided by operators. They must be warned about dangerous areas.

Be careful not to contact high-voltage connections or 115 volt ac input connections when installing or operating this equipment.

Whenever the nature of the operation permits, keep one hand away from the equipment to reduce the hazard of current flowing through the body.

WARNING Do not be misled by the term "low voltage". Potentials as low as 50 volts may cause death under adverse conditions.

For Artificial Respiration, refer to FM 21-11.



## **SAFETY PRECAUTION**

A periodic review of safety precautions in TB 385-4, Safety Precautions for Maintenance of Electrical/Electronic Equipment, is recommended. When the equipment is operated with covers removed, DO NOT TOUCH exposed connections or components. MAKE CERTAIN you are not grounded when making connections or adjusting components inside the test instrument.



TECHNICAL MANUAL

No. 11-6625-2735-14-1

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DEPARTMENT OF THE ARMY  
Washington, DC, 17 June 1982

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**OSCILLOSCOPE OS-261B(V)1/U  
(TEKTRONIX MODEL 475 WITH OPTION 04)  
(NSN 6625-01-101-1318)  
AND  
OSCILLOSCOPE OS-261C(V)1/U  
(TEKTRONIX MODEL 475 WITH OPTION 04  
AND OPTION 07)  
(NSN 6625-01-119-7314)**

**REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS**

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual direct to: Commander, US Army Communications-Electronics Command and Fort Monmouth, ATTN: DRSEL-ME-MP, Fort Monmouth, New Jersey 07703-5007. In either case, a reply will be furnished direct to you.

This manual is an authentication of the manufacturer's commercial literature which, through usage, has been found to cover the data required to operate and maintain this equipment. Since the manual was not prepared in accordance with military specifications, the format has not been structured to consider levels of maintenance.

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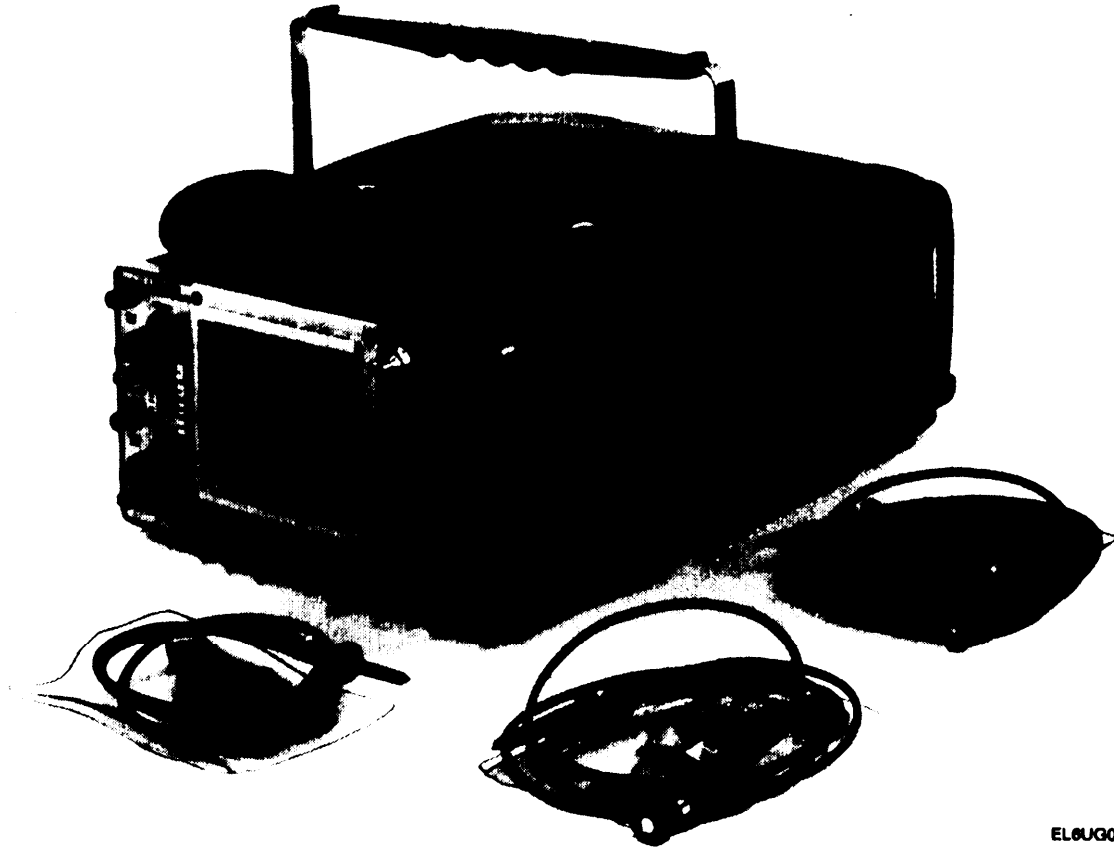
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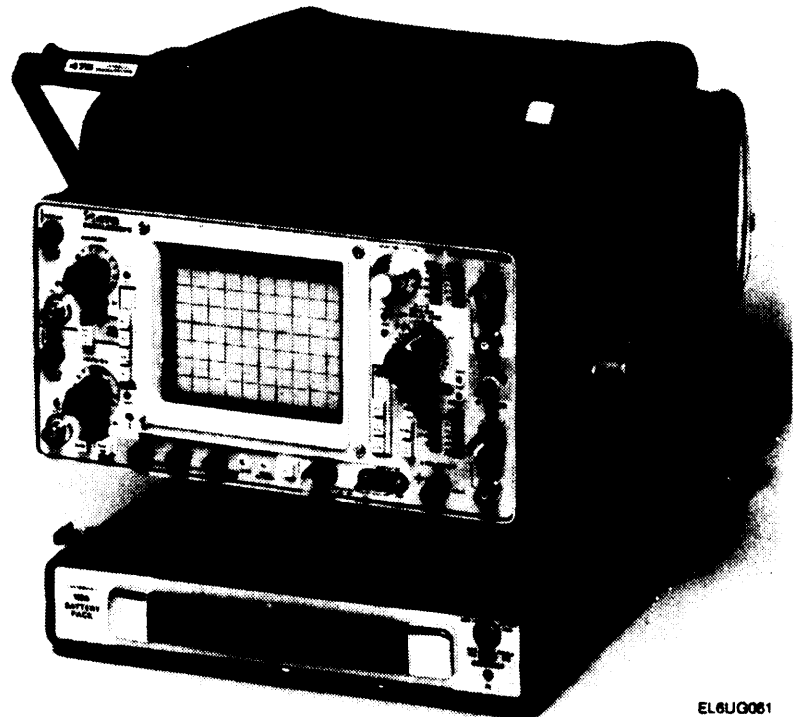


EL6UG001

Fig. 1-1. Oscilloscope OS-261B(V)1/U and OS-261C(V)1/U.

NOTE

UNITS WITH OPTION 07, POWER SUPPLY  
PP-7549/U (TEKTRONIX MODEL 1106),  
WILL USE TM 11-6625-2973-14 FOR POWER  
SUPPLY MAINTENANCE.



EL6UG061

Fig. 1-1.1. Oscilloscope, OS-261B and OS-261C(V)1/U, Power Supply -1106 Battery Pack.



# SECTION 0

## INTRODUCTION

### Scope

This manual describes Oscilloscope OS-261B(V)1/U and OS-261C(V)1/U and provides instructions for operation and maintenance. Throughout this manual, the OS-261B(V)1/U is referred to as Tektronix Model 475 with option 04, and the OS-261C(V)1/U is referred to as Tektronix Model 475 with option 07.

### Consolidated Index of Army Publications and Blank Forms

Refer to the latest issue of DA Pam 310-1 to determine whether there are new additions, changes, or additional publications pertaining to the equipment.

### Maintenance Forms, Records, and Reports

a. *Reports of Maintenance and Unsatisfactory Equipment.* Department of the Army forms and procedures used for equipment maintenance will be those prescribed by DA Pam 738-750 as contained in Maintenance Management Update.

b. *Report of Packaging and Handling Deficiencies.* Fill out and forward SF 364 (Report of Discrepancy (ROD)) as prescribed in AR 735-11-2/DLAR 4140.55/NAVMATINST 4355.73A/AFR 400-54/MCO 4430.3F.

c. *Discrepancy in Shipment Report (DISREP) (SF 361).* Fill out and forward Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 55-38/NAVSUPINST 4610.33C/AFR 75-18/MCO P4610.19D/DLAR 4500.15.

### Reporting Equipment Improvement Recommendations (EIR)

If your OS-261B(V)1/U and OS-261C(V)1/U needs improvement, let us know. Send us an EIR. You, the user, are the only one who can tell us what you don't like about your equipment. Let us know why you don't like the design. Put it on an SF 368 (Quality Deficiency Report). Mail it to Commander, US Army Communications-Electronics Command and Fort Monmouth, ATTN: DRSEL-ME-MP, Fort Monmouth, New Jersey 07703-5007. We'll send you a reply.

### Administrative Storage

To prepare the equipment for administrative storage, ascertain its operability and reliability. In addition, use the proper packing materials.

### Destruction of Army Electronics Materiel

Destruction of Army electronics materiel to prevent enemy use shall be in accordance with TM 750-244-2.



# GENERAL INFORMATION AND INSTALLATION

## Introduction

The 475 Oscilloscope is a 200 megahertz bandwidth portable instrument designed to operate in a wide range of environmental conditions. The lightweight, compact design combines accurate high-frequency measurement capability and ease of transportation.

The dual-channel, DC-to-200 megahertz vertical deflection system provides calibrated deflection factors from 2 millivolts to 5 volts/division. A BW/TRIG VIEW switch permits limiting the bandwidth of the vertical system to reduce interference from high-frequency signals when viewing lower-frequency, low-level signals. The switch also permits displaying of the signal applied to the 'A' Trigger Generator on the CRT.

The trigger circuits provide stable sweep triggering to beyond the 200 megahertz 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 permits the A

sweep to trigger in a stable manner on aperiodic signals or complex digital words. The horizontal deflection system has calibrated sweep rates from 0.5 second to 0.01 microsecond/division. A X10 magnifier increases each sweep rate by a factor of 10 to provide a maximum sweep rate of one nanosecond per division in the .01 $\mu$ s position. The delayed and mixed sweep features allow the start of 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). Regulated DC power supplies provide stable instrument performance over a wide range of line voltages and frequencies. Maximum power consumption of the instrument is approximately 100 watts.

## Characteristics

The following instrument specifications apply over an ambient temperature range of  $-15^{\circ}\text{C}$  to  $+55^{\circ}\text{C}$  unless otherwise specified. Warmup time for specified accuracies is 20 minutes. The calibration procedure given in Section 6, if performed completely, will ensure the instrument meets the electrical characteristics listed in this section.

**TABLE 1-1  
ELECTRICAL**

Characteristics	Performance Requirements	Supplemental Information
<b>VERTICAL DEFLECTION SYSTEM (CH 1 and CH 2)</b>		
Deflection Factor Calibrated Range	2 mV to 5 V/DIV in 11 steps; 1-2-5 sequence.	
Cascaded Operation (CH 2 VERT SIGNAL OUT Connected to CH 1)	Deflection Factor to Approximately 400 $\mu$ V/div. Bandwidth: DC to $\geq$ 50 MHz.	CH 2 VERT SIGNAL OUT into CH 1 input. DC coupled using a 50 $\Omega$ , 42" RG58A/U cable terminated in 50 $\Omega$ at CH 1 input.
Uncalibrated (VAR VOLTS/DIV) Range	Provides continuously variable deflection factors between the calibrated steps. Extends maximum uncalibrated deflection factor to at least 12.5 volts per division in the 5 V/DIV position.	At least 2.51
Low Frequency Linearity		0.1 division or less compression or expansion of 2 division signal at center screen positioned to the upper and lower extremes of the graticule area.
Deflection Factor Accuracy	Within 3% of indicated deflection.	With GAIN set at 5 mV/DIV.
Bandwidth -15° C to +40°C	DC to 200 MHz.	CH 1 and CH 2 at all deflection factors, from a 50 $\Omega$ terminated source.
+40°C to +55°C	DC to 175 MHz.	
Risetime -15°C to +40°C	1.75 ns or less (Calculated) <sup>1</sup> .	
+40°C to +55°C	2.0 ns or less (Calculated) <sup>1</sup> .	
AC Coupled Lower 3 dB point	10 Hz or less with 1X probe	1 Hz or less with 10X probe.
Bandwidth with 100 or 20 MHz BW Switch in 20 MHz Position	Approximately 20 MHz	-3 dB point between 15 MHz and 20 MHz.
Bandwidth with 100 or 20 MHz BW Switch in 100 MHz Position	Approximately 100 MHz	3 dB point between 75 MHz and 125 MHz.
Input Resistance and Capacitance	1 M $\Omega$ within 2% paralleled by approximately 20 PF	

<sup>1</sup>Risetime is calculated from the formula:  $\frac{0.35}{\text{BW (in megahertz)}}$

**TABLE 1-1 (cont)**  
**ELECTRICAL**

Characteristics	Performance Requirements	Supplemental Information
<b>VERTICAL DEFLECTION SYSTEM (cont)</b>		
Step Response  Positive-Going Step Aberrations (0°C to 40°C)  At 5 mV/DIV		+4%, -4%, 4% P-P
Negative-Going Step		Add 3% to positive-going step aberrations.
Added Mode		Add 3% to positive-going step aberrations.
Common-Mode Rejection Ratio (ADD Mode with CH 2 inverted)		20:1 at 1 kHz for common-mode signals of 8 divisions or less.
Trace Shift as VAR is Rotated		Adjusts to 2 divisions or less.
INVERT Trace Shift		Within 1 division from center screen when switching from normal to inverted.
Channel Isolation		At least 100:1 at 50 MHz.
Position Range		At least + 12 and - 12 divisions from graticule center.
Signal Delay Between CH 1 and CH 2		0.25 ns or less at 5 mV/DIV
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.	
Chopped Mode Repetition Rate	Approximately 1 MHz.	20%, +30%

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
<b>TRIGGER SYSTEM</b>		
Sensitivity  DC Coupled	0.3 div internal or 50 mV external from DC to 40 MHz, increasing to 1.5 div internal or 250 mV external at 200 MHz.	
AC Coupled	0.3 div internal or 50 mV external from 60 Hz to 40 MHz, increasing to 1.5 div internal or 250 mV external at 200 MHz. Attenuates signals below about 60 Hz.	
HF REJ Coupled	0.5 div internal or 100 mV external from 60 Hz to 50 kHz. Attenuates signals below about 60 Hz and above about 50 kHz.	
LF REJ Coupled	0.5 div internal or 100 mV external from 50 kHz to 40 MHz, increasing to 1.5 div internal or 500 mV external at 200 MHz. Attenuates signals below about 50 kHz.	
Trigger Jitter	0.2 ns or less at 200 MHz at 1 ns/DIV sweep rate (X10 MAG on).	
External Trigger Input  Maximum Input Voltage	250 V DC + peak AC or 250 V P-P AC (1 kHz or less).	
Input Resistance and Capacitance	1 MΩ within 10%, paralleled by approximately 20 pF	

**TABLE 1-1 (cont)**  
**ELECTRICAL**

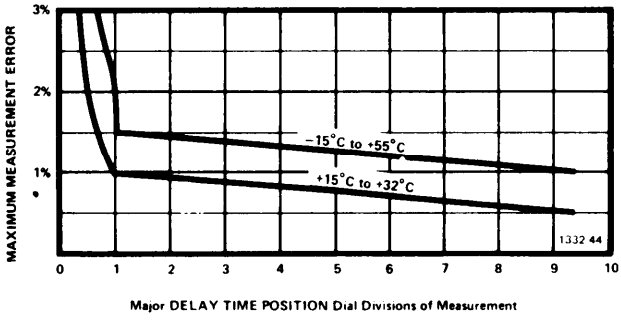
Characteristics	Performance Requirements	Supplemental Information
<b>TRIGGER SYSTEM (cont)</b>		
LEVEL Control Range  EXT	At least + and -2 V, 4 V P-P.	
EXT ÷10	At least + and -20 V, 40 V P-P. Exclude LF REJ coupling mode.	
Trigger View  Deflection Factor	Approximately 50 mV/DIV.	±20%. Exclude LF REJ and HF REJ trigger coupling modes.
Risetime		≤4.0 ns over the 10% to 90% part of the fast-rise portion.
Delay Difference		≤2.5 ns with a 5 division signal having 1 ns or less risetime from a 25 Ω source, centered vertically with equal cable length from signal source to vertical channel and external trigger inputs, each terminated in 50 Ω.
Centering of Trigger Point		Adjustable to within 1.0 division of center screen.
<b>Horizontal DEFLECTION SYSTEM</b>		
Calibrated Sweep Range  A Sweep or B DLY'D Sweep	0.5 s/DIV to 0.01 μs/DIV in 24 steps; 1-2-5 sequence. X10 MAG extends maximum sweep rate to 1 ns/DIV.	
A Delaying Sweep (or A INTEN)	0.5 s/DIV to 0.05 μs/DIV in 22 steps; 1-2-5 sequence.	

TABLE 1-1 (cont)  
ELECTRICAL

Characteristics	Performance Requirements		Supplemental Information
<b>HORIZONTAL DEFLECTION SYSTEM (cont)</b>			
Calibrated Sweep Accuracy  + 20°C to +30°C  A or B DLY'D Sweep	UNMAGNIFIED	MAGNIFIED	Accuracy specification applies over the full 10 divisions of deflection unless otherwise specified.  For all sweeps; exclude the first 25 ns when checking 0.01 and 0.02 $\mu\text{s}/\text{div}$ unmagnified sweep rates.
5 ms/DIV to 0.01 $\mu\text{s}/\text{DIV}$	$\pm 1\%$	$\pm 2\%$	For all sweeps except B; exclude the first 25 ns or 2 unblanked div (whichever is greater) and all beyond the 100th division of the sweep when checking magnified sweep rates. For B sweep; exclude the first 25 ns or 5 unblanked div (whichever is greater) and all beyond the 100th division of the sweep when checking B magnified sweep rates.
.5 s/DIV to 10 ms/DIV	$\pm 2\%$	$\pm 3\%$	
A INTEN Sweeps (or A Delaying)			
0.5 s/DIV to 0.05 $\mu\text{s}/\text{DIV}$	$\pm 2\%$	*3%	
-15°C to +55°C  All Sweeps	$\pm 3\%$	$\pm 4\%$	
X10 Magnified Sweep Accuracy	Within 5% over any 2 division interval.		
Mixed Sweep Accuracy	Within 3%		Accuracy applies over 8 divisions of deflection. B sweep must be at least 1 TIME/DIV setting faster than A Sweep on all ranges. When checking A TIME/DIV accuracy, exclude the first 0.5 division after the display start; when checking B TIME/DIV accuracy, exclude the first 0.2 division or 0.1 $\mu\text{s}$ (whichever is greater) after the transition of A to B.
VAR TIME/DIV Control Range	Continuously variable between calibrated settings. Extends the slowest A sweep rate to at least 1.25 seconds per division.		At least 2.5:1.
Sweep Length (A Only)			At least 10.1 divisions.
A Trigger Holdoff	Increases sweep holdoff time to at least 9 times the TIME/DIV switch setting.		



**TABLE 1-1 (cont)**  
**ELECTRICAL**

Characteristics	Performance Requirements		Supplemental Information
<b>HORIZONTAL DEFLECTION SYSTEM (cont)</b>			
Magnified Registration			Within 0.5 division from graticule center at 1 ms/DIV when switching X10 magnifier from on to off.
POSITION Control Range			Start of sweep must position to right of graticule center. End of sweep must position to left of graticule center. Check made at 1 ms/DIV.
Delay Time and Differential Time Measurement Accuracy (simplified)  Over One or More Major Dial Divisions	+15°C to +35°C (+600F to +95°F)	-15°C to +55°C (+5°F to +131°F)	Exclude dial settings of 0.00 thru 0.50 for 0.5 sec through 1 μs/DIV delaying sweep rates. Exclude dial settings of 0.00 thru 1.00 for .5 μs thru .05 μs/DIV delaying sweep rates.
	±1%	±1.5%	
Over Less Than One Major Dial Division	±0.01 Major Dial Division	+0.02 Major Dial Division	
Delay Time and Differential Time Measurement Accuracy (see Fig. 1-2)	 <p style="text-align: right;">EL6UG025</p> <p><b>Fig. 1-2. Detailed Delay Time and Differential Time Measurement accuracy.</b></p>		
Delay Pickoff Jitter	Within 0.002% (less than one part in 50,000) of the maximum available delay time when operating the instrument on power line frequencies above 52 Hz, decreasing to 0.005% (less than one part in 20,000) on power line frequencies of 48 to 52 Hz		
Delay Range	From 0.05 μs or less to at least 5 seconds after the start of the delaying (A) sweep.  Maximum available delay time is ten times the setting of the A TIME/DIV switch.		

**TABLE 1-1 (cont)**  
**ELECTRICAL**

<b>Characteristics</b>	<b>Performance Requirements</b>	<b>Supplemental Information</b>
<b>X-Y OPERATION</b>		
Sensitivity	Same as vertical deflection system.	Extreme counterclockwise position of TIME/DIV switch. CH 2 OR X-Y button of VERT MODE switch must be pushed
Deflection Accuracy	Same as vertical deflection system.	
Variable Range	Same as vertical deflection system.	
X-Axis Bandwidth	DC to 3 MHz.	
Input Capacitance	Same as vertical deflection system.	
Input Resistance	Same as vertical deflection system.	
Maximum Input Voltage	Same as vertical deflection system.	
Phase Difference Between X and Y Axis Amplifiers		Within 1° from DC to 1 MHz. Within 3° from 1 MHz to 2 MHz.
X Axis Low Frequency Linearity		0.2 div or less compression or expansion of a 2 div signal at center screen, positioned to horizontal extremes of display area.
<b>CALIBRATOR</b>		
Output Voltage		<b>Adjusted to within 0.5% at 25°C, ±5°C</b>
0°C to +40°C	300 mV within 1.0%.	
-15°C to +55°C		300 mV within 1.5%.
Repetition Rate	Approximately 1 kHz.	Within 25%.
Output Resistance		Approximately 9.4 Ω.
Output Current		
+20°C to +30°C	30 mA within 2%	
-15°C to +55°C		30 mA within 2.5%
<b>Z AXIS INPUT</b>		
Sensitivity	5 V P-P signal causes noticeable modulation at normal intensity.	Positive-going signal from ground decreases intensity.
Useable Frequency Range	DC to 50 MHz.	
Maximum Input Voltage		100 V (DC plus peak AC). 100 V P-P AC at 1 kHz or less.

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
<b>SIGNAL OUTPUTS</b>		
CH 2 VERT SIGNAL OUT	One division of deflection gives approximately 20 mV into 1 M $\Omega$ load.	
Output Voltage	One division of deflection gives approximately 10 mV into 50 $\Omega$ load.	
Output Resistance		Approximately 50 $\Omega$ .
Bandwidth	DC to at least 50 MHz into 50 $\Omega$ .	
Output DC Level	Approximately 0 V.	
A and B + GATE Outputs		
Output Voltage	Approximately 5 V positive-going.	
Output Resistance		Approximately 500 $\Omega$ .

POWER SOURCE

Line Voltage Ranges (AC, RMS)		
115V		
Low	110 V, $\pm 10\%$ .	99 V to 121 V.
Medium	115 V, $\pm 10\%$ .	103.5 V to 126.5 V.
High	120 v, $\pm 10\%$ .	108 V to 132 V.
230 V		
Low	220 V, $\pm 10\%$ .	198 V to 242 V.
Medium	230 V, $\pm 10\%$ .	207 V to 253 V.
High	240 V, $\pm 10\%$ .	216 V to 264 V.
Direct Current (option 07)	12 vdc 24 vdc	11.5 vdc to 14 vdc 22 vdc to 28 vdc
Line Frequency	48 Hz to 440 Hz.	
Maximum Power Consumption	100 watts at 115 V, 60 Hz.	

TABLE 1-1 (cont)  
ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
<b>CATHODE-RAY TUBE</b>		
Horizontal Resolution		At least 15 lines/division
Vertical Resolution		At least 15 lines/division.
Display Area	8 x 10 cm.	
Geometry		0.1 division or less of tilt or bowing.
Raster Distortion		0.1 division or less.
Normal Accelerating Potential		Approximately 18,000 V.
Trace Rotation Range		Adequate to align trace with horizontal center line.
Standard Phosphor	P31.	
Optional Phosphor	P11.	

**TABLE 1-2**  
**ENVIRONMENTAL**

Characteristics	Performance Requirements	Supplemental Information
Temperature		
Operating (AC)	-15°C to +55°C.	
Storage	-55°C to +75°C.	
Altitude		
Operating	To 15,000 feet. Maximum operating temperature decreased 1°C/1,000 feet above 5,000 feet.	
Storage	To 50,000 feet.	
Humidity (Operating and Storage)	5 cycles (120 hours) referenced to MIL-E-16400F.	
Vibration (Operating)	15 minutes along each of three major axes at a total displacement of 0.025 inch P-P (4 g's at 55 Hz) with frequency varied from 10 Hz-to 55 Hz to 10 Hz in one minute sweeps. After sweep vibration in each axis, hold frequency steady at each major resonance for 3 minutes, or if no such resonances are found, hold at 55 Hz for three minutes.	
Shock (Operating and Non-operating)	30 g's, 1/2 sine, 11 ms duration, 2 shocks per axis each direction for a total of 12 shocks.	
Transportation	Meets the limits of National Safe Transit Committee test procedure 1A with a 30-inch drop.	

**TABLE 1-3**  
**PHYSICAL**

<b>Characteristics</b>	<b>Information</b>
Construction	
Chassis	Aluminum alloy.
Panel	Aluminum alloy with anodized finish.
Cabinet	Blue vinyl-coated aluminum alloy.
Circuit Boards	Glass laminate etched-wiring.
Overall Dimension	
Height	
With Feet and Pouch	7.5 inches (19.1 cm).
Without Pouch	6.2 inches (15.7 cm).
Width	
With Handle	12.9 inches (32.8 cm).
Without Handle	11.5 inches (29.2 cm).
Depth	
Including Panel Cover	18.1 inches (46 cm).
Handle Extended	20.3 inches (51.5 cm).
Weight	
With Panel Cover, Accessories, and Accessory Pouch	25.3 pounds (11.5 kg).
Without Panel Cover, Accessories, and Accessory Pouch.	22.8 pounds (10.3 kg).
Domestic Shipping Weight	32.7 pounds (14.8 kg).
Export Shipping Weight	Approximately 48.0 pounds (21.8 kg).

**Standard Accessories**

Standard accessories supplied with the 475 are listed in the Mechanical Parts List, in this Service manual. For optional accessories available for use with the 475, see the Tektronix, Inc., catalog.

## Installation

The following paragraphs include instructions for unpacking, inspecting, and installing the instrument, and the basic information required to operate the oscilloscope within the design environmental, power, and space limitations. (For more detailed information on specifications, refer to table 1-1.)

**Unpacking.** Unpack the oscilloscope as outlined in the following procedure:

### NOTE

*If storage space is available, it is recommended that all packing material be saved for possible future use. Thus, unpacking should be accomplished carefully so as not to damage the packing material.*

1. Open top of carton and remove styrofoam packing case and accessory box.
2. Open styrofoam packing case and remove the oscilloscope.
3. Open accessory box and remove accessories.
4. Remove oscilloscope from polyethylene bag.
5. Place styrofoam packing case and accessory box inside carton. Store carton in dry place.

### Checking Unpacked Equipment. Check the oscilloscope after unpacking.

1. Inspect the equipment for damage incurred during shipment. If the equipment has been damaged, report the damage on SF 364.
2. Check the equipment against the component listing in the operator's manual and on the packing slip to see if the shipment is complete. Report all discrepancies in accordance with the instructions of DA Pam 738-750. The equipment should be placed in service even though a minor assembly or part that does not affect proper functioning is missing.
3. Check to see whether the equipment has been modified. (Equipment which has been modified will have the MWO number on the front panel, near the nomenclature plate.) Check also to see whether all currently applicable MWO's have been applied. (Current MWO's applicable to the equipment are listed in DA Pam 310-1.)

**Environmental Requirements.** The following paragraphs describe the environmental operating conditions for the oscilloscope.

The oscilloscope can be operated where the ambient air temperature is in the range of -28° C to +65° C, and can be stored where the temperature range is -62° C to +75° C. After storage at temperatures outside of the operating ranges, allow the chassis temperature to stabilize within the operating limits before applying power.

Oscilloscope cooling is provided by a fan drawing air through the cabinet. Components that require the most cooling are either mounted externally at the rear of the cabinet on a heat radiator or are provided with individual heatsinks. Clearance must be provided on all sides for air flow. Do not block or restrict air flow through any holes in the cabinet by placing objects on or against the oscilloscope.

A thermal cutout in the oscilloscope provides protection by interrupting power to the unit if the internal temperature exceeds a safe operating level. Power is automatically restored when the temperature returns to a safe level. Operation in confined areas or near heat-producing equipment may cause the thermal cutout to actuate.

The normal operating position of the oscilloscope is horizontal, setting on a flat surface, on the 4 feet provided on the bottom surface. However, under difficult operating conditions (such as limited space), the oscilloscope may be used in other positions without impairment of the electrical characteristics, including setting the cabinet on the six protective bumpers on the rear surface. It is important to remember that, in positions other than the normal horizontal position, characteristics such as cooling and resistance to shock and vibration are altered. therefore, operation in other than the normal position should be for short periods only and with more than normal care exercised to protect the oscilloscope from damage.

**Power Requirements.** The oscilloscope is designed to be operated from either a 115-volt nominal or 230-volt nominal line voltage source. In addition, one of three operating ranges may be selected around each nominal line voltage. The voltage selector jumper on the rear panel (figure 2-1) allows selection of the operating voltage. With option 07 installed, the oscilloscope may be operated from either a 12 vdc or 24 vdc power source.

**Space Requirements.** The oscilloscope is provided with feet on the bottom surface to provide space for cooling air flow. Maintain this clearance by always setting all four feet solidly on a flat surface. In addition, always maintain at least 2 inches of clearance at both sides, top, and rear of the unit.





# OPERATING INFORMATION

## PRELIMINARY INSTRUCTIONS

### Introduction

This section of the manual is intended to allow the operator to become familiar with the instrument's power requirements, functions of controls and connectors, and how to obtain a few basic displays.

### Safety Information

#### WARNING

*This instrument may be damaged if operated with the Line Voltage Selector Switch or the Regulating Range Selector set for the wrong applied line voltage. Please read the following instructions before operating to be sure that the requirements for instrument power and user safety are met.*

#### Power Cord Conductor Identification

Conductor	Color	Alternate Color
Ungrounded (Line)	Brown	Black
Grounded (Neutral)	Blue	White
Grounding (Earthing)	Green-Yellow	Green-Yellow

This 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 3-wire system) is not recommended, since only the line conductor has over-current (fuse) protection within the instrument.

This instrument has a 3-wire power cord with a 3-terminal polarized plug for connection to the power source and safety-earth. The ground terminal of the plug is directly connected to the instrument frame. For electric-shock protection, insert this plug in a mating outlet with a safety-earth contact. If a 3-to-2 wire adapter is used to connect this instrument to a 2-wire ac power system, be sure to connect the ground lead of the adapter to earth (ground). Failure to complete the ground system may allow the chassis of this instrument to be elevated above ground potential and pose a shock hazard.

### Operating Power Sources

This instrument can be operated from either a 115 volt or 230 volt nominal line voltage source, 48 to 440 Hertz. The Line Voltage Selector switch in the instrument converts the instrument from a one nominal operating voltage to the other. The Regulating Range Selector assembly on the instrument rear panel selects 1 of 3 regulating ranges for each nominal line voltage, and also contains the line fuse for overload protection. The instrument can also be operated from a 12 vdc or 24 vdc power source.

#### Line Voltage and Regulating Range

To select the correct nominal line voltage, regulating range and line fuse, proceed as follows:

1. Disconnect the instrument from the power source.
2. Set the Line Voltage Selector switch (located near the right rear of instrument) to indicate the desired nominal line voltage.
3. Loosen the 2 captive screws that hold the cover on the Regulating Range Selector assembly; then pull on the cover to remove.
4. Check Table 2-1 for the recommended rating of the line fuse to be used with the desired nominal line voltage. Check the fuse in the selector switch cover for the recommended rating or install a fuse with the recommended rating. The instrument Accessory Pouch should contain a spare fuse for each nominal line voltage at anytime.

**TABLE 2-1**  
**Regulating Ranges**

Range Selector Switch Position	Regulating Range	
	115 Volts Nominal	230 Volts Nominal
LO (Switch bar in lower holes)	99 to 121 volts	198 to 242 volts
M (Switch bar in middle holes)	103.5 to 126.5 V	207 to 253 V
HI (Switch bar in upper holes)	108 to 132 volts	216 to 264 volts
Fuse Rating	1.5 A 3AG Fast-blow	6.75 A 3AG Fast-blow

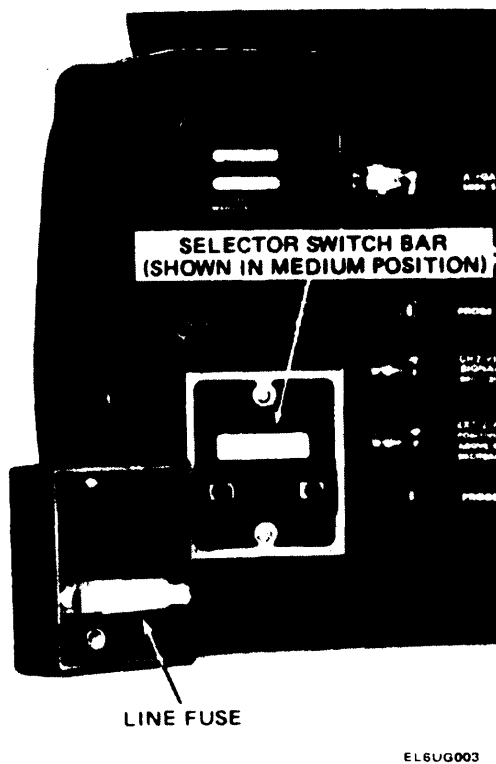


Fig. 2-1. Regulating Range Selector and Line Fuse.

5. Check Table 2-1 for the recommended range position of the Range Selector Switch Bar (see Figure 2-1). Select a range which is centered about the average line voltage to which the instrument is to be connected. The middle position ("M") is a typical setting.

6. If necessary, gently pull out the Range Selector Switch Bar, slide the bar to the desired position and plug it back in.

7. Install the cover on the Regulating Range Selector assembly and gently tighten the 2 captive screws.

8. Connect the instrument to the recommended power source, pull the instrument POWER switch to ON and begin usage of the 475 Oscilloscope.

**Options**

Options are available to alter oscilloscope performance to meet particular applications. A number in either MOD slot (see instrument rear panel) indicates that the instrument contains an option.

Refer to the Option section in this manual to find any change in operating instructions as a result of the option.

**CONTROLS AND CONNECTORS**

**General**

The major controls and connectors for operation of the 475 are located on the front panel of the instrument. A few auxiliary functions are provided on the rear panel. Fig. 2-2 shows the front and rear panels of the 475. A brief description of each control and connector is given here. More detailed operating information is given in the 475 Oscilloscope Operators Manual.

**Cathode-Ray Tube (CRT) and Display**

BEAM FINDER	Limits the display to within the graticule area, independently of display position or applied signals and sets the display brightness to a normal viewing level.
INTENSITY	Controls brightness of the display.
FOCUS	Provides adjustment for optimum display definition.
SCALE ILLUM	Controls graticule brightness.
ASTIG	Screwdriver adjustment used in conjunction with the FOCUS control to obtain a well-defined display. Does not require readjustment in normal use.
TRACE ROTATION	Screwdriver adjustment to align the trace with the horizontal graticule lines.
<b>Vertical Deflection System (Channel 1 &amp; Channel 2)</b>	
POSITION	Controls the vertical position of the trace. In the X-Y mode of operation, the CH 2 control positions on the Y-axis (vertically) and the CH 1 POSITION control positions on the X-axis (horizontally).
CH1 OR X	Input connector for Channel 1 deflection signals or X-axis deflection in the X-Y mode of operation.

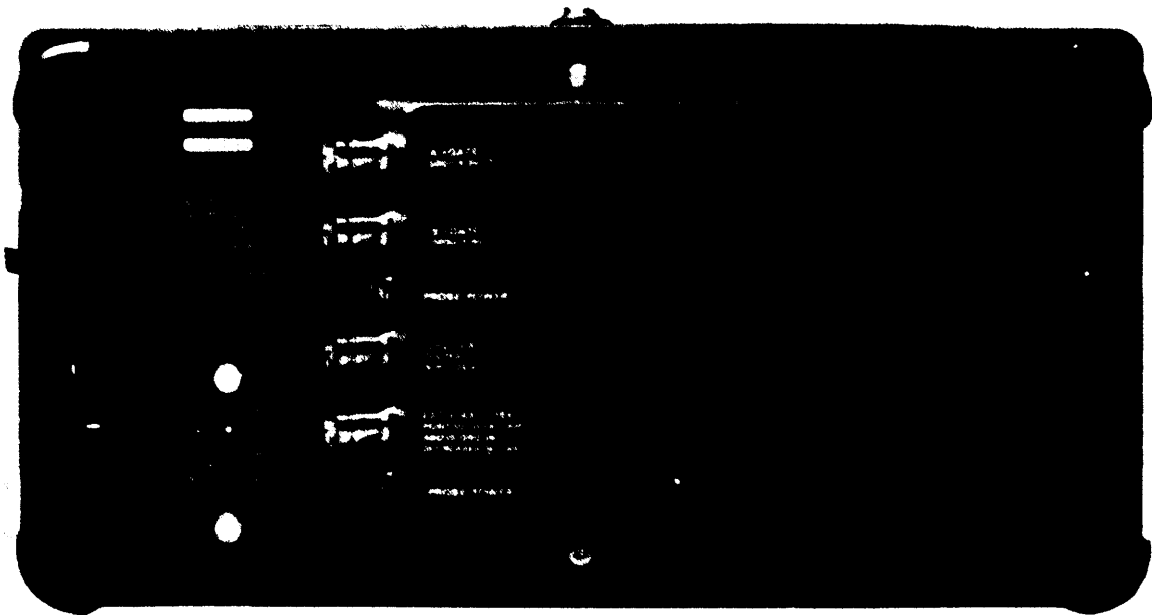
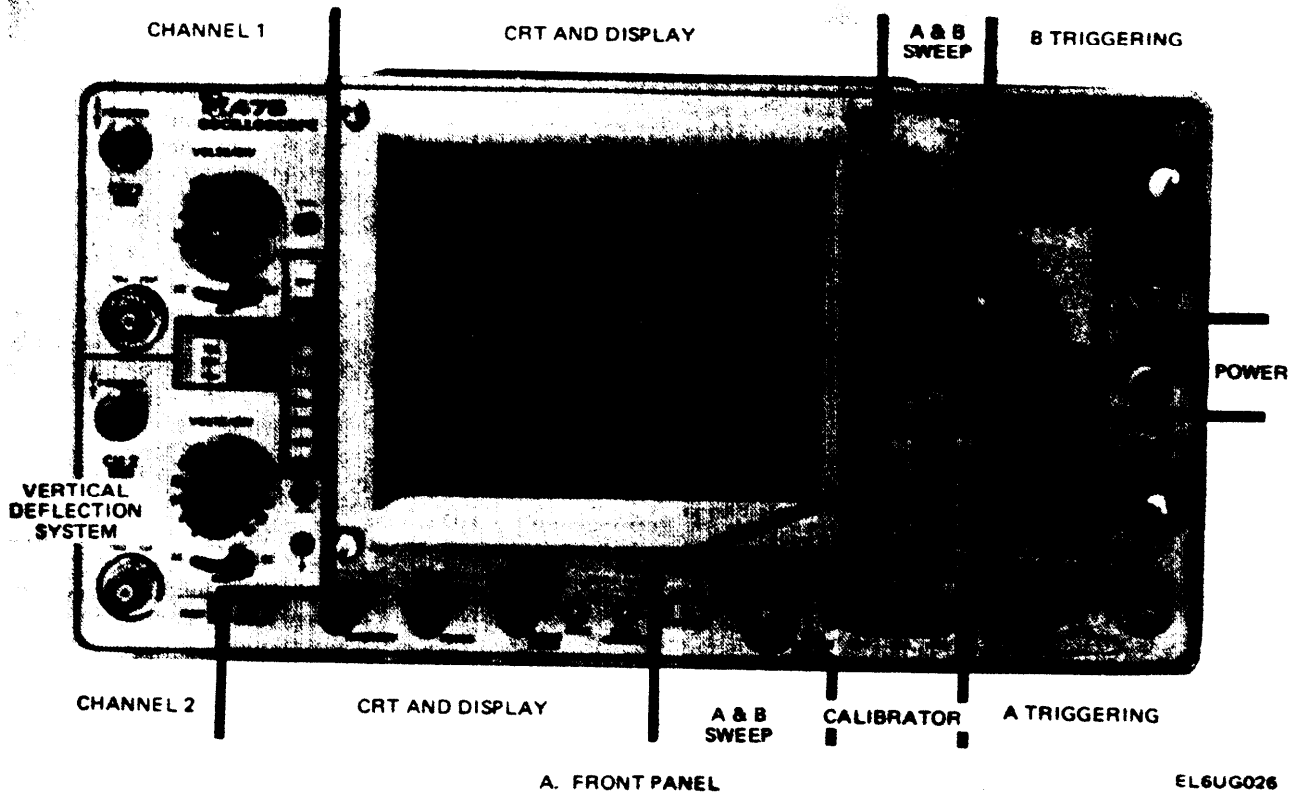


Fig. 2-2. Front panel and rear panel controls and connectors.

CH 2 OR Y	Input connector for Channel 2 deflection signals or Y-axis deflection in the X-Y mode of operation.	100 (MHz): When TRIG VIEW button is pulled to the first detent (100 indicated on yellow band of TRIG VIEW knob) the upper bandwidth of the complete Vertical Deflection System is limited to approximately 100 MHz.
GAIN (2 and 5 mV)	Screwdriver adjustments to set the gain of the Vertical Preamp.	
VOLTS/DIV	Selects vertical deflection factor in a 1-2-5 sequence (VAR control must be in the calibrated detent for the indicated deflection factor).	20 (MHz): When TRIG VIEW button is pulled to the second detent (100 and 20 indicated on yellow band of TRIG VIEW knob) the upper bandwidth of the complete Vertical Deflection System is limited to approximately 20 MHz.
VAR	Provides continuously variable uncalibrated deflection factors between the calibrated settings of the VOLTS/DIV switch.	
UNCAL	Light indicates that the VAR control is not in the calibrated position.	TRIG VIEW: When the TRIG VIEW button is pushed and held, the output of the Vertical Preamplifier is interrupted, and the trigger signal selected by the setting of A TRIGGER SOURCE switch is displayed on the crt.
Input coupling (AC-GND-DC)	<p>Selects the method of coupling signal to the input of the Vertical Amplifier.</p> <p>AC: Signal is capacitively coupled to the Vertical Amplifier. DC component of signal is blocked. Low-frequency limit (lower -3 dB point) is about 10 Hertz.</p> <p>GND: Input signal is removed and the input circuit is grounded. Does not ground the input signal.</p> <p>DC: All components of the input signal are passed to the Vertical Amplifier.</p>	<p>When the TRIG VIEW button is pushed and held, the crt display available is explained in each of the following settings of the A TRIGGER SOURCE switch.</p> <p style="text-align: center;"><i>NOTE</i></p> <p><i>The signals displayed are affected by the coupling characteristics of the A TRIGGER COUPLING switch positions (see A Trigger Coupling information in this section).</i></p> <p><i>The A TRIGGER LEVEL control affects the triggering and the vertical positioning when using a TRIG VIEW display.</i></p>
100 OR 20 MHz BW/ TRIG VIEW	Multi-purpose switch that limits vertical bandwidth or displays an external triggering signal. Full bandwidth of 200 MHz is provided in the switch position obtained when the TRIG VIEW is pushed in, then released. The full bandwidth position serves as the reference for the following settings.	<p>NORM: Any signal that is displayed in full bandwidth position is viewed with an increase in signal amplitude.</p> <p>CH 1: Any signal that is displayed in CH 1 of VERT MODE, in full bandwidth position, is viewed with an increase in signal amplitude.</p>

CH 2: Any signal that is displayed in CH 2 of VERT MODE, in full bandwidth position, is viewed with an increase in signal amplitude.

CH 2 OR X-Y: Displays Channel 2 only. Must be pushed when operating in X-Y mode.

LINE: The power line signal is displayed at an amplitude approximately equalling full vertical graticule deflection.

**A and B Triggering (both where applicable)**

**COUPLING**

Determines the method used to couple signal to input of trigger circuits.

EXT: The signal present at the A TRIGGER external input connector will be displayed.

AC: Rejects DC and attenuates signals below about 60 Hz. Accepts signals above about 60 Hz.

EXT ÷ 10: The signal present at the A TRIGGER external input connector will be displayed, but will be reduced approximately 10 times of that viewed in EXT.

LF REJ: Rejects DC and attenuates signals below about 50 kHz. Accepts signals above about 50 kHz.

**INVERT**

Pushbutton switch that inverts the Channel 2 display.

HF REJ: Accepts signals between 60 Hz and 50 kHz. Rejects DC and attenuates all signals outside the above range.

**VERT MODE**

Selects the vertical mode of operation.

DC: Accepts all trigger signals between DC and 200 MHz or greater.

CH 1: Displays Channel 1 only.

**SOURCE**

Selects source of trigger signal.

ALT: Dual-trace display of signals using both channels. Display is switched between channels at the end of each sweep.

NORM: Internal trigger signal obtained from Vertical Deflection System. Actual source is signal(s) displayed on crt.

ADD: Signals applied to the CH 1 OR X and the CH 2 OR Y connectors are algebraically added and the sum is displayed on the crt. The INVERT switch in Channel 2 allows the display to be CH 1 + CH 2 or CH 1 – CH 2.

CH 1: A sample of the signal connected to the CH 1 OR X input connector is used as a trigger signal.

CHOP: Dual-trace display of signals on both channels. Display is switched between channels at an approximate repetition rate of 1 megahertz.

CH 2: A sample of the signal connected to the CH 2 OR Y input connector is used as a trigger signal.

EXT: Trigger signal obtained from signal connected to the External Trigger Input connector.

EXT  $\div 10$  (A Trigger circuit only): External trigger signal attenuated by a factor of 10.

STARTS AFTER DELAY (B trigger circuit only): B sweep starts immediately after the delay time selected by the DELAY TIME POSITION dial and the DELAY TIME switch.

LINE (A trigger circuit only): Trigger signal obtained from a sample of the line voltage applied to the instrument.

NORM: With the proper trigger control settings, A Sweep can be initiated by signals that are within the frequency range selected by the COUPLING switch. In the absence of an adequate trigger signal or when the trigger controls are misadjusted, there is no trace.

SINGL SWP: After a sweep is displayed, further sweeps cannot be presented until the SINGL SWP pushbutton is pressed again. The display is triggered as for NORM operation using the A Triggering controls.

SLOPE

Selects the slope of the trigger signal which starts the sweep.

+: Sweep can be triggered from the positive-going portion of the trigger signal.

-: Sweep can be triggered from the negative-going portion of the trigger signal.

TRIG Indicator

A light on condition indicates that A Sweep Generator is triggered and will produce a stable display.

A TRIG HOLDOFF

Provides control of holdoff time between sweeps to obtain stable displays when triggering in aperiodic signals (such as complex digital words). Variable can increase hold-off time up to at least 9 times the setting of the TIME/DIV switch. In the B ENDS A position (fully clockwise), the A Sweep is reset at the end of the B Sweep to provide the fastest possible sweep repetition rate for delayed sweep presentations.

LEVEL

Selects the amplitude point on the trigger signal at which the sweep is triggered.

A TRIG MODE

Determines the operating mode for the A Trigger Circuit.

AUTO: With the proper trigger control settings, A Sweep can be initiated by signals that have repetition rates above about 20 Hertz and are within the frequency range selected by the COUPLING switch. In the absence of an adequate trigger signal or when the trigger controls are misadjusted, the sweep free-runs to produce a reference trace.

External Trigger Input (not labeled)

Input connectors for external trigger signals.

**A and B Sweep**

DELAY TIME POSITION

Provides variable sweep delay between 0.00 and 10.00 times the delay time indicated by the DELAY TIME switch.

A AND B TIME/DIV AND DELAY TIME	A TIME/DIV switch (clear plastic outer flange) selects the basic delay time to be multiplied by the DELAY TIME POSITION dial setting) for delayed-sweep operation. The B TIME/DIV switch (inner dark knob) selects the sweep rate for A only displays or for the B portion of a delayed sweep display. VAR control must be in the calibrated detent for calibrated sweep rates. Disables sweep for X-Y operation.	MIX: The first part of the horizontal sweep is displayed at a rate set by the A TIME/DIV switch and the latter part of the sweep at a rate set by the B TIME/DIV switch. Relative amounts of the display allocated to each of the two rates are determined by the setting of the DELAY TIME POSITION dial.
VAR	Provides continuously variable (uncalibrated) sweep rates between the calibrated settings of the TIME/DIV switch. Varies the A Time Base sweep rate in the nondelayed mode of horizontal operation and the B Time Base sweep rate in the delayed sweep mode. Extends the slowest sweep rate to at least 1.25 seconds/division. Sweep rate is calibrated when the control is rotated fully clockwise to the calibrated detent.	A INTEN: Displayed sweep rate determined by the A TIME/DIV switch. An intensified portion appears on the display during the B sweep time. This switch position provides a check of the duration and position of the B sweep (delayed sweep) with respect to the delaying sweep (A).
UNCAL	Light that indicates when the VAR TIME/DIV control is out of the calibrated detent and the horizontal sweep rate is uncalibrated.	Horizontal POSITION Positions the display horizontally.  Horizontal FINE Provides more precise horizontal position adjustments.
X10 MAG Indicator	Light that indicates when the X10 MAG is turned on.	X10 MAG Pushbutton Increases the displayed sweep rate by a factor of 10.
READY	Light that indicates that A Sweep has been prepared to present a single sweep upon receipt of an adequate trigger signal.	<b>Calibrator and Power</b> CALIBRATOR A combination current loop/squarewave voltage output device. Provides a 30 mA squarewave current, 300 mV squarewave voltage signal with a repetition rate of approximately 1 kHz.
HORIZ DISPLAY	Selects the horizontal mode of operation.	POWER Turns instrument power on and off.
	A: Horizontal deflection provided by A TIME/DIV switch.	

LOW LINE Indicator Light that indicates the applied line voltage is below the lower limit of the regulating range selected by the Regulating Range Selector assembly.

**Rear Panel**

A + GATE Output connector providing a positive-going rectangular pulse coincident with the A sweep time.

B + GATE Output connector providing a positive-going rectangular pulse coincident with the B sweep time.

CH 2 VERT SIGNAL OUT Output connector providing a sample of the signal applied to the CH 2 input connector.

EXT Z AXIS Input Input connector for intensity modulation of the crt display.

Regulating Range Selector Selects the regulating range of the internal power supplies (low, medium, high; determined by specific line voltage applied to the instrument).

PROBE POWER Connectors that make operating power available for active device probe systems.

Rear Panel Feet Provide temporary support for the instrument and provide a convenient cord wrap to store power cord when instrument is not in use.

**OBTAINING BASIC DISPLAYS**

**Introduction**

The following instructions will allow the operator who is unfamiliar with the operation of the 475 to obtain the basic displays commonly used. Before proceeding with these instructions, preset the instrument controls as follows:

Vertical Controls

VERT MODE Switch CH 1  
 VOLTS/DIV Switches Proper position determined by amplitude of signal to be applied.  
 VOLTS/DIV VAR Controls Calibrated detent.  
 Input Coupling Switches AC  
 Vertical POSITION Controls Midrange  
 100 or 20 MHz BW Switch Not limited (Yellow band not visible).  
 INVERT Switch Button out  
 INTENSITY Control Fully counterclockwise  
 FOCUS Control Midrange  
 SCALE ILLUM Control Midrange

Trigger Controls (both A and B if applicable)

SLOPE Switch +  
 LEVEL Control 0  
 SOURCE Switch NORM  
 COUPLING Switch AC  
 TRIG MODE Switch AUTO  
 A TRIG HOLDOFF Control NORM

Horizontal Sweep Controls

TIME/DIV Switches Locked together at 1 ms  
 TIME/DIV VAR Calibrated detent  
 HORIZ DISPLAY Switch A  
 X10 MAG Switch Off (button out)  
 POSITION Control Midrange  
 FINE Control Midrange

**Normal Sweep Display**

1. Pull the POWER switch to on (button out). Allow several minutes for instrument warmup.
2. Connect an external signal to the CH 1 input connector.



3. Advance the INTENSITY control until the display is visible. If the display is not visible with the INTENSITY control at midrange, press the BEAM FINDER pushbutton and adjust the CH 1 VOLTS/DIV switch until the display is reduced in size vertically; then center the compressed display with the vertical and horizontal POSITION controls; release the BEAM FINDER pushbutton. Adjust the FOCUS control for a well-defined display.

4. Set the CH 1 VOLTS/DIV switch and CH 1 POSITION control for a display that remains in the display area vertically.

5. Adjust the A Trigger LEVEL control for a stable display.

6. Set the TIME/DIV switch and the horizontal POSITION control for a display that remains in the display area horizontally.

### Magnified Sweep Display

1. Preset the instrument controls and follow steps 1 through 6 for obtaining a Normal Sweep Display.

2. Adjust the horizontal POSITION control to move the area to be magnified to within the center graticule division of the crt. If necessary, change the TIME/DIV switch setting so the complete area to be magnified is within the center division.

3. Set the X10 MAG switch to the on position (button in) and adjust the horizontal POSITION control for precise positioning of the magnified display. Divide the TIME/DIV setting by 10 to determine the magnified sweep rate.

### Delayed Sweep Displays

1. Preset the instrument controls and follow steps 1 through 6 for obtaining a Normal Sweep Display.

2. Set the HORIZ DISPLAY switch to A INTEN and the B Trigger SOURCE switch to STARTS AFTER DELAY.

3. Pull out the B TIME/DIV switch knob and turn clockwise so the intensified zone on the display is the desired length. Adjust the INTENSITY control to achieve the desired display brightness.

4. Adjust the DELAY TIME POSITION dial to position the intensified zone to the portion of the display to be delayed.

5. Set the HORIZ DISPLAY switch to B DLYD. The intensified zone on the display noted in step 3 is now being displayed in delay form. The delayed sweep rate is indicated by the line on the B TIME/DIV switch knob.

6. For a delayed sweep display that will exhibit less jitter, set the B Trigger SOURCE switch to the same position as the A Trigger SOURCE switch and adjust the B Trigger LEVEL control for a stable display. If the A Trigger SOURCE switch is in the LINE position, a sample of the line voltage will have to be supplied to the B Trigger circuit externally.

### Mixed Sweep Display

1. Preset the instrument controls and follow steps 1 through 6 for obtaining a Normal Sweep Display.

2. Pull out the B TIME/DIV switch knob and turn clockwise to the desired sweep rate. Adjust the INTENSITY control to achieve the desired display brightness.

3. Set the HORIZ DISPLAY switch to MIX. The crt display now contains more than one time factor on the horizontal axis. The first portion of the display is at the A Time Base sweep rate and the latter part is at the B Time Base sweep rate. The start of the B Time Base portion of the display can be changed by adjusting the DELAY TIME POSITION control.

### X-Y Display

1. Preset the instrument controls and turn the instrument power on. Allow several minutes for instrument warm-up.

2. Set the TIME/DIV switch to X-Y and the VERT MODE to CH 2. Apply the vertical signal to the CH 2 OR Y input connector and the horizontal signal to the CH 1 OR X input connector. The CH 2 POSITION control will provide vertical positioning and the CH 1 POSITION control will provide horizontal positioning.

3. Advance the INTENSITY control until the display is visible. If the display is not visible with the INTENSITY control at midrange, press the BEAM FINDER push button and adjust the CH 1 and CH 2 VOLT/DIV switches until the display is reduced in size both vertically and horizontally; then center the compressed display with the POSITION controls; release the BEAM FINDER pushbutton. Adjust the FOCUS control for a well-defined display.



# CIRCUIT DESCRIPTION

## Introduction

This section of the manual describes the circuitry used in the 475 Oscilloscope. The description begins with a discussion of the instrument, using a basic block diagram. Next, each circuit is described in detail, using detailed block diagrams when appropriate, to show the relationships between the stages in each major circuit.

## Digital Logic

Digital logic techniques are used to perform many functions within this instrument. The function and operation of the logic circuits are described using logic symbology and terminology. All logic functions are described using the positive logic convention. Positive logic is a system of notation where the more positive of two levels (HI) is called the true or 1 state; the more negative level (LO) is called the false or 0 state. The HI-LO method of notation is used in this logic description. The specific voltages that constitute a HI or LO state vary between individual devices.

### NOTE

*The HI-LO logic notation can be conveniently converted to 1-0 notation by disregarding the first letter of each step. Thus:*

$$\begin{aligned} HI &= 1 \\ LO &= 0 \end{aligned}$$

It should be noted that not all of the integrated circuit devices in this instrument are digital logic devices. The function of non-digital devices are described individually, using operating waveforms or other techniques to illustrate their function.

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**BLOCK DIAGRAM**

**General**

The following discussion is provided to aid in understanding the overall concept of the 475 Oscilloscope before the individual circuits are discussed in detail. A basic block diagram of the 475 Oscilloscope is shown in Fig. 3-1. Only the basic interconnections between the individual blocks are shown on this diagram. Each block represents a major circuit within the instrument. The numbered diamond in each block refers to the complete circuit diagram of that major circuit and this diagram can be found in the Diagrams Section of this manual.

A complete block diagram is located in the Diagrams Section of this manual. This block diagram shows the overall relationship between all of the circuits. Complete schematics of each circuit are also given in the Diagrams Section. Refer to these diagrams throughout the following circuit description for electrical values, waveforms and relationships of the front panel controls to the individual stages.

Signals to be displayed on the CRT are applied to the CH 1 OR X or CH 2 OR Y connectors. The input signals are then amplified by the Preamplifier circuits. Each Preamplifier circuit includes separate vertical deflection factor, input coupling, balance, gain, and variable attenuation controls. The Channel 2 Preamplifier circuit also contains an INVERT feature to invert the Channel 2 signal as displayed on the CRT.

The output of each Vertical Preamplifier circuit connects to the Vertical Channel Switching circuit. This circuit selects the channel(s) to be displayed. An output signal from this circuit connects to the Z Axis Amplifier circuit to blank out the switching transients between channels when in the chopped mode of operation. The Vertical Channel Switching circuit also provides the Channel 2 VERT SIG OUT signal (available on the instrument rear panel) as well as the signals used for sweep triggering in the NORM, CH 1, and CH 2 positions of the trigger SOURCE switches and the signal used for X-axis deflection in the X-Y mode of horizontal operation.

The output of the Vertical Channel Switching circuit connects to the Vertical Output Amplifier through the Delay Line. The Delay Line provides a fixed amount of signal delay through the vertical deflection system to allow viewing the leading edge of a triggering waveform. The Vertical Output Amplifier circuit provides the final amplification for the signal before it is connected to the vertical deflection plates of the CRT. This circuit includes the BEAM FINDER switch, which limits the vertical and horizontal deflection to within the viewing area, and sets the display brightness to a normal viewing level to aid in locating an off-screen display.

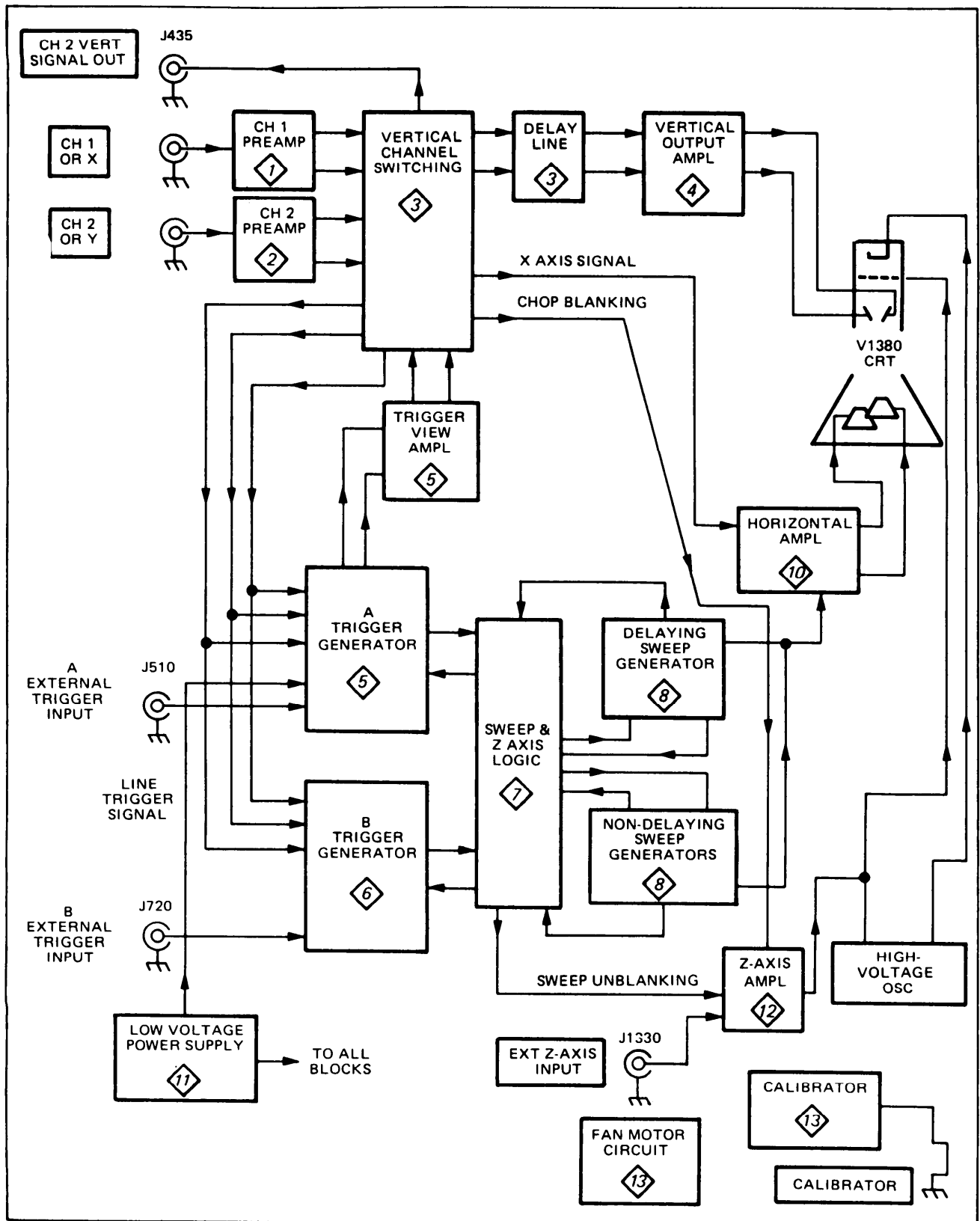


Fig. 3-1. Basic block diagram of the 475.

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The A and B Trigger Generator circuits produce an output pulse that initiates generation of the sawtooth sweep signals produced by the A or B Sweep Generator circuits. The input signal to the Trigger Generator circuits can be individually selected from the Channel 1 signal, Channel 2 signal, the signal(s) displayed on the CRT (NORM), a signal connected to the external trigger input connectors, or a sample of the line voltage applied to the instrument. Each trigger circuit contains separate level, slope, coupling, and source controls.

There are three sweep generator circuits in the 475. For purposes of explanation, they are called Delaying, Slow Non-Delaying, and Fast Non-Delaying. The Delaying Sweep generates a range of sweep rates from 0.5 second to 0.05 microsecond/division. The Slow Non-Delaying Sweep generator provides the 0.5 second through 1 microsecond/division sweep rates and the Fast Non-Delaying Sweep Generator provides the sweep rates of 0.5 through 0.01 microsecond/division.

The Delaying Sweep runs when the instrument is operated in a delayed-sweep mode (MIX, A INTEN or B DLY'D) and is displayed as the A portion of a MIX or A INTEN display. In B DLY'D mode the Delaying Sweep is used to delay the Non-Delaying Sweep, which is displayed on the CRT. The sweep rate for the Delaying-Sweep Generator is selected by the A TIME/DIV switch (skirt knob). One of the Non-Delaying Sweeps (depending on the sweep rate selected) will run and may be displayed in all modes of the HORIZ DISPLAY switch. In the A mode (knobs locked) the Non-Delaying Sweep is displayed as the A Sweep and in the MIX mode, displayed as the B DLY'D Sweep. In the A INTEN mode, the Non-Delaying Sweep is displayed as the intensified portion and in the B DLY'D mode is displayed as the B DLY'D Sweep. The sweep rate for the Non-Delaying Sweep Generator is selected by the B TIME/DIV switch (DLY'D SWEEP knob). It may be helpful to see Table 3-2, found later in this section.

The TRIG MODE switch controls the mode of operation of the sweep generator deriving the A portion of a display. In the AUTO position, the absence of an adequate trigger signal causes the sweep to free run. In the NORM position, a horizontal sweep is presented only when correctly triggered by an adequate trigger signal. Pushing the SINGL SWP pushbutton allows one (and only one) sweep to be presented. The Z Axis Logic circuit produces an unblinking gate signal to unblank the CRT so that the display can be presented. This gate signal is coincident with the sawtooth produced by the sweep generator. The Z Axis Logic Circuit also produces, at the end of each sweep, a gate signal that is supplied to the Vertical Channel Switching circuit. This pulse switches the display between channels at the end of each sweep when the Vertical Deflection System is operating in the ALT mode.

The outputs of the sweep generators are amplified by the Horizontal Amplifier to produce horizontal deflection for the CRT except in the fully counterclockwise (X-Y) position of the TIME/DIV switch. The Horizontal Amplifier contains a 10X magnifier to increase the sweep rate by a factor of 10 in any A or B TIME/DIV switch position. Other horizontal deflection signals can be connected to the Horizontal Amplifier by using the X-Y mode of operation. When the TIME/DIV switch is set to X-Y, the X-axis signal is connected to the Horizontal Amplifier circuit through the Channel 1 Vertical Preamp circuit.

The Z Axis Amplifier circuit determines the CRT intensity and blanking. The Z Axis Amplifier circuit sums the current inputs from the INTENSITY control, the Vertical Channel Switching circuit (chopped blanking), the Z Axis Logic circuit (unblinking), and the external Z AXIS INPUT connector. The output level of the Z Axis Amplifier circuit controls the trace intensity through the CRT circuit. The CRT circuit provides the voltages and contains the controls necessary for operation of the cathode-ray tube.

The Power Supply circuit provides the low voltage power necessary for operation of this instrument. This voltage is distributed to all of the circuits in the instrument.

The Calibrator circuit provides a square-wave output with accurate voltage and current amplitudes, which can be used to check the calibration of the instrument and the compensation of probes. The CALIBRATOR current loop provides an accurate current source for calibration of current measuring probe systems.

## CHANNEL 1 PREAMP

### General

Input signals for vertical deflection on the CRT can be connected to the CH 1 OR X input connector. In the X-Y mode of operation, the input signal connected to the CH 1 OR X connector provides the horizontal (X-axis) deflection (TIME/DIV switch set to X-Y, VERT MODE switch set to CH 2 OR X-Y). The Channel 1 Preamp circuit provides control of input coupling, vertical deflection factor, gain, and DC balance. Fig. 3-2 shows a detailed block diagram of the Channel 1 Preamp circuit. A schematic of this circuit is shown on Diagram 1 at the rear of this manual.

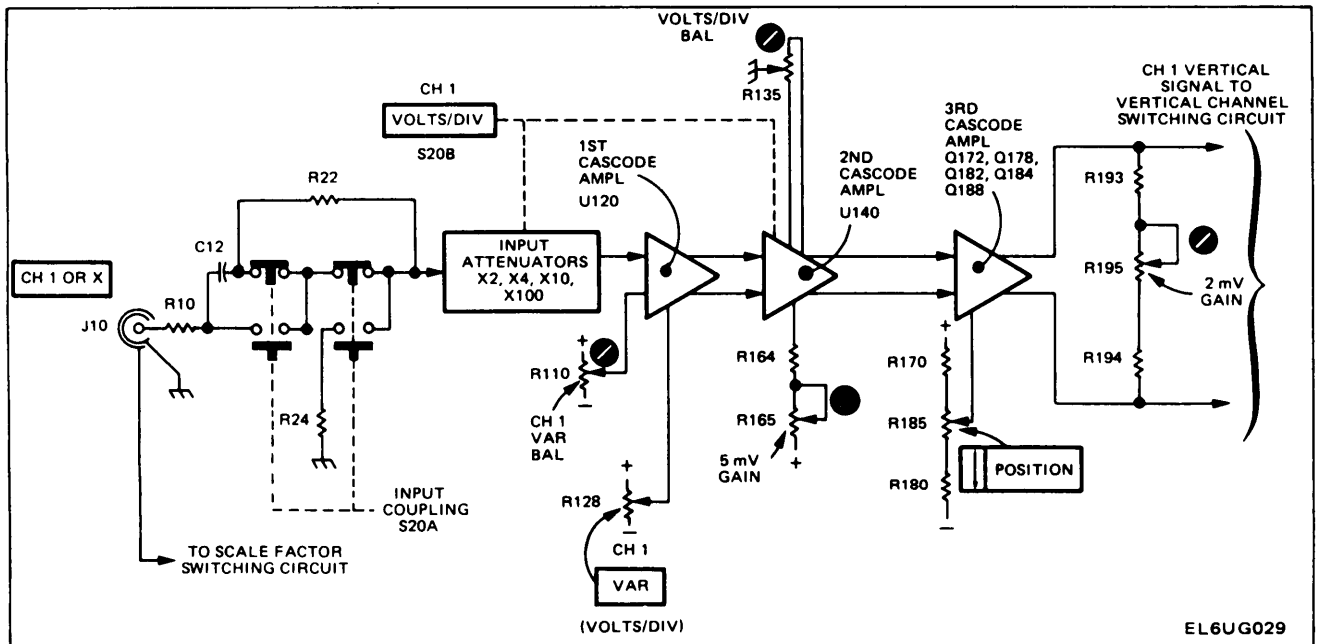


Fig. 3-2. Detailed block diagram of the Channel 1 Vertical Preamp circuit.

**Input Coupling**

Signals applied to the input connector can be AC coupled, DC coupled, or internally disconnected from the input to the Vertical Input Amplifier circuit. When Input Coupling switch S20A is set for DC coupling, the input signal is coupled directly to the Input Attenuator stage. When AC coupled, the input signal passes through capacitor C12. This capacitor prevents the DC component of the signal from passing to the amplifier. In the GND position, S20A opens the signal path and connects the input of the amplifier to ground through R24. This provides a ground reference without the need to disconnect the applied signal from the input connector. Resistor R22, connected across the input coupling switch, allows C12 to be pre-charged in the ground position, which prevents generation of large voltage transients at the input to the amplifier and allows the trace to remain on screen when switched to the AC position.

**Input Attenuator**

The effective overall deflection factor of each channel of the 475 is determined by the appropriate VOLTS/DIV switch setting. The basic deflection factor of the Vertical Deflection System is 5 millivolts/division of CRT deflection. To achieve the deflection factor values indicated on the front panel, precision attenuators are switched into the circuit and, in the 2 mV position, the gain of the Second Cascode Amplifier stage is increased.

For the VOLTS/DIV switch positions above 5 mV, attenuators are switched into the circuit singly or in pairs to help produce the vertical deflection factors indicated. These attenuators are frequency-compensated voltage dividers. In addition to providing constant attenuation at all frequencies within the bandwidth of the instrument, the Input Attenuators are designed to maintain the same input RC characteristics for each setting of the VOLTS/DIV switch. Each attenuator contains an adjustable series capacitor to provide correct attenuation at high frequencies and an adjustable shunt capacitor to provide correct input capacitance.

**NOTE**

*Each attenuator is a hybrid encapsulated plug-in assembly; therefore, replacement of individual components within the attenuator are not possible. Should defects occur, the attenuator must be replaced as a unit.*

**First Cascode Amplifier**

The first amplifier stage in the Channel 1 Preamp circuit is hybrid circuit U120. U120 basically consists of an integrated emitter-coupled, push-pull, cascode amplifier and two discrete field-effect transistors (FET) mounted on a ceramic substrate with the thick-film resistors. The stage is a paraphase amplifier and converts the single-ended input signal to push-pull output signals. CR104 and CR107 provide protection for the input to U120 if large negative-going signals or DC levels are applied to the CH 1 OR X input connector.

This input amplifier stage contains the CH 1 VAR VOLTS/DIV control. This control provides continuously variable (uncalibrated) vertical deflection factors between the calibrated positions of the VOLTS/DIV switch. With the VAR control in its calibrated detent (wiper at ground), the output transistors of U120, whose collectors connect to pins 5 and 9, are conducting; the output transistors whose collectors connect to pins 6 and 8 are biased off. Thus, the current available to the following amplifier stage is that flowing from pins 5 and 9.

When the VAR control is rotated out of its calibrated detent, the transistors whose collectors connect to pins 6 and 8 begin to conduct. The current they conduct is robbed from the other output transistors. This causes two things to occur:

1. The current flowing in the collectors of the transistors connected to pins 5 and 9 is less now than when the VAR control was in its calibrated detent.

2. The current available to the following amplifier stage is the algebraic sum of the currents in the collectors tied together (i.e., pins 8 and 9 and pins 5 and 6). Since the two collectors tied together have signals of opposite polarity, the signal available to the following amplifier stage is less than that when the VAR control was in its calibrated detent. The component values selected for the variable function provide a variable attenuation ratio of approximately 2.5 to 1. The Channel 1 Variable Balance adjustment R110 adjusts for no trace shift in the display when rotating the VAR control. The Channel 1 UNCAL light indicates when the Channel 1 VAR control is out of its calibrated detent. The components connected between pins 2 and 3 of U120 provide high-frequency compensation for the stage.

### Second Cascode Amplifier

The second amplifier stage in the Channel 1 Preamp circuit is U140. U140 is an integrated emitter-coupled, push-pull, cascode amplifier similar to that used in U120. It is used as a push-pull amplifier and has 2 mV and 5 mV gain adjustments that determine the overall gain of the Channel 1 Preamp circuit. The output signals available to the next stage for amplification are taken from pins 5 and 9 of U140.

The gain of U140 is determined by biasing the output transistors connected to pins 6 and 8 to conduct more or less current. As more current is conducted through the transistors connected to pins 6 and 8, that much less is conducted through the transistors connected to pins 5 and 9. The current conducted by the transistors connected to pins 5 and 9 in the 2 mV position of the VOLTS/DIV switch is approximately 2.5 times the current conducted by the same transistors in all of the other VOLTS/DIV switch positions. This results in increased gain and a DC level shift at the signal output terminals of U140. The VOLTS/DIV switch compensates for a shift in the DC level by shorting out part of the common-mode resistance (R157) when operating with 2 mV sensitivity. Gain Switch Balance adjustment R135 adjust the DC balance of the stage, so there is no baseline shift in the CRT display when switching between the 2 mV and 5 mV positions of the CH 1 VOLTS/DIV switch. The remainder of the components connected between pins 2 and 3 of U140 provide high-frequency compensation for the stage.

### Third Cascode Amplifier

The third amplifier stage in the Channel 1 Preamp circuit is a discrete component cascode amplifier made up of Q172, Q178, Q182, Q184, and Q188. Q184 is a relatively constant current source for Q172 and Q182. Q172 and Q182 convert the input voltage signals into current signals which are in turn converted back to voltage signals by Q178 and Q188 respectively. R172 and R182 provide thermal compensation and C172 and C182 AC-couple the signal around R172 and R182 to reduce Miller effect. C175 and R175 are variable high-frequency compensation adjustments while CR170, CR174, and RT170 offset compensation changes associated with variations in ambient temperature. As temperature increases, the value of RT170 decreases. This results in a decrease in voltage across CR170 and CR174. CR170 and CR174 are voltage-variable capacitance semiconductors whose capacitance increases with a decrease in reverse voltage across them. Thus, CR170 and CR174 will provide more peaking at higher temperatures. T178 is a toroid inductor that cancels high-frequency common-mode signals generated by the previous stages. The Channel 1 Vertical Position Centering adjustment centers the range of control of the Channel 1 POSITION control.

## CHANNEL 2 PREAMP



### General

The Channel 2 Preamp circuit is virtually the same as the Channel 1 Preamp circuit. Only the differences between the two circuits are described here. Portions of this circuit not described in the following description operate in the same manner as for the Channel 1 Preamp circuit. Fig. 3-3 shows a detailed block diagram of the Channel 2 Preamp circuit. A schematic of this circuit is shown on Diagram 2, at the rear of this manual.



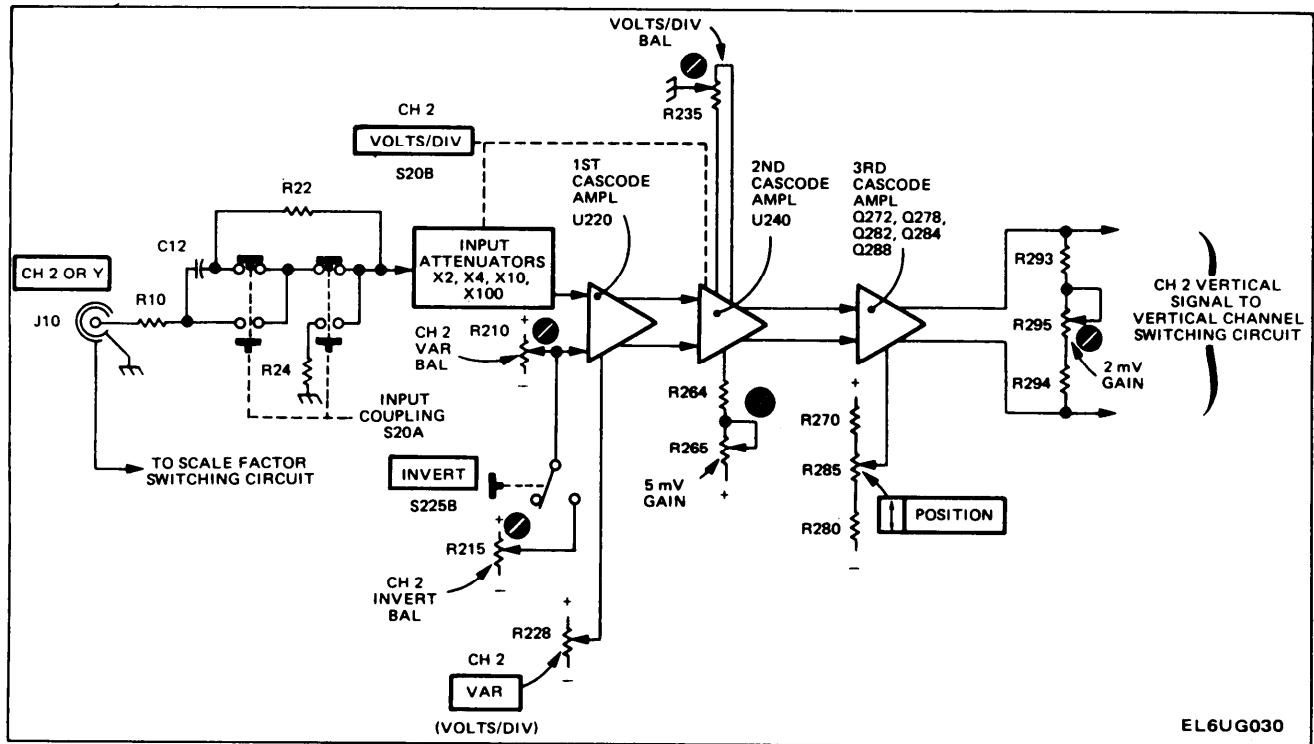


Fig. 3-3. Detailed block diagram of the Channel 2 Vertical Preamp circuit.

**First Cascode Amplifier**

Basically, the First Cascode Amplifier stage in Channel 2 operates as described for the First Cascode Amplifier stage in Channel 1. However, the Channel 2 First Cascode Amplifier also contains the INVERT switching function. This allows the Channel 2 signal to be inverted as displayed on the CRT. The INVERT switch, when pushed, changes the biasing on the output transistors of U220 so that the normally inactive transistors are now carrying the signal. Since their outputs are cross-coupled from side to side the output signal is of opposite polarity to that available in the normal (button out) position of the INVERT switch. The Channel 2 Invert Balance adjustment R215 adjusts the DC. balance of the stage to eliminate baseline shift in the display when switching from a normal to an inverted display.

**VERTICAL CHANNEL SWITCHING** 3

**General**

The Vertical Channel Switching circuit determines whether the Channel 1 or the Channel 2 Preamp signal or both will be connected to the Vertical Output Amplifier circuit. In the ALT and CHOP modes of operation, both channels are alternately displayed on a shared-time basis. The Vertical Channel Switching circuit also provides several internal trigger signals to the Trigger Generator circuits, the Channel 2 VERT SIGNAL OUT signal to a connector on the rear panel, and the chopped blanking signal to the Z Axis Amplifier. Fig. 3-4 shows a detailed block diagram of the Vertical Channel Switching circuit. A schematic of this circuit is shown on Diagram 3 at the rear of this manual.

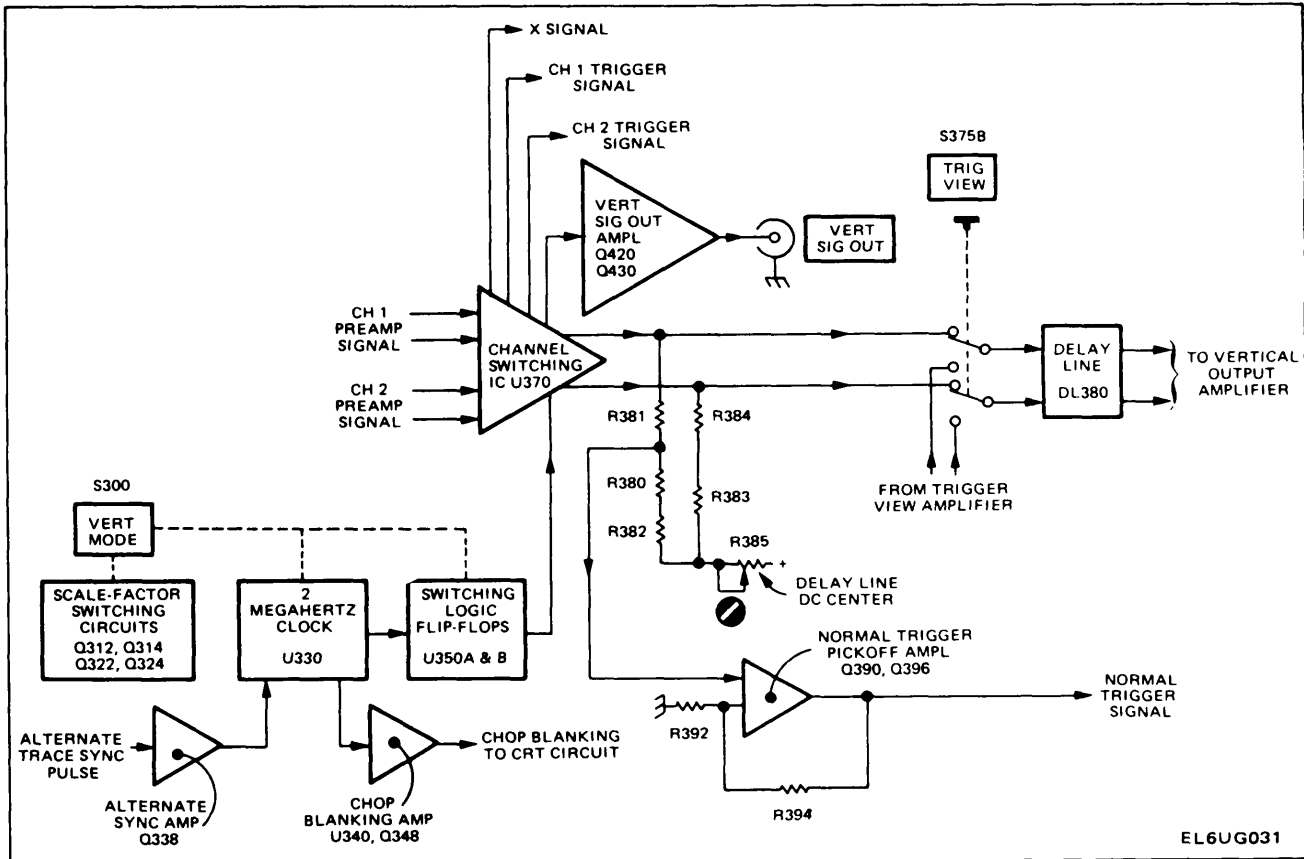


Fig. 3-4. Detailed block diagram of the Vertical Channel Switching circuit.

**Channel Switch IC**

The Channel Switch IC U370 determines which of the Preamp signals will be passed to the Vertical Output Amplifier. The push-pull Preamp signals connect between pins 2 and 3 (Channel 2) and between pins 10 and 11 (Channel 1) of U370. The logic levels connected to pins 1, 12, 13, and 16 determine what signals are presented at output pins 14 and 15. The following logic truth table (Table 3-1) defines the switching function of U370.

TABLE 3-1  
Input/Output Logic for U370

Pin 1	Pin 12	Pin 13	Pin 16	Output Signal Pins 14, 15
1	0	1	0	Channel 2
0	1	0	1	Channel 1
1	1	0	0	Add (Algebraic sum of Channel 1 and 2)

U370 also makes available samples of the Channel 1 signal at pins 8 and 9 and samples of the Channel 2 signal at pins 4 and 5. The output signals at pins 4, 5, 8, and 9 are always present when signals are applied to the channel inputs regardless of the switching logic levels applied to U370. The Channel 1 signal present at pin 9 provides drive to the Horizontal Amplifier in the X-Y mode of horizontal operation. The Channel 1 signal at pin 8 and the Channel 2 signal at pin 4 are used by the Trigger Generator circuits in the appropriate positions of the Trigger SOURCE switches. The Channel 2 signal at pin 5 connects to the Channel 2 Vertical Signal Out Amplifier.

**Switching Logic Flip-Flops**

U350A and U350B are edge-triggered flip-flops that derive the switching logic for the Channel Switch IC U370. In the CH 1, CH 2, and ADD positions of the VERT MODE switch the output logic from U350A and U350B is determined by the voltage levels applied to the clear (pins 1 and 13) and preset (pins 4 and 10) inputs. In the ALT mode of operation the flip-flops are switched by the alternate-trace sync pulse applied to their clock inputs through Q338 and U330B. In the CHOP mode, the clock pulse generated by U330C and U330D switch the flip-flops at a one-megahertz rate.

### Two Megahertz Clock

U330C and U330D form an astable multivibrator having a repetition rate of two megahertz. The rectangular output waveform connects to the Switching Logic Flip-Flops through nand gate U330B. Only in the CHOP position of the VERT MODE switch is a LO level applied to the input of inverter U330A. This puts a logical HI in pin 13 of U330D, which permits the astable multivibrator to free-run. At the same time, Q338 is biased on, which puts a logical HI on pin 5 of U330B. Thus, the signal present at pin 6 of U330B will be the two-megahertz clock signal.

### Chop Blanking Amplifier

The Chop Blanking Amplifier Q348 provides an output pulse to the Z Axis Amplifier circuit, which blanks out the transitions between the Channel 1 and Channel 2 traces when operating in the CHOP mode. The inherent propagation delay of inverters U340A, U340B, and U340C are used to provide some signal delay to the chop blanking signal. This allows the blanking signal and the channel switching transient to arrive in the CRT simultaneously.

### Channel 2 Signal Output Amplifier

Q420 and Q430 compose the Channel 2 Vertical Signal Output Amplifier. A sample of the Channel 2 signal from pin 5 of Channel Switch IC U370 is amplified and inverted by Q420. CR422 provides thermal compensation for the base-emitter junction of Q420. Common-base amplifier Q430 provides the final amplification and isolates the output from the internal amplifier circuitry. Output impedance of the amplifier is equal to the parallel combination of R431 and R432 (approximately 50 ohms).

### Normal Trigger Pickoff Amplifier

The trigger signal for NORM trigger operation is obtained from a sample of the vertical deflection signal that is available from pin 15 of U370. Normal Trigger DC Center Adjustment R425 sets the DC level of the normal trigger output signal so that the sweep is triggered at the 0 level of the displayed signal when the Triggering LEVEL control is set to 0. Q390 and Q396 are connected as a non-inverting feedback amplifier. Gain of the stage is approximately 2.75.

### Scale-Factor Switching Circuits

The vertical deflection factor for each channel is indicated by back-lighting the appropriate figures imprinted on the flange of each VOLTS/DIV knob. For purposes of explanation, only the circuit action of the Channel 1 Scale-Factor Switching circuit is discussed.

With a cable or an X1 probe connected to the CH 1 OR X input connector, the probe coding ring terminal on the connector is not contacted, and therefore presents an open to the base of Q312. This causes Q312 to be biased off and the X10 display factor bulb to be off. The base level of Q314 is held low by this action, thus Q314 is biased on and conducts current to light the X1 display factor bulb.

When an X10 probe with a scale-factor switching connector is attached to the CH 1 OR X input connector, the probe coding ring terminal on the connector is contacted; the base of Q312 is connected through R311, R310 and an 11,000-ohm resistor (within the probe) to ground. Now, Q312 conducts through X10 display-factor bulb DS312. The positive level at the collector of Q312 turns Q314 off, the X10 display factor bulb is on, and the X1 display factor bulb is off.

## VERTICAL OUTPUT AMPLIFIER



### General

The Vertical Output Amplifier provides the final amplification for the vertical deflection signal. This circuit includes the BEAM FINDER function. The BEAM FINDER pushbutton, when pressed, limits the vertical and horizontal deflection to within the viewing area and sets the trace intensity to a normal viewing level to aid in locating an off-screen display. A schematic of the Vertical Output Amplifier is shown on Diagram 4 at the rear of this manual.

### First IC Amplifier

The first amplifier stage in the Vertical Output Amplifier is integrated circuit U450. U450 is basically an emitter-coupled, push-pull, cascode amplifier cell. Biasing is arranged so that there is no phase-inversion through the stage. The signal from the delay line is applied to the amplifier through C441, L441, L442, C445, and L444. These inductances and capacitances are part of the etched runs of the circuit board and provide some high-frequency peaking by forming a T-coil circuit without mutual coupling. Most of the remaining external components connected between pins 2 and 3 of U450 provide high-frequency compensation for the delay line. Connected between pins 2 and 3 of U450, internally, a resistor (approximately 33 ohms) has a large effect on the gain of the stage.

RT452 changes in value with variations in ambient temperature to compensate for temperature-associated changes in amplifier gain. The BEAM FINDER pushbutton, when pressed, removes -8 volts from the top of R459. This reduces the dynamic swing capabilities of the stage to limit the display on the CRT to within the viewing area. The gain of the Vertical Output Amplifier section is adjusted in this stage by adjusting Vertical Output Gain R449.

Second IC Amplifier

The second amplifier stage in the Vertical Output Amplifier is integrated circuit U470. U470 is a multi-stage cascode amplifier cell. The input signal is applied to pins 1 and 5 with the inverted output signal taken from pins 9 and 12. Pins 2 and 4 are emitter connections. Some of the components connected between pins 2 and 4 provide slower time constants to compensate for signal rolloff that occurs in the delay line, while the remaining components compensate for thermal considerations in the stage. The Output Bias adjust (R487) sets the DC levels within the stage to optimize the operating performance of U470. The output signal from U470 connects directly to the deflection plates of the CRT.

A TRIGGER GENERATOR



General

The A Trigger Generator circuit produces the trigger pulse used to start the Sweep Generator circuit that provides the A portion of the CRT display. The trigger pulse is derived from the internal trigger signal from the vertical deflection system, an external signal connected to the external trigger input connector, or a sample of the line voltage connected to the instrument. Controls are provided to select trigger level, slope, coupling, and source. Fig. 3-5 shows a detailed block diagram of the A Trigger Generator circuit. A schematic of this circuit is shown on Diagram 5 at the rear of this manual.

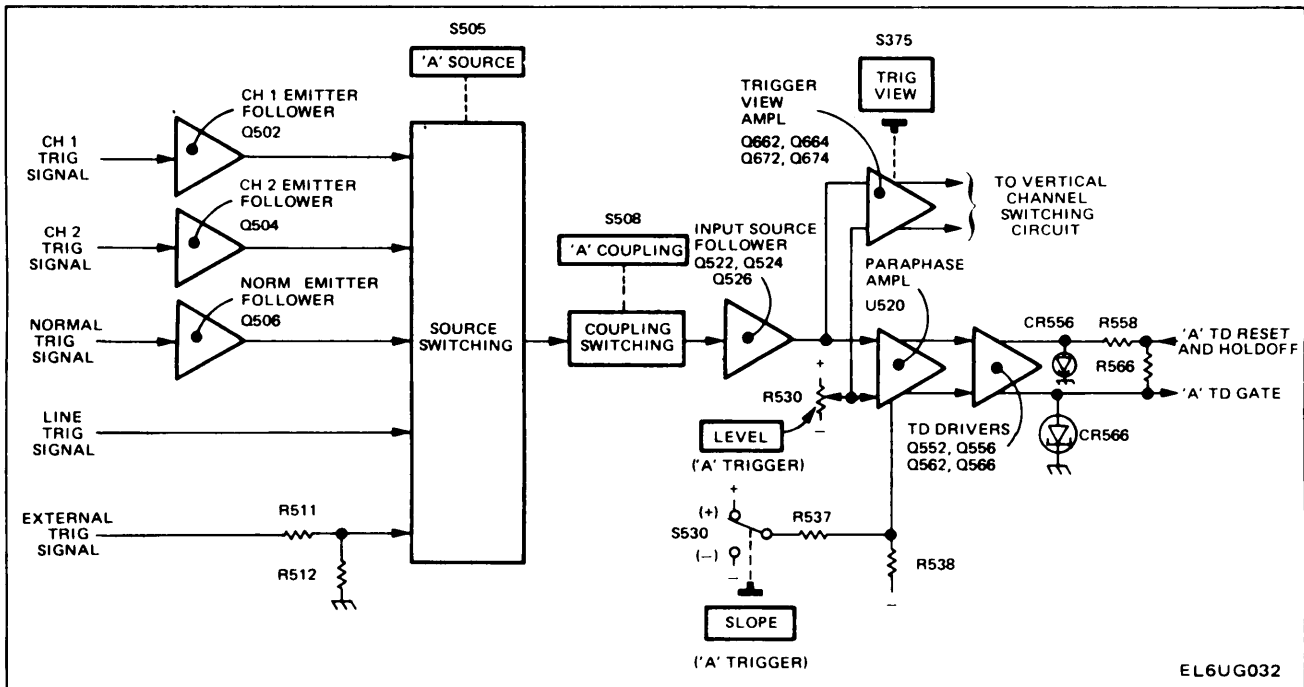


Fig. 3-5. Detailed block diagram of the A Trigger Generator circuit.

### Trigger Source

Trigger SOURCE switch S505 selects the source of the trigger signal. The sources available to the A Trigger Generator circuit are the signal being displayed (NORM), Channel 1 (CH 1), Channel 2 (CH 2), the instrument line voltage (LINE), and external signals (EXT and EXT  $\pm 10$ ). Emitter followers Q502, Q504, and Q506 provide isolation between the input to the A Trigger Circuit and the output of the Vertical Channel Switching Circuit.

In the LINE mode of triggering, a sample of the power line frequency is obtained from the secondary of the power transformer T1400 in the Low Voltage Power Supply circuit. The Trigger COUPLING switches should not be in the LF REJ mode when using the instrument line voltage as a trigger signal source.

### Trigger Coupling

The Trigger COUPLING switches offer a means of accepting or rejecting certain components of the trigger signal. In the AC, LF REJ, and HF REJ mode of trigger coupling, the DC component of the trigger signal is blocked by coupling capacitors C515 or C516. Frequency components below about 60 Hz are attenuated when using AC or HF REJ coupling and below about 50 kHz when using LF REJ coupling. The higher frequency components of the trigger signal are passed without attenuation. In the HF REJ mode of trigger coupling, the high frequency components of the trigger signal (above about 50 kHz) are attenuated, while the lower frequency components (between about 60 Hz and 50 kHz) are passed without attenuation. The DC mode of trigger coupling passes unattenuated all signals from DC to 200 MHz and above.

### Input Source Follower

Transistor Q522 is a FET (field-effect transistor) connected as a source follower. It provides a high input impedance (set primarily by R517) for the trigger signal; it also provides isolation between the Trigger Generator circuit and the trigger signal sources. CR519 provides input protection for Q522 if excessively high amplitude negative-going input signals are present. Q524 is a high-impedance, relatively constant current source for Q522 and provides a measure of temperature compensation for Q522. The output signal from the Source Follower is taken from Emitter Follower Q526.

### Paraphase Amplifier

U520 is a paraphase amplifier stage that converts the single-ended input from Emitter Follower Q526 into a dual-ended push-pull output, which is applied to one of the Tunnel Diode Driver stages. Trigger Centering adjustment R534 sets the level at pin 14 of U520 (through emitter follower Q532) so that the display is correctly triggered

when the LEVEL control is centered. The LEVEL control varies the level at pin 14 of U520 to select the point on a trigger signal where triggering occurs.

The slope of the input signal that triggers the Sweep Generator circuit is determined by the setting of the SLOPE switch S530. When the SLOPE switch is set to the + position, the output signal at pin 8 of U520 is inverted with respect to the input signal, and the output signal at pin 9 is in phase with respect to the input signal. When the SLOPE switch is set to the – position, the output signal at pin 8 is in phase with respect to the input signal, and the output signal at pin 9 is inverted with respect to the input signal.

### Tunnel Diode Driver

Q552, Q556, Q562 and Q566 are common-emitter amplifier stages that provide the signal currents necessary to switch the triggering tunnel diodes. CR556 and CR566 are ten-milliampere tunnel diodes. Quiescently, CR556 and CR566 are biased into their low voltage states and Q566 cannot provide sufficient current to switch CR566 to its high voltage state. When the input signal increases the current in Q556 slightly above its quiescent state, this current and the current through R555 is sufficient to bias CR556 into its high voltage state. The anode of CR556 steps positive to an approximately +0.5 volt level. Since less current is required to maintain a tunnel diode in its high voltage state than is required to switch it to its high voltage state, approximately 6 mA of current is additionally available to switch CR566 to its high voltage state. Thus, the next time Q566 conducts signal current, CR566 steps to its high voltage state sending a positive pulse to the logic circuit to initiate sweep action. The A Trig Sensitivity adjustment, R565, adjusts the tunnel diode bias to the proper level that will not allow CR566 to be switched to his high voltage state until CR556 has been switched to its high voltage state. At the end of the sweep time and during holdoff, a negative level is applied to the junction of R558 and R566, thereby resetting both CR556 and CR566 to their low voltage states. The reset level remains during holdoff time to ensure that a sweep gating signal is not generated until the sweep circuit has returned to its quiescent state.

### Trigger View Amplifier

The Trigger View Amplifier circuit amplifies a sample of the signal present in the A Trigger Generator circuit and passes it on to the Vertical Output Amplifier for display on the CRT when the TRIG VIEW pushbutton is impressed. This provides a method of making a quick and convenient check of the signal being used to trigger the oscilloscope and is intended primarily to be used to check the timing difference between the trigger signal and the vertical deflection signal.

The amplifier consists of two emitter-coupled push-pull amplifier stages. The emitter source voltage for Q662 and Q672 is switched on and off by the TRIG VIEW pushbutton. With the TRIG VIEW pushbutton not pushed, the emitters of Q662 and Q672 are returned to ground through R665. This reverse-biases the base-emitter junctions of the transistors, preventing any loading of the A Trigger Generator circuit. When the TRIG VIEW pushbutton is pushed, the emitters are now returned to +15 volts through R663 and R679. This forward biases Q662 and Q672 to allow signal amplification. Trigger View Centering adjustment R673 adjusts for correct DC balance in the circuit.

Normally, the output of the Vertical Channel Switching circuit is applied to the input of the Delay Line. When the TRIG VIEW pushbutton is pushed, the signal from the Vertical Channel Switching circuit is removed and the output from the Trigger View Amplifier is applied in its place.

## B TRIGGER GENERATOR

### General

The B Trigger Generator circuit produces the trigger pulse used to start the Sweep Generator circuit that provides the B portion of the CRT display. The B Trigger Generator circuit is virtually the same as the A Trigger Generator circuit and only the differences between the two are described here. A schematic of this circuit is shown on Diagram 6 at the rear of this manual.

### Trigger Source

The B Trigger Generator circuit has no LINE or EXT  $\div 10$  positions on its Trigger SOURCE switch. If the Generator is to be triggered from a line voltage signal or the external trigger signal is to be attenuated, it must be accomplished in some other manner. The B Trigger SOURCE switch does have a STARTS AFTER DELAY position, however, the A Trigger SOURCE switch does not. This position allows the B portion of a display to start immediately after the selected delay time without waiting for a triggering signal.

## SWEEP AND Z-AXIS LOGIC

### General

The Sweep and Z Axis Logic Circuit derives the logic levels necessary to control the sequence of events associated with sweep generation and CRT unblinking. The +A and +B GATE signals are also generated in this circuit. Positive logic terminologies and symbologies are used in the following explanation of circuit operation. Fig. 3-6 shows a detailed block diagram of the Sweep and Z-Axis Logic circuits. A schematic of this circuit is shown on Diagram 7 at the rear of this manual.

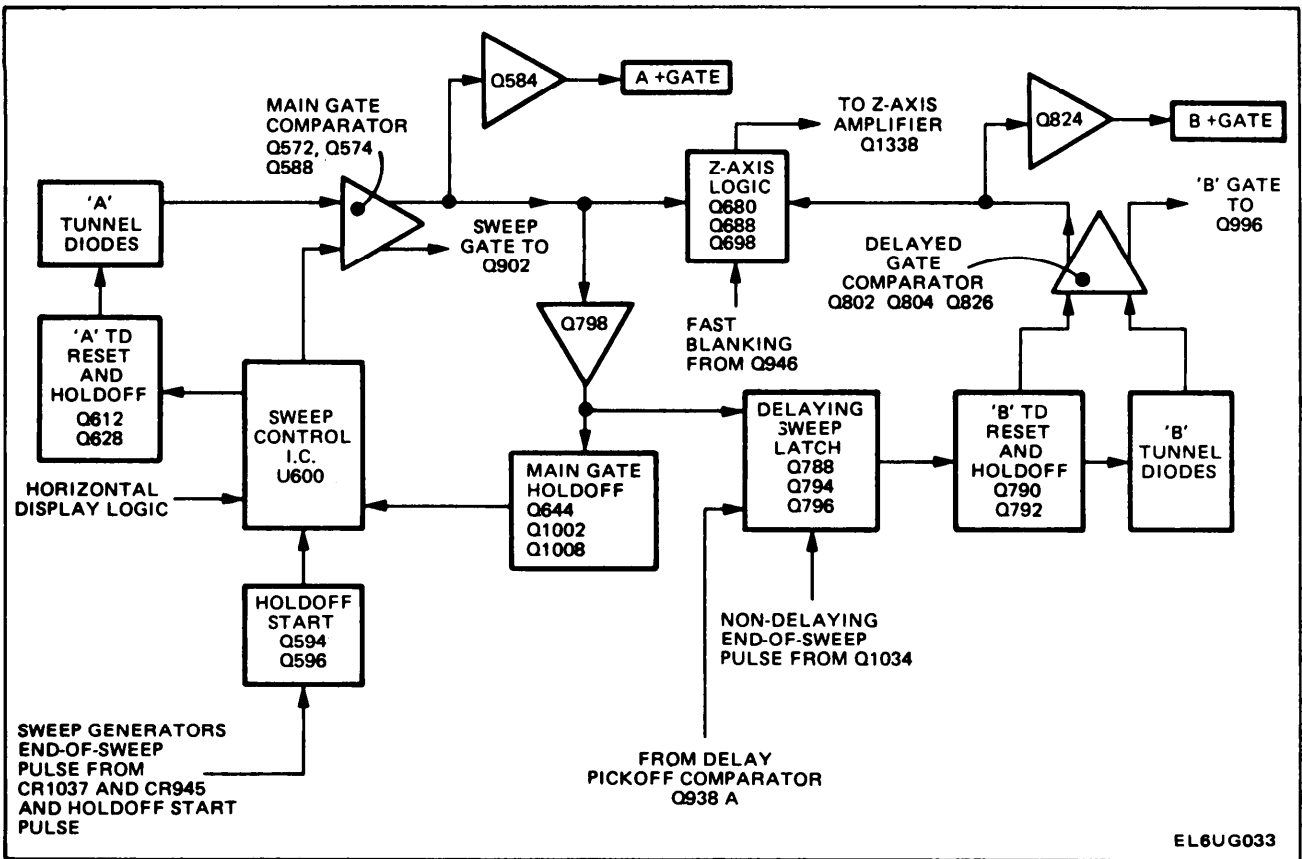


Fig. 3-6. Detailed block diagram of the Sweep and Z-Axis Logic circuits.

**Sweep Control Integrated Circuit**

U600 is the Sweep Control Integrated Circuit. Several functions are performed in this stage, depending on the mode of operation of the instrument sweep generators. The following is a brief explanation of the function associated with each pin of the IC.

**Pin 1.** This is the positive tunnel diode input. The signal connected here comes from the A Firing TD in the A Trigger Generator circuit. The voltage level switches from 0 to +0.5 volts and is compared with pin 2 internally.

**Pin 2.** This is the negative tunnel diode input. A fixed DC level established by R602 and R603 provides the reference for comparison with pin 1.

**Pin 3.** This is the positive tunnel diode output terminal. In the AUTO mode of operation (TRIG MODE set to AUTO) at the end of the holdoff time period, pin 1, pin 16 and pin 19 are LO, and pin 8 is HI. This causes the gate level at pin 3 to step LO to turn Q574 on, which initiates a sweep.

**Pin 4.** This is the negative tunnel diode output terminal; connected to +5 volts in this application.

**Pin 5.** Input terminal for a negative 5 volts through VR608 from the -8-volt supply.

**Pin 6.** This is the auto RC timing terminal. R609 and C609 determine the amount of time between loss of trigger signal and the generation of an auto gate at pin 3 when TRIG MODE is set to AUTO.

**Pin 7.** This terminal lights the TRIG light when a triggering gate has occurred, causing pin 1 to go HI.

**Pin 8.** This is the holdoff timing terminal. The time between the end of an individual sweep and the start of the next sweep is determined by RC components that affect the time constant of voltage of pin 8. The TIME/DIV control selects fixed components in the holdoff timing circuit and the A TRIG HOLDOFF control allows a variable holdoff setting in each position of the TIME/DIV control. When pin 8 goes HI, pin 17 will go LO and allow the trigger tunnel diodes to fire on an incoming signal or generate an auto gate in the Auto mode if pin 6 is HI.

**Pin 9.** Ground terminal.

**Pin 10.** This is the holdoff output; connected to ground in this application,

**Pin 11.** This terminal lights the READY light when operating in the single sweep mode.

**Pin 12.** This is the single sweep mode terminal. When +5 volts is connected to this terminal, the sweep operates in the single sweep mode; when the terminal is left open or grounded, the sweep operates in the repetitive mode.

**Pin 13.** Connected to ground in this application.

**Pins 14 and 15.** Single Sweep reset terminals. Pressing the SINGL SWP pushbutton prepares the single sweep circuitry to respond to the next triggering event. Also, this action causes the READY light to be lit.

**Pin 16.** This is the holdoff start input terminal. A HI on this pin resets the sweep and starts the holdoff period. This sets pin 17 HI to reset and hold the trigger tunnel diodes LO and allows pin 3 to go HI.

**Pin 17.** This is the sweep disable output terminal. The gate level at this terminal is HI during holdoff and LO otherwise.

**Pin 18.** This is the lockout input terminal; +5 volts applied to this terminal disables all sweep action.

**Pin 19.** This is the auto mode terminal. Grounding this terminal enables auto sweep operation.

**Pin 20.** Input terminal for the +5-volt supply.

### Main Gate Comparator

Q1572 and Q574 form the Main Gate Comparator and are connected as a voltage comparator, where both transistors do not conduct at the same time. The input signal to the stage is the positive-going trigger signal from the A Firing Trigger TD in the A Trigger Generator circuit. The signal at the collector of Q574 is inverted by Q588, is connected to the Z Axis Logic Multivibrator to control CRT blanking, and to Q584 to generate the A + GATE output signal. The signal at the collector of Q572 connects to the base of the Main Gate Amplifier stage (Q902) in the Sweep Generators circuit to initiate sweep generation.

### Delayed Gate Comparator

Q802 and Q804 form the Delayed Gate Comparator and are connected as a voltage comparator where both transistors do not conduct at the same time. The input signal to the stage is the positive-going trigger signal from the B Firing Trigger TD in the B Trigger Generator circuit. The signal at the collector of Q804 is inverted by Q826 and is connected to the Z Axis Logic Multivibrator to control CRT blanking and to Q824 to generate the B + GATE output signal. The signal at the collector of Q802 connects to the base of the Delayed Gate Amplifier stage (Q996) in the Sweep Generators circuit to initiate sweep generation.

### A Trigger TD Reset Circuit

Transistors Q612 and Q628 are connected as a Schmitt Trigger circuit and form the A Trigger TD Reset Circuit. (A Schmitt Trigger circuit is a bistable pulse generator in which an output pulse of constant amplitude exists only as long as the input voltage exceeds a certain dc value.)

At the start of holdoff, pin 17 of U600 steps HI. This turns on Q612 and turns Q628 off. The collector signal of Q612 connects to the Trigger Tunnel Diodes in the A Trigger Generator circuit and resets them to their LO state. At the end of holdoff pin 17 steps LO, Q612 turns off, and Q628 turns on to allow the tunnel diodes to fire on the next trigger signal.

### Holdoff Start Circuit

Q594 and Q596 form the Holdoff Start Circuit. The input signal to the stage is a momentary positive-going end-of-sweep signal from the Sweep Generators circuit or from the Delayed Latch circuit. The positive-going signal turns Q594 on which in turn turns on Q596. The positive-going signal at the collector of Q596 is connected to pin 16 of U600 to reset the sweep and start the holdoff period. This signal is also used in the Vertical Switching Circuit to switch between channels in the ALT mode of operation.

### Z Axis Logic Multivibrator

Q688 and Q698 are basically a Schmitt Trigger circuit and form the Z Axis Logic Multivibrator. Quiescently, with the CRT display blanked, Q688 is on and Q698 is off. The signal to switch states of the multivibrator (and thereby unblank the CRT) can come from the Main Gate Comparator (via Q588 and CR681) or from the Delayed Gate Comparator (via Q826 and C684). The negative going signals turn off Q688 and cause Q698 to turn on. The positive going signals that return the multivibrator to its original state (thereby blanking the CRT display) come from Q588 via CR682 and CR683, or from Q680 via CR680 and CR683. Q680 is used primarily to ensure proper early turn-off of the CRT display at faster sweep rates. In the



MIX or A INTEN positions of the HORIZ DISPLAY switch, some additive unblinking is accomplished to slightly increase the intensity of the B portion of the display. In these positions of the switch, -8 volts is connected to the cathodes of CR693 and CR694 through R692. Now, when the Z-Axis signal from the collector of Q826 steps negative at the beginning of the B portion of the display, CR693 is made to conduct less current, which makes a slight amount of additional unblinking current available to the Z-Axis Amplifier through CR694 and R692.

### Delaying Sweep Latch Circuit

Q788, Q794, and Q796 form the Delaying Sweep Latch Circuit. The circuit function is used during the three delayed sweep modes of operation that the instrument is capable of (MIX, A INTEN, and B DLY'D). Q938A, in the Delay Pickoff Comparator of the Delaying Sweep Generator, is the current source for the emitters of Q794 and Q796. Prior to the end of the delay time selected by the A TIME/DIV switch and DELAY TIME POSITION control, Q938A is off, thereby causing both Q794 and Q796 to be off also. The base level of Q794 sits at a more negative level than does the base of Q796 so that when Q938A turns on, at the delay pickoff point, Q794 will turn on and Q796 will remain off. The resultant positive movement at the collector of Q794 is connected to the B Trigger TD Reset Circuit.

The end-of-sweep pulse from the Non-Delaying Sweep Generators connects to the emitter of Q788. When this pulse steps positive at the end of a delayed sweep, Q788 turns off and the current through R788 pulls the base of Q794 positive. This turns off Q794 and causes Q796 to turn on. The circuit remains in this state until the Delaying Sweep Generator ends its sweep and resets the Delay Pickoff Comparator. In the B ENDS A position of the A TRIG HOLDOFF control, +5 volts is connected to R798. This enables the diode gate composed of CR799 and CR592. Now, when the end-of-sweep pulse signals the end of a delayed sweep, the positive movement at the collector of Q796 is connected to the base of Q594 and ends the delayed sweep. Instead of waiting until the end of the delaying sweep. This mode of operation gives the fastest possible sweep repetition rate when operating in the delayed sweep mode.

### B Trigger TD Reset Circuit

Q790 and Q792 are connected as a Schmitt Trigger and form the B Trigger TD Reset Circuit. At all times other than when the Non-Delaying Sweep Generators are running, Q790 is on, which holds the trigger tunnel diodes in the B Trigger Generator circuit in their LO states. At the end of the delay time selected by the A TIME/DIV switch and DELAY TIME POSITION control, the positive movement at the collector of Q794 turns on Q792 and causes Q790 to turn off. The tunnel diodes in the B Trigger Generator are capable of being biased into their HI states. Also, if the B

Triggering SOURCE switch is in the STARTS AFTER DELAY TIME position, the negative movement at the collector of Q792 reverse biases CR811, letting the -8volt supply pull down on the base of Q804 in the Delayed Gate Comparator. This turns on Q804 and causes Q802 to turn off, which initiates a delayed sweep.

### Main Sweep Holdoff Gate and Delayed Sweep Override Amplifier

During the interval of the main gate, Q798 functions as a holdoff gate and is biased off to provide a forward bias on Q1002 (Q1002 is located on diagram 9). This turns on Q1002, discharges the holdoff capacitors and maintains a current path to keep the capacitors discharged.



During the delayed sweep, Q798 functions as an override amplifier. It is possible, with the right combination of control settings, to achieve a delayed sweep presentation where the delayed sweep would normally want to continue running after the end of the delaying sweep. For instance, if the TIME/DIV controls are set only 1 or 2 ranges apart and the DELAY TIME POSITION control is set to a 8.50 setting. Under these conditions the delaying sweep end-of-sweep pulse occurs before the delayed sweep end-of-pulse. The positive movement on the collector of Q588 at the time of the delaying sweep end-of-sweep pulse turns Q798 on. The negative movement on the collector of Q798 pulls down on the collectors of Q794 and Q796, through CR793 and CR792 respectively, which in turn pulls down on the base of Q792. This turns off Q792 and causes Q790 to turn on, which resets the B Trigger Tunnel Diodes to their LO states, thereby terminating the delayed sweep.

### A +GATE And B +GATE Amplifiers

Q584 and Q824 are the A +GATE and B +GATE amplifiers respectively. They provide the +GATE output signals available at the instrument rear panel. These output gate signals are positive-going rectangular waveforms, approximately 5 volts in amplitude, coincident with their respective sweep waveforms.

### LOW LINE Indicator Circuit

Q1492, Q1498, and their associated circuitry monitor the unregulated voltage in the +50 volt supply and provide a visual indication (via the LOW LINE indicator on the front panel) when the applied line voltage falls below the lower regulating limit selected by the Regulating Range Selector assembly Q1482. This provides operating power to the CRT graticule lights that is adjustable via the SCALE ILLUM control R1480.

SWEEP GENERATORS   
 TIMING AND HORIZONTAL DISPLAY   
 SWITCHING

**General**

The Sweep Generators provide several sweep display modes, dependent upon the horizontal mode selected by the HORIZ DISPLAY switch. One sweep generator may be employed as a delay circuit for a second sweep generator, permitting a variety of useful display modes. Before the discussion of sweep generation, it is helpful to become familiar with each principle mode of horizontal display and its associated sweep generator, sweep gate and sweep display labeling. See Table 3-2 for a list of sweep generator, sweep gate and sweep display terminology whenever needed throughout the following sweep generators discussion.

The Sweep Generators produce the sawtooth voltages that are amplified by the Horizontal Amplifier to provide horizontal deflection on the CRT. These sawtooth voltages are produced on command (trigger pulses) from the Trigger Generator circuits. The Sweep Generator circuits also produce gate waveforms that are used by the Z Axis Logic circuit to unblank the CRT during sweep time, and by the Sweep Logic circuit to terminate sweep generation. There are three Sweep Generator circuits in the instrument. Operation of all three is very similar; therefore only the operation of the Delaying Sweep Generator and the differences in operation of the three generators is discussed. Fig. 3-7 shows a detailed block diagram of the Sweep Generators. A schematic of the Sweep Generators is shown on Diagram 8 and a schematic of the Timing And Horizontal Display Switching is shown on Diagram 9 at the rear of this manual.

**TABLE 3-2**  
**Horizontal Display Sweep Generator Terminology**

HORIZ DISPLAY Switch Setting	CRT DISPLAY		Gate that Initiates Swoop
	Portion of Sweep Displayed on CRT	Sweep Generator Used for Display	
A (TIME/DIV Knobs Locked)	A	Non-Delaying	Main
A (TIME/DIV Knobs Unlocked)	A	Delaying	Main
MIX	A (First Portion)	Delaying	Main
	B (Last Portion)	Non-Delaying	Delayed
A INTEN	A	Delaying	Main
	B (Intensified Portion)	Non-Delaying	Delayed
B DLY'D	B	Non-Delaying (After being delayed by Delaying Sweep)	Delayed

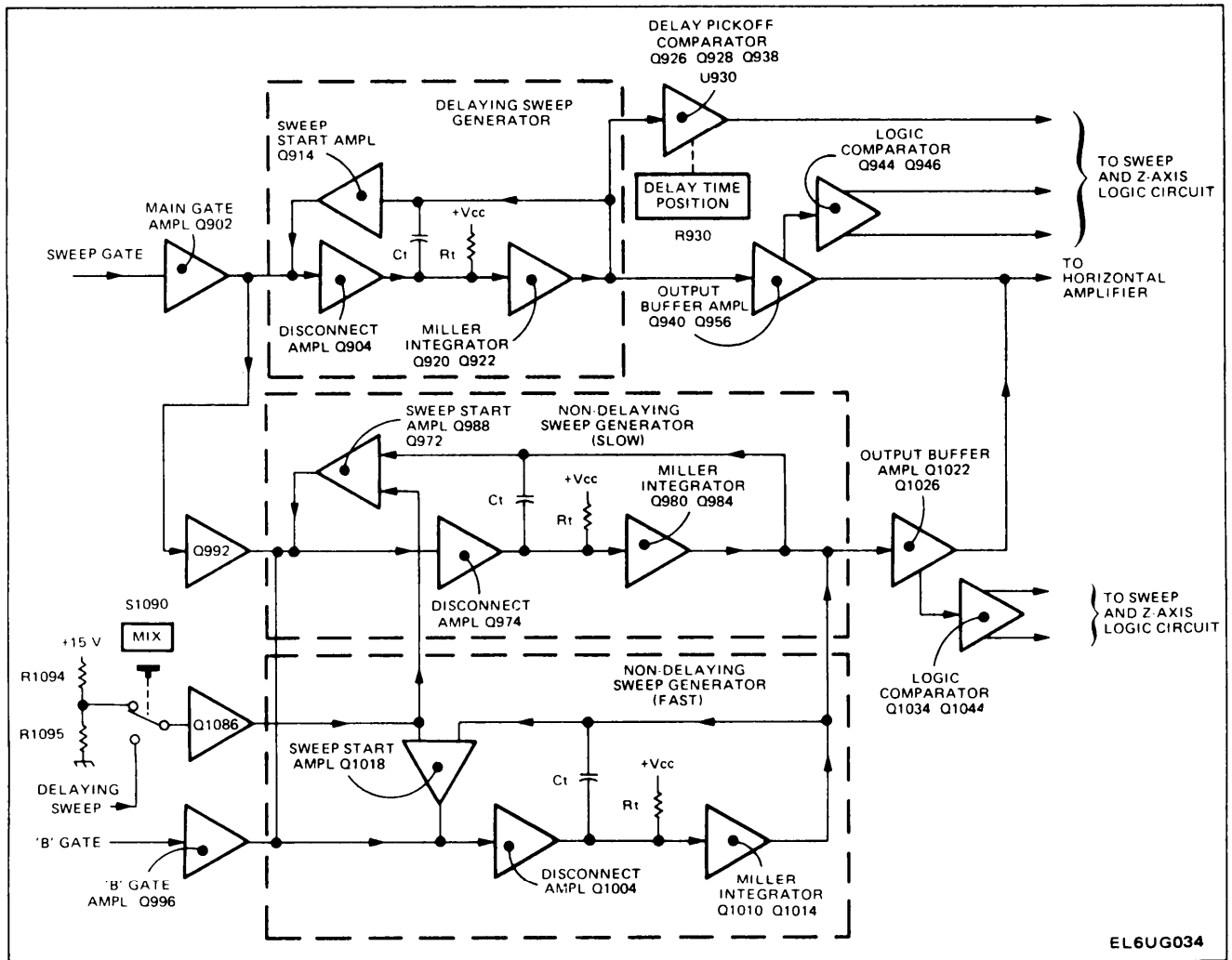


Fig. 3-7. Detailed block diagram of the Sweep Generator circuits.

**Delaying Sweep Generator**

Basically the Delaying Sweep Generator is composed of Q904, Q920, Q922, and Q914. This generator runs in the A INTEN, MIX, and B DLY'D positions of the HORIZ DISPLAY switch and generates the A portion of the display. In these modes the sweep rate is selected by the A TIME/DIV switch (skirt knob).

**Main Gate Amplifier**

Q902 is the Main Gate Amplifier stage. The negative-going Main Gate waveform from the Sweep Logic circuit is applied to the base of Q902. The amplified and inverted waveform at the collector of C902 is applied to the Delaying Sweep Generator (through CR903), or to both of the Non-Delaying Sweep Generators (through Q992) in the A sweep mode. This initiates sweep generation.

**Sweep Disconnect Amplifier**

Q904 is the Sweep Disconnect Amplifier. The biasing on the base of this stage determines whether the Delaying Sweep Generator will run. In the A position of the HORIZ DISPLAY switch, the anode of CR907 is connected to +5 volts through R908 and the HORIZ DISPLAY switch circuit. This biases the base of Q904 far enough positive that the positive-going gates on the emitter cannot turn off Q904. Q904 therefore conducts all of the timing current through R905, R904, and timing resistor  $R_t$ , charging timing capacitance  $C_t$ . When the HORIZ DISPLAY switch is in any position other than A, CR907 is reverse-biased, which lets the base of Q904 be biased at a level that will allow the positive-going gates on the emitter of Q904 to interrupt the current flow through Q904. When Q904 turns off, the timing current starts to discharge timing capacitance  $C_t$ .

### Sawtooth Sweep Generator

Q920 and Q922 form a Miller integrator circuit. When the current through the Sweep Disconnect Amplifier Q904 is interrupted, timing capacitance C, begins to discharge through timing resistor R<sub>t</sub>. The timing resistor and capacitance are selected by the A TIME/DIV switch to provide the various sweep rates listed on the instrument front panel. The output signal at the collector of Q922 is a negative-going sawtooth voltage waveform.

### Sweep Start Amplifier

Just before the sweep starts to run down, the levels at the bases of Q914 are approximately equal. When the sweep starts to run down, the base of Q914B goes negative, which increases the forward bias on CR914B. This in turn decreases the forward bias on CR914A, which very shortly after the start of the sweep, becomes reverse biased to interrupt the current through Q914A. The circuit remains in this condition until after the sweep retrace is complete. When the circuit returns to quiescence, Q914A begins to conduct through R904. This sets the current through Q904 which in turn establishes the DC level starting point for the sweep.

### Output Buffer Amplifier

Q940 and Q956 form the Output Buffer Amplifier. Q940 is an emitter follower and Q956 is a common-base amplifier whose emitter is current-driven by the signal. The Output Buffer Amplifier provides the output sawtooth signal current to the Horizontal Amplifier and provides a measure of isolation between the Sawtooth Generator and the Horizontal Amplifier. Intensified Gain adjustment R950 adjusts the gain of the stage to match the output signal amplitude with that of the Non-Delaying Sweep Generators.

The Delaying Sweep Output Buffer Amplifier passes the signal to the Horizontal Amplifier when the HORIZ DISPLAY switch is in the A INTEN position and the TIME/DIV switches are not in the X-Y position. When the TIME/DIV switches are in the X-Y position the anode of CR956 is connected to +5 volts. This sets the base of Q956 at a positive enough level to reverse bias Q956 and prevent passage of the Delaying Sweep signal to the Horizontal Amplifier. With the TIME/DIV switches not in the X-Y position and the HORIZ DISPLAY switch in the A INTEN position, R955 is connected to 8 volts (through Q1099 in the Horizontal Display Switching circuit) and the anode of CR956 is not connected to any voltage. This forward biases CR955 and sets the base of Q956 at a DC level of approximately +4.3 volts. Now Q956 is forward biased and the Delaying Sweep signal is passed to the Horizontal Amplifier.

### Delaying Sweep End Difference Amplifier

Q944 and Q946 are connected as a voltage comparator and generate the logic pulses that signal the end of sweep and blank the CRT display at the end of the sweep. Prior to the generation of a sawtooth voltage waveform by the Delaying Sweep Generator, the base of Q944 is at an approximate -1.6 volt level. The base of Q946 is held at about -3 volts by the divider made up of R948 and R949. Therefore, Q946 is reversed biased and not conducting and Q944 is forward biased and is conducting. When the sweep voltage at the emitter of Q940 begins to go in a negative direction, the base of Q944 follows until the base of Q944 goes more negative than the base of Q946. Q944 turns off and Q946 turns on, generating a positive pulse at the collector of Q944 and a negative pulse at the collector of Q946. The positive pulse at the collector of Q944 signals the end of sweep and starts the holdoff period. The negative pulse at the collector of Q946 signals the Z-Axis Logic circuit to blank the CRT and prevent any further display.

### Delay Pickoff Comparator

The Delay Pickoff Comparator stage allows selection of the amount of delay from the start of the Delaying Sweep Generator before one of the Non-Delaying Sweep Generators is turned on. The amount of delay available is variable from 0.00 to 10.00 times the setting of the A TIME/DIV switch. The sweep rate of the Delayed (non-decaying) Sweep Generator is determined by the setting of the B TIME/DIV switch.

Q926A and Q926B are connected as a voltage comparator. Q928 is a relatively constant current source for Q926. Q938 is also connected as a voltage comparator circuit and is used to improve the switching capabilities of the stage. The reference voltage for the Delay Pickoff Comparator stage is provided by DELAY TIME POSITION control R930. U930 is an integrated circuit containing two high-gain amplifier cells used in a feedback amplifier configuration. They provide accurate fixed voltages (determined by settings of Delay Start, R938, and Delay Stop, R936) connected to the DELAY TIME POSITION control to allow precise delay pickoff. The instrument is calibrated so that the major dial divisions of the DELAY TIME POSITION control correspond to major divisions of horizontal deflection on the CRT graticule. For example, if the DELAY TIME POSITION control is set to 5.00, the Non-Delaying Sweep Generator is delayed five divisions of the Delaying Sweep time before it can produce a sweep.

The sawtooth voltage waveform from the Delaying Sweep Generator is connected to the gate of Q926B. The quiescent level of the delaying sawtooth biases Q926B on and its drain is negative enough to bias Q938B on. Q926A and Q938A are off and not conducting. As the Delaying Sweep sawtooth voltage goes down, the gate of Q926B also goes down. When it goes more negative than the level at the gate of C926A (established by the DELAY TIME POSITION control), C926A conducts and Q926B turns off. This also switches the states of Q938A and B and produces a positive-going rectangular current pulse at the collector of Q938A. This initiates the B sweep when B TRIG SOURCE is set to STARTS AFTER DELAY or enables the B Trigger Tunnel Diodes in all other positions of B TRIG SOURCE switch. When the Delaying Sweep resets, Q926B again conducts and Q926A is turned off. This switches C938A and B back to their original states.

### Non-Delaying Sweep Generators

There are two Non-Delaying Sweep Generators. In any position of the HORIZ DISPLAY switch, one of these generators will be running. They generate the displayed sweep in the A position of the HORIZ DISPLAY switch and the B portion of a display in the remaining positions. The B TIME/DIV switch (DLY'D SWEEP knob) selects the sweep rate for these generators. One generator provides the 0.5 second through 1 microsecond sweep rates, while the other generator provides the 0.5 microsecond through 0.01 microsecond sweep rates.

Either the "Main" Gate or the Delayed Gate can initiate sweep generation by the Non-Delaying Sweep Generators. When the HORIZ DISPLAY switch is in the A position and the TIME/DIV knobs are locked, a positive voltage is applied to the emitter of Q992, through R922 and Q1062. Q992 is forward biased, and the "Main" Gate is passed on to the Non-Delaying Sweep Generators through CR922 and CR971 or CR1001. In all the other positions of the HORIZ DISPLAY switch and when the TIME/DIV knobs are unlocked, a negative voltage is applied to the emitter of Q922 to reverse bias Q992 and prevent the "Main" Gate from reaching the generators. Now, only the "B" Gate can initiate sweep action in the Non-Delaying Sweep Generators.

### "B" Gate Amplifier

Q996 is the "B" Gate Amplifier stage. The negative-going waveform from the Sweep Logic circuit is applied to the base of Q996. The amplified and inverted waveform at the collector of Q996 is applied to the Non-Delaying Sweep Generators through CR996 and CR971 or CR1001 to initiate sweep generation.

### Non-Delaying Sweep Generator Differences

Basically the Non-Delaying Sweep Generators operate in the same manner as the Delaying Sweep Generator. The "fast" generator (Q1004, Q1010, Q1014, and Q1018) has only one timing capacitance (the parallel combination of C1008 and C1009). The capacitance is variable to achieve precise timing accuracy. Timing resistors are selected by the B TIME/DIV switch to provide the fastest six sweep speeds listed on the front panel.

Q988 and Q1018 are Sweep Start Amplifiers and establish the DC level starting points for the sweeps. The "slow" generator (Q974, Q980, Q984, Q988, and Q972) has an additional emitter follower (Q972). This emitter follower increases the current-gain of the loop to speed up the retrace time of the generator (determined by the time required to discharge the timing capacitor).

### Mixed Mode Operation

Normally, Q1086 is an emitter follower with a fixed dc level at its base established by R1094 and R1095. The fixed level at the emitter of Q1086, in turn, is applied to the bases of Q1018 and Q968 through CR1017 and CR987 respectively. This sets the quiescent current flow through Q988 and Q1018 to establish the dc level starting points for the sweeps as previously explained. However, when the HORIZ DISPLAY switch is in the MIX position, the fixed level at the base of Q1086 is replaced by the sawtooth voltage waveform being generated by the Delaying Sweep Generator. Now, the dc level starting point of the Non-Delaying Generator that is running is constantly being changed by the Delaying Sweep sawtooth until the Delaying Sweep runs down to a voltage determined by the setting of the DELAY TIME POSITION control. At this time, one of the disconnect transistors (Q974 in the "slow" Non-Delaying Generator, or Q1004 in the "fast" Non-Delaying Generator, depending on the settings of the TIME/DIV controls) is turned off, allowing the appropriate Non-Delaying Generator to begin a ramp waveform determined by the setting of B DLY'D control. The output waveform from the Non-Delaying Sweep Generator that is running will be a composite sawtooth waveform with the first and last parts occurring at a rate determined by the Delaying Sweep Generator (last part blanked out of CRT display) and the middle part occurring at a rate determined by one of the Non-Delaying Sweep Generators.

### Non-Delaying Sweep End Difference Amplifier

Q1044 and Q1034 are connected as a voltage comparator, and generate the same sort of logic pulses as the Logic Comparator in the Delaying Sweep Generator circuit. The positive-going pulse at the collector of Q1034 signals the end of the Non-Delaying Sweep, and the negative-going pulse at the collector of Q1044 blanks the display at the end of the Non-Delaying Sweep. However, the logic pulses from this comparator are not always allowed to pass to the Sweep and Z-Axis Logic circuits.

In the A INTEN position of the HORIZ DISPLAY switch, +5 volts is connected to the anode of CR1049. This forward biases CR1044, which sets the collector of Q1044 at approximately +0.7 volts. This keeps CR1046 reversed biased and prevents completely blanking the CRT at the end of the Non-Delaying Sweep portion of the display. In the A INTEN, MIX, and B DLY'D positions of the HORIZ DISPLAY switch, -8 volts is connected to the anode of CR1036 through R1090. This turns off the diode gate (CR1034 and CR1037) preventing a Non-Delaying Sweep end-of-sweep pulse output from Q1034 collector which would terminate the Delaying Sweep. This pulse is allowed to reset the Non-Delaying Sweep through Q788. In the A position of the HORIZ DISPLAY switch (knobs locked), a more positive voltage is connected to the anode of CR1036. This enables CR1034 and CR1037, thus allowing the Main Sweep end-of-sweep pulse to pass to the Sweep Logic circuit. The logic levels are generated by the HORIZ DISPLAY switch, Q1062, Q1066 and Q1099.

**TIME/DIV Functions (Knobs Unlocked)**

Normally, when the HORIZ DISPLAY switch is set to A, the Non-Delaying Sweep Generator is being used to display A Sweep. When the DLY'D SWEEP control (inner

knob of TIME/DIV) is unlocked and set to a faster sweep rate, the Non-Delaying Sweep Generator is then being used to display A Sweep. In this mode, the A TIME/DIV (skirt knob) must be used to control A Sweep rates.

**HORIZONTAL AMPLIFIER** 10

**General**

The Horizontal Amplifier circuit provides the output signals to the CRT horizontal deflection plates. The signal applied to the input of the Horizontal Amplifier is determined by the TIME/DIV switch. The signal can be a sawtooth waveform generated within the instrument, or some external signal applied to the CH 1 OR X input connector (X-Y mode of operation). The Horizontal Amplifier also contains the X10 magnifier, horizontal positioning controls, and some beam finder circuitry. Fig. 3-8 shows a detailed block diagram of the Horizontal Amplifier circuit. A schematic of this circuit is shown on Diagram 10 at the rear of this manual.

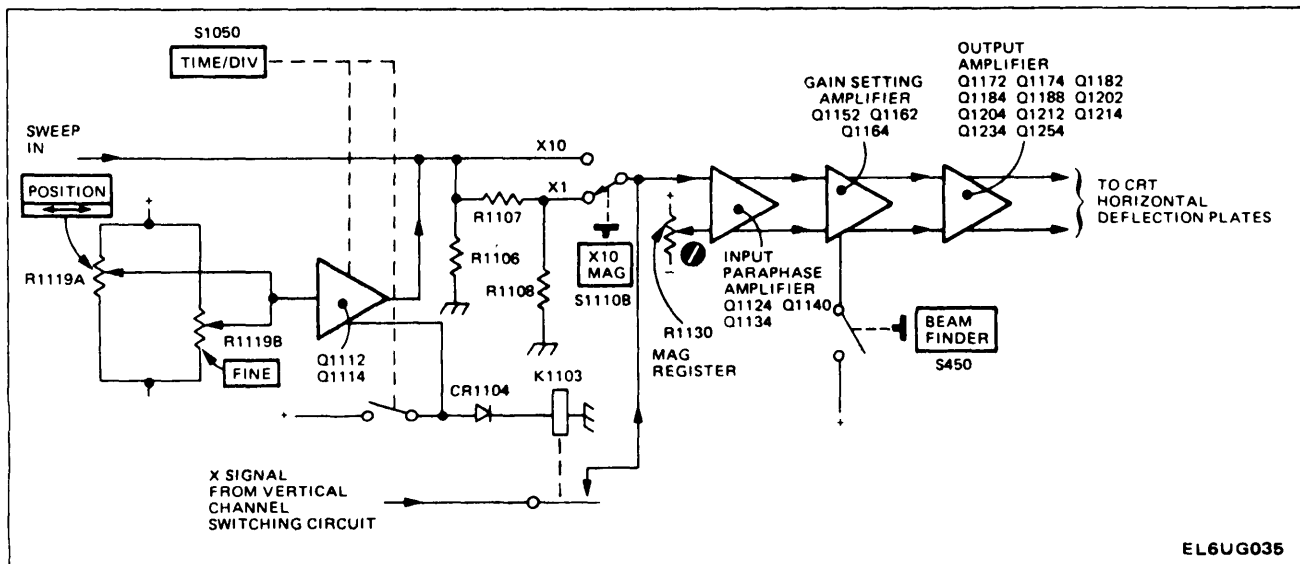


Fig. 3-8. Detailed block diagram of the Horizontal Amplifier circuit.

### Input Paraphase Amplifier

Q1124 and Q1134 form the Input Paraphase Amplifier. This is an emitter-coupled amplifier stage that converts the single-ended input signal to a push-pull output signal. The X10 Magnifier circuitry is in this stage and consists of a divide-by-ten attenuator R1106-R1107-R1108. When the X10 Magnifier is on, the input signal is applied unattenuated to the Input Paraphase Amplifier. When the X10 Magnifier is off, the input signal is applied to the Input Paraphase Amplifier through the attenuator. X10 MAG indicator DS1110 lights when the X10 Magnifier is being used. CR1121 and CR1122 limit signal amplitudes at the input to the amplifier to prevent amplifier overdrive. Q1140 is a relatively constant current source for Q1124 and Q1134. CR1140 provides temperature compensation for the base-emitter junction of Q1140. Magnifier Registration adjustment R1130 balances quiescent DC current in Q1124 and Q1134 so that a center screen display does not change position when the X10 Magnifier is turned on.

Q1112 and Q1114 together form a temperature compensated current source that is an interruptible path for the horizontal positioning currents. When the TIME/DIV switch is in any position other than X-Y, the anodes of CR1103, CR1104, and CR1111 are connected to -8 volts through R1104, which reverse-biases them. In the X-Y position of the TIME/DIV switch, +5 volts is connected directly to the anodes of CR1103, CR1104, and CR1111. This accomplishes three things. First, the emitter-base junction of Q1114 is reverse biased, which prevents the Horizontal POSITION and FINE controls from having any effect on the display. Second, relay K1103 is energized, which connects the X-axis signal from the Channel 1 Preamplifier to the input to the Horizontal Amplifier. Third, +5 volts is connected to the Channel 1 Scale Factor Switching circuit so that both deflection factor indicators are operating. When operating in the X-Y mode, R1102 adjusts for correct X-axis gain and L1103 adjusts to reduce the phase differences between the horizontal (X) and vertical (Y) signal paths.

### Gain Setting Amplifier

Q1152 and Q1162 are an emitter-coupled push-pull amplifier stage. The gain of this stage is adjusted to match the CRT sensitivity. When the BEAM FINDER pushbutton is pushed, R1168 is switched into the circuit. This reduces the current through this stage, thereby limiting horizontal deflection to within the limits of the CRT viewing area. Q1152 and Q1162 operate in an overdriven mode. This means at the extremes of signal amplitude, one side will be turned off while the other side is still conducting. This condition generates some common-mode signal differences between Q1152 and Q1162. Q1164 monitors any common-mode signal differences (through R1165 and R1167) and conducts to minimize them.

### Output Amplifier

The push-pull signal from the Gain Setting Amplifier is connected to the Output Amplifier. Each half of the Output Amplifier can be considered as a single-ended feedback amplifier, which amplifies the signal at its input to produce a voltage output to drive one of the horizontal deflection plates of the CRT. Both halves of the Output Amplifier are basically the same with only minor differences; therefore, only the upper amplifier (drives the + horizontal deflection plate) and the differences will be explained.

Q1172 and Q1174 are connected in a Darlington configuration. Q1234 is a feedback amplifier in the feedback path for the output amplifier. Q1234 sets DC levels and reduces the impedance of the feedback path. Q1202 and Q1204 form a complementary amplifier that provides the output signal to drive the + deflection plate of the CRT. CR1173 clips excessive signal amplitudes and sets a sweep start voltage level for the positive deflection plate. R1175, C1233, and C1179 are high-frequency compensation adjustments. R1256 centers the output signal swing within the dynamic swing capabilities of the output amplifier.

There are two signal paths through each half of the Output Amplifiers. Slow signal transitions are applied to the CRT through Q1172, Q1174, and Q1204 with feedback via R1233 and R1235. C1235, C1233, and C1178-C1179 compensate the amplifier and provide a fast AC signal path from one side of the amplifier to the other. The lower amplifier (drives the - horizontal deflection plate) is basically the same as the upper except for two things. Q1188 is a relatively constant current source for Q1182 and Q1184. VR1216 shifts the DC level of the signal from the collectors of Q1182 and Q1184 to the emitter level of Q1214.

## LOW-VOLTAGE POWER SUPPLY



### General

The Low-Voltage Power Supply circuit provides the operating power for this instrument from six regulated power supplies and one unregulated power supply. Electronic regulation is used to provide stable, low-ripple output voltages. Fig. 3-9 shows a detailed block diagram of the Power Supply circuit. A schematic of this circuit is shown on Diagram 11 at the rear of this manual.

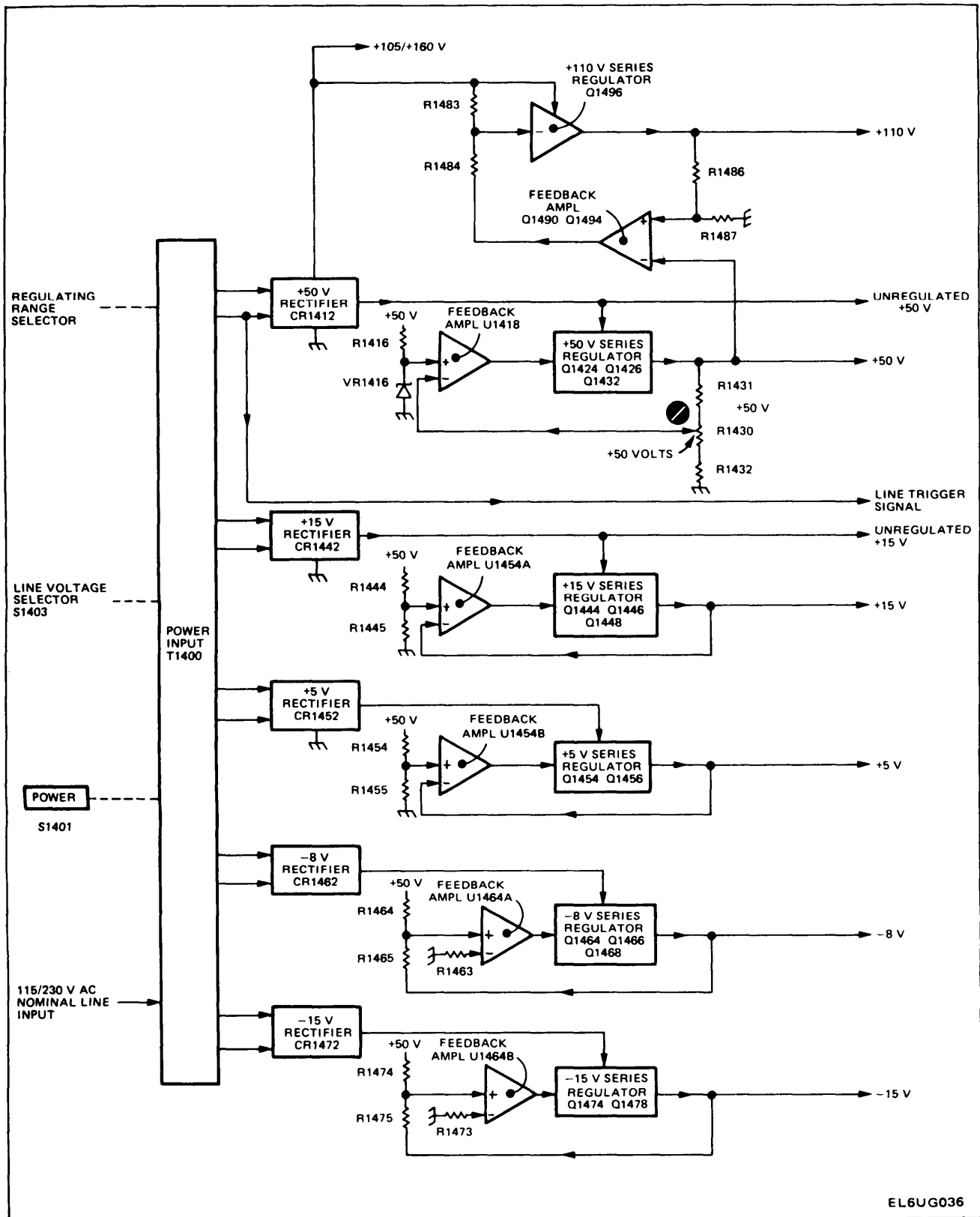


Fig. 3-9. Detailed block diagram of the Power Supply circuit.



## Power Input

Power is applied to the primary of transformer T1400 through Line Fuse F1401, POWER switch S1401, Thermal Cutout S1402, Line Voltage Selector switch S1403, and the Regulating Range Selector. Line Voltage Selector switch S1403 connects the split primaries of T1400 in parallel for 115-volt nominal operation, or in series for 230-volt nominal operation. Line Fuse F1401 should be changed for each nominal line voltage (current rating of fuse for 230-volt operation must be 0.75A fast; for 115-volt operation current rating of fuse must be 1.5A fast).

Thermal cutout S1402 provides thermal protection for this instrument. If the internal temperature of the instrument exceeds a safe operating level, S1402 opens to interrupt the applied power. When the temperature returns to a safe level, S1402 automatically closes to reapply the power.

The vacant windings between pins 10, 10A, 11, 12, and 12A or T1400 are intended for use with the optional Inverter Circuit Board (Option 7) or for use with a 475 Oscilloscope modification, a Power Supply Board (475 DM43 and DM40).

## Secondary Circuit

The -8 volt, -15 volt, +5 volt, +15 volt, +50 volt, and +110 volt supplies are series-regulated supplies. U1418, U1454A and B, and U1464A and B are high-gain amplifier cells with differential inputs. These amplifiers monitor variations in the output voltages and generate error signals to maintain relatively constant output levels. Each regulated supply contains a current-limiting circuit that provides short circuit protection to prevent instrument damage if a supply is inadvertently shorted to ground. Additionally, unregulated voltages are used from the +15 volt and +50 volt supplies.

**+50-Volt Supply.** The +50-Volt Power Supply provides the reference voltage for all remaining regulated supplies in the instrument. The following discussion includes the description of the +50-Volt Series Regulator, +50-Volt Feedback Amplifier, +50-Volt Reference, and +50-Volt Current Limiting stages. Since these stages are closely related in the production of the +50-volt regulated output voltage, their operation is most easily understood when discussed as a unit.

CR1412 functions as a full-wave, center-tapped, bridge rectifier and provides an unregulated output voltage (approximately +65 volts) for the +50-Volt Power Supply. This voltage is filtered by C1414 and is connected to the +50-Volt Series Regulator, Q1426, to provide a sufficient collector supply for stable regulation over a wide range of ac power line voltages. Zener diode VR1416 sets a reference level of about +9 volts at the positive input of Feedback Amplifier U1418. A sample of the output voltage from the +50-Volt Supply is connected to the negative input of U1418 through divider R1430-R1431-R1432. R1430 in this divider is adjustable to set the output level of the +50-Volt Supply. The 2 input voltages at Feedback Amplifier U1418 are compared and any error between the 2 inputs is amplified. The amplified error output from U1418 drives Q1424 and Q1426 and controls the output voltage of the power supply.

Regulation occurs as follows: If the output level of this supply decreases (due to an increase in load, for example) the voltage across divider R1430-R1431-R1432 decreases also. This results in a more negative feedback level at pin 2 of U1418 than that established by the reference voltage at pin 3. The difference in voltage levels is amplified and polarity is inverted by U1418. The result is that voltage increases at pin 1 of U1418. This increase in voltage causes a more positive voltage at the base of Q1424. More current is allowed to flow through Q1424 to result in increased conduction of the +50-volt Series Regulator Q1426. The output voltage increases, thereby achieving regulation of the +50-volt power supply.

The +50-volt Current Limiting stage, Q1432, protects the +50-Volt Series Regulator if excess current is demanded from this supply. Since the load is connected to this supply through R1426, all current must flow through this resistor. When excess current is demanded from the +50-Volt Series Regulator, due to a short circuit or similar malfunction at the output of this supply, the voltage drop across R1426 increases, causing a higher positive voltage at the emitter of Q1426 than the supply output voltage. This increased voltage is coupled through the emitter-to-base junction of Q1426 to voltage divider R1424 and R1425. Under normal conditions, this divider sets the base level of Q1432 for a biased-off condition. However, when the power supply load increases beyond preset limits, or the supply output becomes short circuited, the positive going change across the divider R1424-R1425 causes Q1432 to become biased on. The collector current of Q1432 reduces the voltage at the base of Q1424 to limit the conduction of current through Q1426 and R1426 to a preset value. This mode of operation is called foldback because both the supply voltage and current are reduced during overload. The supply automatically returns to normal operation when the overload is removed.

**+110-Volt Supply.** CR1412 functions as a full-wave center-tapped rectifier and provides an unregulated output voltage (approximately +136 volts) for the +110-Volt Power Supply. This voltage is filtered by C1412 and is connected to the +110-Volt Series Regulator, Q1496, to provide sufficient collector supply for stable regulation over a wide range of ac power line voltages. Transistors Q1490 and Q1494 are connected as a comparator. A sample of the output voltage from the +110-Volt Supply, through divider R1486, R1487, is connected to the base of Q1490. The base of Q1494 is connected to the +50-Volt Supply to provide a reference voltage. The error output at the collector of Q1494 reflects the difference, if any, between these 2 inputs. This error output drives Q1496 and controls the output voltage of the power supply.

Regulation occurs as follows: If the output level of this supply decreases (due to an increase in load, for example) the voltage at the base of Q1490 decreases also. This decreased voltage when compared to the reference voltage at the base of Q1494 results in a decreased voltage at the collector of Q1494. A portion of this decreased voltage is connected to the base of Q1496 causing increased conduction. The output voltage increases, thereby achieving regulation of the +110-volt power supply.

A current limiting stage, Q1497, protects the +110-Volt Supply if excess current is demanded from this supply. All output current from the +110-Volt Supply must flow through R1489. Transistor Q1497 senses the voltage drop across R1489. Under normal operating conditions, Q1497 is biased off. However, when excess current is demanded from the +110-Volt Series Regulator due to a short circuit or similar malfunction at the output of this supply, the voltage drop across R1489 increases until it is sufficient to forward bias Q1497. The collector current of Q1497 pulls the base of Series Regulator Q1496 positive and turns it off. The output current from the supply is then limited by R1488 and the +110-Volt Supply is thereby protected.

**+15-Volt Supply.** Basic operation of all stages in the +15-Volt Supply is the same as for the +50-Volt Supply. The +15 volt reference for this supply is established by divider R1444-R1445 between +50 volts and ground. Any change in the output level of the supply is compared at Feedback Amplifier U1454A, which produces a signal of inverted polarity at its output (pin 1). This change is coupled to +15-Volt Series Regulator Q1448 through Q1446 to correct the change in output voltage. Transistor Q1444 provides current limiting (foldback operation) if the supply load increases beyond preset limits or becomes shorted to ground.

**+5-Volt Supply.** Basic operation of all stages in the +5-Volt Supply is the same as described in the +50-Volt Supply and the +15-Volt Supply. The +5 volt reference for this supply is established by divider R1454-R1455 between +50 volts and ground. Any change in the output level of the supply is compared at Feedback Amplifier U1454B which produces a signal of inverted polarity at its output (pin 7). This change is coupled to +5-Volt Series Regulator Q1456 to correct the change in the output voltage. Transistor Q1454 provides current limiting (foldback operation) if the supply load increases beyond preset limits or becomes shorted to ground.

**-8-Volt Supply.** Basic operation of all stages in the -8-Volt Supply is the same as described in previous supplies. The reference level for this supply (0 volt) is established by the ground connection through R1463 to pin 2 of Feedback Amplifier U1464A. Feedback voltage to pin 3 of U1464A is provided by divider R1464-R1465 between +50 volts and the -8-Volt Supply output. The divider ratio of R1464-R1465 is 10:1 so the level at pin 3 is 0 volt when the supply is operating properly. Any change in the output level of the supply is compared at U1464A, which produces a correction signal of the same polarity as its output (pin 1). This change is coupled to the -8-volt Series Regulator, Q1468, through Q1466 to correct the change in output voltage. Transistor Q1464 provides current limiting (foldback operation) if the supply load increases beyond preset limits or becomes shorted to ground.

**-15-Volt Supply.** Basic operation of all stages in the -15-Volt Supply is the same as described in the -8-Volt Supply. The reference level for this supply (0 volt) is established by the ground connection through R1473 to pin 6 of Feedback Amplifier U1464B. The feedback voltage (0 volt) to pin 5 of U1464B is provided by divider R1474-R1475 between +50 volts and the -15-Volt Supply output. Any change in the output voltage of the supply is compared at U1464B, which produces a correction signal of the same polarity at its output (pin 7). This change is coupled to the base of -15-Volt Series Regulator Q1478 to correct the change in output voltage. Transistor Q1474 provides current limiting (foldback operation) if the supply load increases beyond preset limits or becomes shorted to ground.

## CRT CIRCUIT

### General

The CRT Circuit provides the voltage levels and control circuits necessary for operation of the cathode-ray tube (CRT). Fig. 3-10 shows a detailed block diagram of the CRT Circuit. A schematic of this circuit is shown on Diagram 12 at the rear of this manual.

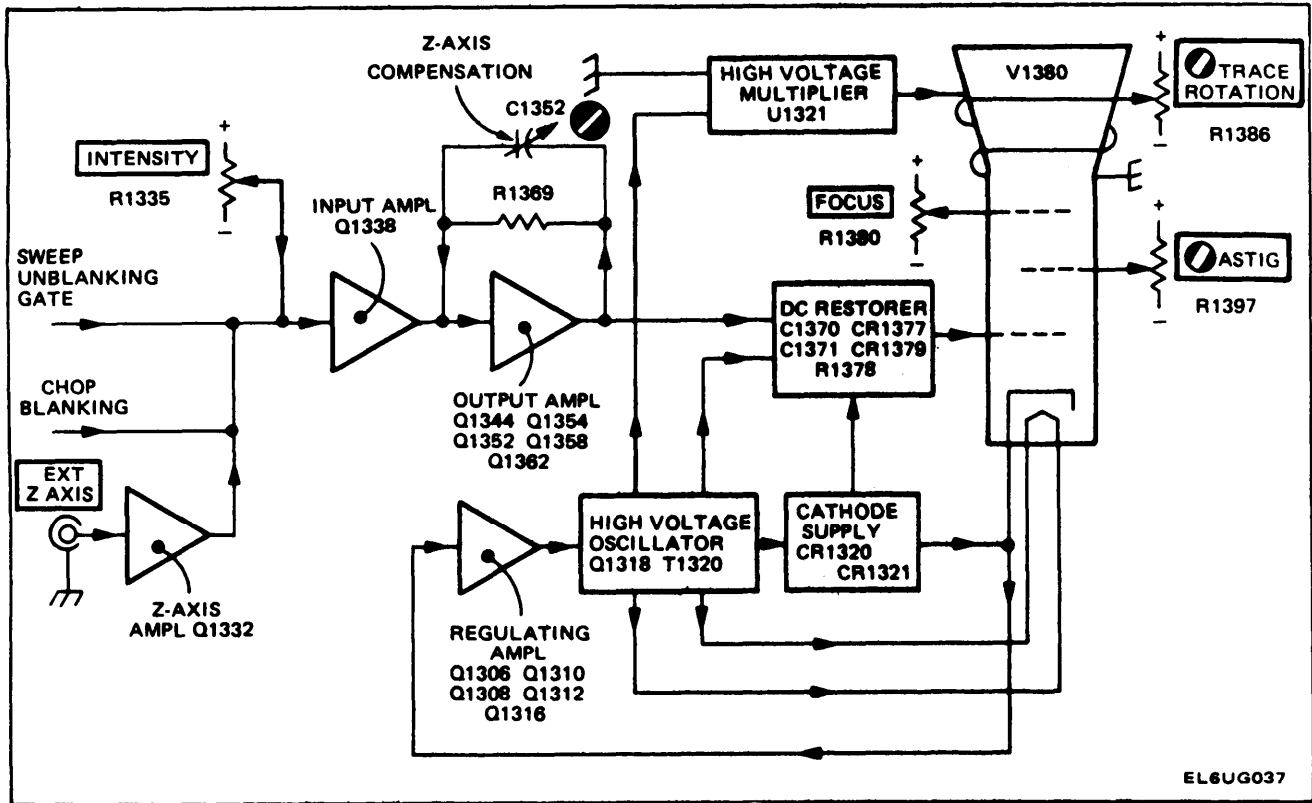


Fig. 3-10. Detailed block diagram of the CRT circuit.

### High Voltage Oscillator

Q1318 and associated circuitry compose the high-voltage oscillator that produces the drive for high-voltage transformer T1320. When the instrument is turned on, current through Q1316 provides forward bias for Q1318. Q1318 conducts and the collector current increases, which develops a voltage across the collector winding of T1320. This produces a corresponding voltage increase in the feedback winding of T1320, which is connected to the base of Q1318, and Q1318 conducts even harder. Eventually the rate of collector current increase in Q1318 becomes less than that required to maintain the voltage across the collector winding and the output voltage drops. This turns Q1318 off by way of the feedback voltage to the base. The voltage waveform at the collector of Q1318 is a sine wave at the resonant frequency of T1320. Q1318 remains off during the negative half cycle while the field collapses in the primary of T1320. When the field is collapsed sufficiently, the base of Q1318 becomes forward biased into conduction again and the cycle begins anew. The amplitude of sustained oscillation depends upon the average current delivered to the base of Q1318. The frequency of oscillation is approximately 50 kilohertz. Fuse F1318 protects the unregulated +15-volts supply in the event the High-Voltage Oscillator stage becomes shorted. C1318 and L1318 decouple the +15-volt supply line and prevent the current changes present in the circuit from affecting the +15-volt regulated supply.

### High-Voltage Regulator

Feedback from the CRT cathode -2450 volt supply is applied to the base of Q1306 through R1303A. Any change in the level at the base of Q1306 produces an error signal at the collector of Q1306, which is amplified by Q1308 and Q1316 and applied to the base of Q1318 through the feedback winding of T1320. Regulation occurs as follows.

If the output voltage at the -2450 volt test point starts to go positive (less negative), this positive-going change is applied to the base of Q1306. Q1306 conducts harder, which in turn causes Q1308 and Q1316 to conduct harder. This results in greater bias current to the base of Q1318 through the feedback winding of T1320. Now, Q1318 is biased closer to its conduction level so that it comes into conduction sooner to produce a larger induced voltage in the secondary winding of T1320. This increased voltage appears as a more negative voltage at the -2450 volt test point to correct the original positive-going change. By sampling the output from the CRT cathode supply in this manner, the total output of the High-Voltage Supply is held relatively constant.

Q1312 and Q1310 compose an overvoltage protection circuit. In the event the regulating action of the circuit should cause the CRT cathode supply to approach approximately -3000 volts, the voltage level at the emitter of Q1316 will be very close to -6 volts. Normally Q1312 and Q1310 are biased off and do not conduct. When the voltage level at the emitter of Q1316 reaches approximately -6volts, Q1312 is biased into conduction, which in turn biases Q1310 on. Q1310 now starts to reduce the base drive applied to Q1318 and prevents the amplitude of oscillations from increasing. This prevents the CRT cathode supply from going more negative than approximately -3300 volts.

### High-Voltage Rectifiers and Output

The high-voltage transformer T1320 has two output windings. One winding provides filament voltage for the cathode-ray tube. The filament voltage can be supplied from the High-Voltage Supply, since the cathode-ray tube has a very low filament current drain. The filament of the cathode-ray tube is elevated to the cathode level to prevent cathode-to-filament arcing. The other winding of T1320 is used to derive both the negative cathode potential and the positive anode accelerating potential.

The positive accelerating potential is supplied by High Voltage Multiplier U1321. Regulated output voltage is approximately +15,500 volts, The negative cathode potential is supplied by a voltage doubler circuit, C1320, CR1320 and CR1321. Voltage output is -2450 volts. Variations in supply voltage are monitored by the High-Voltage Regulator circuit to provide a regulated high-voltage output.

### Control-Grid DC Restorer

The Control-Grid DC Restorer couples dc and low frequency components of the Z-Axis Amplifier signal to the CRT control grid. This allows the Z-Axis Amplifier to control the CRT beam current (intensity). The potential difference between the Z-Axis Amplifier output and the control grid (about 2450 volts) prohibits direct coupling.

The dc restorer is actually a cathode-referenced bias supply for the CRT control grid. Quiescently, its output voltage is more negative than the CRT cathode by an amount set by the voltage level across VR1374, the setting of Grid Bias adjustment R1375, and the voltage at the output of the Z-Axis Amplifier.

When the secondary-winding output of T1320 swings positive, C1372 charges through C1326, R1326, R1372, CR1379, and R1379 to a voltage level that equals the voltage determined by VR1374 and the setting of Grid Bias adjustment R1375. At this voltage level, (approximately +15 volts) CR1373 turns on, preventing any additional

increase in positive voltage. When the secondary-winding output swings negative, CR1373 turns off, then CR1371 turns on and clamps the less positive voltage swing at C1372 to the voltage level of the Z-Axis Amplifier. During this less positive voltage swing, C1372 discharges through CR1377 into C1371. Capacitor C1371 holds the voltage constant at the CRT control grid; it also provides a path for the fast rising and falling portions of the Z-Axis Amplifier output to be coupled to the CRT control grid for blanking and unblinking.

### CRT Control Circuits

Focus of the CRT display is controlled by FOCUS control R1380. The Focus Tracking control, R1335B, located in a series resistor network with the FOCUS control, is ganged with the INTENSITY control to reduce focus variations when changing the INTENSITY setting. The ASTIG adjustment R1397 which is used in conjunction with the FOCUS control to provide a well-defined display, varies the positive level on the astigmatism grid. Geometry adjustment R1390 varies the positive level on the horizontal deflection plate shields to control the overall geometry of the display.

Two adjustments control the trace alignment by varying the magnetic field around the CRT. Y Align adjustment R1385 controls the current through L1385, which affects the CRT beam after vertical deflection but before horizontal deflection. Therefore, it affects only the vertical (Y) components of the display. TRACE ROTATION adjustment R1386 controls the current through L1386 and affects both vertical and horizontal rotation of the beam.

### Z-Axis Amplifier

The Z-Axis Amplifier circuit controls the CRT intensity level from several inputs. The effect of these input signals is to either increase or decrease the trace intensity, or to completely blank portions of the display. The input transistor, Q1338, is a current-driven, low input impedance amplifier. It provides termination for the input signals as well as isolation between the input signals and the following stages. The current signals from the various control sources are connected to the emitter of Q1338 and the algebraic sum of the signals determines the collector conduction level.

Q1344, Q1352, Q1354, Q1358, and Q1362 compose a feedback amplifier stage. R1369 is the feedback resistor and C1352 provides high-frequency compensation. Q1344 is an emitter follower that provides drive to the output complementary amplifier made up of Q1352, Q1354, and Q1358. Q1358 is a device with higher frequency characteristics than Q1354 and is used to improve the overall frequency capabilities of the Z-Axis Amplifier. On the fast positive-going output signal peaks, Q1358 depletes the charge on C1358. Then, on the negative-

going signal peaks, Q1362 is pulsed on to renew the charge on C1358. CR1367 provides protection to the Z-Axis Amplifier circuitry in the event of short duration arcing in the CRT High-Voltage Power Supplies.

In the 0.1 s, 0.2 s, 0.5 s, and X-Y positions of the TIME/DIV switch, the anode of CR1337 is connected to ground. This limits how negative the operating level at the emitter of Q1338 can go to reduce the unblinking capabilities of the amplifier, thereby reducing the possibility of inadvertently burning the CRT phosphor. When the BEAM FINDER pushbutton is pressed, -8 volts is connected to the junction of R1342 and R1346. This biases Q1338 off which in turn causes CR1343 to be reverse biased. Now the output of the Z-Axis Amplifier is isolated from all of the circuit's normal signal inputs. The output level of the amplifier is set at a nearly fixed level (approximately +25 volts) determined by the parallel value of R1343 and R1346 divided into the feedback resistance of the amplifier. This sets the sweep intensity to a normal viewing level.

## CALIBRATOR



### General

The Calibrator circuit produces a square-wave output signal with accurate voltage and current amplitudes. This output is available as a voltage or current at the CALIBRATOR current loop on the instrument front panel. Fig. 3-11 shows a detailed block diagram of the Calibrator circuit. A schematic of this circuit is shown on Diagram 13 at the rear of this manual.

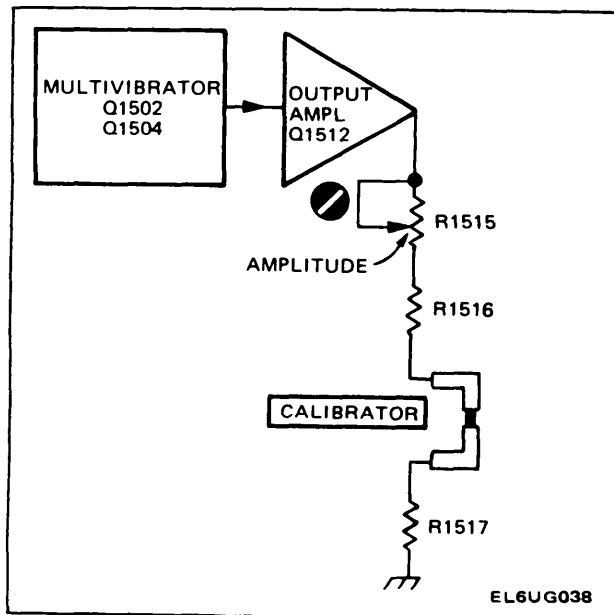


Fig. 3-11. Detailed block diagram of the Calibrator circuit.

## Multivibrator

Q1502 and Q1504 along with their associated circuitry compose an astable multivibrator. The basic frequency of the multivibrator is approximately one kilohertz and is essentially determined by the RC combination of C1505, R1502, and R1504. Q1502 and Q1504 alternately conduct, producing a square-wave signal that is taken from the collector of Q1504.

## Output Amplifier

The output signal from the Multivibrator overdrives Output Amplifier Q1512 to produce a square wave at the output. When the base of Q1512 goes positive, Q1512 is cut off and the collector level drops down to ground. When the base goes negative, Q1512 is biased into saturation and the collector of Q1512 rises positive to about +5 volts. Amplitude adjustment R1515 adjusts the resistance between the collector of Q1512 and ground to determine the amount of current allowed to flow, which in turn determines the voltage developed across R1517.

## FAN MOTOR CIRCUIT



### General

The fan motor used in the 475 is a brushless DC motor using Hall Effect devices. The fan motor control circuitry varies the rotational speed of the fan as the operating temperature changes.

Two Hall Effect devices inside the motor, and 4 transistors U8061A, B, C, and D (U1690-A-D for early SN) compose a sine-wave generator to drive the motor windings. Each of the 4 transistors is controlled by 1/2 of a Hall element to generate 1/4 of the sine-wave cycle.

As the ambient temperature increases, the value of thermistor RT8038 (RT1696 for early SN) decreases. This biases Q8067 (Q1698 for early SN) on harder to conduct more current through the Hall devices and turn the motor winding control transistor on harder. The harder the transistor is conducting, the faster the fan rotates.

Typical fan speed variation with ambient temperature is:

- 15°C, approx. 800 RPM
- +25°C, approx. 2000 RPM
- +55°C, approx. 3100 RPM



# MAINTENANCE

This section of the manual contains directions for Cabinet removal, preventive maintenance, troubleshooting and corrective maintenance of the 475.

## MAINTENANCE SECTION OUTLINE

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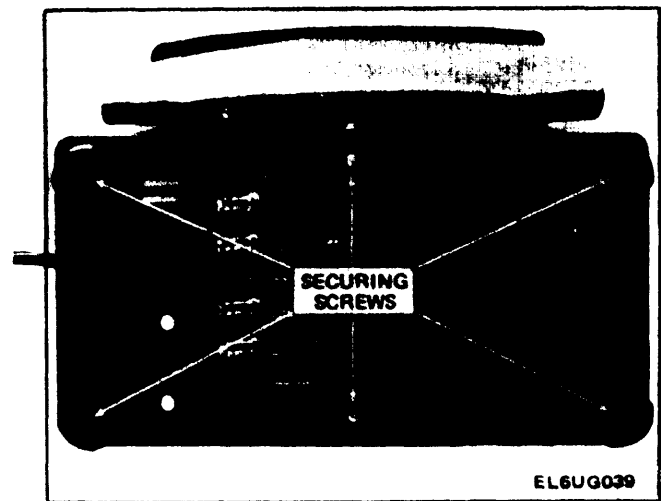
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**CABINET AND RACK ADAPTER  
 REMOVAL**

**Standard Cabinet Removal**

The standard instrument cabinet can be removed in the following manner:

1. Disconnect the instrument power cord from the power source.
2. Install the front-panel cover and set the instrument face on a flat surface.
3. Unwrap the power cord from the instrument feet.
4. Remove the 6 screws indicated in Fig. 4-1 and remove the rear cabinet frame with feet and screws from the instrument as an intact assembly.



**Fig. 4-1. Removing the standard cabinet.**



5. Lift the cabinet up until it is separated from the instrument and power cord.

**WARNING**

*Dangerous potentials exist at several points throughout this instrument. When the instrument is operated with the cabinet removed, do not touch exposed connections or components. Some transistors may have elevated cases. Disconnect power before cleaning the instrument or replacing parts.*

### Standard Cabinet Installation

The standard instrument cabinet should be installed in the following manner:

1. Disconnect the instrument power cord from the power source.
2. If the Vertical Output circuit-board cover is not in place, install the cover on the top of main chassis. Where parts were removed or replaced check all sections of the instrument for proper assembly. It may be helpful to use the diagrams in Section 7, Mechanical Parts List, for the locations of parts.
3. 475 DM-series only—If the DM-series main circuit-board is not in place, install the board on the main chassis.
4. Install the front-panel cover and set the instrument face on a flat surface.
5. Place the cabinet handle against the bottom of the cabinet (bottom of cabinet is nearest the carrying handle pivot points).
6. Pull the power cable through the cabinet and slide the cabinet over the instrument using care to avoid pinching cables or damaging components that protrude from circuit boards.
7. Using both hands, press lightly on the top and bottom sides of the cabinet until the front edge of the cabinet is inserted into the braided gasket groove around the full periphery of the front cabinet frame.
8. Pull the power cord through the rear cabinet frame, align a cutout portion in the frame for proper fit at the regulating-range selector cover and work the frame into place.

9. Set the feet and screws in place and exert a light downward pressure on the rear cabinet frame with 1 hand and arm. Press lightly on the top and bottom sides of cabinet with the other hand, checking that cabinet edge is properly seated in the gasket groove of both front and rear frames. Continue to exert a downward pressure and tighten the 6 screws of the rear frame to a snug fit. Do not over-tighten these screws.

The standard cabinet protects this instrument from dust in the interior and also provides protection to personnel from the operating potentials present. In addition, the cabinet reduces the emi (electromagnetic interference) radiation from the instrument and interference to the display due to other equipment.

The front-panel cover provides a dust-tight seal around the front panel and protects the front panel when storing or transporting the instrument.

### Rack Adapter Removal

The Rack Adapter can be removed from the instrument in the following manner:

1. Remove the hardware that fastens the Rack Adapter to the rack and pull the adapter partially out. Disconnect the instrument power cord from the power source and remove any interconnecting cables.

#### NOTE

*It is desired to tilt the Rack Adapter and Instrument, remove a screw from the rear of each slide section mounted to the Rack Adapter. These securing screws are an important part of the mounting and should be installed when tilt operation is not necessary.*

2. Remove the Rack Adapter, with instrument, from the rack and set the bottom of the complete assembly on a flat surface.

3. Remove 2 setscrews from the top, front of Rack Adapter chassis, (A 0.125-inch Allen wrench is required to remove the setscrews.) It may be helpful to use the diagrams in Section 7, Mechanical Parts List, for the locations of parts.

4. Remove 10 screws that hold the rear support plate to an angle bracket on one side, to the Rack Adapter chassis on the opposite side, and to the rear of the instrument. Remove the rear support-plate and blue-plastic rear frame.

5. Slide the instrument forward through the adapter cabinet, using both hands (front and rear) to lift and guide the instrument until separated from the Rack Adapter.

**WARNING**

*Dangerous potentials exist at several points throughout this instrument. When the instrument is operated with the Rack Adapter removed, do not touch exposed connections or components. Some transistors may have elevated cases. Disconnect power before cleaning the instrument or replacing parts.*

**Rack Adapter Installation**

The Rack Adapter should be installed in the following manner:

1. Disconnect the instrument power cord from the power source.

2. If the Vertical Output circuit-board cover is not in place, install the cover on the top of the 475 main chassis. Check all sections of the instrument where parts were removed or replaced for proper assembly. It may be helpful to use the diagrams in Section 7, Mechanical Parts List for the locations of parts.

3. Set the bottom of the Rack Adapter on a flat surface, pull the power cord through the cabinet portion of the Rack Adapter and slide the instrument rearward using both hands (front and rear) to lift and guide the instrument until fully inserted. Use care to avoid pinching cables or damaging components that protrude from circuit boards.

4. Check that the front edge of the cabinet portion of the Rack Adapter is inserted into the braided gasket groove around the full periphery of the instrument front-frame. Pull the power cord through the blue-plastic rear frame, align a cutout portion in the plastic frame for proper fit at the regulating-range selector cover, and work the frame into place.

5. Apply the rear support bracket to the rear of the Rack Adapter. Install, without tightening, 6 screws that secure the rear support bracket through the blue-plastic frame to the rear of the instrument and 4 screws that secure the rear support bracket to an angle bracket and to the Rack Adapter chassis.

6. Check that all parts of the complete assembly are properly seated, then tighten to a snug fit the screws at the rear of the instrument and the screws at the adapter chassis. Do not overtighten these screws.

7. Install 2 setscrews at the top-front of the Rack Adapter chassis (A 0.125-inch Allen wrench is required to install the setscrews.)

8. Mount the Rack Adapter slide sections to the rack slide assemblies, connect the power cord, connect any interconnecting cables, push the Rack Adapter into final operating position, and install the adapter-to-rack hardware.

The Rack Adapter cabinet (Part No. 016-0556-00) for the 475 provides the proper electrical environment for the instrument, reduces dust collection, reduces handling damage to a minimum, and provides a means for mounting the instrument solidly to a surface such as a rack or console.

**PREVENTIVE MAINTENANCE**

**Introduction**

Preventive maintenance consists primarily of cleaning and visual inspection. When performed on a regular basis, preventive maintenance can prevent instrument breakdown and improves the reliability of this instrument. The severity of the environment to which the 475 is subjected will determine the frequency of maintenance. A convenient time to perform preventive maintenance is just prior to recalibration of the instrument.

**Cleaning**

The cabinet provides protection against dust in the interior of the instrument. Operation without the cabinet in place necessitates more frequent cleaning. The front cover provides a measure of dust protection for the front panel and the crt face. The front-panel cover should be install when storing or transporting the instrument.

**CAUTION**

*The volts/division attenuators use a plastic material (polyphenylene oxide) that is easily damaged by the use of carbon-based solvents. Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Do not use chemicals that contain acetone, benzene, toluene, xylene, petroleum ether, white kerosene, carbon tetrachloride, methylene chloride, trichloroethane, trichlorotrifluoroethane (freon 113, -tf, -ta, -tmc) and trichlorethylene. Recommended cleaning agent for general interior cleaning, except switch contacts, is isopropyl alcohol. (Read the information under Cleaning, Switch Contacts, before attempting to clean in the area of the volts/division attenuators). As a second choice, in the absence of these cleaners, it is safe to use ethyl alcohol (fotocol, ethanol) and methyl alcohol (methanol).*

*Most spray circuit-coolants contain freon 12 as a propellant. Because many freons adversely affect switch contacts, check the contents and brand name before using a spray coolant. Recommended circuit coolant for the volts/division attenuators is isopropyl alcohol.*

**Switch Contacts.** Most of the switching in the 475 is accomplished with circuit-board mounted, cam-actuated contacts. Care must be exercised to preserve the high-frequency characteristics of these switches. Seldom is switch cleaning necessary, but if it is required, observe the following precautions.

For cleaning the switch contacts, isopropyl alcohol is the recommended solvent to use. Apply the isopropyl alcohol with a camel-hair brush. Do not use cotton swabs as they tend to snag on contacts, possibly causing damage, and leave strands of cotton, causing intermittent electrical contact.

**WARNING**

*Compressed air shall not be used for cleaning purposes except where reduced to less than 29 pounds per square inch (psi) and then only with effective chip guarding and personnel protective equipment. Do not use compressed air to dry parts when TRICHLOROTRI FLUOROETHANE has been used. Compressed air is dangerous and can cause serious bodily harm if protective means or methods are not observed to prevent chip or particle (of whatever size) from being blown into the eyes or unbroken skin of the operator or other personnel.*

**General Interior.** Dust in the interior of the instrument should be removed occasionally due to its electrical conductivity under high-humidity conditions. Accumulations of dirt should be removed as often as operating conditions require because dirt can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides an electrical conduction path that can result in instrument failure. The best way to clean the interior is to blow off the accumulated dust with dry, low-pressure air (approximately 9 lb/in<sup>2</sup>). Remove any dirt that remains with a soft brush or a cloth dampened with a mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces or for cleaning ceramic terminal strips and circuit boards.

**Exterior.** Loose dust accumulated on the outside of the 475 can be removed with a soft cloth or small paint brush. The paint brush is particularly useful for dislodging dirt on and around the front-panel controls. Dirt that remains can be removed with a soft cloth dampened in a mild detergent and water solution. Abrasive cleaners should not be used.

**CRT Face, Filter and Shields.** Clean the Individual blue or clear plastic implosion shields and the crt face with a soft, lint-free cloth dampened with denatured alcohol (ethyl alcohol) or a mild detergent and water solution. Install only one implosion shield between the bezel and crt face. The optional crt mesh filter can be cleaned in the following manner.

1. Hold the filter in a vertical position and brush lightly with a soft watercolor brush to remove light coatings of dust and lint.

2. Greasy residues or dried-on dirt can be removed with a solution of warm water and a neutral pH liquid detergent. Use the brush to lightly scrub the filter.

3. Rinse the filter thoroughly in clean water and allow to air dry.

4. If any lint or dirt remains, use clean low-pressure air (approximately 9 lb/in<sup>2</sup>) to remove. Do not use tweezers or other hard cleaning tools on the filter as the special finish may be damaged.

5. When not in use, store the mesh filter in a lint-free, dust proof container such as a plastic bag.

**Air Filter.** The air filter should be visually checked every few weeks and cleaned or replaced if dirty. More frequent inspections are required under severe operating conditions. The following procedure is suggested for cleaning the filter. If the filter is to be replaced, order new air filters.

1. Remove the filter by pulling it out of the retaining frame on the rear panel. Be careful not to drop any of the accumulated dirt into the instrument.

2. Flush the loose dirt from the filter with a stream of hot water.

3. Place the filter in a solution of mild detergent and hot water and let it soak for several minutes.

4. Squeeze the filter to wash out any dirt which remains.

5. Rinse the filter in clear water and allow it to dry.

6. Coat the dry filter with an air-filter adhesive.

7. Let the adhesive dry thoroughly.

8. Install the filter in the retaining frame.

### Visual Inspection

The instrument should be inspected occasionally for such defects as broken connections, broken or damaged ceramic strips, improperly seated semiconductors, damaged or improperly installed circuit boards, and heat-damaged parts.

The corrective procedure for most visible defects is obvious; however, particular care must be taken if heat-damaged components are found. Overheating usually indicates other trouble in the instrument; therefore, it is important that the cause of overheating be corrected to prevent recurrence of the damage.

### Lubrication

The fan motor and most of the potentiometers used in the 475 are permanently sealed and generally do not require periodic lubrication. The switches used in the 475, both cam- and lever-type, are installed with proper lubrication applied where necessary and will only rarely require any additional lubrication. It is recommended that a regular periodic lubrication program not be performed on any of the components used in the 475.

### Semiconductor Checks

Periodic checks of the transistors and other semiconductors in the 475 are not recommended. The best check of semiconductor performance is actual operation in the instrument.

### Recalibration

To ensure accurate measurements, check the calibration of this instrument in accordance with TB 43-180. In addition, replacement of component may necessitate recalibration of the affected circuits. The calibration procedure can also be helpful in localizing certain troubles in the instrument. In some cases, minor troubles maybe revealed and/or corrected by recalibration. Complete calibration instructions are given in TB 11-6675-2735-35-1.

## TROUBLESHOOTING

### Introduction

The following Information is provided to facilitate troubleshooting of the 475. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component. An understanding of the circuit operation is

helpful in locating troubles, particularly where integrated circuits are used. See the Circuit Description section for this information.

### Troubleshooting Aids

**Diagrams.** Complete circuit diagrams are given on foldout pages in the Diagram section. The component number and electrical value of each component in this instrument are shown on the diagrams (see first page of the Diagrams section for definition of the reference designators and symbols used to identify components in this instrument). Each main circuit is assigned a series of component numbers. Table 4-1 lists the main circuits in the 475 and the series of component numbers assigned to each. Important voltages and waveforms are also shown on the diagrams. The portions of the circuit mounted on circuit boards are enclosed with blue lines.

**Circuit Board illustrations.** To aid in locating circuit boards in the instrument, a circuit board location illustration is placed on the back of the pullout page preceding the circuit diagram. An illustration of the circuit board, with circuit components of the following circuit diagram identified, is also included on this page. Each circuit board illustration is arranged to facilitate rapid physical location of components listed on the schematic diagrams.

**Component Locations Illustrations.** To aid in locating test points and components, the Component Locations pages permit very rapid location of test points and components.

**Resistor Color-Code.** In addition to the brown composition — resistors, some metal-film resistors and some wire-wound resistors are used in the 475. The resistance values of wire-wound resistors are usually printed on the body of the component. The resistance values of composition resistors and metal-film resistors are color-coded on the components with EIA color-code (some metal-film resistors may have the value printed on the body). The color-code is read starting with the stripe nearest the end of the resistor. Composition resistors have four stripes, which consist of two significant figures, a multiplier, and a tolerance value (see Fig. 4-2). Metal-film resistors have five stripes consisting of three significant figures, a multiplier, and a tolerance value.

**Capacitor Color-Code.** The capacitance values of common disc capacitors and small electrolytics are marked on the side of the component body. The white ceramic and epoxy-coated tantalum capacitors used in the 475 are color-coded, using a modified EIA code (see Fig. 4-2).

**TABLE 4-1**  
**Circuit Number-to-Diagram Locator**

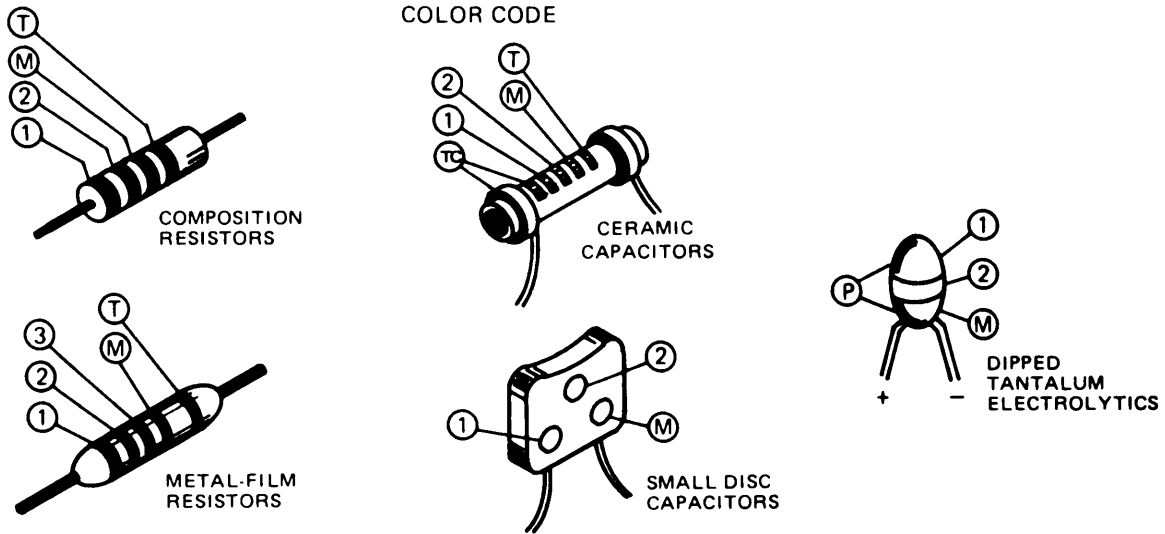
Circuit Number Series	Name of Circuit	Diagram Number
10 — 49	CH 1 ATTENUATORS	1
100 — 199	CH 1 VERTICAL PREAMP	
10 — 69	CH 2 ATTENUATORS	2
200 — 299	CH 2 VERTICAL PREAMP	
300 — 439	VERTICAL CHANNEL SWITCHING	3
440 — 499	VERTICAL OUTPUT AMPLIFIER	4
500 — 570, R579 (See LV POWER SUPPLY for more 500-series numbers)	A TRIGGER GENERATOR	5
660 — 679		
700 — 709		
710 — 786, R789	B TRIGGER GENERATOR	6
571 — 629	SWEEP AND Z AXIS LOGIC	7
640 — 649		
680 — 699		
787 — 829		
1492 — 1499 (See LV POWER SUPPLY for more 1490-series numbers)		
900 — 1049	SWEEP GENERATORS	8
1050 — 1099	TIMING AND HORIZONTAL DISPLAY SWITCHING	9
1100— 1269	HORIZONTAL AMPLIFIER	10
C507, R507, C508, R508, R529 C1335, LR1335, C1336, LR1336 1400 — 1490 R1495, Q1494, Q1496, Q1497	LV POWER SUPPLY	11
1300— 1399	CRT CIRCUIT	12
1500 — 1519	CALIBRATOR	13
1690 — 1699	FAN CIRCUIT	

**Diode Color-Code.** The cathode end of each glass-encased diode is indicated by a stripe, a series of stripes, or a dot. For most silicon or germanium diodes with a series of stripes, the color-code identifies the three significant digits of the Tektronix Part Number using the resistor color-code system (e g , a diode color-coded pink — or — blue—, brown —gray—green indicates Tektronix Part No 152-0185-00). The cathode and anode ends of metal-encased diodes can be identified by the diode symbol marked on the body.

**Semiconductor Lead Configuration.** Fig 4-3 shows the lead configuration for the semiconductors used in this instrument, as viewed from the bottom of these miconductors

#### Troubleshooting Equipment

The following equipment is useful for troubleshooting in the 475.



① ② and ③ - 1ST, 2ND, AND 3RD SIGNIFICANT FIGS.    T AND/OR TC COLOR CODE MAY NOT BE PRESENT ON SOME CAPACITORS;  
 M - MULTIPLIER    T - TOLERANCE;  
 TC - TEMPERATURE COEFFICIENT.    P - POLARITY AND VOLTAGE RATING

COLOR	SIGNIFICANT FIGURES	RESISTORS		CAPACITORS			DIPPED TANTALUM VOLTAGE RATING
		MULTIPLIER (OHMS)	TOLERANCE	MULTIPLIER (pF)	TOLERANCE		
					OVER 10pF	UNDER 10pF	
BLACK	0	1	---	1	±20%	±2pF	4VDC
BROWN	1	10	±1%	10	±1%	±0.1pF	6VDC
RED	2	10 <sup>2</sup> or 100	±2%	10 <sup>2</sup> or 100	±2%	---	10VDC
ORANGE	3	10 <sup>3</sup> or 1 K	±3%	10 <sup>3</sup> or 1000	±3%	---	15VDC
YELLOW	4	10 <sup>4</sup> or 10K	±1%	10 <sup>4</sup> or 10,000	+100% -0%	---	20VDC
GREEN	5	10 <sup>5</sup> or 100 K	±1/2%	10 <sup>5</sup> or 100,000	±5%	±0.5pF	25VDC
BLUE	6	10 <sup>6</sup> or 1 M	±1/4%	10 <sup>6</sup> or 1,000,000	---	---	35VDC
VIOLET	7	---	±10%	10 <sup>7</sup> or 10,000,000	---	---	50VDC
GRAY	8	---	---	10 <sup>-2</sup> or 0.01	+80% -20%	±0.26pF	---
WHITE	9	---	---	10 <sup>-1</sup> or 0.1	±10%	±1pF	3VDC
GOLD	---	10 <sup>-1</sup> or 0.1	±5%	---	---	---	---
SILVER	---	10 <sup>-2</sup> or 0.01	±10%	---	---	---	---
NONE	---	---	±20%	---	±20%	±1pF	---

EL6UG040

Fig. 4-2. Color codes for resistors and capacitors.

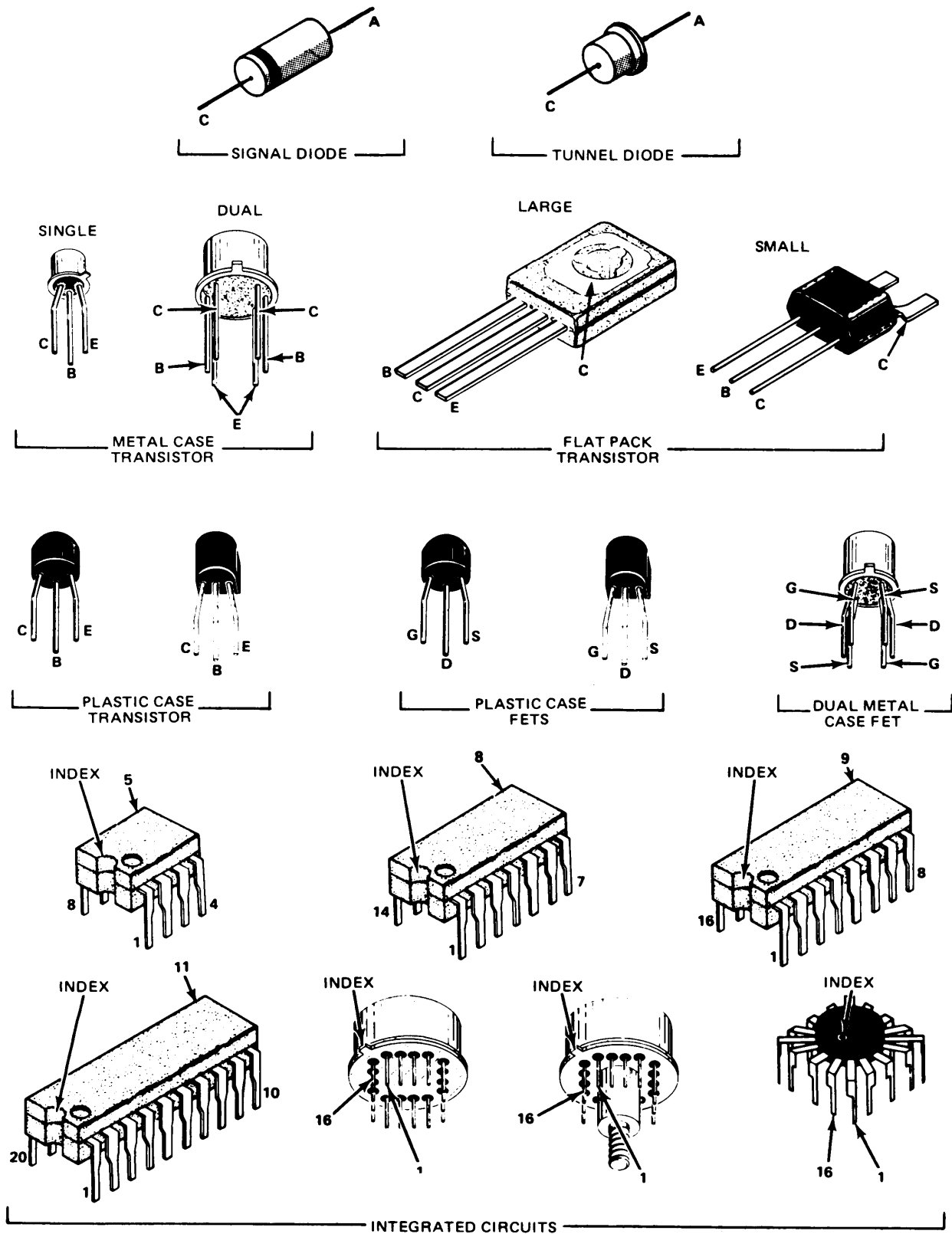


Fig. 4-3. Lead configurations of semiconductors used in this instrument.

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### 1. Semiconductor Tester

Description: Dynamic — type tester. Must be capable of measuring reverse breakdown voltages of at least 400 volts.

Purpose: To test the semiconductors used in this instrument.

Recommended type: Tektronix 576 Curve Tracer or Tektronix 577 (D1 or D2) Curve Tracer with 177 Test Fixture.

### 2. Test Oscilloscope

Description: Frequency response, dc to 75 megahertz or greater; deflection factor, 1 millivolt to 5 volts/division; Input impedance, 1 megohm, 20 picofarads; sweep rate, 0.5 second/division to 50 nanoseconds/division. A 10X, 10-megohm voltage probe should be used to reduce circuit loading for waveform measurements. A 1X, 1-megohm voltage probe should be used for power supply ripple checks.

Purpose: To check operating waveforms in this instrument.

Recommended type: Tektronix 7603 Oscilloscope with 7A13 Amplifier and 7650 Time-Base units. Use a P6053 10X probe and a P6011 1X probe.

### 3. Multimeter

Description: Non-loading Digital Multi meter. Voltmeter, 10 megohm input impedance and 0 to 150 volts range; dc voltage accuracy, within 0.15%; display, 4-1/2 digits. Ohmmeter, 0 to 20 megohms.

Purpose: To check voltages and for general troubleshooting in this instrument.

Recommended type: Tektronix DM 501 Digital Multi-meter (requires a TM 500-series power module).

### 4. Variable Autotransformer

Description: Output variable from 0 to 140 volts, 1.2 amperes minimum rating. Must have 3-wire power cord, plug, and receptacle.

Purpose: To vary the input line voltage when troubleshooting in the power supply.

Recommended type: General Radio W8MT3VM or W10MT3W Metered Variac Autotransformer.

## Troubleshooting Techniques

This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks ensure proper connection, operation and calibration. If the trouble is not located by these checks, the remaining steps aid in locating the defective component. When the defective component is located, it should be replaced following the replacement procedure given under Corrective Maintenance.

**1. Check Control Settings.** Incorrect control settings can indicate a trouble that does not exist. If there is any question about the correct function or operation of any control, see the Operating Instructions section of this manual.

**2. Check Associated Equipment.** Before proceeding with troubleshooting of the 475, check that the equipment used with this instrument is operating correctly. Check that the signal is properly connected and that the interconnecting cables are not defective. Also, check the power source.

**3. Check Instrument Calibration.** Check the calibration of this instrument, or the affected circuit if the trouble exists in only one circuit. The apparent trouble may only be a result of misadjustment and may be corrected by calibration. Complete calibration instructions are given in the Calibration section of this manual.

**4. Visual Check.** Visually check the portion of the instrument in which the trouble is located. Many troubles can be located by visual indications such as unsoldered connections, broken wires, damaged circuit boards, damaged components, etc.

**5. Isolate Trouble to a Circuit.** To isolate trouble to a particular circuit, note the trouble symptom. The symptom often identifies the circuit in which the trouble is located. When trouble symptoms appear in more than one circuit, check affected circuits by taking voltage and waveform readings. Typical voltages and waveforms are given on the schematics in the Diagrams section.

**6. Circuit Troubleshooting Sequence.** If the instrument is found to have inoperative functions in more than one area of the main oscilloscope circuits, repair the circuits in the order specified in the following list.

a. L.V POWER SUPPLY (Check +50 V, +110 V, +15 V, +5V, —15 V and —8 V supplies.)



b. HIGH VOLTAGE (Check oscillator and regulator, over-voltage protection circuit and secondary load.)

c. A SWEEP (Set TRIG MODE to AUTO; repair until sweep is repetitive.)

d. HORIZONTAL AMPLIFIER (Turn horizontal POSITION; repair until each deflection plate output has proper voltage swing.)

e. VERTICAL OUTPUT AMPLIFIER (Turn vertical POSITION; repair until each deflection plate output has proper voltage swing.)

f. Z AXIS (set TRIG MODE to SINGL SWP; repair until spot display is controlled by INTENSITY.)

g. All remaining inoperative functions.

The preceding recommended troubleshooting sequence is intended to be a quick approach to circuit troubleshooting. See Special Troubleshooting information listing in this section for detailed troubleshooting instructions.

Fig. 4-4 provides a guide in locating a defective circuit. This chart may not include checks for all possible defects; use steps 7 through 9 in such cases. Start from the top of the chart and perform the given checks on the left side of the page until a step is found which does not produce the indicated results. Further checks and/or the circuit in which the trouble is probably located are listed to the right of this step.

After the defective circuit has been located, it may be helpful to read the applicable part of the Circuit Description section and Special Troubleshooting Information part of this section to aid in locating defective components. After doing this, see steps 7 through 9 for additional information.

**7. Check Circuit Board Interconnections.** After the trouble has been isolated to a particular circuit, check for loose or broken connections at circuit-board interconnecting pins, plugs and end-lead connectors.

**8. Check Voltages and Waveforms.** Often the defective component can be located by checking for the correct voltage or waveform in the circuit. Typical voltages and waveforms are given on the diagrams.

#### NOTE

*Voltages and waveforms given on the diagrams are not absolute and may vary slightly between instruments. To obtain operating conditions similar to those used to take these readings, see the voltage and waveforms page with each schematic diagram. On this page, note the recommended test equipment, front-panel control settings, voltage and waveform conditions, and test equipment cable connection Instructions. Voltages and waveforms given on the schematics should be checked against each instrument while it is operating properly. Deviations should be noted on the schematics for later reference.*

**9. Check Individual Components.** The following procedures describe methods of checking individual components. Components which are soldered in place should be checked after disconnecting one end from the circuit. This isolates the measurement from the effects of surrounding circuitry.

#### a. SEMICONDUCTORS

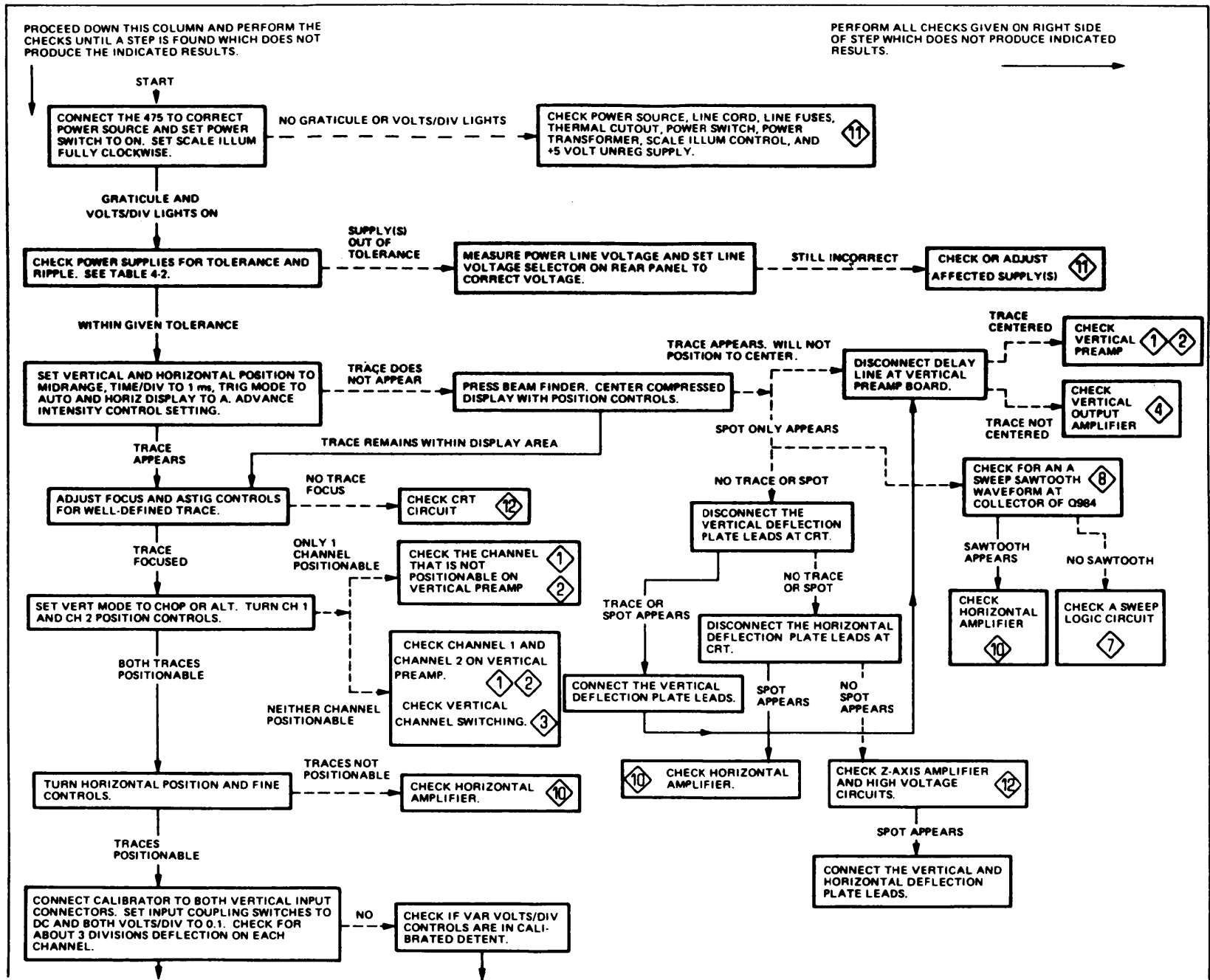
#### **WARNING**

*Power switch must be turned off before removing or replacing components.*

A good check of transistor operation is actual in-circuit performance under operating conditions and most transistors in the 475 can be checked this way. A transistor can be most effectively checked by substituting a new component for it (or one which has been checked previously). However, be sure that circuit conditions are not such that a replacement transistor might also be damaged. If substitute transistors are not available, use a dynamic tester. Static-type testers are not recommended, since they do not check operation under simulated operating conditions.

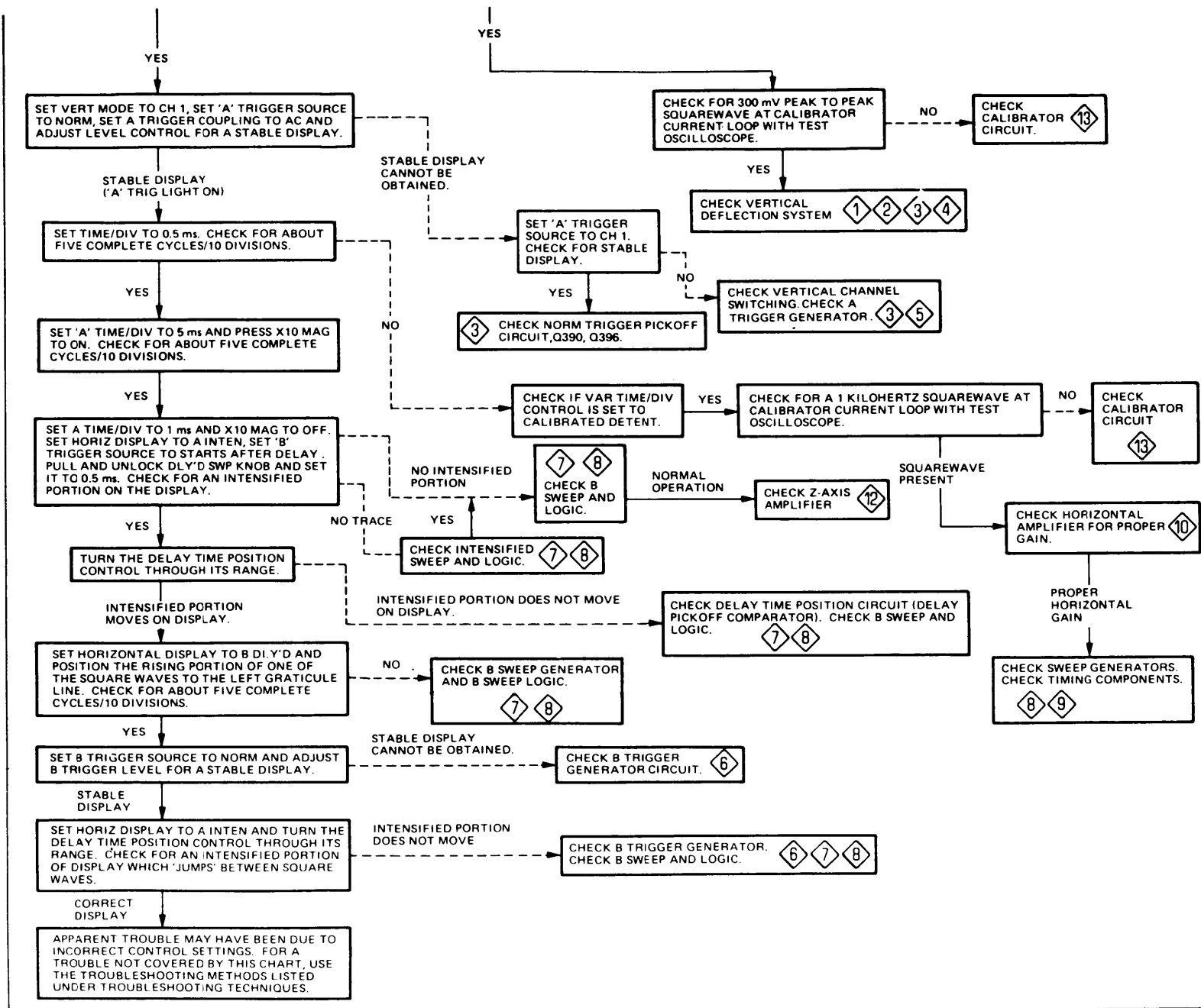
When troubleshooting transistors with a voltmeter, measure the emitter-to-base and emitter-to-collector voltages to determine if the voltages are consistent with normal circuit voltage. Voltages across a transistor vary with the type of device and its circuit function. Some of these voltages are predictable. The emitter-to-base voltage of a conducting silicon transistor will normally be 0.6 to 0.8 volts. The emitter-to-collector voltage of saturated transistors is approximately 0.2 volts. Because these values are small, the best way to check them is by connecting the voltmeter across the junction and using a sensitive voltmeter setting, rather than by comparing 2 voltages taken with respect to ground (both leads of the voltmeter must be isolated from ground if this method is used).

Fig. 4-4. Troubleshooting chart for the 475 Oscilloscope.



ELBU G042

Fig. 4-4. Troubleshooting chart for the 475 Oscilloscope (cont.).



EL6UG043

If values less than these are obtained, either the device is short-circuited or no current is flowing in the circuit. If values are in excess of the base-emitter values given, the junction is back-biased or the device is defective. Values in excess of those given for emitter-collector could indicate either a non-saturated device operating normally, or a defective (open-circuited) transistor. If the device is conducting, voltage will be developed across resistances in series with it; if it is open, no voltage will be developed across resistances in series with it unless current is being supplied by a parallel path.

When troubleshooting field-effect transistors, the voltage across its elements can be checked in the same manner as transistors. However, it should be remembered that usual operation has the gate-to-source junction reverse biased, or 0 biased, as is used in many circuits in the 475.

IC's (integrated circuits) can be checked with a voltmeter, test oscilloscope, or by direct substitution. A good understanding of circuit operation is essential to troubleshooting circuits using IC's. Use care when checking voltages and waveforms around the IC's so that adjacent leads are not shorted together. A convenient means of clipping a test probe to the 14- and 16-pin IC's is with an IC test clip. This device also doubles as an extraction tool. The lead configuration for the semiconductors used in this instrument are shown on Fig. 4-3.

b. DIODES. A diode can be checked for an open or shorted condition by measuring the resistance between terminals after disconnecting one end from the circuit. With an ohmmeter set to the R X 1 k scale, the resistance should be very high in one direction and very low when the leads are reversed.



*Do not measure funnel diodes with an ohmmeter; use a dynarnlc tester (such as a Tekfronix Type 576 Transistor-Curve Tracer).*

Voltmeter checks on diodes can be performed in much the same manner as on transistor emitter-to-base junctions. Silicon diodes should have 0.6 to 0.8 volts across the junction when conducting. Higher readings indicate that they are either back biased or defective, depending on polarity.

c. RESISTORS. Check the resistors with an ohmmeter after disconnecting one end from the circuit. Check the Electrical Parts List for the tolerance of the resistors used in this Instrument. Resistors normally do not need to be replaced unless the measured value varies widely from the specified value.

d. INDUCTORS. Check for open inductors by checking continuity with an ohmmeter. (It may be helpful to disconnect one end of the inductor when checking continuity.) Shorted or partially shorted inductors can also be found by checking the waveform response when high-frequency signals are passed through the circuit. Partial shorting often reduces high-frequency response (increases roll-off).

e. CAPACITORS. A leaky or shorted capacitor can be detected by checking resistance with an ohmmeter, on the highest scale, after disconnecting one end from the circuit. Do not exceed the voltage rating of the capacitor (some ohmmeters use 30 volts as source voltage). The resistance reading should be high after initial charge of the capacitor. An open capacitor can also be detected with a capacitance meter or by checking whether the capacitor passes ac signals.

f. ATTENUATORS. The thick film attenuators are best checked by substitution. If only one channel of the 475 is not operating properly, and there is reason to believe an attenuator is defective, replace the suspected attenuator with the same attenuator from the other channel and check instrument operation. If proper operation results, order a new attenuator. (See Component Replacement for replacement instructions.)

**10. Repair and Readjust the Circuit.** If any defective parts are located, follow the replacement procedures given in this section. Be sure to check the performance of any circuit that has been repaired or that has had any electrical components replaced. Recallbration of the affected circuit may be necessary.

**Special Troubleshooting Information**

**General.** The following information provides a procedure for troubleshooting some of the more complex circuits in the 475. A thorough understanding of the circuit operation is essential before troubleshooting in these areas. Read the applicable portions of the Circuit Description in Section 3 before proceeding. This troubleshooting procedure refers to the diagrams operating voltages and waveforms given in Section 8. Specifications for the equipment necessary to troubleshoot in these procedures are given earlier in this section under Troubleshooting Equipment.

Troubleshooting the L.V. Power Supplies. Incorrect operation of all circuits often indicates trouble in the power supply. Check first for correct voltage of the individual supplies. A defective component elsewhere in the instrument can appear as a power-supply trouble and may also affect the operation of other circuits. Table 4-2 lists the tolerances of the power supplies in this instrument. Check or repair the power supplies in the sequence specified in Table 4-2. These voltages are measured between the power-supply test points and ground. If a power-supply voltage is within the listed tolerance, the supply can be assumed to be working correctly. If outside the tolerance, the +50-volt supply may be misadjusted or other supplies may be operating incorrectly. Use the procedure given in TB 11-6625-2735-35-1 to adjust the +50-volt supply if adjustment is necessary.

**TABLE 4-2**  
**Power Supply Tolerance and Ripple**

Power Supply	Tolerance	Typical Ripple (peak-to-peak)
+50V	0.5% (250 mV)	2 mV
+110V	3% (3.3 V)	1 V
+15V	1.5% (225 mV)	2 mV
+5V	1.5% (75 mV)	2 mV
-15V	1.5% (225 mV)	2 mV
- 8 V	1.5% (120 mV)	2 mV

Connect the 475 to a variable autotransformer. Then, check each power supply for correct ripple with a test oscilloscope, while varying the autotransformer throughout the regulating range of this instrument (see rear panel regulating range selector cover for regulating range). Table 4-2 lists the typical ripple of the power supplies in this instrument. Measure the ripple between the power supply test points and ground.

A malfunction in the power supply can be caused by one or more supplies being shorted to ground. Check the resistance of the individual supplies to ground against the typical resistances listed in Table 4-3. Be sure the instrument is not connected to a power source when making these measurements to prevent error in resistance readings and to prevent possible meter damage.

**TABLE 4-3**  
**Power Supply Resistance Check<sup>1</sup>**

Supply	Ohmmeter Scale <sup>2</sup>	Typical Resistance To Ground <sup>1</sup>	
		+ Lead At Supply	- Lead At Supply
+110V	20 K	11 kΩ	9.3 kΩ
+50 V	20 K	2.7 kΩ	2.7 kΩ
+15V	2 K	63	63 Ω
4-5 V	2 K	46	46 Ω
-15 V	2 K 20 K	480 -----	----- 10 kΩ
-8 V	2 K	32	32 Ω
UNREG	20 K	14 kΩ	-----
+50 V	2 K	-----	500
+105/ 160 V	20 K 2 K	12 kΩ -----	----- 1 kΩ

If any of the supplies are shorted to ground, repair them until normal resistance readings are obtained. Connect the instrument to the correct power source and check the supplies for proper voltages listed in Table 4-2. If two or more of the individual supplies have incorrect voltages, repair them in the order listed in Table 4-2.

The +50 volt supply is the reference for all other supplies and must be repaired first. The +15 volt supply and the +5 volt supply should be working properly before repair on the -8 volt supply or the -15 volt supply is attempted.

When repairing a power supply in the 475 the following Information may be helpful. The +50-volt supply is used as an example to identify component functions.

1. Check for proper voltage and ripple from the diode bridge rectifier (CR1412 in the +50-volt supply; check at collector of the series regulator for any supply).

<sup>1</sup>Instrument power cord should be removed from power source.

<sup>2</sup>Readings taken with a digital ohmmeter (see item 3 under Troubleshooting Equipment in this section).

<sup>3</sup>Readings are normal if within 50% of listed value.

2. Check that the current-limiting transistor is off (Q1432 in the +50 volt supply) by measuring base-to-emitter voltage. If the supply is current limiting, remove the power from circuit boards, individually, until the supply voltage returns to normal and the circuit board drawing excess power is identified. To remove power to circuit boards, disconnect plugs, or desolder and lift one end of decoupling networks, or move circuit boards enough to clear interconnecting pins.

3. Measure the reference voltage at the supply operational amplifier and check for proper voltage (pin 3 of U1418 of +50 volt supply; negative input of the operational amplifier of any supply).

**Troubleshooting the High-Voltage Circuit.** There are 3 major areas of concern when troubleshooting this circuitry; the high-voltage oscillator and regulator, the over-voltage protection circuit, and the secondary load including the crt and the high-voltage multiplier. By disconnecting the appropriate circuit, the high voltage should come up. It may be helpful to use the following information, in sequence, to troubleshoot an inoperative high-voltage circuit. Remove the high voltage circuit cover. Refer to figure 7-8 for component locations.

1. Check the collector of Q1316 for approximately -0.7 volts to approximately +1.6 volts.

2. Check the positive end of C1318 for approximately +21 volts.

3. Check the collector of Q1318 for approximately +21 volts.

4. Disconnect and lift one end of CR1329.

5. Disconnect the crt base socket to eliminate crt loading.

6. Check or replace C1316.

7. If the oscillator still does not come up, the high-voltage multiplier could be defective. Remove the Vertical Preamp board to expose the multiplier and disconnect the center tap of the high-voltage transformer from the multiplier tie point.

Troubleshooting the Sweep Circuits. The sweep circuits should be repaired in the following order:

- A (Sweep)
- A INTEN (Intensified Sweep)
- B DLY'D (Sweep)
- MIX (Sweep)

#### A Sweep and Logic

1. Remove all external signals to the instrument, set TIME/DIV to 1 ms (lock knobs), set HORIZ DISPLAY to A and set TRIG MODE to AUTO.

2. Remove Q572 from its socket. This will cause only the Slow Non-Delaying Sweep Generator (A Sweep), which normally should be in operation, to stay at a low voltage level. Check the collector of (3984 for approximately +0.3 volt. Check the collector of Q1014 for approximately +16.4 volts. Check the collector of Q922 for approximately +146 volts.

Set TIME/DIV to 0.5  $\mu$ s or faster. This should cause the Slow-Non-Delaying Sweep Generator to run up and the Fast Non-Delaying Sweep Generator to run down. Check the collector of Q984 for approximately +16.4 volts and check the collector of Q1014 for approximately +0.3 volt.

At this point, the A Sweep holdoff should be in a reset condition. Check TP588 for approximately -4 volts. Check the emitter of Q644 for approximately 0 volt.

When Q572 was removed from its socket, pin 16 of U600 went positive, which is the equivalent of a holdoff start pulse. Check pin 16 of U600 for approximately +2.5 volts. Check pin 17 of U600 for approximately +1.7 volts. Check TP572 for approximately 0 volt. Check pin 3 of U600 for approximately +0.2 volt.

3. Install Q572 and remove Q574 from its socket. This will cause only the Fast Non-Delaying Sweep Generator, which normally should be in operation, to stay at a start (high) voltage level. Check the collector of Q1014 for approximately +14 volts. Set TIME/DIV to 1 ms. Check the collector of Q984 for approximately +14 volts.

At this point the A Sweep holdoff should be at a high level. Check TP588 for approximately +2 volts. Check the emitter of Q644 for approximately +4.3 volts.

Now, pin 3 of U600 should have a low auto gate voltage. Check TP572 for approximately 0 volt. Check pin 16 of U600 for approximately 0 volt. Check pin 17 of U600 for approximately -0.7 volt. Check pin 6 of U600 for approximately +4.8 volts. Check pin 3 of U600 for approximately -0.2 volt. Install Q574 and check the collector of Q984 for a repetitive sweep waveform.

#### A INTEN Sweep and Logic

Remove all external signals to the instrument, set TIME/DIV to 1 ms (lock knobs), set HORIZ DISPLAY to A INTEN and set TRIG MODE to AUTO.

1. Remove Q572 from its socket. This will cause the A Intensified Sweep Generator (A Sweep), which normally should be in operation, to stay at a low voltage level. Check the collector of Q922 for approximately +0.3 volt. Check the collector of Q1014 for approximately +16.4 volts. Check the collector of Q984 for approximately +14 volts.

The A Sweep holdoff should now be in a reset condition. Check TP588 for approximately -4 volts. Check the emitter of Q644 for approximately 0 volt.

When Q572 was removed from its socket, pin 16 of U600 went positive, which is the equivalent of a holdoff start pulse. Check pin 16 of U600 for approximately +2.5 volts. Check pin 17 of U600 for approximately +1.7 volts. Check TP572 for approximately 0 volt. Check pin 3 of U600 for approximately +0.2 volt.

2. Install Q572 and remove Q574 from its socket. This will cause only the A Intensified Sweep Generator, (which normally should be in operation) to stay at a start (high) voltage level. Check the collector of Q922 for approximately +13.9 volts.

At this point, the A Sweep holdoff should be at a high voltage level. Check TP588 for approximately +2 volts. Check the emitter of Q644 for approximately +4.3 volts.

Pin 3 of U600 should now have a low auto gate voltage. Check TP572 for approximately 0 volt. Check pin 16 of U600 for approximately 0 volt. Check pin 17 of U600 for approximately -0.7 volt. Check pin 6 of U600 for approximately +4.8 volts. Check pin 3 of U600 for approximately -0.2 volt. Install Q574 and check the collector of Q922 for a repetitive sweep waveform.

#### B DLY'D Sweep and Logic

The A Sweep and A INTEN sweep should be working properly before starting this procedure. Remove all external signals to the instrument, set TIME/DIV to 1 ms (lock knobs), set HORIZ DISPLAY to B DLY'D and set TRIG MODE to AUTO.

1. Remove Q574 from its socket. Check the collector of Q922 for approximately +14.5 volts. Check the base of Q792 for approximately -5 volts. Check the collector of Q792 for approximately +1.2 volts. Check TP802 for approximately 0 volt. Check TP826 for approximately -1.8 volts. Check TP996 for approximately -3.7 volts. Check the collector of Q984 for approximately +14 volts.

2. Install Q574 and remove Q572. Check the collector of Q922 for approximately +0.2 volt. Check the base of Q792 for approximately -2 volts. Check the collector of Q792 for approximately -0.7 volt. Check TP802 for approximately 0 volt. Check TP826 for approximately -3.8 volts. Check TP996 for approximately -1.7 volts. Check the collector of Q984 for approximately 0.2 volt. Install Q572 and check the collector of Q984 for a repetitive sweep waveform.

#### MIX Sweep and Logic

The A Sweep, A INTEN Sweep and B DLY'D Sweep should be working properly before starting this procedure. Remove all external signals to the Instrument, set ATIME/DIV to 1 ms, unlock knobs and set BTIME/DIV to 0.1 ms, set HORIZ DISPLAY to MIX, set TRIG MODE to AUTO and set B TRIGGER SOURCE to STARTS AFTER DELAY.

Compare the waveform obtained at pin 10 of J5 against the waveform at the collector of Q922 and check for similarity. Check TP996 for a delayed gate, with an amplitude of approximately -1.7 volts, that occurs during the run down ramp on the collector of Q922. The time position of the delayed gate can be decontrolled with DELAY TIME POSITION. Check the collector of Q984 for a fast ramp waveform that occurs during a slow ramp waveform. The fast ramp waveform runs down at a rate set by the B TIME/DIV control and is positioned in time by the DELAY TIME POSITION control.

**Troubleshooting the Horizontal Amplifier.** The Horizontal Amplifier contains push-pull circuitry that can be checked in the following manner:

Set TIME/DIV to 1 ms (lock knobs) and set TRIG MODE to SINGL SWP. Remove Q1114, Q956 and Q1026 from their sockets. Connect a voltmeter between the base of Q1152 and the base of Q1162; adjust R1130 for 0 volt. Check the voltages in the amplifier against the voltages listed on the Horizontal Amplifier schematic diagram. Check the voltage at the bases of Q1124 and Q1134 for balance and apply this balance check procedure to each stage, proceeding toward the amplifier output.

Install Q1114, Q956 and Q1026 in their sockets and check for a repetitive sweep.

**Troubleshooting the Vertical System.** The instrument front panel TRIG VIEW control provides a quick way to find trouble in this circuitry. Press the TRIG VIEW pushbutton and adjust A TRIGGER LEVEL control to bring the trace to the crt viewing area. If unable to obtain a trace, look for a problem in the Vertical Output Amplifier. If a trace can be obtained, look for a problem in the Channel 1 or Channel 2 Preamplifier or the Vertical Channel Switching circuitry.

When troubleshooting the vertical deflection system, the best procedure is to start from the input and work to the output of the problem-circuit area (determined by previous checks using TRIG VIEW pushbutton).

#### Preamplifier Troubleshooting

The following procedure can be used for Channel 1 or Channel 2 Preamplifier. Channel 1 is described as an example to identify circuit functions.

Remove any external signal from the instrument input. Check the input of U120 (pin 13) for 0 volt. Connect a voltmeter between pins 5 and 9 of U120 and adjust CH 1 VAR BAL (R110) for 0 volt. Measure from pin 5 or 9 of U120 to ground and check for the recommended voltage listed on the appropriate Vertical Preamp schematic diagram.

Connect the voltmeter between pins 5 and 9 of U140 and adjust CH 1 VOLTS/DIV BAL (R135) for 0 volt. Measure from pin 5 or 9 of U140 to ground and check for the recommended voltage on the diagram. Check the collectors of Q172 and Q182 for voltages listed on the diagram.

Connect the voltmeter between the collectors of Q178 and Q188 and adjust the vertical POSITION control for 0 volt. Measure from the collector of Q178 or Q188 to ground and check for voltages listed on the diagram.

#### Vertical Channel Switch Troubleshooting

The collector voltages of Q178 and Q188 must be balanced as detailed in the preceding steps before starting this procedure.

Set VERT MODE to CH 1 and check the dc voltages in the channel switching circuitry for the voltages listed on the Vertical Channel Switching schematic diagram. Do not check waveforms until dc operation is normal.

#### Vertical Output Amplifier Troubleshooting

Disconnect the delay line connection on the Vertical Preamp board. This requires the use of a soldering iron (a 40 to 60 Watt iron works best) to unsolder the delay line ground connection.

Check for the recommended voltages listed on the Vertical Output Amplifier diagram.

**Troubleshooting the Z-AXIS Circuit (CRT Circuit).** Set TIME/DIV to 1 ms (lock knobs) and set TRIG MODE to SINGL SWP. Disconnect and lift one end of CR1343. Check the voltage at TP1364 for approximately +6 volts. Press the BEAM FINDER pushbutton and check the voltage at TP1364 for approximately +25 volts. If these voltages cannot be obtained, check the voltage across VR1362 for approximately +6.2 volts. Remove Q1362 from its socket and check the voltage at the base of Q1352 for approximately +1.3 volts. Check the base of Q1344 for approximately +0.6 volt.

If the above-mentioned voltages can be obtained, disconnect and lift one end of CR1341. Check the voltage swing at the collector of Q1338 for approximately +7.8 volts to -1.3 volts while turning INTENSITY control from full counterclockwise to full clockwise. If these voltages cannot be obtained, check the voltage at the base of Q1338 for -1.75 volts. Remove Q1332 from its socket. Disconnect J1333 and J1334 (coaxial-type end-lead connectors) from their sockets. Repeat the voltage swing check at the collector of Q1338 as performed previously.

Connect J1333, J1334, CR1343 and CR1341 to the circuit board. Install Q1362 and Q1332 in their sockets.

## CORRECTIVE MAINTENANCE

### Introduction

Corrective maintenance consists of component replacement and instrument repair. Special techniques required to replace components in this instrument are given here.



## Obtaining Replacement Parts

Refer to Repair Parts and Special Tools List TM 11-6625-2735-24P-1 for correct part number and identification.

## Soldering Techniques

### WARNING

*Always disconnect the instrument from the power source before attempting to solder in the instrument.*

Ordinary 60/40 solder and a 15-to 40-watt pencil-type soldering iron can be used to accomplish the majority of the soldering to be done in the 475. If a higher wattage-rated soldering iron is used on the etched circuit boards, excessive heat can cause the etched circuit wiring to separate from the board base material.

### CAUTION

*The Vertical Preamplifier Attenuator circuit boards are made of material easily damaged by excessive heat. When soldering to these boards, do not use a soldering iron with a rating of more than approximately 15 watts. Avoid prolonged applications of heat to circuit-board connections. Use only isopropyl alcohol when cleaning this circuit board.*

The following technique should be used to replace a component on a circuit board. Most components can be

replaced without removing the boards from the instrument.

1. Grip the component lead with long-nose pliers. Touch the soldering iron to the lead at the solder connection. Do not lay the iron directly on the board, as it may damage the board.

2. When the solder begins to melt, pull the lead out gently. If unable to pull the lead without using force, try removing the other end of component as it may remove easier.

### NOTE

*The reason that some component leads seem troublesome to remove is due to a bend placed on each lead during machine insertion of the component in the circuit-board manufacturing process. The purpose of the bent leads is to hold the component in place during a flow-soldering, manufacturing process that solders all components at once.*

If a component lead is extremely difficult to remove, it may be helpful to straighten the leads on the back side of the board with a small screwdriver or pliers while heating the soldered connection.

Desolder the component from the circuit board using heat on the component lead so that the solder will stay behind on the board. If it is desired to remove solder from a circuit board hole for easier installation of a new component, a vacuum-type resoldering tool or a solder-removing wick should be used for this purpose.

3. Bend the leads of the new component to fit the holes in the board. If the component is replaced while the board is mounted in the instrument, cut the leads so they will just protrude through the board. Insert the leads into the holes in the board so the component is firmly seated against the board (or as positioned originally). If it does not seat properly, heat the solder and gently press the component into place.

4. Touch the iron to the connection and apply a small amount of solder to make a firm solder joint. To protect heat-sensitive components, hold the lead between the component body and the solder joint with a pair of long-nose pliers or other heat sink.

5. Clip the excess lead that protrudes through the board (if not clipped in step 3).

6. Clean the area around the solder connection with a flux-remover solvent. Be careful not to remove information printed on the board.

When soldering to the ceramic strips in the Instruments slightly larger soldering iron can be used. It is recommended that a solder containing about 3% silver be used when soldering to these strips to avoid destroying the bond to the ceramic material. This bond can be broken by repeated use of ordinary tin-lead solder or by the application of too much heat; however, occasional use of ordinary solder will not break the bond if excessive heat is not applied.

Observe the following precautions when soldering to a ceramic terminal strip.

1. Use a hot iron for a short time. Apply only enough heat to make the solder flow freely.

2. Maintain a clean, properly tinned tip.

3. Avoid putting pressure on the ceramic terminal strip.

4. Do not attempt to fill the terminal-strip notch with solder; use only enough solder to cover the wires adequately.

5. Clean the flux from the terminal strip with a flux-remover solvent.

If it becomes necessary to solder in the general area of any of the high-frequency contacts in the instrument, clean the contacts immediately upon completion of the soldering. Refer to Cleaning—Switch Contacts under PREVENTIVE MAINTENANCE for recommended cleaners and procedures.

### Small Component Replacement

#### WARNING

*Always disconnect the instrument from the power source before attempting to replace components.*

**General.** The exploded-view drawings associated with the Mechanical Parts List (located at rear of manual) may be helpful in the removal or disassembly of individual components or sub-assemblies.

**Transistor and IC Replacement.** Transistors and IC's (Integrated circuits) should not be replaced unless they are actually defective. If removed from their sockets during routine maintenance return them to their original sockets. Unnecessary replacement or switching of semiconductor devices may affect the calibration of the Instrument. When a transistor is replaced, check the operation of the part of the instrument that may be affected.

Any replacement component should be of the original type or a direct replacement. Bend the leads to fit the socket and cut the leads to the same length as on the component being replaced. See Fig 4-3 for lead configurations and basing used in this instrument.

If a replacement transistor is made by a different manufacturer than the original, check the manufacturer's basing diagram for correct basing. All transistor sockets in this instrument are wired for the standard basing as used for metal-cased transistors.

The chassis-mounted power supply transistors and their mounting bolts are insulated from the chassis. In addition, silicone grease is used to increase heat transfer capabilities. Install the insulators and replace the silicone grease when replacing these transistors. The grease should be applied to both sides of the mica insulators, and should be applied to the bottom side of the transistor where it comes in contact with the insulator.

#### WARNING

*Handle silicone grease with care. Avoid getting silicone grease in the eyes. Wash hands thoroughly after use.*

## NOTE

*After replacing a power transistor, check that the collector is not shorted to ground before applying power.*

**WARNING**

*Voltages are present on the exterior surface of the chassis-mounted power supply transistors if the power is applied to the instrument and the POWER switch is on. Also, voltages may be present several minutes after the instrument is turned off.*

**Interconnecting Pin Replacement.** Two methods of interconnection are used in this instrument to connect the circuit boards with other boards and components. When the interconnection is made with a coaxial cable, a special end-lead connector plugs into a socket on the board. Other interconnections are made with a pin soldered onto the board. Two types of mating connections are used for these interconnecting pins. If the mating connector is on the end of a lead, an end-lead pin connector is used which mates with the interconnecting pin. The following information provides the replacement procedure for the various types of interconnecting methods.

## a. COAXIAL-TYPE END-LEAD CONNECTORS.

Replacement of the coaxial-type end-lead connectors requires special tools and techniques; only experienced maintenance personnel should attempt replacement of these connectors. It is recommended that the cable or wiring harness be replaced as a unit. For cable or wiring harness part numbers, see the Mechanical Parts List.

## b. CIRCUIT-BOARD PINS.

To replace a pin which is mounted on a circuit board, first disconnect any pin connectors. Then, unsolder the damaged pin and pull it out of the circuit board with a pair of pliers. Be careful not to damage the wiring on the board with too much heat. Remove the ferrule from the new interconnecting pin and press the new pin into the hole in the circuit board. Position the pin in the same manner as the old pin. Then, solder the pin on both sides of the circuit board if the old pin was bent at an angle to mate with a connector, bend the new pin to match the associated pins.

## c. CIRCUIT-BOARD PIN SOCKETS.

The pin sockets on the circuit boards are soldered to the rear of the board. To replace one of these sockets, first

unsolder the pin (use a vacuum-type resoldering tool or a solder-removing wick to remove excess solder). Then straighten the tabs on the socket and remove it from the hole in the board. Place the new socket in the circuit board hole and press the tabs down against the board. Solder the tabs of the socket to the circuit board; be careful not to get solder into the socket.

## NOTE

*The spring tension of the pin sockets ensures a good connection between the circuit board and the pin. This spring tension can be destroyed by using the pin sockets as a connecting point for spring-loaded probe tips, alligator clips, etc.*

## e. END-LEAD PIN CONNECTORS.

The pin connectors used to connect the wires to the interconnecting pins are clamped to the ends of the associated leads. To replace damaged end-lead pin connectors, remove the old pin connector from the end of the lead and clamp the replacement connector to the lead.

Some of the pin connectors are grouped together and mounted in a plastic holder; the overall result is that these connectors are removed and installed as a multi-pin connector. To provide correct orientation of this multi-pin connector when it is replaced, an arrow is stamped on the circuit board and a matching arrow is molded into the plastic housing of the multi-pin connector. Be sure these arrows are aligned as the multi-pin connector is replaced. If the individual end-lead pin connectors are removed from the plastic holder, note the color of the individual wires for replacement.

**Ceramic Terminal Strip Replacement.** Replacement strips (including studs) and spacers are supplied under separate part numbers. However, the old spacers may be re-used if they are not damaged.

To replace a ceramic terminal strip, use the following procedure.

## REMOVAL:

1. Unsolder all components and connections on the strip. To aid in replacing the strip, it may be advisable to mark each lead or draw a sketch to show location of the components and connections.

2. Pry or pull the damaged strip from the chassis.

3. If the spacers come out with the strip, remove them from the stud pins for use on the new strip (spacers should be replaced if they are damaged).

**REPLACEMENT:**

1. Place the spacers in the chassis holes.
2. Carefully press the studs of the strip into the spacers until they are completely seated. If necessary, use a soft mallet and tap very lightly, directly over the stud, to seat the strip completely.
3. If the stud extends through the spacers, cut off the excess.
4. Replace all components and connections. Observe the soldering precautions given under Soldering Techniques in this section.

**Fuse Replacement.** Table 4-4 gives the rating, location, and functions of the fuses used in this instrument.

**TABLE 4-4**

**Fuse Rating, Location and Functions**

Circuit Number	Rating	Location	Function
F1401	1.5 A Fast	Rear Panel	115-volt line
F1401	0.75 A Fast	Rear Panel	230-volt line
F1318	1.5 A Fast	Rear of Main Interface Board	High Voltage
F1601	15 A Fast	Front of Inverter Chassis	Inverter Input (Option 7 Only)

**Cam Switch Replacement.** A complete cam switch is actually a cam switch assembly. Each assembly consists of a delrin-material cam that is rotated by a front-panel knob and a set of contacts (mounted on an adjacent circuit board) that are actuated by the lobes on the cam.

**CAUTION**

*Repair of cam-type should be undertaken only by experienced maintenance personnel. Switch alignment and spring tension of the contacts must be carefully maintained for proper operation of the switch. For this reason, it is recommended that the switch assembly be replaced as a unit.*

If a cam switch must be removed from a circuit board the circuit board containing the cam switch must be removed from the instrument. See the circuit-board replacement part of this section for circuit board removal instructions.

Disconnect the flexible coupling between cam switch and variable controls. Remove two connecting screws from each support block that holds the cam to the circuit board. Carefully lift the cam assembly from the circuit board and perform an inspection, cleaning or replacement as intended.

Reassemble the cam-switch assembly by reversing the previous process. Give careful attention to alignment and spacing of support blocks as the cam is mated to its circuit board. Do not bend circuit boards at any time in reassembly and use a very low torque to tighten the mounting screws (two fingers on the screwdriver is enough torque).

**Circuit Board Replacement**

Occasionally it may be necessary to gain access to the reverse side of a circuit board or to remove one circuit board to gain access to another. The following procedures outline the necessary steps to facilitate instrument disassembly. Most of the connections to the circuit boards in the instrument are made with pin connectors. However, some connections are soldered to the board. Observe the soldering precautions given under Soldering Techniques given in this section.

**WARNING**

*Always disconnect the instrument from the power source before attempting to remove circuit boards.*

To aid in identifying and locating circuit boards in the instrument, see Fig. 4-5 for the locations of circuit boards. In the following circuit-board replacement procedure, determine the circuit board to be removed or replaced, find the name of the board listed within this procedure, and follow the removal or installation instructions. To aid in identifying small components described in this procedure, use the diagrams in Section 7, Mechanical Parts List, in this manual.

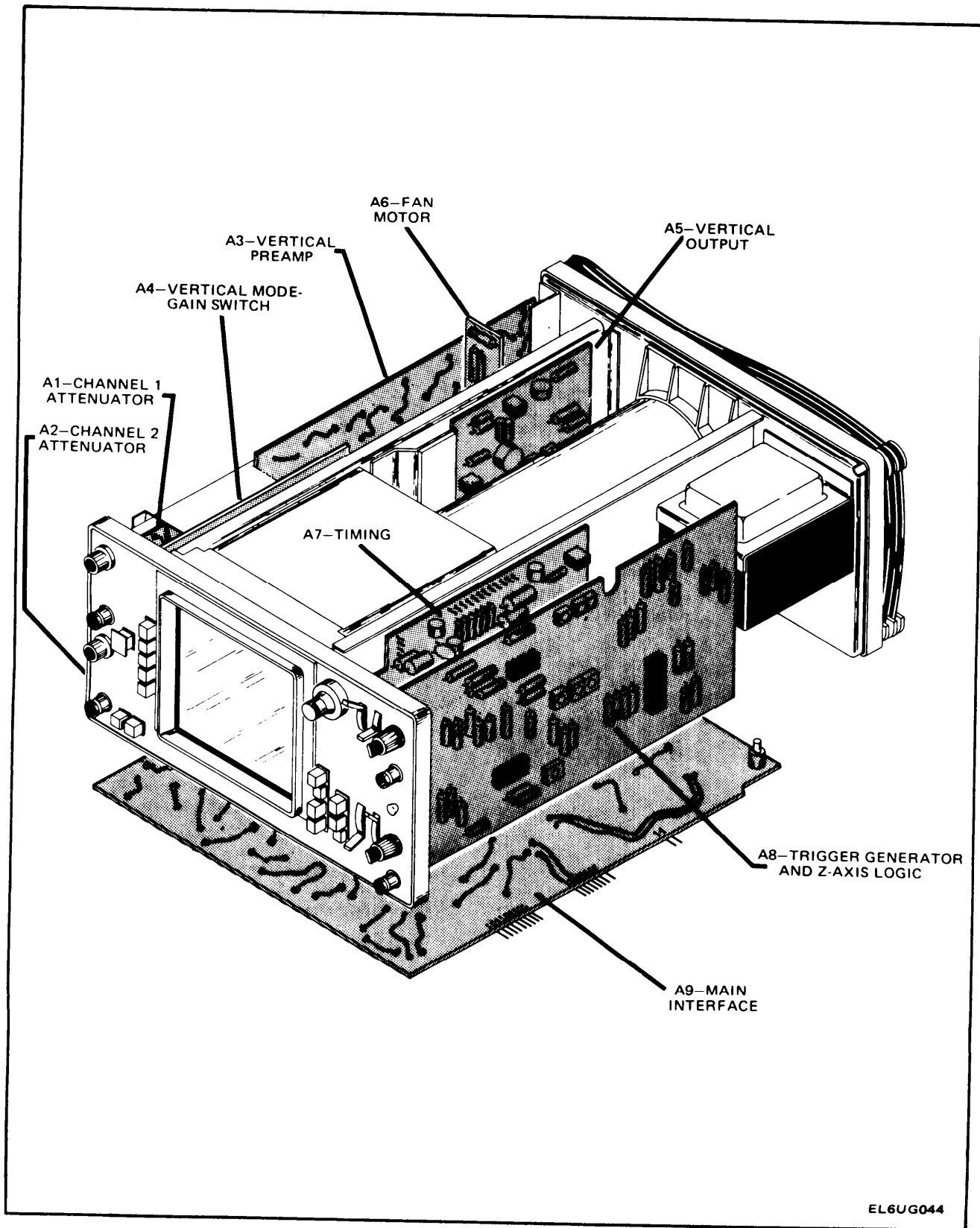


Fig. 4-5. Locations of circuit boards in the 475 Oscilloscope.

**Vertical Preamp Board Removal.** Remove the board as follows:

1. 475 DM 43 and DM 40 only—Disconnect three ribbon-cables from the DM 43 or DM 40 Main circuit board. Remove the screws from the rear of the Main circuit board chassis and separate the board and chassis assembly from the instrument chassis.

2. Remove both vertical POSITION control shafts. This requires a 0.050-inch Allen wrench to loosen the front setscrew in each coupling.

3. Remove the TRIG VIEW, 100 OR 20 MHz BW control shaft. Loosen the coupling setscrew with a 0.050-inch Allen wrench.

4. Remove the INVERT control extension shaft. Insert a scribe or small screwdriver between the end of the white plastic switch-shaft and the inside end of the black plastic extension-shaft and pry gently.

5. Disconnect eight coaxial cables from the front and back sides of the board and confirm color coding of each cable with its jack number in the following list. Record any exceptions to this procedure for reference when reassembling.

a. Cable to J380 is white with black and brown stripes.

b. Cable to J385 is white with black and red stripes.

c. Cable to J399 is white with a yellow stripe.

d. Cable to J430 is white with a violet stripe.

e. Cable to J405 is white with a blue stripe.

f. Cable to J410 is white with a green stripe.

g. Cable to J400 (back of board) is white with a brown stripe.

h. Cable to J349 (bottom, back of board, rear of INVERT switch) is white with a red stripe.

6. Disconnect the delay-line connection on the Vertical Preamp board. This requires the use of a soldering iron (a 40 to 60-Watt iron works best) to unsolder the delay-line ground connection.

7. Unsolder the capacitor lead at the Vertical Preamp board (bottom, back of board, between the rear of the INVERT switch and J349) using a 15-Watt soldering iron.

8. At the Vertical Preamp board unsolder one end of a wire braid that connects between the bottom of the Vertical Preamp and the Main Interface board under the high-voltage shield.

9. Disconnect three ribbon-cables from the Vertical Mode-Gain Switch board and confirm the number of wires in each cable with its plug number in the following list. Note locations of cables to facilitate correct reinstallation.

a. Disconnect a six-wire cable from P329.

b. Disconnect a seven-wire cable from P160.

c. Disconnect a ten-wire cable from P260.

10. At a feed-through terminal near U120 and U220, unsolder two 30-ohm resistors that connect each attenuator to the Vertical Preamp board. Loosen attenuator screws for clearance if necessary.

11. Remove the Vertical Preamp board mounting-hardware at eight locations described in the following list. A small Phillips screwdriver is required.

a. Remove the screw, cabinet-ground spring, and hexagonal post at center of the board.

b. Remove two screws that mount the board to two long posts on the main chassis near top and bottom center of the Vertical Preamp board.

c. Remove three screws that mount the board to the rear preamp bracket (at left edge of board).

d. Remove two screws at the right edge of the board (one screw mounts each attenuator chassis to the board).

12. Remove the Vertical Preamp circuit-board, using care to prevent damage to any of the components as the board is removed.

To install the Vertical Preamp circuit-board, reverse the removal procedure.

**Vertical Mode-Gain Switch Board Removal.** The Vertical Mode-Gain Switch board and the Channel 1 and Channel 2 attenuators are removed as a unit.

1. Remove the Vertical Preamp circuit-board as outlined previously.

2. Remove the two UNCAL light lenses (VAR VOLTS/DIV UNCAL). Pry them away from front panel with a fingernail and pull them straight out

3. Remove the VAR and VOLTS/DIV knobs. Set these knobs fully clockwise and loosen their setscrews. This requires a 1/16-inch Allen wrench.

4. Remove the AC-G ND-DC switch knobs by pulling the knobs away from the switch, using a tight finger-grip.

5. Remove both attenuator shields, using a small Phillips screwdriver (each is held with five screws and washers),

6. Disconnect four ribbon-cables from the Vertical Mode-Gain Switch board and confirm the number of wires in each cable with its plug number in the following list. Note the locations of cables to facilitate correct reinstallation.

a. Disconnect a five-wire cable from the Main Interface board at P300.

b. Disconnect a one-wire cable from the Main interface board at P128.

c. Disconnect two three-wire cables from the VOLTS/DIV sensitivity indicator-lights at P310 and P320.

7. Unsolder the braid connecting the CH 2 attenuator to the Main Interface, at the Main Interface board.

8. Remove the four nuts that secure the attenuators to the front casting and remove the two screws that mount the board to two posts on the main chassis.

9. Remove the Vertical Mode-Gain Switch circuit-board and attenuator assembly from the instrument, using care to prevent damage to any of the components as the board is removed.

To install the Vertical Mode-Gain Switch circuit-board and attenuator assembly, reverse the removal procedure. To align the VERT MODE switch pushbuttons, hold the assembly in place with a slight forward pressure and use a small tool to reach through the front panel to align the buttons. Do not tighten the circuit-board securing screws until the securing nuts at the front of the attenuator chassis are tight and the circuit board is aligned properly.

**Trigger Generator and Z-Axis Logic Board Removal.** Remove the board as follows:

1. 475 DM 43 and DM 40 only—Disconnect three ribbon-cables from the DM 43 or DM 40 Main circuit board. Remove two screws from the rear of the main circuit-board chassis and separate the board chassis from the instrument chassis.

2. Remove the LOW LINE, READY, and TRIG light lenses. Pry them away from the front panel with a fingernail and pull them straight out.

3. Remove the POWER extension shaft from the power-switch plastic actuator. Use a small flat-blade screwdriver to pry apart the coupling of the shaft and actuator, using caution to prevent damage to the coupling.

4. Disconnect four ribbon-cables from the board as directed in the following list.

a. Disconnect a four-wire cable near Q752 at the top of the board (cable from B TRIGGER LEVEL control).

b. Disconnect a four-wire cable near J706, located two inches below the cable previously removed (cable from A TRIGGER LEVEL control).

c. Disconnect one-wire cable near the left end of J3 at the bottom of the board.

d. Disconnect a five-wire cable from P644 at the bottom, back of the board (cable from A TRIG HOLDOFF control).

5. Disconnect eight coaxial cables from the front and back sides of the board and confirm color coding of each cable with its jack number in the following list. Record any exceptions to this procedure for reference when reassembling.

a. Cable to J704 is white with a blue stripe.

b. Cable to J702 is white with a green stripe.

- c. Cable to J706 is white with a yellow stripe.
- d. Cable to J664 is white with black and brown stripes.
- e. Cable to J674 is white with black and red stripes.
- f. Cable to J694 is white with black and orange stripes.
- g. Cable to J824 is white with an orange stripe.
- h. Cable to J584 is white with a red stripe.

6. Unsolder two 33-ohm resistors from the external trigger input connectors.

7. Remove the POWER switch mounting-bracket from the board. A 3/16-inch nut driver will be required to remove a mounting nut.

8. Remove five board-mounting screws (two each at left and right edges, and one screw at the top center of the board).

9. Center A and B trigger coupling and source switches, then remove the Trigger Generator and Z-Axis Logic circuit-board from the instrument.

To install the Trigger Generator and Z-Axis Logic board, reverse the removal procedure.

**Timing Board Removal.** Remove the board as follows:

1. Remove the Trigger Generator and Z-Axis Logic circuit-board as outlined previously.

2. Remove the X10 MAG and UNCAL light lenses. Pry them away from the front panel with a fingernail and pull them straight out.

3. Remove the VAR and TIME/DIV knobs. Set these knobs fully clockwise and loosen their setscrews. A 1/16-inch Allen wrench is required.

4. Remove the hexagonal post and the board mounting-screws.

5. Remove the Timing circuit-board from the instrument. Use caution to prevent damage to the connecting pins on bottom of the board.

To install the Timing circuit-board, reverse the removal procedure,

**Vertical Output Board Removal.** Remove the board as follows:

1. Remove the Vertical Output circuit-board shield (if installed).

2. Disconnect the three-wire cable from the top-front of the Vertical Output board.

3. Disconnect two wires from the board at the crt neck pins.

4. Unsolder the delay-line ground terminal at the delay-line connection with the board (a 40 to 60-Watt soldering iron works best). Disconnect and dress the delay line away from the board.

5. Unsolder the flexible grounding braid from the case of integrated circuit U470 using a 40 to 60-Watt soldering iron.

6. Remove the integrated-circuit mounting-nut from the main chassis. A 1/4-inch open-end wrench may be necessary to remove the nut.

7. Remove the two circuit-board screws along the top edge of the board and remove the Vertical Output circuit-board.

To install the Vertical Output circuit-board, reverse the removal procedure.

**Fan Motor Board Removal.** Remove the board as follows:

1. Remove the Vertical Preamp circuit-board as outlined previously.

2. Disconnect a two-wire ribbon-cable at the Fan Motor board.

3. Loosen the setscrew in the fan impeller coupling with a 0.050-inch Allen wrench.



4. Remove two thread-forming screws nearest the Fan Motor circuit-board, that hold the fan motor mount to the main chassis.

5. Remove the fan motor and Fan Motor circuit-board as a unit.

To install the Fan Motor circuit-board, reverse the removal procedure.

**Inverter Board Removal (Option 7 only).** Remove the board as follows:

1. Remove the Vertical Output circuit-board shield (if installed).

2. Unsolder five wires from the power-transformer terminals and confirm each wire color with its location in the following list.

- a. Wire to terminal 10 is white with a brown stripe.
- b. Wire to terminal 10A is white with a red stripe.
- c. Wire to terminal 11 is white with a gray stripe.
- d. Wire to terminal 12A is white with an orange stripe.
- e. Wire to terminal 12 is white with a yellow stripe.

3. Remove two screws from the inverter chassis (one screw at the front and one at the rear of the inverter chassis, near the top of the instrument main chassis). Remove one remaining screw from the main chassis to the inverter chassis, accessible through the space along the bottom of the power transformer. A long Phillips screwdriver is necessary to remove all three screws.

4. Remove the Inverter chassis from the instrument, using care to prevent damage to interconnecting wires that pass through the hole in the main chassis.

5. Remove the screws holding the Inverter circuit-board to the Inverter chassis.

To install the Inverter circuit-board, reverse the removal procedure.

**Power Supply Board Removal (475 DM 43 and DM 40 only).** Remove the board as follows:

1. Remove the Vertical Output circuit-board shield (if installed).

2. Disconnect one ribbon-cable from the rear of the 475 DM 43 or DM 40 Main circuit-board and guide the plug through a slotted opening in the main circuit-board chassis.

3. Unsolder five-wires from the power transformer and confirm each wire color with its location in the following list.

- a. Wire to terminal 10 is white with a brown stripe.
- b. Wire to terminal 10A is white with a red stripe.
- c. Wire to terminal 11 is white with an orange stripe.
- d. Wire to terminal 12A is white with a yellow stripe.
- e. Wire to terminal 12 is white with a green stripe.

4. Remove two screws from the Power Supply board chassis (one screw each at the front and rear of the Power Supply board chassis near the top of the 475 main chassis). Remove one remaining screw from the main chassis to the power supply chassis (accessible through the space along the bottom of power transformer). A long Phillips screwdriver is necessary to remove all three screws.

5. Remove the power supply chassis from the instrument, using care to prevent damage to interconnecting wires that pass through the hole in the main chassis.

6. Remove a piece of tape from the insulation-wrap to gain access to the board components.

7. Remove the two screws holding the Power Supply circuit-board to the power supply chassis.

8. Remove three Keps nuts and a plastic bar that hold a transistor and two integrated circuits to the power supply chassis.

9. Unsolder two ribbon-cables, noting the color codes and wire positions. If board replacement is intended, connect the wires to the new board.

To install the Power Supply circuit-board, reverse the removal procedure.

**Main Interface Board Removal.** If repair is necessary on the reverse side of the Main Interface circuit-board, it may be possible to gain access to that area by removal of one or two circuit boards as outlined previously. Consider this first or proceed with the Main Interface board removal procedure.

The Main Interface circuit-board can be removed as follows:

1. Remove the Vertical Preamp circuit-board as outlined previously.
2. Remove the Trigger Generator and Z-Axis Logic board as outlined previously.
3. Remove the high-voltage shield and remove the Vertical Output circuit-board shield (if installed).
4. Remove the BEAM FINDER and X10 MAG pushbutton extension-shafts. Insert a scribe or small screwdriver between the end of the white plastic switch-shaft and the inside end of the black plastic extension-shaft and pry gently.
5. Remove the INTENSITY, FOCUS, SCALE ILLUM, ASTIG and TRACE ROTATION control extension-shafts. Loosen the front setscrew in each coupling with a 0.050-inch Allen wrench.
6. Disconnect twelve ribbon or wire cable-connectors from the Main Interface circuit-board and confirm the number and color of wires for each plug and its location in the following list.
  - a. Disconnect one-wire from pin E at the top-left of the board.
  - b. Disconnect a two-wire cable from pins B and C at the top-left of the board.
  - c. Disconnect a two-wire cable near the rear of the intensity control (cable from the y-axis alignment coil).
  - d. Disconnect a two-wire cable near Q1482 (cable from the graticule lamps).
  - e. Disconnect a four-wire cable at the right-center of the board (cable from POSITION and FINE controls).

- f. Disconnect a four-wire cable at the rear of the A TRIG HOLDOFF control (cable from the DELAY TIME POSITION control).

- g. Disconnect a two-wire cable from the Calibrator current loop.

- h. Disconnect four, two-wire cables near F1318 at the bottom-left of the board. The cable wires to +15 are red with a brown stripe. The cable wires to -15 are violet with a brown stripe. Cable wires to the pins nearest the fuse (GND) are black. Cable wires to the remaining pins are red with a black stripe.

7. Disconnect two coaxial-cables from the left-center of the board. The cable to J1302 is white with a gray stripe and the cable to J1334 is white with black and orange stripes.

8. Disconnect the horizontal deflection plate leads at the crt. This requires a pair of long-nose pliers or tweezers for best removal or reinstallation.

9. Disconnect a three-wire cable from the Vertical Output board.

10. Disconnect a two-wire cable from the Fan Motor board.

11. Unsolder a 10-ohm, 1/2 watt resistor from the center-tap terminal of the ceramic thick-film resistor mounted near the Vertical Output circuit-board.

12. Unsolder ten wires from the Main interface circuit-board and confirm each wire color with its location in the following list (all wires from crt socket).

- a. Wire to pad 5 is white with a green stripe.
- b. Wire to pad 10 is white with black and brown stripes.
- c. Wire to pad 7 is white with a violet stripe.
- d. Wire to pad 8 is white with a gray stripe.
- e. Wire to the one-notch ceramic-strip is white with a yellow stripe.

- f. Wire to the -2450 test point is solid red.
- g. Wire to the right-hand notch on the three-notch ceramic-strip is white with an orange stripe.
- h. Wire to pad 14 (lowest of a pair of wires between the large high-voltage capacitors) is white with brown and yellow stripes.
- i. Wire to pad 1 (upper pad between the large high-voltage capacitors) is white with a brown stripe.
- j. Wire to second notch on the five-notch ceramic-strip (notch containing junction of a 0.01 microfarad capacitor, a 10-megohm resistor, and a diode) is white with brown and red stripes.

13. Remove the three power transistor mounting-screws from Q1468, Q1426, and Q1448 on the rear subpanel bracket.

14. Remove the mounting screw from transistor Q1456 near the lower-rear corner of the board.

15. Remove the mounting screw from transistor Q1482 near the top-right corner of the board.

16. Remove the four hexagonal posts that mount the high-voltage shield. Use a 3/16-inch nut driver.

17. Remove seven Main Interface board mounting-screws.

18. Disconnect the crt anode-lead plug from the high-voltage multiplier jack. Ground this lead to the instrument main-chassis to remove any stored charge. Pry the multiplier jack from its mounting clip with a medium-size screwdriver.

19. Separate the Main Interface circuit-board from the instrument chassis, using care to prevent damage to components and wiring. Carefully thread the interconnecting cables through the board and chassis, as necessary, to avoid strain on any cable. Let the board pivot on the power-transformer leads still connected to the board.

Perform repairs on the reverse side of the Main Interface board, if repair is intended. To reinstall the board, reverse the removal procedure. If intentions are to replace the Main Interface circuit-board, continue with this procedure.

20. Unsolder the power-transformer wires from the Main Interface board and confirm each wire color with its location in Fig. 4-6. Record any exceptions to this procedure to facilitate reassembly.

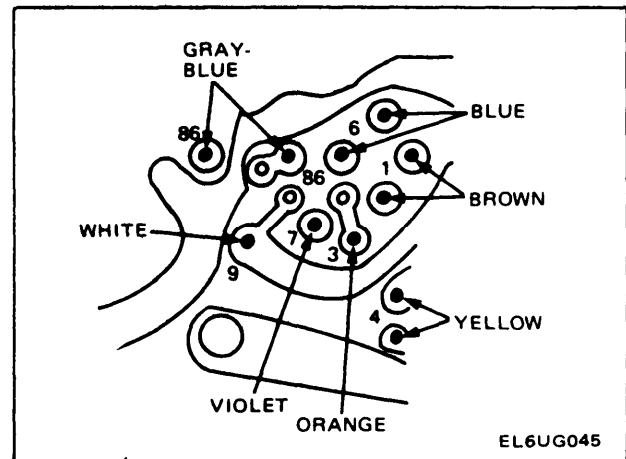


Fig. 4-6. Locations of power transformer secondary wires.

21. Remove the Main Interface circuit-board, using care to prevent strain on any of the wires.

22. Remove the solder from the holes in the circuit-board wire-terminal pads, where wires were removed in this procedure, to facilitate installation.

To install the Main interface circuit-board, reverse the removal procedure.

### Power Transformer Removal

The Power Transformer can be removed as follows:

1. Remove the Trigger Generator and Z-Axis logic circuit-board as outlined previously.

2. Remove the regulating-range selector cover and the blue rear-panel of the instrument.

3. Option 4 only—Remove the power line input filter (emi filter).

4. Remove the transformer leads from the regulating-range selector body. The leads may be installed by simply pushing them into place. Record the color and location of each wire to facilitate correct reassembly.

5. Option 7 only—Unsolder five wires from the transformer terminals and confirm each wire color with its location in the following list.

- a. Wire to terminal 10 is white with a brown stripe.
- b. Wire to terminal 10A is white with a red stripe.
- c. Wire to terminal 11 is white with a gray stripe.
- d. Wire to terminal 12A is white with an orange stripe.
- e. Wire to terminal 12 is white with a yellow stripe.

6. 475 DM 43 and DM 40 only—Unsolder five wires from the transformer terminals and confirm each wire color with its location in the following list.

- a. Wire to terminal 10 is white with a brown stripe
- b. Wire to terminal 10A is white with a red stripe.
- c. Wire to terminal 11 is white with an orange stripe.
- d. Wire to terminal 12A is white with a yellow stripe.
- e. Wire to terminal 12 is white with a green stripe.

7. Remove two screws and Keps nuts that hold the transformer bracket to the rear of the main chassis. Remove two Keps nuts that hold the transformer bracket to the main chassis and the transformer electrical shield. A 5/16-inch, nut-driver wrench is helpful for easiest removal of these nuts.

8. Unsolder the wires from the thermal cutout on the transformer bracket and note the wire colors.

9. Unsolder the transformer wires from the Main Interface board as directed in the Main Interface board removal procedure, part 20.

10. Remove the transformer from the instrument.

11. Remove the solder from the holes in the circuit-board wire-terminal pads, where wires were removed in this procedure, to facilitate installation.

To install a new Power Transformer, reverse this removal procedure.

### Cathode-ray Tube Removal

**WARNING**

*Use care when handling a crt. Projective clothing and safety glasses should be worn. Avoid striking it on any object which might cause it to crack or implode. When storing a crt, place it in a protective carton or set it face down on a smooth surface in a protected location with a soft mat under the faceplate to protect it from scratches.*

1. 475 DM 43 and DM 40 only—Disconnect three ribbon-cables from the DM 43 or DM 40 main circuit-board. Remove two screws from the rear of the main circuit-board chassis and separate the board and chassis assembly from the instrument chassis.

2. Remove the Vertical Output circuit-board shield (if installed).

3. Remove two flat-head screws from the blue-plastic cover at the rear of the instrument. Carefully position the blue-plastic cover to allow access to the screws holding the crt rear cover, then remove the crt rear cover.

4. Disconnect the crt anode plug from the high-voltage jack and touch the lead to the chassis to remove any stored charge.

5. Disconnect the crt base socket from the rear of the crt.

6. Disconnect the four vertical deflection plate leads from the Vertical Output board at the crt neck pins.

7. Disconnect the two horizontal deflection plate leads from the Main Interface board at the crt neck pins (accessible through an opening at center of the Main Interface board).

8. Remove the crt bezel and implosion shield.

9. Hold one hand on the crt base and slowly push the crt forward, guiding the crt face with the other hand. Guide the anode plug through the crt shield opening while slowly pulling the crt out of the instrument. The plastic corner-pads may fall loose when the crt is removed; save them for reinstallation. Set the crt on a soft material to prevent scratching.

#### **Cathode-ray Tube Installation**

1. Position the crt rear-support (plastic centering bracket) inside the crt shield approximately 1-1/2-inches from the rear of the shield.

2. Check that the plastic corner-pads are in place and seated at the front corners of the crt opening.

3. Insert the crt into the shield. Guide the crt anode lead through the hole in the shield.

4. Slowly push the crt the rest of the way into the crt shield. If the crt does not go in all the way, pull it part way out and find the reason for binding. It may be necessary to reposition the rear-support bracket or a plastic corner-pad for best installation.

5. Clean the crt faceplate, implosion shield and bezel as directed under Cleaning—Exterior information at the beginning of this section and install the parts. Lightly tighten the four bezel screws (approximately 5-inch pounds).

6. Connect the crt base socket, install the crt rear cover with two round-head screws and install the blue-plastic cover on the rear of the instrument with two flat-head screws.

7. Connect the crt anode lead and carefully connect the deflection plate leads. After each lead is connected, lightly pull on the lead to be sure that it will remain in place.

8. 475 DM 43 and DM 40 only—install the DM 43 or DM 40 main circuit-board chassis on the 475 chassis. Install two screws at the rear of the main circuit-board chassis and connect three ribbon-cables to the board.

9. If the crt was replaced, part of the 475 calibration will need to be checked or adjusted. See Table 4-5 under Recalibration After Repair (later in this section) for a listing of calibration checks and adjustments that need to be checked after crt replacement.

#### **High-Voltage Multiplier Removal**

1. Remove the Vertical Preamp circuit-board as outlined previously.

2. Remove the cathode-ray tube as outlined previously.

3. Remove the high-voltage shield from the Main Interface circuit-board and remove one screw near the INTENSITY potentiometer.

4. Remove four hexagonal posts, used to mount the high-voltage shield, from the Main Interface board with a 3/16-inch nut-driver.

5. Remove the two nylon nuts from the Main Interface board near C1328.

6. Remove three screws holding the multiplier shield to the main chassis and remove the shield.

7. Unsolder the black wire from the Multiplier at the Main Interface board.

8. Unsolder one wire from a post on the High-Voltage Multiplier.

9. Unsolder the flexible grounding-braid from the case of integrated circuit U470 (on the Vertical Output board), using a 40 to 60-Watt soldering iron.

10. Remove one screw that holds the crt neck shield to the black-plastic rear bracket.

11. Hold the crt base socket away from the neck shield and slide the shield to the rear of the instrument about 2 inches.

12. Pry the Multiplier jack from its mounting clip on the main chassis.

13. Remove the High-Voltage Multiplier. If necessary, carefully pry the Main Interface board away for easier removal and guide the Multiplier jack through the main chassis.

14. To install the High-Voltage Multiplier, reverse the removal procedure. Use the Cathode-ray Tube installation procedure for installing the crt.

**Delay Line Removal**

1. Remove the cathode-ray tube as outlined previously.

2. Disconnect a two-wire cable near the rear of the INTENSITY control (cable from y-axis alignment coil).

3 Remove a screw connecting a solder lug and heavy braid from the Vertical Output board at the crt neck shield.

4. Remove one screw that holds the crt neck shield to the black-plastic rear bracket.

5. Hold the crt base socket away from the neck shield and remove the crt neck shield through the main chassis rear opening, using care to guide the y-axis coil cable through the board and chassis holes.

6. Remove the Keps nut and delay-line bracket holding the Delay Line to the main chassis.

7. Disconnect the Delay Line ends at the Vertical Preamp and Vertical Output boards. This may require the use of a soldering iron (a 40 to 60-Watt iron works best).

8. Remove the Delay Line, using care to guide the Delay Line ends through the main chassis holes without causing sharp bends in the line.

To install the Delay Line, reverse the removal procedure. Use the Cathode-ray Tube Installation procedure for installing the crt.

**Recalibration After Repair**

After any electrical component has been replaced, the calibration of that particular circuit should be checked, as well as the calibration of other closely related circuits. Table 4-5 lists the adjustments that may interact with a repair in a particular circuit. The table is also useful as a list of calibration adjustments that should be checked if an adjustment is made when performing the Calibration procedure. Perform a calibration check of each interaction, using the appropriate step in the Calibration procedure found in TB 11-6625-2735-35-1.

**Instrument Repackaging**

Save and re-use the package in which your instrument was shipped. If the original packaging is unfit for use or not available, repackage the instrument as follows:

1. Obtain a carton of corrugated cardboard having inside dimensions of no less than six inches more than the instrument dimensions; this will allow for cushioning. Refer to the following table for carton test strength requirements.
2. Surround the instrument with polyethylene sheeting to protect the finish of the instrument.
3. Cushion the instrument on all sides by tightly packing dunnage or urethane foam between carton and instrument, allowing three inches on all sides.
4. Seal carton with shipping tape or industrial stapler.

**SHIPPING CARTON TEST STRENGTH**

Gross Weight (lb)	Carton Test Strength (lb)
0-10	200
10-30	275
30-120	375
120-140	500
140-160	600

TABLE 4-5

CALIBRATION INTERACTION AFTER REPAIR OR ADJUSTMENT

		POWER SUPPLY DC LEVELS	HIGH VOLTAGE POWER SUPPLY	CRT GRID BIAS	CRT TRACE ROTATION	CRT Y-AXIS ALIGNMENT	GEOMETRY	Z-AXIS COMPENSATION	VERTICAL OUTPUT BIAS	VERTICAL SHIELD VOLTAGE	DELAY-LINE DC CENTER	CH 1 OR CH 2 VAR VOLTS/DIV BALANCE	CH 1 OR CH 2 VOLTS/DIV BALANCE	CH 1 OR CH 2 POSITION CENTERING	VERTICAL OUTPUT GAIN	CH 1 OR CH 2 GAIN	(VERTICAL) HIGH-FREQ. COMPENSATION	VERTICAL TRANSIENT RESPONSE	A OR B TRIGGER SENS, SYMM AND CTRG	A TRIGGER DC CENTERING	TRIGGER VIEW CENTERING	HORIZONTAL GAIN	INTENSIFIED GAIN	DELAY START AND DELAY STOP	MAGNIFIED REGISTRATION	A TIMING	X GAIN	X-Y PHASE DIFFERENCE	CALIBRATOR OUTPUT AMPLITUDE
LOW VOLTAGE POWER SUPPLY																													
HIGH VOLTAGE POWER SUPPLY																													
Z-AXIS AMPLIFIER CIRCUIT																													
TRACE ROTATION																													
CRT Y-AXIS ALIGN																													
GEOMETRY																													
VERTICAL PREAMP CIRCUIT																													
VERTICAL OUTPUT AMPLIFIER CIRCUIT																													
VERTICAL CHANNEL SWITCHING CIRCUIT																													
VERTICAL OUTPUT BIAS																													
VERTICAL SHIELD VOLTAGE																													
DELAY-LINE DC CENTER																													
CH 1 OR CH 2 VAR VOLTS/DIV BALANCE																													
CH 1 OR CH 2 VOLTS/DIV BALANCE																													
VERTICAL OUTPUT GAIN																													
CH 1 OR CH 2 GAIN																													
VERTICAL TRANSIENT RESPONSE																													
TRIGGER GENERATOR CIRCUIT																													
A OR B TRIGGER SENS, SYMM AND CTRG																													
A TRIGGER DC CENTERING																													
HORIZONTAL AMPLIFIER CIRCUIT																													
HORIZONTAL GAIN																													
SWEEP GENERATORS CIRCUIT																													
SWEEP AND Z-AXIS LOGIC CIRCUIT																													
A TIMING																													
X GAIN																													
X-Y PHASE DIFFERENCE																													
CRT CHANGE																													





# PERFORMANCE CHECK

## IMPORTANT—PLEASE READ BEFORE USING THIS PROCEDURE

### Introduction

The following procedure is intended to be used for incoming inspection to determine the acceptability of newly purchased or recently recalibrated instruments. This procedure does not check every facet of the instrument's calibration; rather it is concerned primarily with those portions of the instrument that are essential to measurement accuracy and correct operation. Removing the instrument cabinet is not necessary to perform this procedure. All checks are made from the front panel. This procedure is also useful as an aid in troubleshooting and preventive maintenance.

### Using This Procedure

**Outline.** To aid in locating a step in the Performance Check, an outline is given preceding the Performance Check procedure.

**Partial Procedures.** A partial check of performance is often desirable after replacing components or to verify performance of a portion of the instrument between major recalibration. To check only part of the instrument, set the controls as given under the nearest preceding Control Settings and use the Equipment Required list preceding the desired portion of the procedure.

## TEST EQUIPMENT REQUIRED

### General

The following test equipment and accessories, or its equivalent, is required for a complete performance check of the 475. Specifications given for the test equipment are the minimum necessary for accurate calibration. Therefore, some of the specifications listed here may differ from the actual performance capabilities of the test equipment. All test equipment is assumed to be correctly

calibrated and operating within the listed specifications. Detailed operating instructions for the test equipment are not given in this procedure. Refer to the instruction manual for the test equipment if more information is needed. Minimum test equipment specifications must include the use of any special required accessories (such as the precision output cable included with the SG503). Refer to Maintenance Allocation Chart in Appendix D of this manual for approved test equipment.

### Special Calibration Fixtures

Special Tektronix calibration fixtures are used only where they facilitate checking instrument performance. These special calibration fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

### Performance Check Equipment Alternatives

All of the listed test equipment is required to completely check this instrument. However, complete checking may not always be necessary or desirable. The user may be satisfied with checking only selected characteristics, thereby reducing the amount of test equipment actually required.

The equipment listed in the Performance Check Procedure is based on the first item of equipment given as an example of applicable equipment. When other equipment is substituted, control settings or equipment setups may need to be altered to meet the requirements of the substitute equipment. If the exact item of test equipment given as an example in the Test Equipment list is not available, first check the Specifications column carefully to see if any other equipment is available which might suffice. Then check the Usage column to see what this item is used for. If used for a check or adjustment that is of little or no importance to your measurement requirements, the item and corresponding step(s) can be deleted.

TABLE 5-1

## Test Equipment Required For Performance Check

Description	Minimum Specifications	Usage	Examples
1. Amplitude Calibrator	Amplitude accuracy, within 0.25%; signal amplitude, 2 millivolts to 20 volts; output signal, 1 kilohertz square wave.	Vertical checks. Trigger view gain check; External Z-Axis check.	a. Tektronix PG 506 Calibration Generator. <sup>1</sup> b. Tektronix 067-0502-01 calibration fixture.
2. Sine-Wave Generator	Frequency, 350 kilohertz to above 200 megahertz; output amplitude, variable from 15 millivolts to 4 volts peak-to-peak; output impedance, 50 ohms; reference frequency, 50 to 350 kilohertz; amplitude accuracy, constant within 3% of reference frequency as output frequency changes.	Vertical centering, bandwidth and isolation checks; Trigger checks: X bandwidth check.	a. Tektronix SG 503 Leveled Sine-Wave Generator. <sup>1</sup> (Use for all frequencies.) b. Tektronix Type 191 Constant-Amplitude Signal Generator. (Use at frequencies of 100 megahertz and below). AND Wavetek Model 1001A (use only for checking 200 megahertz bandwidth and triggering.)
3. Time-Mark Generator	Marker outputs, 2 nanoseconds to 0.5 second; marker accuracy, within 0.1%; trigger output, 1 millisecond to 0.1 microsecond, time coincident with markers.	Horizontal timing checks.	a. Tektronix TG 501 Time-Mark Generator. <sup>1</sup> b. Tektronix 2901 Time-Mark Generator.
4. Low-Frequency Generator	Frequency, 10 Hertz to 50 kilohertz; output amplitude, variable from 10 millivolts to 4 volts peak-to-peak.	Low-frequency trigger checks.	a. Tektronix SG 502 Oscillator. <sup>1</sup> b. General Radio 1310 B Oscillator with a binding post to BNC adapter.
5. Cable (2 required)	Impedance, 50 ohms: length, 42 inches; connectors, BNC.	Used throughout procedure for signal interconnection.	a. Tektronix Part Number 012-0057-01.
6 Cable (2 required)	Impedance, 50 ohms, length 18 inches, connectors. BNC.	Used throughout procedure for signal interconnection.	a. Tektronix Part Number 012-0076-00.
7 50-Ohm Signal Pickoff	Frequency response, 50 kilohertz to 875 megahertz: impedance, 50 ohms for signal input, signal output and trigger output.	Trigger checks.	a. Tektronix CT-3 Signal Pickoff. Part Number 017-0061-00.
8 Adapter	Connectors, BNC Female to BNC Female.	Used throughout procedure for signal interconnection.	a. Tektronix Part Number 103-0028-00.

<sup>1</sup>Requires a TM 500-Series Power Module.

TABLE 5-1 (cont)

Description	Minimum Specifications	Usage	Examples
9. Adapter	Connectors, GR874 to BNC Female.	Trigger checks.	a. Tektronix Part Number 017-0063-00.
10. Adapter	Connectors, GR874 to BNC Male.	Used in Trigger System procedure for signal interconnection.	a. Tektronix Part Number 017-0064-00.
11. Elbow Adapter	Connectors, BNC Male to BNC Female.	Used in Trigger System procedure for signal interconnection.	a. Tektronix Part Number 103-0031-00.
12. T-Connector	Connectors, BNC	Used throughout procedure for signal interconnection.	a. Tektronix Part Number 103-0030-00.
13. 10X Attenuator	Ratio, 10X; impedance, 50 ohms; connectors, BNC	Vertical bandwidth check. Trigger checks.	a. Tektronix Part Number 011-0059-02
14. 5X Attenuator	Ratio, 5X; impedance, 50 ohms; connectors, BNC	Trigger checks.	a. Tektronix Part Number 011-0060-02
15. Termination (2 required)	Impedance, 50 ohms; connectors, BNC.	Used throughout procedure for proper signal termination.	a. Tektronix Part Number 011-0049-01.
16. 10X Probe	Scale-factor switching; connector, ENC.	Scale factor check. Calibrator check.	a. Tektronix P6075 Probe (supplied with 475 oscilloscope). b. Tektronix P6065 Probe.
17. 500 MHz Filter	Impedance, 50 ohms; frequency, adjustable; connectors, BNC.	Used for High-Speed Timing checks.	a Tektronix 500 MHz Filter calibration fixture, Part Number 067-0684-00.
18. Screwdriver	Length, three-inch shaft; bit size, 3/32 inch.	Used to adjust TRACE ROTATION, ASTIG, GAIN.	a. Xcelite R-3323.

**OUTLINE FOR PERFORMANCE CHECK**

**DISPLAY AND VERTICAL SYSTEM CHECK**

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**TRIGGER SYSTEM CHECK**

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**PRELIMINARY PROCEDURE FOR PERFORMANCE CHECK**

**Operating Voltage**

Before applying power to the instrument, check that the line voltage selector and the regulating range selector are in the correct positions for the line voltage the instrument will be operated on.

**Power Source**

Connect the 475 to a power source that meets the voltage and frequency requirements of this instrument.

**Warm Up**

Turn on the 475 and allow at least 20 minutes before starting the Performance Check procedure.

**Operating Temperature**

The performance of this instrument can be checked at an ambient temperature within  $-15^{\circ}\text{C}$  to  $+55^{\circ}\text{C}$  unless stated otherwise in the procedure. This instrument should be checked at an ambient temperature of  $+20^{\circ}\text{C}$  to  $+30^{\circ}\text{C}$  for best overall accuracy.

## DISPLAY AND VERTICAL SYSTEM CHECK

<b>Equipment Required</b>	
1. Amplitude Calibrator	6. 10X BNC Attenuator
2. Sine-Wave Generator	7. 50-Ohm BNC Termination (2 required)
3. 42-inch 50-Ohm BNC Cable (2 required)	8. BNC Female-to-BNC Female Adapter
4. 18-inch 50-Ohm BNC Cable (2 required)	9. BNC T-Connector
5. 10X Probe (see Table 5-1, 10X Probe examples)	10. Screwdriver

**Control Settings**

POWER ON

**Display**

INTENSITY Midrange  
 FOCUS Midrange  
 SCALE ILLUM Midrange

**Vertical (CH 1 and CH 2)**

POSITION Midrange  
 VOLTS/DIV 5 mV  
 VAR VOLTS/DIV Calibrated detent  
 AC-GND-DC DC  
 INVERT Off (button out)  
 VERT MODE CH 1  
 100 or 20 MHz BW 20

**Trigger (A and B)**

COUPLING AC  
 LEVEL 0  
 SLOPE +  
 A TRIGGER SOURCE NORM  
 B TRIGGER SOURCE STARTS AFTER DELAY  
 TRIG MODE AUTO  
 A TRIGGER HOLDOFF NORM

**Sweep**

A TIME/DIV 1 ms  
 B TIME/DIV 1 ms  
 VAR TIME/DIV Calibrated detent  
 DELAY TIME POSITION Fully counterclockwise  
 HORIZ DISPLAY A  
 X10 MAG Off (button out)  
 POSITION (Horiz) Midrange  
 FINE Midrange

**1. Check Display Controls**

- a. Turn the INTENSITY control through its range and return to a normal intensity setting.
- b. CHECK—For control of trace intensity from minimum to maximum intensity.
- c. Turn CH 1 POSITION through its range and return to a midrange setting.
- d. CHECK—That the trace can be positioned over the entire graticule area.
- e. Set VERT MODE to CH 2, turn CH 2 POSITION through its range and return to a midrange setting.
- f. CHECK—That the trace can be positioned over the entire graticule area.
- g. Return VERT MODE to CH 1 and position the trace to the center horizontal graticule line.
- h. CHECK—That the trace is aligned with the center horizontal graticule line.
- i. ADJUST—TRACE ROTATION (front panel screwdriver adjustment) to align the trace with the center horizontal graticule line.
- j. Turn the SCALE ILLUM control through its range.

k. CHECK—For control of graticule illumination from minimum to maximum settings.

l. Set the amplitude calibrator for a 20 millivolt output and connect to CH 1 input through a 42-inch 50-ohm BNC cable.

m. Set A TRIGGER LEVEL for a stable display.

n. CHECK—For well-defined focusing on front corners of the displayed waveform.

o. ADJUST—FOCUS control and ASTIG (front panel screwdriver adjustment) together for the best-defined front corners on the displayed waveform.

p. Turn INTENSITY fully counterclockwise and press BEAM FINDER pushbutton.

q. CHECK—For a compressed waveform of normal intensity, within graticule area.

r. Release BEAM FINDER pushbutton and return INTENSITY to a normal setting.

## 2. Check Vertical Input Functions

a. Position the bottom of CH 1 display to the center horizontal graticule line.

b. Set CH 1 AC-GND-DC switch to GND.

c. CHECK—For no vertical deflection and that trace is at center horizontal graticule line.

d. Set CH 1 AC-GND-DC switch to AC.

e. CHECK—That display is centered in graticule area.

f. Move test signal cable to CH 2 input and set VERT MODE to CH 2.

g. Position the bottom of CH 2 display to the center horizontal graticule line.

h. Set CH 2 AC-GND-DC switch to GND.

i. CHECK—For no vertical deflection and that trace is at center horizontal graticule line.

j. Set CH 2 AC-GND-DC switch to AC.

k. CHECK—That display is centered in graticule area.

l. Disconnect all test equipment.

m. CHECK—That the light under 5 mV of CH 2 VOLTS/DIV knob is on.

n. Connect a 10X probe with a scale-factor switching connector to CH 2 input.

### NOTE

*Use a probe listed in test equipment required, Table 5-1, under 10X Probe examples.*

o. CHECK—That the light under 5 mV is extinguished and the light under 50 mV comes on.

p. Set VERT MODE to CH 1.

q. CHECK—That the light under 5 mV of CH 1 VOLTS/DIV knob is on.

r. Move the 10X probe to CH 1 input.

s. CHECK—That the light under 5 mV is extinguished and the light under 50 mV comes on.

t. Remove the 10X probe.

## 3. Check CH 1 and CH 2 GAIN

a. Set the amplitude calibrator for a 20 millivolt output and connect to CH 1 input through a 42-inch 50-ohm BNC cable.

b. Set CH 1 and CH 2 AC-GND-DC switches to DC.

c. CHECK—The display for 4 divisions of amplitude.

d. ADJUST—CH 1 GAIN, 5 mV adjustment, through the upper 5 mV access hole at left side of cabinet for 4 divisions of amplitude.

e. CHECK—All settings of CH 1 VOLTS/DIV for accuracy, within 3%, using the settings listed in Table 5-2.

**TABLE 5-2**  
**Vertical Deflection Accuracy**

VOLTS/DIV Switch Setting	Amplitude Calibrator Output	Vertical Deflection in Divisions	Maximum Error for 3% Accuracy
2 mV	10 millivolts	5	±0.15 div
5 mV	20 millivolts	4	Previously set
10 mV	50 millivolts	5	±0.15 div
20 mV	0.1 volt	5	±0.15 div
50 mV	0.2 volt	4	±0.12 div
0.1 V	0.5 volt	5	±0.15 div
0.2 V	1 volt	5	±0.15 div
0.5 V	2 volts	4	±0.12 div
1 V	5 volts	5	±0.15 div
2 V	10 volts	5	±0.15 div
5 V	20 volts	4	±0.12 div

f. Set VERT MODE to CH 2, set amplitude calibrator for a 20 millivolt output and move signal cable to CH 2 input.

g. CHECK—The display for 4 divisions of amplitude.

h. ADJUST—CH 2 GAIN, 5 mV adjustment, through the lower 5 mV access hole at left side of cabinet for 4 divisions of amplitude.

i. CHECK—All settings of CH 2 VOLTS/DIV for accuracy, within 3%, using the settings listed in Table 5-2.

**4. CHECK CH 2 and CH 1 VAR VOLTS/DIV Range**

a. Set the amplitude calibrator to 50 millivolts and set CH 1 and CH 2 VOLTS/DIV to 10 mV.

b. Turn CH 2 VAR VOLTS/DIV fully counterclockwise.

c. CHECK—That the CH 2 UNCAL light turns on when the CH 2 VAR VOLTS/DIV control is out of calibrated detent.

d. CHECK—That display amplitude reduces to 2 divisions or less.

e. Return CH 2 VAR VOLTS/DIV to calibrated detent.

f. Set VERT MODE to CH 1 and move signal cable to CH 1 input.

g. Turn CH 1 VAR VOLTS/DIV fully counterclockwise.

h. CHECK—That the CH 1 UNCAL light turns on when the CH 1 VAR VOLTS/DIV control is out of calibrated detent.

i. CHECK—That display amplitude reduces to 2 divisions or less.

j. Return CH 1 VAR VOLTS/DIV to calibrated detent.

**5. Check ADD Mode Operation**

a. Set VERT MODE to ADD and set CH 1 and CH 2 VOLTS/DIV to 5 mV.

b. Remove the test signal cable from CH 1 input. Connect to the cable: a BNC female-to-BNC female adapter, a BNC T-connector, two 18-inch 50-ohm BNC cables and connect the cables to CH 1 and CH 2 inputs.

c. Set the amplitude calibrator for a 10 millivolt output and center the display on graticule using equal settings of CH 1 and CH 2 POSITION controls.

d. CHECK—For a display of 4 divisions, within 3% (0.12 division).

e. Press INVERT pushbutton.

f. CHECK—That display amplitude reduces to approximately 0.

g. Return INVERT pushbutton to normal (button out).

h. Disconnect all test equipment.

**6. Check ALT Mode Operation**

a. Set VERT MODE to ALT, set 100 OR 20 MHz BW control to full bandwidth position and set A TRIGGER LEVEL fully clockwise.

b. Position the 2 traces approximately 4 divisions apart.

c. CHECK—That the traces alternate at all settings of TIME/DIV except X-Y.

### 7. Check CHOP Mode Operation

a. Set VERT MODE to CHOP, set TIME/DIV to 1  $\mu$ s, set CH 1 and CH 2 AC-GND-DC switches to GND and adjust A TRIGGER LEVEL for a stable display.

b. CHECK—For complete blanking of switching transients between chopped segments.

c. CHECK—That the duration of 1 cycle is approximately 1 division,

### 8. Check Vertical Amplifier Bandwidth

a. Set VERT MODE to CH 1, set TIME/DIV to 0.5 ms and set CH 1 and CH 2 AC-G ND-DC switches to DC.

#### NOTE

*See test equipment required, Table 5-1, for selection of sine-wave generator with a 200 megahertz output.*

b. Connect the sine-wave generator output cable to a 10X BNC attenuator, to a 50-ohm termination, to CH 1 input.

c. Set the sine-wave generator for a 6 division display of reference frequency. (It may be necessary to insert more attenuation to reduce display amplitude.)

#### NOTE

*If generator has no reference frequency setting, set for 5 megahertz.*

d. Without changing the generator output amplitude, increase the output frequency until the display is reduced to 4.2 divisions.

e. CHECK—For a generator frequency reading of 200 megahertz or more ( $-15^{\circ}\text{C}$  to  $+40^{\circ}\text{C}$ ).

f. Set VERT MODE to CH 2 and move test signal setup to CH 2 input.

g. CHECK—Repeat the bandwidth check procedure, parts c, d and e.

### 9. Check Bandwidth Limit Operation

a. Set 100 OR 20 MHz BW control to 100.

#### NOTE

*If may be necessary to change sine-wave generators. See test equipment required, Table 5-1 for selection of generator with an output of 100 megahertz and below.*

b. Set the sine-wave generator for a 6 division display of reference frequency.

c. Without changing the generator output amplitude, increase the output frequency until the display is reduced to 4.2 divisions.

d. CHECK—For a generator reading of approximately 100 megahertz.

e. Set 100 OR 20 MHz BW control to 20.

f. Set the sine-wave generator for a 6 division display of reference frequency.

g. Without changing the generator output amplitude, increase the output frequency until the display is reduced to 4.2 divisions.

h. CHECK—For a generator reading of approximately 20 megahertz.

i. Return 100 OR 20 MHz BW control to full bandwidth.

### 10. Check Cascaded Bandwidth

a. Set VERT MODE to CH 1.

b. Connect CH 2 VERT SIGNAL OUT (output connector on rear panel) through a 42-inch 50-ohm BNC cable, to a 50-ohm termination and connect to CH 1 input.

c. Set the sine-wave generator for a 6 division display of reference frequency.

d. Without changing the generator output amplitude, increase the output frequency until the display is reduced to 4.2 divisions.

e. CHECK—For a reading of 50 megahertz or more.

f. Disconnect all test equipment.



## TRIGGER SYSTEM CHECK

<b>Equipment Required</b>	
1. Sine-Wave Generator	8. GR-To-BNC Male Adapter
2. Low-Frequency Generator	9. BNC Female-To-BNC Female Adapter
3. Amplitude Calibrator	10. BNC Elbow
4. 50-Ohm Signal Pickoff	11. BNC T-Connector
5. 42-inch 50-Ohm BNC Cable	12. 10X BNC Attenuator
6. 18-inch 50-Ohm BNC Cable (2 required)	13. 5X BNC Attenuator
7. GR-To-BNC Female Adapter	14. 50-Ohm BNC Termination (2 required)

### Control Settings

POWER ON

#### Display

INTENSITY Midrange  
 FOCUS Midrange  
 SCALE ILLUM Midrange

### Sweep

**A TIME/DIV** 50  $\mu$ s (new setting)  
**B TIME/DIV** 50  $\mu$ s (new setting)  
 VAR TIME/DIV Calibrated detent  
 DELAY TIME POSITION Fully counterclockwise  
 HORIZ DISPLAY A  
 X10 MAG Off (button out)  
 POSITION (Horiz) Midrange  
 FINE Midrange

### Vertical (CH 1 and CH 2)

POSITION Midrange  
 VOLTS/DIV 5 mV  
 VAR VOLTS/DIV Calibrated detent  
 AC-GND-DC DC  
 INVERT Off (button out)  
 VERT MODE CH 1  
 100 OR 20 MHz BW Full bandwidth (push in, then release)

### Trigger (A and B)

COUPLING AC  
 LEVEL 0  
 SLOPE +  
 A TRIGGER SOURCE NORM  
**B TRIGGER SOURCE** **NORM (new setting)**  
 TRIG MODE AUTO  
 A TRIGGER HOLDOFF NORM

### 11. Check A Low-Frequency Triggering

a. Connect the low-frequency generator output to a 42-inch 50-ohm BNC cable, to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch 50-ohm BNC cables, to CH 1 input and A TRIGGER external input.

b. Set the low-frequency generator for a 5 division, 50 kilohertz display, then set CH 1 VOLTS/DIV to 50 mV.

c. CHECK—That a stable triggered display can be obtained in AC, LF REJ, HF REJ and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

d. Set CH 1 VOLTS/DIV to 5 mV.

e. Set the low-frequency generator for a 3 division, 50 kilohertz display, then set CH 1 VOLTS/DIV to 50 mV.

f. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

g. Set the low-frequency generator for a 2 division, 50 kilohertz display, then set A TRIGGER SOURCE to EXT (100 millivolts at external input).

h. CHECK—Repeat part c.

i. Set CH 1 VOLTS/DIV to 0.1 V and set A TRIGGER SOURCE to EXT ÷ 10.

j. Set the low-frequency generator for a 5 division, 50 kilohertz display (500 millivolts at inputs), then set CH 1 VOLTS/DIV to 0.5 V.

k. CHECK—Repeat part f.

1. Set CH 1 VOLTS/DIV to 10 mV and set A TRIGGER SOURCE to EXT.

m. Set the low-frequency generator for a 5 division, 50 kilohertz display (50 millivolts at external input), then set CH 1 VOLTS/DIV to 50 mV.

n. CHECK—Repeat part f.

o. Set A TRIGGER SOURCE to NORM, set CH 1 VOLTS/DIV to 5 mV, set TIME/DIV to 10 ms and set 100 OR 20 MHz BW control to 20.

p. Set the low-frequency generator for a 5 division, 60 Hertz display, then set CH 1 VOLTS/DIV to 50 mV.

q. CHECK—That a stable triggered display can be obtained in DC, HF REJ and AC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

r. Set A TRIGGER COUPLING to LF REJ.

s. CHECK—That a stable triggered display cannot be obtained with adjustment of A TRIGGER LEVEL.

t. Set CH 1 VOLTS/DIV to 5 mV and set A TRIGGER COUPLING to AC.

u. Set the low-frequency generator for a 3 division, 60 Hertz display, then set CH 1 VOLTS/DIV to 50 mV.

v. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

w. Set the low-frequency generator for a 2 division, 60 Hertz display, then set A TRIGGER SOURCE to EXT (100 millivolts at external input).

x. CHECK—Repeat part q.

y. Set A TRIGGER COUPLING to LF REJ.

z. CHECK—Repeat part s.

aa. Set A TRIGGER COUPLING to AC.

ab. Set the low-frequency generator for a 1 division, 60 Hertz display (50 millivolts at external input).

ac. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

ad. Disconnect all test equipment.

#### NOTE

*Use a sine-wave generator with an output of 100 megahertz and below for the following parts.*

ae. Connect the sine-wave generator output cable to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch 50-ohm BNC cables. Connect an 18-inch cable through a 50-ohm termination to CH 1 input and connect the other 18-inch cable through a 50-ohm termination to A TRIGGER external input.

af. Set TIME/DIV to 0.5  $\mu$ s.

ag. Set the sine-wave generator for a 2 division, 3 megahertz display (100 millivolts at external input).

ah. Set A TRIGGER COUPLING to HF REJ.

ai. CHECK—That a stable triggered display cannot be obtained with adjustment of A TRIGGER LEVEL.

aj. Set CH 1 VOLTS/DIV to 5 mV, set TIME/DIV to 2  $\mu$ s and set A TRIGGER SOURCE to NORM.

ak. Set the sine-wave generator for a 5 division, 1 megahertz display, then set CH 1 VOLTS/DIV to 50 mV.

al. CHECK—Repeat part ai.

am. Return A TRIGGER COUPLING to AC.

an. Disconnect all test equipment.

## 12. Check B Low-Frequency Triggering

a. Set TIME/DIV to 50  $\mu$ s, set CH 1 VOLTS/DIV to 5 mV and set HORIZ DISPLAY to B DLY'D. (B DLY'D sweep will not appear when not triggered).

b. Connect the low-frequency generator output to a 42-inch 50-ohm BNC cable, to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch 50-ohm BNC cables, to CH 1 input and B TRIGGER external input.

c. Set the low-frequency generator for 50 kilohertz, then set the generator for a 5 division display and set CH 1 VOLTS/DIV to 50 mV.

d. CHECK—That a stable triggered display can be obtained in AC, LF REJ, HF REJ and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

e. Set CH 1 VOLTS/DIV to 5 mV.

f. Set the low-frequency generator for a 3 division, 50 kilohertz display, then set CH 1 VOLTS/DIV to 50 mV.

g. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

h. Set the low-frequency generator for a 2 division, 50 kilohertz display, then set B TRIGGER SOURCE to EXT (100 millivolts at external input).

i. CHECK—Repeat part d of this step.

j. Set CH 1 VOLTS/DIV to 10 mV.

k. Set the low-frequency generator for a 5 division, 50 kilohertz display (50 millivolts at external input), then set CH 1 VOLTS/DIV to 50 mV.

l. CHECK—Repeat part g.

m. Set B TRIGGER SOURCE to NORM, set CH 1 VOLTS/DIV to 5 mV and set TIME/DIV to 10 ms.

n. Set the low-frequency generator for a 5 division, 60 Hertz display, then set CH 1 VOLTS/DIV to 50 mV.

o. CHECK—That a stable triggered display can be obtained in HF REJ, DC and AC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

p. Set B TRIGGER COUPLING to LF REJ.

q. CHECK—That a stable triggered display cannot be obtained with adjustment of B TRIGGER LEVEL.

r. Set CH 1 VOLTS/DIV to 5 mV and set B TRIGGER COUPLING to AC.

s. Set the low-frequency generator for a 3 division, 60 hertz display, then set CH 1 VOLTS/DIV to 50 mV.

t. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

u. Set the low-frequency generator for a 2 division, 60 hertz display, then set B TRIGGER SOURCE to EXT (100 millivolts at external input).

v. CHECK—Repeat part o.

w. Set B TRIGGER COUPLING to LF REJ.

x. CHECK—Repeat part q.

y. Set B TRIGGER COUPLING to AC.

z. Set the low-frequency generator for a 1 division, 60 Hertz display (50 millivolts at external input). (It may be necessary to maintain triggering as amplitude is reduced.)

aa. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

ab. Disconnect all test equipment.

**NOTE**

*Use a sine-wave generator with an output of 100 megahertz and below for the following parts.*

ac. Connect the sine-wave generator output cable to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch 50-ohm BNC cables. Connect an 18-inch cable through a 50-ohm termination to CH 1 input and connect the other 18-inch cable through a 50-ohm termination to B TRIGGER external input.

ad. Set TIME/DIV to 0.5  $\mu$ s and set B TRIGGER SOURCE to STARTS AFTER DELAY.

ae. Set the sine-wave generator for a 2 division, 3 megahertz display (100 millivolts at external input).

af. Set B TRIGGER COUPLING to HF REJ and set B TRIGGER SOURCE to EXT.

ag. CHECK—That a stable triggered display cannot be obtained with adjustment of B TRIGGER LEVEL.

ah. Set CH 1 VOLTS/DIV to 5 mV, set TIME/DIV to 2  $\mu$ s and set B TRIGGER SOURCE to STARTS AFTER DELAY.

ai. Set the sine-wave generator for a 5 division, 1 megahertz display, then set CH 1 VOLTS/DIV to 50 mV, and set B TRIGGER SOURCE to NORM.

aj. CHECK—Repeat part ag.

ak. Set B TRIGGER COUPLING to AC and set B TRIGGER SOURCE to STARTS AFTER DELAY.

**13. Check B 40 Megahertz Triggering**

a Set TIME/DIV to 0.05  $\mu$ s and set 100 OR 20 MHz BW to full bandwidth (push in, then release).

b. Set the sine-wave generator for a 1 division, 40 megahertz display, then set B TRIGGER SOURCE to EXT (50 millivolts at external input).

c. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

d Set B TRIGGER SOURCE to NORM, set CH 1 VOLTS/DIV to 5 mV, set CH 2 VOLTS/DIV to 50 mV and move signal cable setup from B TRIGGER external input to CH 2 input.

e Set the sine-wave generator for a 3 division, 40 megahertz display, set CH 1 VOLTS/DIV to 50 mV, retrigger if necessary, then set the display to graticule center with CH 1 POSITION.

f. Set VERT MODE to CH 2 and move the display to graticule center with CH 2 POSITION. (Retrigger if necessary.)

g. Return VERT MODE to CH 1.

h. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

i. Return B TRIGGER COUPLING to AC.

j. CHECK—That a stable triggered display can be obtained in NORM, CH 1 and CH 2 positions of B TRIGGER SOURCE with adjustment of B TRIGGER LEVEL.

k. Return B TRIGGER SOURCE to NORM.

**14. Check A 40 Megahertz Triggering**

a. Set HORIZ DISPLAY to A and check that A TRIGGER SOURCE is in NORM and A TRIGGER COUPLING is in AC.

b. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

c. Return A TRIGGER COUPLING to AC.

d. CHECK—That a stable triggered display can be obtained in CH 1 and CH 2 positions of A TRIGGER SOURCE with adjustment of A TRIGGER LEVEL.

e. Return A TRIGGER SOURCE to NORM and move test signal cable from CH 2 input to A TRIGGER external input.

f. Set the sine-wave generator for a 1 division, 40 megahertz display, then set A TRIGGER SOURCE to EXT.

g. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

h. Return A TRIGGER SOURCE to NORM and A TRIGGER COUPLING to AC.

i. Disconnect all test equipment.

#### 15. Check A 200 Megahertz Triggering

*NOTE*

*It may be necessary to change to a sine-wave generator with a 200 megahertz output.*

a. Connect the sine-wave generator output cable through a GR-to-BNC female adapter to the through signal input of the 50-ohm signal pickoff. Connect the through signal output of the signal pickoff to a GR-to-BNC male adapter, to a 10X BNC attenuator, to a 50-ohm BNC termination, to a BNC elbow, to A TRIGGER external input.

b. Connect the 10% signal output of the signal pickoff to an 18-inch 50-ohm BNC cable, to a 50-ohm termination, to CH 1 input.

c. Set the sine-wave generator for a 1.5 division, 200 megahertz display.

d. Set TIME/DIV to 0.01  $\mu$ s and press X10 MAG to on.

e. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained in AC, LF REJ and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

f. Set TIME/DIV to 0.1 ms and set A TRIGGER SOURCE to EXT.

g. Set the sine-wave generator for a 5 division display of reference frequency (250 millivolts at external input), then set to 200 megahertz.

*NOTE*

*If generator has no reference frequency setting, set for 5 megahertz.*

h. Set TIME/DIV to 0.01  $\mu$ s.

i. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

j. Replace the 10X BNC attenuator in test signal setup with a 5X BNC attenuator (500 millivolts at external input) and set A TRIGGER COUPLING to LF REJ.

k. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained with adjustment of A TRIGGER LEVEL.

#### 16. Check B 200 Megahertz Triggering

a. Move test signal setup from A TRIGGER external input to B TRIGGER external input.

b. Set A TRIGGER SOURCE to NORM, set A TRIGGER COUPLING to AC, set HORIZ DISPLAY to B DLY'D, set B TRIGGER SOURCE to EXT and set B TRIGGER COUPLING to LF REJ.

c. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained with adjustment of A and B TRIGGER LEVEL controls.

d. Replace the 5X BNC attenuator with a 10X BNC attenuator (250 millivolts at external input).

e. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of A and B TRIGGER LEVEL controls.

f. Set B TRIGGER SOURCE to STARTS AFTER DELAY and set TIME/DIV to 1  $\mu$ s.

g. Set the sine-wave generator for a 1.5 division, 200 megahertz display.

h. Set B TRIGGER SOURCE to NORM and set TIME/DIV to 0.01  $\mu$ s.

i. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained in AC, LF REJ, and DC positions of B TRIGGER COUPLING with adjustment of A and B TRIGGER LEVEL controls.

j. Disconnect all test equipment.

#### **17. Check TRIG MODE NORM Operation**

a. Set HORIZ DISPLAY to A, set TIME/DIV to 1 ms, set X10 MAG to off (button out), set INTENSITY, if necessary, for a convenient trace intensity and set B TRIGGER COUPLING to AC.

b. Set the amplitude calibrator for a 50 millivolt output and connect to CH 1 input through a 42-inch 50-ohm BNC cable.

c. Set A TRIGGER LEVEL for a stable triggered display.

d. Set TRIG MODE to NORM.

e. CHECK—For a stable triggered display.

f. Remove the test signal from CH 1 input.

g. CHECK—For no visible trace.

#### **18. Check TRIG MODE SINGL SWP Operation**

a. Return the test signal cable to CH 1 input.

b. Press and release SINGL SWP pushbutton.

c. Remove the test signal cable from CH 1 input.

d. Press and release SINGL SWP pushbutton.

e. CHECK—That READY light turns on.

f. Return the test signal cable to CH 1 input.

g. CHECK—That READY light is extinguished.

h. Press and release SINGL SWP pushbutton.

i. CHECK—For a single-sweep display (1 sweep only).

j. Set TRIG MODE to AUTO.

#### **19. Check TRIG VIEW Operation**

a. Move signal cable from CH 1 input to A TRIGGER external input and set A TRIGGER SOURCE to EXT.

b. Set the amplitude calibrator for a 200 millivolt output.

c. Press TRIG VIEW and hold it in.

d. Position the waveform for a maximum amplitude display with A TRIGGER LEVEL control.

e. CHECK—For approximately 4 divisions of display.

f. Release TRIG VIEW.

g. Disconnect all test equipment.

## HORIZONTAL SYSTEM CHECK

Equipment Required	
1. Time-Mark Generator	4. 500 MHz Filter
2. Sine-Wave Generator	5. 42-inch 50-Ohm BNC Cable (2 required)
3. Amplitude Calibrator	6. 50-Ohm BNC Termination (2 required)
	7. 10X Probe (see Table 5-1, 10X Probe examples)

### Control Settings

POWER ON

#### Display

INTENSITY Midrange  
 FOCUS Midrange  
 SCALE ILLUM Midrange

### Sweep

A TIME/DIV 1 ms  
 B TIME/DIV 1 ms  
 VAR TIME/DIV Calibrated detent  
 DELAY TIME POSITION Fully counterclockwise  
 HORIZ DISPLAY A  
 X10 MAG Off (button out)  
 POSITION (Horiz) Midrange  
 FINE Midrange

### Vertical (CH 1 and CH 2)

POSITION Midrange  
**VOLTS/DIV 0.5 V (new setting)**  
 VAR VOLTS/DIV Calibrated detent  
 AC-GND-DC DC  
 INVERT Off (button out)  
 VERT MODE CH 1  
 100 OR 20 MHz BW Full bandwidth (push in, then release)

#### Trigger (A and B)

COUPLING AC  
 LEVEL 0  
 SLOPE +  
**A TRIGGER SOURCE NORM (new setting)**  
**B TRIGGER SOURCE STARTS AFTER DELAY (new setting)**  
 TRIG MODE AUTO  
 A TRIGGER HOLDOFF NORM

### 20. Check VAR TIME/DIV Range

- a. Set the time-mark generator for 5 millisecond time marks and connect through a 42-inch 50-ohm BNC cable, to a 50-ohm BNC termination, to CH 1 input.
  
- b. Set A TRIGGER LEVEL for a stable triggered display, then set VAR TIME/DIV fully counterclockwise.
  
- c. CHECK—That VAR TIME/DIV UNCAL light is illuminated.
  
- d. CHECK—For at least 6 time marks between first and last graticule lines.
  
- e. Return VAR TIME/DIV control to calibrated detent.

**21. Check Sweep Length and Horizontal POSITION Range**

- a. Set time-mark generator for 1 millisecond time marks.
- b. CHECK—Sweep length for approximately 10.1 divisions.
- c. Turn POSITION and FINE (Horiz) controls fully clockwise. (Also check that each control will position the trace.)
- d. CHECK—That the start of sweep is to the right of graticule center.
- e. Turn POSITION and FINE (Horiz) controls fully counterclockwise.
- f. CHECK—That the end of sweep is to the left of graticule center.
- g. Recenter POSITION and FINE (Horiz) controls.

**22. Check A Timing Accuracy**

- a. Set TIME/DIV to 0.01  $\mu$ s, set the time-mark generator for 10 nanosecond time marks, set TRIG MODE to NORM, and set A TRIGGER LEVEL for a stable triggered display.

*NOTE*

*Unless otherwise stated, set POSITION and FINE (Horiz) controls so first time mark will coincide with first graticule line and check that a time mark will coincide with last vertical graticule line.*

- b. CHECK—TIME/DIV settings from 0.01  $\mu$ s to 5 ins/division for accuracy, at first and 11th graticule lines, within 1%, from +20°C to +30°C; within 3%, from -15°C to +55°C.

*NOTE*

*Turn INTENSITY full on, note the start of sweep and exclude the first 25 nanoseconds from start of sweep when checking 0.01 and 0.02  $\mu$ s/division. Set time-mark generator, as necessary, to provide 1 or more time marks/division as each TIME/DIV setting is selected, throughout the horizontal check procedure.*

- c. CHECK—TIME/DIV settings from 10 ms to 0.5 s/division for accuracy, at first and 11th graticule lines, within 2%, from +20°C to +30°C; within 3%, from -15°C to +55°C.

**23. Check A INTEN Timing Accuracy**

- a. Set HORIZ DISPLAY to A INTEN, set TIME/DIV to 0.05  $\mu$ s and set time-mark generator for 50 nanosecond time marks (DELAY TIME POSITION should be fully counterclockwise).

- b. CHECK—TIME/DIV settings from 0.05  $\mu$ s to 0.5 s/division for accuracy, at first and 11th graticule lines, within 2%, from +20°C to +30°C; within 3%, from -15°C to +55°C.

**24. Check A INTEN Magnified timing Accuracy**

- a. Set TIME/DIV to 0.05  $\mu$ s, set time-mark generator for 5 nanosecond time marks and press X10 MAG to on.

- b. CHECK—TIME/DIV settings from 0.05  $\mu$ s to 0.5 s/division for accuracy, at first and 11th graticule lines, within 3%, from +20°C to +30°C; within 4%, from -15°C to +55°C (see following note).

*NOTE*

*Turn INTENSITY fully on, note the start of sweep and exclude the first 25 nanoseconds from start of sweep or first 2 major unblanked divisions at norms/intensity (whichever is greater) and all beyond the 100th division.*

**25. Check A Magnified Timing Accuracy**

- a. Set TIME/DIV to 0.01  $\mu$ s, set A TRIGGER SOURCE to EXT and set A TRIGGER COUPLING to LF REJ.

- b. Set the time-mark generator for 2 nanosecond time marks and connect trigger output through a 42-inch 50-ohm BNC cable, to a 50-ohm BNC termination, to A TRIGGER external input (if a 2901 time-mark generator is used, set trigger selector for 0.1 microsecond triggers).

Insert a 500 megahertz filter between the 50-ohm BNC termination and CH 1 input. Adjust the filter for minimum unwanted modulation from the time mark generator, as necessary, whenever 2 or 5 nanosecond time marks are used in this step.



c. Set CH 1 VOLTS/DIV to maintain a convenient display amplitude and set A TRIGGER LEVEL for a stable display. (It may be necessary to adjust A TRIGGER HOLDOFF for best triggered display through this step).

d. CHECK—TIME/DIV settings from 0.01 to 0.05  $\mu$ s/division for accuracy, at first and 11th graticule lines, within 2%, from +20°C to +30°C; within 4%, from -15°C to +55°C.

e. CHECK—That accuracy is within 5% (0.1 division) over any 2 division interval at all TIME/DIV settings (see following note).

NOTE

*If waveform has modulation, check 2 division accuracy between adjacent time marks of equal amplitude.*

*Turn INTENSITY full on, note the start of sweep and exclude the first 25 nanoseconds from start of sweep or first 2 major unblanked divisions at normal intensity (whichever is greater) and all beyond the 100th division.*

f. Remove the trigger cable setup from A TRIGGER external input, set A TRIGGER SOURCE to NORM and set A TRIGGER COUPLING to AC. Remove the 500 megahertz filter.

g. Set TIME/DIV to 0.1  $\mu$ s, set time-mark generator for 10 nanosecond time marks and set CH 1 VOLTS/DIV to maintain a convenient display amplitude.

h. CHECK—TIME/DIV settings from 0.1  $\mu$ s to 5 ins/division for accuracy, at first and 11th graticule lines, within 2%, from +20°C to +30°C, within 4%, from -15°C to +55°C.

**26. Check Differential Delay Time Accuracy**

a. Set HORIZ DISPLAY to B DLY'D and set TIME/DIV to 0.05  $\mu$ s. Pull and unlock DLY'D SW Pknob, set to 0.01  $\mu$ s and set X10 MAG to off.

b. Set time-mark generator for 50 nanosecond time marks.

c. Turn DELAY TIME POSITION to 1.000. Adjust horizontal POSITION to set time mark at center graticule line.

d. Turn DELAY TIME POSITION clockwise until adjacent time mark is at center graticule line and note dial reading.

e. CHECK—For a difference in dial reading of 1.000  $\pm$  0.010, from +15°C to +35°C; +0.0020 from -15°C to +55°C.

f. Turn DELAY TIME POSITION to set every adjacent time-mark to coincide with graticule center and note reading.

g. CHECK—Each reading between any 2 adjacent time-marks for 1.000, within 0.010, from +15°C to +35°C; within 0.020, from -15°C to +55°C. Also, check the difference between any time marks separated by more than 1 major dial division not to exceed maximum error as listed in Table 5-3.

**TABLE 5-3  
Differential Delay Time Accuracy**

Difference in Major Dial Divisions	Maximum Error +15°C to +35°C	Maximum Error 15°C to +55°C
1.000	+0.010	+0.020
2.000	+0.019	+0.029
3.000	+0.027	+0.042
4.000	+0.033	+0.053
5.000	+0.039	+0.064
6.000	+0.043	+0.073
7.000	+0.047	+0.082
8.000	+0.049	+0.089
9.000	+0.050	+0.095

h. CHECK—Display time accuracy as directed in part g, at all settings listed in Table 5-4 not to exceed maximum error listed in Table 5-3.

**TABLE 5-4**  
**Delay Time Settings**

<b>DELAY TIME POSITION Exclusions</b>	<b>A TIME/DIV Switch Setting</b>	<b>B TIME/DIV Switch Setting</b>	<b>Time-Mark Generator Setting</b>
Exclude dial settings of 0.000 through 1.000	0.05 $\mu$ s	0.01 $\mu$ s	50 nanosecond
	0.1 $\mu$ s	0.01 $\mu$ s	0.1 microsecond
	0.2 $\mu$ s	0.02 $\mu$ s	0.2 microsecond
	0.5 $\mu$ s	0.05 $\mu$ s	0.5 microsecond
Exclude dial settings of 0.000 through 0.050	1 $\mu$ s	0.1 $\mu$ s	1 microsecond
	2 $\mu$ s	0.2 $\mu$ s	2 microsecond
	5 $\mu$ s	0.5 $\mu$ s	5 microsecond
	10 $\mu$ s	1 $\mu$ s	10 microsecond
	20 $\mu$ s	2 $\mu$ s	20 microsecond
	50 $\mu$ s	5 $\mu$ s	50 microsecond
	0.1 ms	10 $\mu$ s	0.1 millisecond
	0.2 ms	20 $\mu$ s	0.2 millisecond
	0.5 ms	50 $\mu$ s	0.5 millisecond
	1 ms	0.1 ms	1 millisecond
	2 ms	0.2 ms	2 millisecond
	5 ms	0.5 ms	5 millisecond
	10 ms	1 ms	10 millisecond
	20 ms	2 ms	20 millisecond
	50 ms	5 ms	50 millisecond
	0.1 s	10 ms	0.1 second
	0.2 s	20 ms	0.2 second
0.5 s	50 ms	0.5 second	

**1**If the time-mark generator being used does not have a 1-2-5 sequence, set for 1 or more time marks/division on DELAY TIME POSITION dial.

**27. Check Delay Time Jitter**

a. Set DLY'D SWP to 0.2  $\mu$ s, set A TIME/DIV to 1 ms and set time-mark generator for 1 millisecond time marks.

b. Set DELAY TIME POSITION to 1.000 on dial and position nearest time-mark to graticule center.

c. CHECK—That jitter on the leading edge of the time mark does not exceed 1 division (60 Hertz line) or 2.5 division (50 Hertz line).

d. Set DELAY TIME POSITION to view each time-mark from 2.000 to 9.000 on dial and check delay time jitter for limits stated in part c.

**28. Check MIX (Mixed Sweep) Timing Accuracy**

a. Set DLY'D SWP to 0.02  $\mu$ s, A TIME/DIV to 0.05  $\mu$ s, HORIZ DISPLAY to MIX and DELAY TIME POSITION fully clockwise.

b. Set time-mark generator for 50 nanosecond time-marks.

c. CHECK—A TIME/DIV settings from 0.02  $\mu$ s to 0.5 s/division for accuracy at 2nd and 10th graticule lines (8 division timing), within 3%. Exclude the first 0.5 division from start of sweep when checking A sweep. Set DLY'D SWP at least 1 sweep setting faster than A sweep setting on all ranges. Set time-mark generator to maintain appropriate time marks.

d. Set DELAY TIME POSITION fully counterclockwise, DLY'D SWP to 0.05  $\mu$ s, A TIME/DIV to 0.1  $\mu$ s and set time-mark generator for 50 nanosecond time marks.

e. CHECK—DLY'D SWP settings from 0.05  $\mu$ s to 0.5 s/division for accuracy at 2nd and 10th graticule lines (8 division timing), within 3%. Exclude the first 0.2 division or 0.1 microsecond (whichever is greater) after the transition of A to B. Set DLY'D SWP at least 1 sweep setting faster than A sweep setting on all ranges. Set time-mark generator to maintain appropriate time marks.

f. Disconnect all test equipment.

**29. Check X Gain**

a. Set TRIG MODE to AUTO, set DLY'D SWP to lock knobs, set TIME/DIV to X-Y, set VERT MODE to CH 2 and set X (CH 1) VOLTS/DIV to 5 mV.

b. Set amplitude calibrator to 20 millivolts and connect to X (CH 1) input through a 42-inch 50-ohm BNC cable.

c. Set X (CH 1) and Y (CH 2) POSITION controls to set the 2-dot display at graticule center.

d. CHECK—The deflection between the 2 displayed dots for 4 divisions within 3%.

e. Disconnect all test equipment.

**30. Check X Bandwidth**

*NOTE*

*See test equipment required, Table 5-1, for selection of sine-wave generator with an output of 100 megahertz and below.*

a. Connect the sine-wave generator output cable to a 50-ohm termination, to X input.

b. Set the sine-wave generator for a 4 division horizontal display of reference frequency.

c. Increase the frequency of the sine-wave generator until the display is reduced to 2.8 divisions.

d. CHECK—The sine-wave generator for a reading of 3 megahertz or higher.

e. Disconnect all test equipment.

**GATE OUTPUTS, EXTERNAL Z-AXIS AND CALIBRATOR CHECKS**

<b>Equipment Required</b>	3. 50-Ohm BNC Termination
1. Amplitude Calibrator	
2. 42-inch 50-ohm BNC Cable (2 required)	4. 10X Probe (see Table 5-1, 10X Probe examples)

**Control Settings**

POWER ON

**Display**

INTENSITY Midrange  
 FOCUS Midrange  
 SCALE ILLUM Midrange

**Vertical (CH 1 and CH 2)**

POSITION Midrange  
**VOLTS/DIV 2 V (new setting)**  
 VAR VOLTS/DIV Calibrated detent  
 AC-GND-DC DC  
 INVERT Off (button out)  
**VERT MODE CH 1 (new setting)**  
**100 OR 20 MHz BW 20 (new setting)**

**Trigger (A and B)**

COUPLING AC  
**LEVEL Fully clockwise (new setting)**  
 SLOPE +  
 A TRIGGER SOURCE NORM  
 B TRIGGER SOURCE STARTS AFTER DELAY  
 TRIG MODE AUTO  
 A TRIG HOLDOFF NORM

**Sweep**

**A TIME/DIV 10 μs (new setting)**  
**B TIME/DIV 10 μs (new setting)**  
 VAR TIME/DIV Calibrated detent  
 DELAY TIME POSITION Fully counterclockwise  
**HORIZ DISPLAY A INTEN (new setting)**  
 X10 MAG Off (button out)  
 POSITION (Horiz) Midrange  
 FINE Midrange

**31. Check A and B +GATE Outputs**

a. Connect A +GATE (output connector on rear panel) to CH 1 input through a 42-inch 50-ohm BNC cable.

b. CHECK—The display for a positive pulse amplitude of approximately 5 volts (it may be necessary to increase INTENSITY to view leading edge of positive pulse).

c. Move cable from A +GATE to B +GATE (output connectors on rear panel).

d. CHECK—Repeat part b.

e. Disconnect the cable between B +GATE and CH 1 connectors.

**32. Check CH 2 VERT SIGNAL OUT**

a. Set HORIZ DISPLAY to A, set TIME/DIV to 0.5 ms, set CH 1 VOLTS/DIV to 0.1 V and set CH 2 VOLTS/DIV to 5 mV.

b. Set VERT MODE to CHOP, set CH 1 and CH 2 POSITION controls for 2 traces superimposed on center horizontal graticule line, then set VERT MODE to CH 1.

c. Connect CH 2 VERT SIGNAL OUT (output connector on rear panel) to CH 1 input through a 42-inch 50-ohm BNC cable.

d. Set amplitude calibrator for a 20 millivolt output and connect to CH 2 input through a 42-inch 50-ohm BNC cable.

e. Set A TRIGGER LEVEL for a stable triggered display.

f. CHECK—The square-wave display for approximately 1 division of amplitude near center horizontal graticule line.

g. Set CH 1 VOLTS/DIV to 50 mV and insert a 50-ohm termination between CH 1 input and the connected BNC cable.

h. CHECK—Repeat part f.

i. Disconnect all test equipment.

**33. Check EXT Z-AXIS Operation**

a. Set amplitude calibrator for a 5 volt output and connect to EXT Z-AXIS (input connector on rear panel) through a 42-inch 50-ohm BNC cable.

b. CHECK—For noticeable modulation at normal intensity. Adjust VAR TIME/DIV, if necessary to observe modulation, then return to calibrated detent.

c. Disconnect all test equipment.

**34. Check CALIBRATOR Operation**

a. Set CH 1 VOLTS/DIV to 10 mV and set TIME/DIV to 1 ms.

b. Connect a 10X probe with a scale-factor switching connector between CH 1 input and CALIBRATOR current loop.

*NOTE*

*Use a probe listed in test equipment required, Table 5-1, under 10X Probe examples.*

c. CHECK—The square-wave display for 3 divisions of amplitude and for approximately 1 cycle/division.

d. Disconnect all test equipment.

# SCHEMATIC DIAGRAMS AND OPTIONS 04 AND 07

## Symbols and Reference Designators

Electrical components shown on the diagrams are in the following units unless noted otherwise:

- Capacitors = Values one or greater are in picofarads (pF).  
Values less than one are in microfarads ( $\mu$  F).  
Resistors = Ohms ( $\Omega$ ).

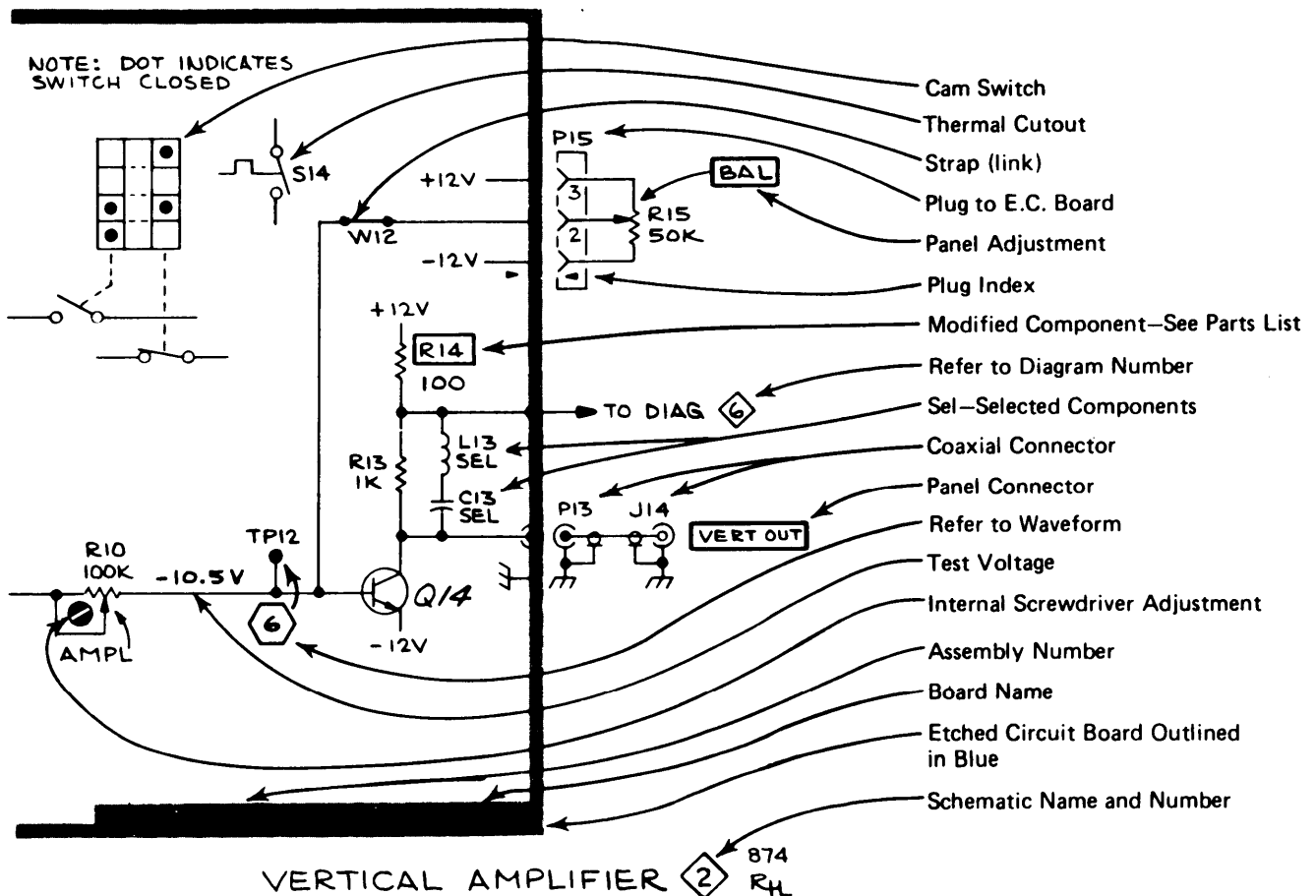
Symbols used on the diagrams are based on USA Standard Y32.2-1967.

Logic symbology is based on MIL-STD-806B in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

<b>A</b>	Assembly, separable or repairable (circuit board, etc.)	<b>H</b>	Heat dissipating device (heat sink, heat radiator, etc.)	<b>RT</b>	Thermistor
<b>AT</b>	Attenuator, fixed or variable	<b>HR</b>	Heater	<b>S</b>	Switch
<b>B</b>	Motor	<b>HY</b>	Hybrid circuit	<b>T</b>	Transformer
<b>BT</b>	Battery	<b>J</b>	Connector, stationary portion	<b>TC</b>	Thermocouple
<b>C</b>	Capacitor, fixed or variable	<b>K</b>	Relay	<b>TP</b>	Test point
<b>CB</b>	Circuit breaker	<b>L</b>	Inductor, fixed or variable	<b>U</b>	Assembly, inseparable or non-repairable (integrated circuit, etc.)
<b>CR</b>	Diode, signal or rectifier	<b>LR</b>	Inductor/resistor combination	<b>V</b>	Electron tube
<b>DL</b>	Delay line	<b>M</b>	Meter	<b>VR</b>	Voltage regulator (zener diode, etc.)
<b>DS</b>	Indicating device (lamp)	<b>P</b>	Connector, movable portion	<b>Y</b>	Crystal
<b>E</b>	Spark Gap	<b>Q</b>	Transistor or silicon-controlled rectifier	<b>Z</b>	Phase shifter
<b>F</b>	Fuse	<b>R</b>	Resistor, fixed or variable		
<b>FL</b>	Filter				

The following special symbols are used on the diagrams:



# OPTION 04

This section describes the features of Option 04 as it pertains to the 475 Oscilloscope. This circuitry modifies the instrument to meet conducted and radiated interference requirements over the frequency range of 150 kHz to 25 MHz (conducted) and 150 kHz to 1 GHz (radiated).

The following additions and changes were made to the standard circuitry to meet the specification requirements:

EMI filter (FL1401) added in series with the input power cord.

Cathode ray tube mesh filter installed to minimize crt faceplate radiation.

Four signal-output bnc connectors on the rear plenum chamber changed to a type that improves shielding of the connected signal leads.

Capacitor added across the transformer secondary windings.

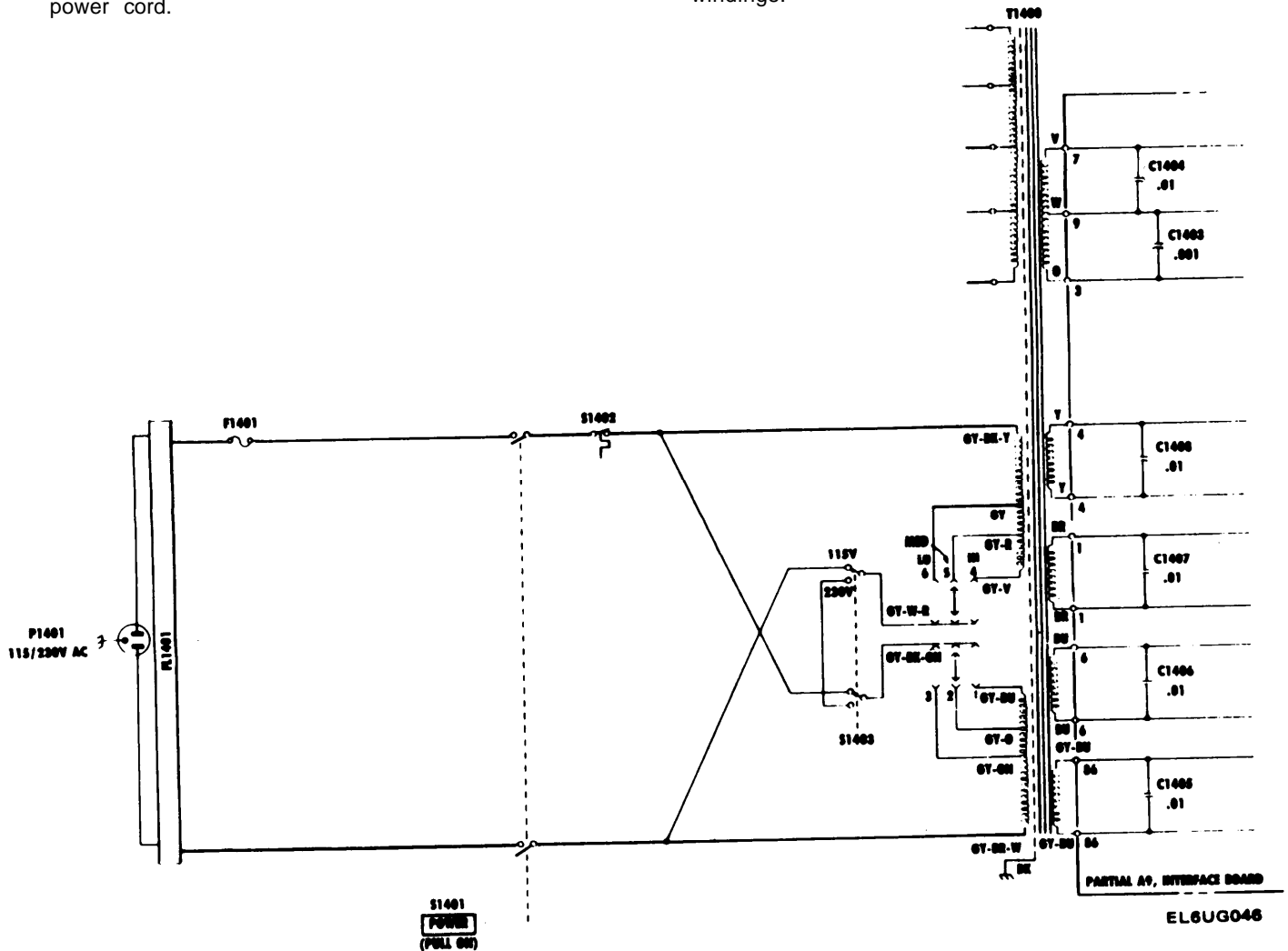


Fig. 6-1. Option 04 schematic diagram.

(FO's 1 through 14 are located in Back of Manual)

# OPTION 7

Option 7 is a dc to ac inverter that permits Tektronix Oscilloscopes to operate on 12 or 24V dc with no performance deterioration. Circuitry is provided to protect against damage due to connection of 24 V when in the 12 V mode of operation.

The 24-volt external input permits use with conventional dc power (marine and aircraft).

Option 7 is an integral part of the oscilloscope. The modified oscilloscope has a three-position voltage input selection slide switch (visible through the right-hand side panel) at the rear of the line voltage selector switch. A dc input connector is located below the fan cover on the rear panel.

## SPECIFICATIONS

### AC Requirements

No increase in ac requirements over those of oscilloscopes not having Option 7.

### DC Requirements

11.5 to 14 volts or 22 to 28 volts. 11.5-volt operation excludes graticule light operation and Option 5. Operating range may be extended to 15 volts or 30 volts with a series dropping resistor. Maximum elevation for + or - power lead is 60 V with respect to oscilloscope chassis ground.

### Temperature

The same operating and nonoperating range as the oscilloscope without Option 7.

## SAFETY CONSIDERATIONS

Option 7 becomes a part of the modified instrument. The safety considerations for the unmodified instrument apply.

## FUNCTION OF CONTROLS AND CONNECTORS

### Mode Switch<sup>1</sup>

AC Applies ac power to the oscilloscope power switch.

<sup>1</sup>Be sure that the 1106 Line Selector switch is set to the correct line voltage for proper battery charging.

DC 12 Permits 12 V operation of the instrument from an external 12 V source.

DC 24 Permits 24 V operation of the instrument from either an external 24 V power source or from the 1106 Power Supply, which may be mechanically attached to the oscilloscope.

### Dc Input Connector

Option 7 mode switch and dc input connector are located on the modified oscilloscope.

## OPERATION AND INSPECTION

Set the oscilloscope and Option 7 for the power source available as listed below.

Power Source	Oscilloscope Line Selector	Option 7 Mode Switch
115 V AC	115	AC
230 V AC	230	AC
12 V DC		12
24 V DC		24
1106 <sup>1</sup>		24

Turn the oscilloscope on. Check that the oscilloscope operates properly on any of the listed power sources that may be available.

Connect the oscilloscope frame to a ground (earth) reference before using.

## CIRCUIT DESCRIPTION

Option 7 is a dc to ac inverter. It operates on 12 or 24 V dc. The circuit description is for 24 V operation unless noted otherwise. Refer to the schematic diagrams (fig. 6-2 and 6-3) throughout the detailed circuit description.

The operating frequency of the inverter is approximately 400 Hz.

**Simplified Block Diagram**

See Figure 6-2. The dc source is applied to the turn-off level circuit, the start circuit and the primary of T1400. If the dc source is above the level set by Turn-Off Level adjustment R1613, the turn-off circuit does not operate.

The start circuit provides a large current surge through 1631 secondary to the bases of Q1652, Q1662, Q1654 and Q1664. This starts the inverter.

The turn-off circuit is activated in two ways. In 24 V operation, Q1622 is turned on by the source voltage dropping below 22 V. In 12 V mode of operation, Q1626 is turned on by the accidental application of 24 V dc.

**Turn-Off Level Circuit**

For the following description, refer to figure 6-3.

The voltage reference for the base of Q1606 is set by R1604, VR1604 and VR1605 for about 9.1 V. This establishes the junction of R1607 and the emitters of Q1606 and Q1608 at about 9.7 V. C1605 helps to hold the 9.1 V level, preventing inverter transients from activating the turn-off circuit and prevents Q1608 from turning on when the inverter is started. This allows the power source time to recover after providing the initial-start surge.

Source voltages higher than 22 V dc cause increased current through R1607, Q1606 and R1609. Q1608 is kept cut off by the increased voltage across R1609 and the resulting change across divider R1611-R1613-R1614. This permits no current through R1617. Since R1617 furnishes bias to Q1622, the transistor is cut off. This permits the collector of Q1622 and the rest of the turn-off circuit to rise to a voltage determined by the inverter circuit and the dc source voltage. The collector of Q1622 may be about 24 V (with respect to minus dc) with a 12 V dc source and about 36 V with a 24 V dc source.

If the dc source voltage drops to less than 22 V, the current through divider R1609, R1611, R1613 and R1614 is decreased. Q1608 conducts, taking current from Q1606, and causing less drop across R1609. This makes Q1608 conduct more and Q1606 is cut off. Current flow through R1617 turns Q1622 on. Q1622 saturates, dropping its collector voltage to about 0.2 V. R1618 limits the maximum base current of Q1622.

During 12 V dc operation, there is no current flow through VR1604 and VR1605, since their series rating, about 18 volts, exceeds the applied voltage. The base current of Q1606, through R1605, turns Q1606 on enough to take all the current through R1607, which causes Q1608 to be cut off.

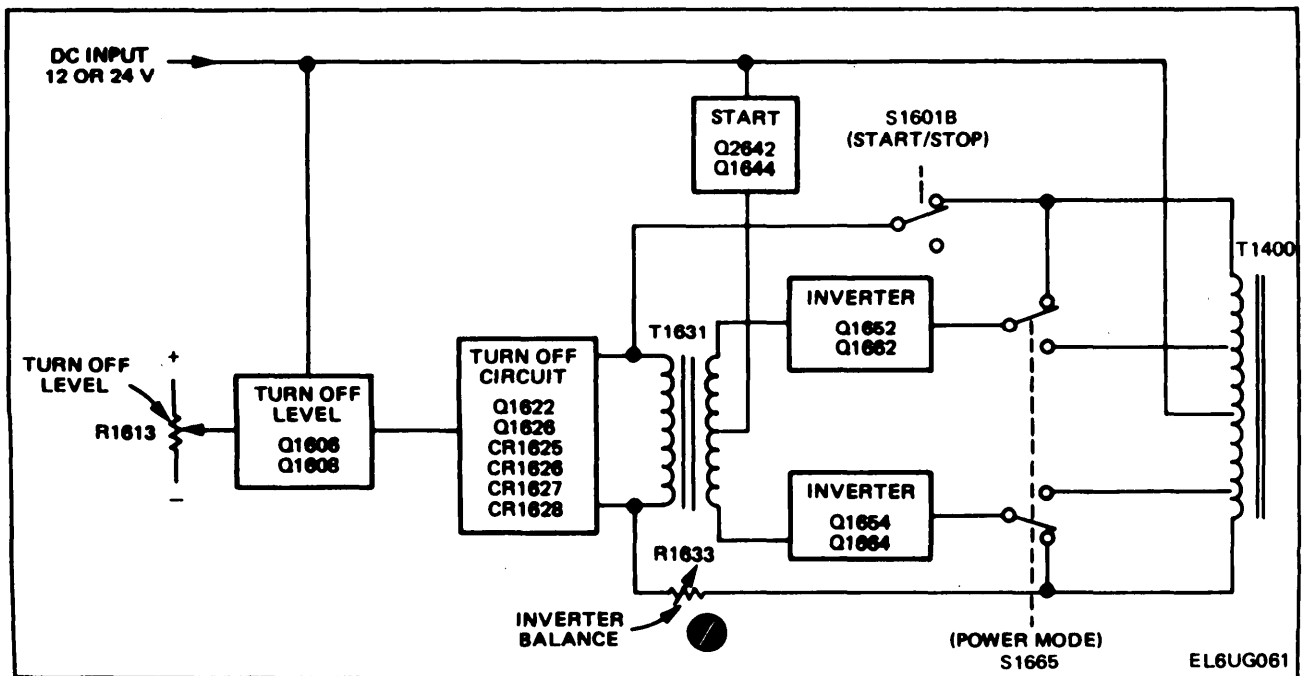


Figure 6-2. Option 07 simplified block diagram.



**Turn-Off Circuit**

Q1622 is off under normal operating conditions until the dc source drops below 22 V and causes Q1622 to conduct. Q1622 does not conduct during 12 V dc operation, since the turn-off level circuit is disabled, CR1625, CR1626, CR1627, and CR1628 form a bridge rectifier. The inverter waveform is rectified to provide operating power for the turn-off circuit. C1626 filters the inverter spikes to keep them from firing Q1626 (scr). R1623 prevents C1626 from charging to the peak-to-peak inverter spikes.

Q1622 saturates when it is turned on. C1622 provides the high current path for feedback current via CR1625 or CR1626. Once the inverter is shut down, R1622 establishes a path to discharge C1622.

If 24 V dc is accidentally applied when the mode switch is in the 12 V position, transformer T1400 attempts to produce two times the correct feedback. This is sufficient to cause VR1622 to conduct. VR1622 provides the firing current for the scr, Q1626. Scr Q1626 fires and shorts out the bridge rectifier and the primary of T1631, stopping the inverter. R1625 prevents Q1626 from being fired by inverter noise, R1624 and C1626 provide holding current for Q1626, keeping it conducting until the surge current created by the over-voltage conditions have terminated. CR1624 permits rapid charging of C1626.

**Start circuit**

When S1601 is closed, the external dc source is applied to C1614, VR1641, and R1645. The initial surge is coupled to Q1642 through C1614, VR1639, and R1641. Transistor Q1642 saturates until Q1614 charges through R1639 to the value determined by VR1639 and the base-emitter junction of Q1642 (about 5.7 volts), then Q1642 is cut off. R1641 limits the base current in Q1642. Zener diode VR1639, once C1614 is charged, makes Q1642 insensitive to input variations. R1642 limits Q1642 collector current. Q1644, R1645, and VR1641 provide a constant current during the time Q1642 is saturated, regardless of the dc source voltage. CR1643 is reverse biased by this starting current. The starting current is applied to the inverter transistors through T1631.

**Inverter Circuit**

The starting surge is applied to the bases of Q1652, Q1662, Q1654, and Q1664 through T1631, R1652, R1662, R1654, and R1664. Since the transistors do not have identical parameters, one pair will conduct before the other, and start the inverter. Operating base current is provided through CR1643.

R1626, R1631, and T1631 primary and secondary are the main frequency-determining components for the inverter. Four base resistors, R1652, R1662, R1654, and

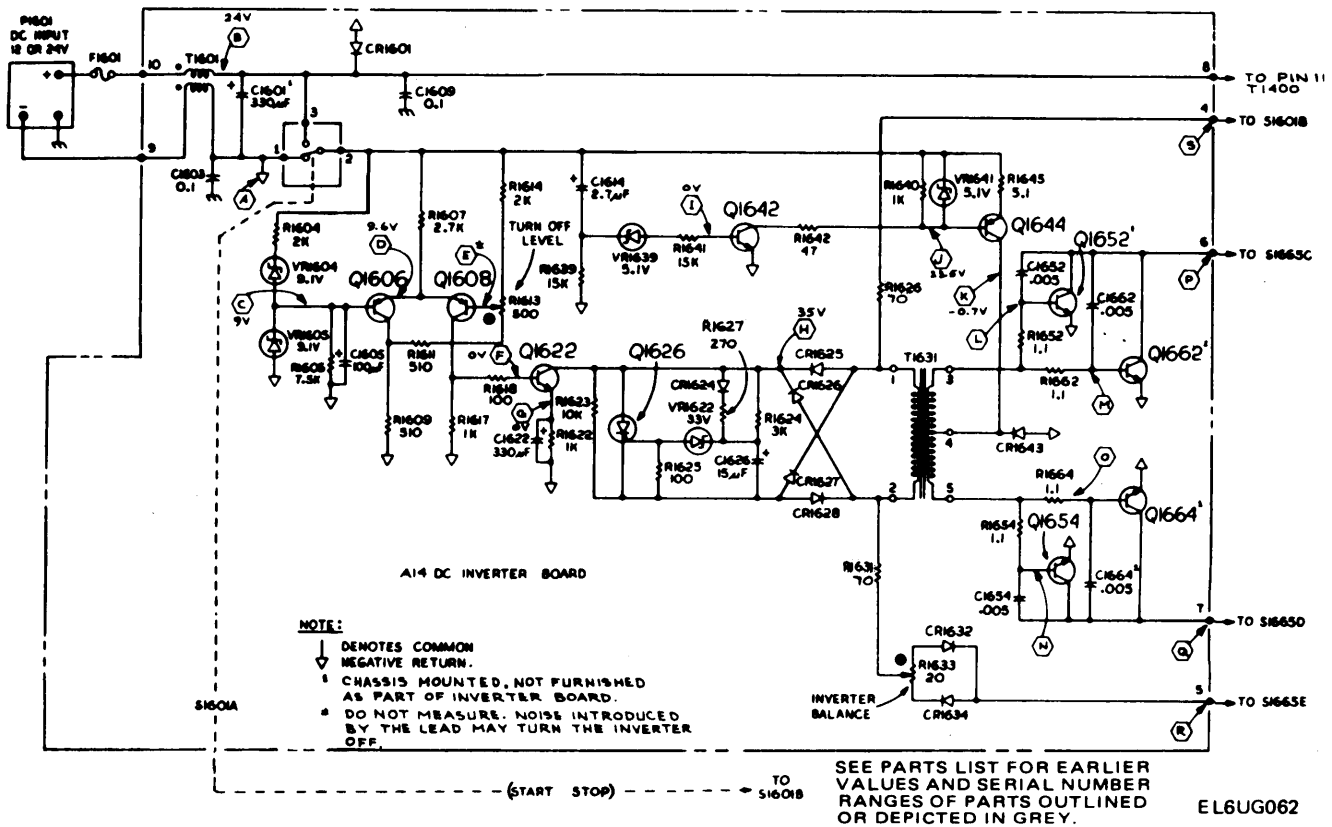


Figure 6-3. Option 07 DC Inverter.

R1664, distribute the drive evenly between the four transistors, C1652, C1662, C1654 and C1664 degenerate the high frequency response and reduce transients.

Feedback to maintain inverter operation is provided from T1400 primary to T1631 primary through R1626, R1631, R1633, CR1632 and CR1634. Resistors R1626 and R1631 provide frequency stability and current limiting. R1633, CR1632, and CR1634 compensate for differences in transistors and components. CR1632 and CR1634 conduct during different inverter half-cycles and permit R1633 to balance the drive to T1400.

C1681, C1682, C1683, C1684, C1685 and C1686 are added to the secondary of T1400 with Option 7 to provide optimum reduction of transients during inverter operation.

**DC Input**

External power is applied through P1601. CR1601 is normally reverse biased. If the wrong polarity external power is applied, CR1601 becomes forward biased and blows fuse F1601. Low-pass network T1601, C1601, C1603, and C1609 is a filter to reduce transients to the dc source.

**Start-Stop Switch**

S1601, Section A in the off (stop) position discharges the capacitors in the turn-off and start circuits. This ensures the correct time constants when S1601 is changed to the on (start) position. In the start position, the dc input is applied to the inverter circuitry by S1601, Section A. At the same time S1601, section B is closed, completing the feedback loop for the inverter transistors, S1601, section B stops the inverter in the off position by opening the feedback loop between T1400 and T1631.

**Power-Mode Switch (S1665)**

See Figure 6-4. Sections A and F connect filter C1671 and R1671 to T1400 during 12 or 24 V operation to reduce converter transients. Sections C and D select either transformer terminals 10A and 12A or 10 and 12, to provide the same secondary output when operating on 12 or 24 V. Sections Band E connect transformer terminals 10 and 12 to S1665, C and D, and to the inverter feedback circuit during both 12 and 24 V operation.

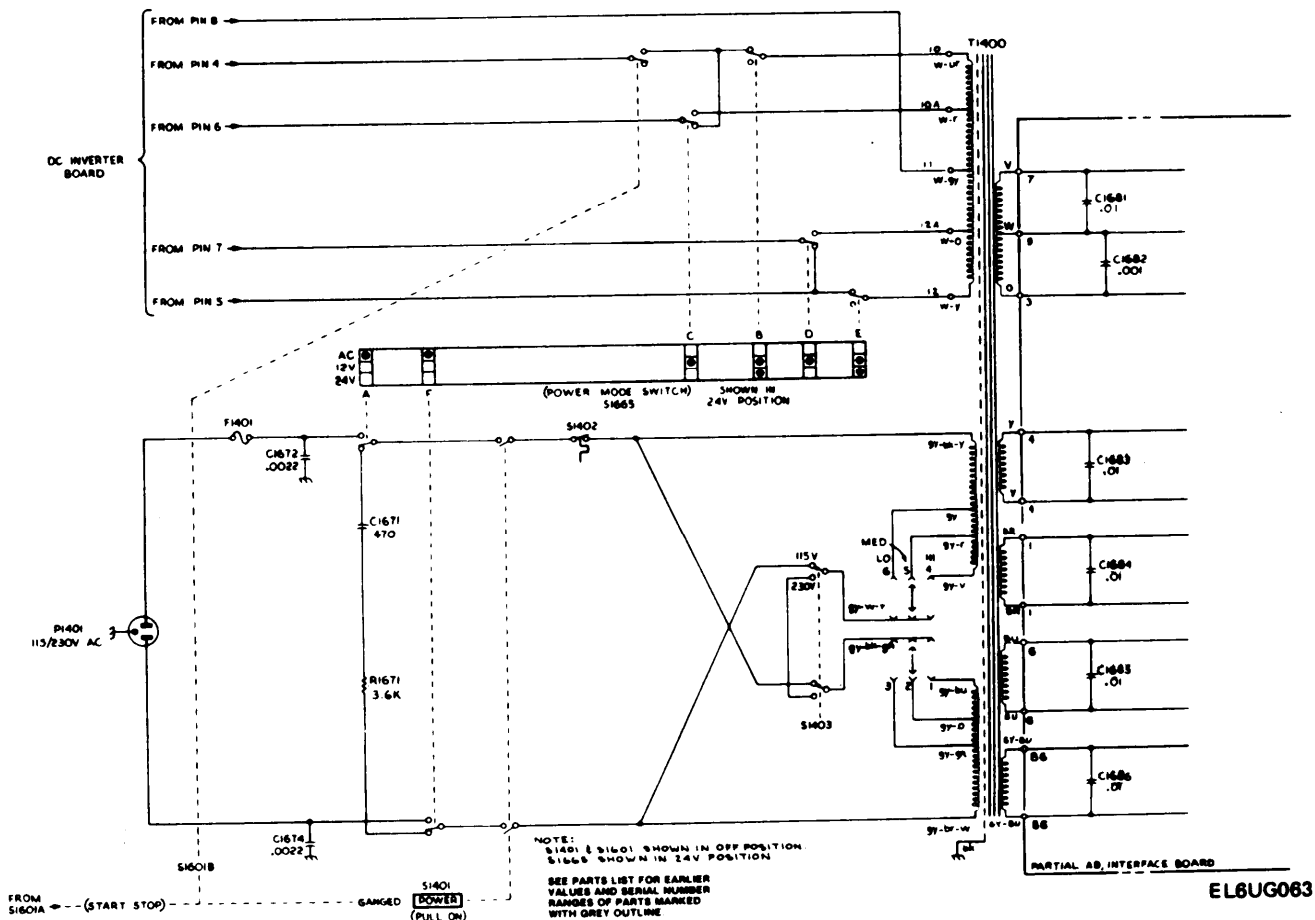


Figure 6-4. Option 07 primary winding.

**Circuit Board Chassis Removal**

The circuit board is mounted on a small chassis located between the power transformer and the crt shield. To remove the chassis, remove three screws. Two thread-forming screws are located at the top of the chassis. One screw is at the bottom of the chassis and is removed from the right-hand side by going just below the power transformer.

**CHECKOUT**

Option 7 may be checked without removing it from the oscilloscope. Test voltages are shown in figure 6-6; idealized waveforms in figure 6-7. The reference letters (A), (B), etc., refer to points indicated on the schematic and circuit board illustrations.

**Equipment Required**

**DC VOLTMETER.** 22 V to 28 V.

**TEST OSCILLOSCOPE.** Used to verify the inverter balance adjustment. If the instrument under test and Option 7 are operational and the power source has a negative ground, they may be used as the test oscilloscope for this check.

**DC POWER SOURCE.** Voltage from 22 V to 28 V and from 11.5 V to 14 V. A source voltage of less than 22 volts will turn off Option 7 when it is operating in the 24 V mode. Starting current in 24 V mode is approximately 4 to 10 A. The dc source must be capable of handling this surge without dropping to 22 V or less. The 12 V starting surge is approximately 15 A.

**NOTE**

*Option 7 is calibrated at the factory using a power supply (having the specifications listed first under the equipment required list). This permits the most accurate setting of the turn-off volts and inverter balance adjustments. Because this type of power supply may not be available, several alternate possibilities are given. The alternate power supplies have drawbacks, including voltage stability vs. time with high discharge rates, see figure 6-5.*

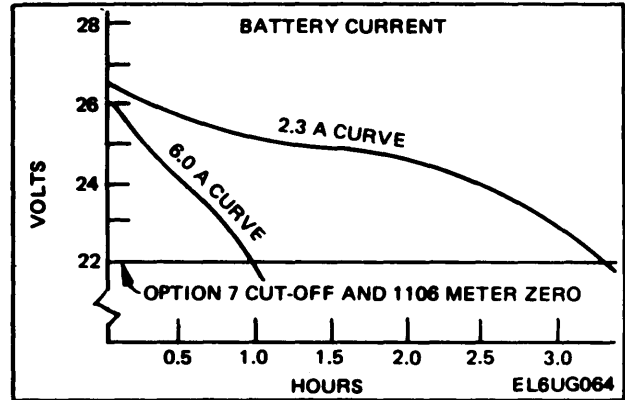
1. Variable power supply with the aforementioned capabilities.

2. Variable power supply with an adequate current rating, in series with items 4 or 5.

3. 1106 Power Supply battery pack.<sup>2</sup>

4. Two 12-volt wet-cell storage batteries, in series, tapped at 20, 22, or 24 V.<sup>3</sup>

5. 18 to 23 Ni Cd cells, 4.0 amp hr (D cells) or greater, furnishing 20 to 28 V.<sup>3</sup>



**Figure 6-5. Typical battery pack discharge curves.**



*This procedure is for an external dc source with the negative lead at ground potential (negative ground system).*

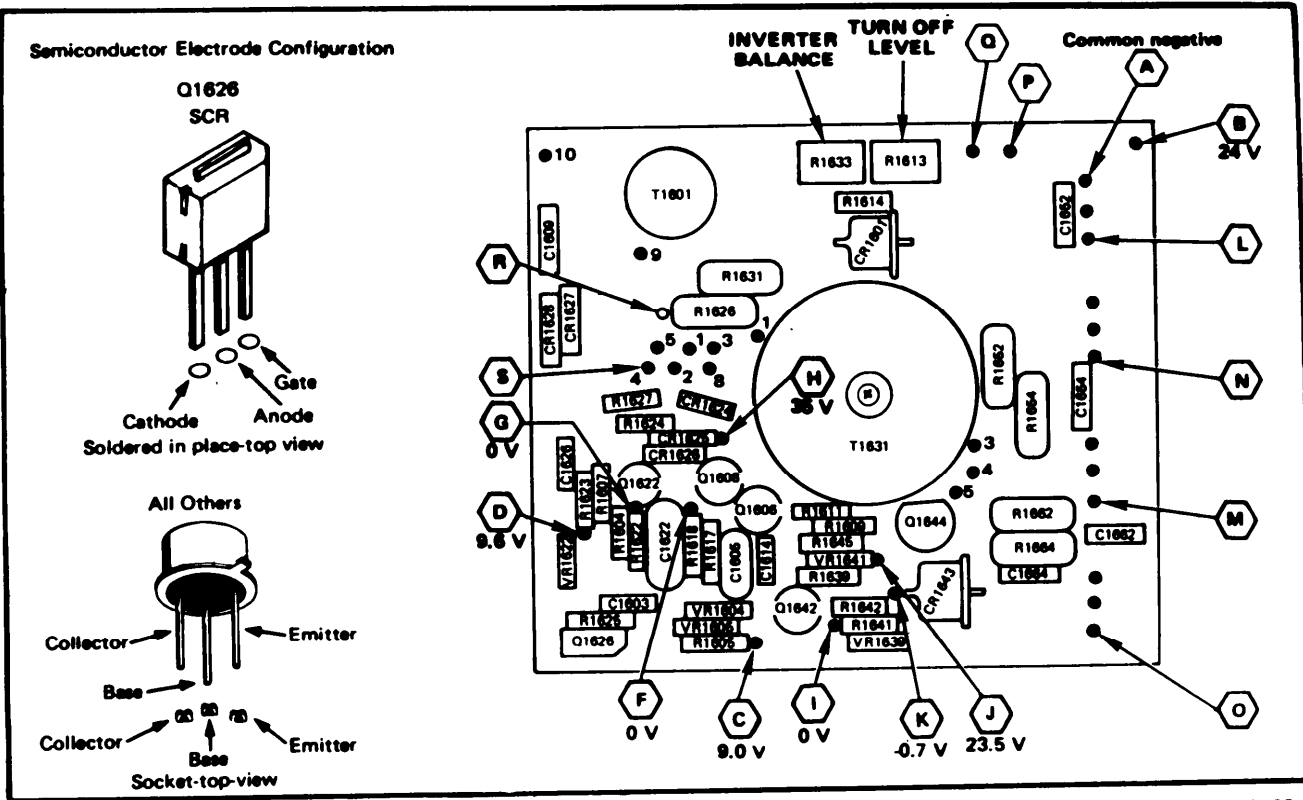
**Operating Range**

a. Connect the dc source to the oscilloscope equipped with Option 7. Operate the oscilloscope in the 24 V mode. Connect the voltmeter between fuse, F1601 (B) and the common negative return (A). Vary the dc source from 28 V to 22 V.

CHECK—Oscilloscope should operate over the voltage range.

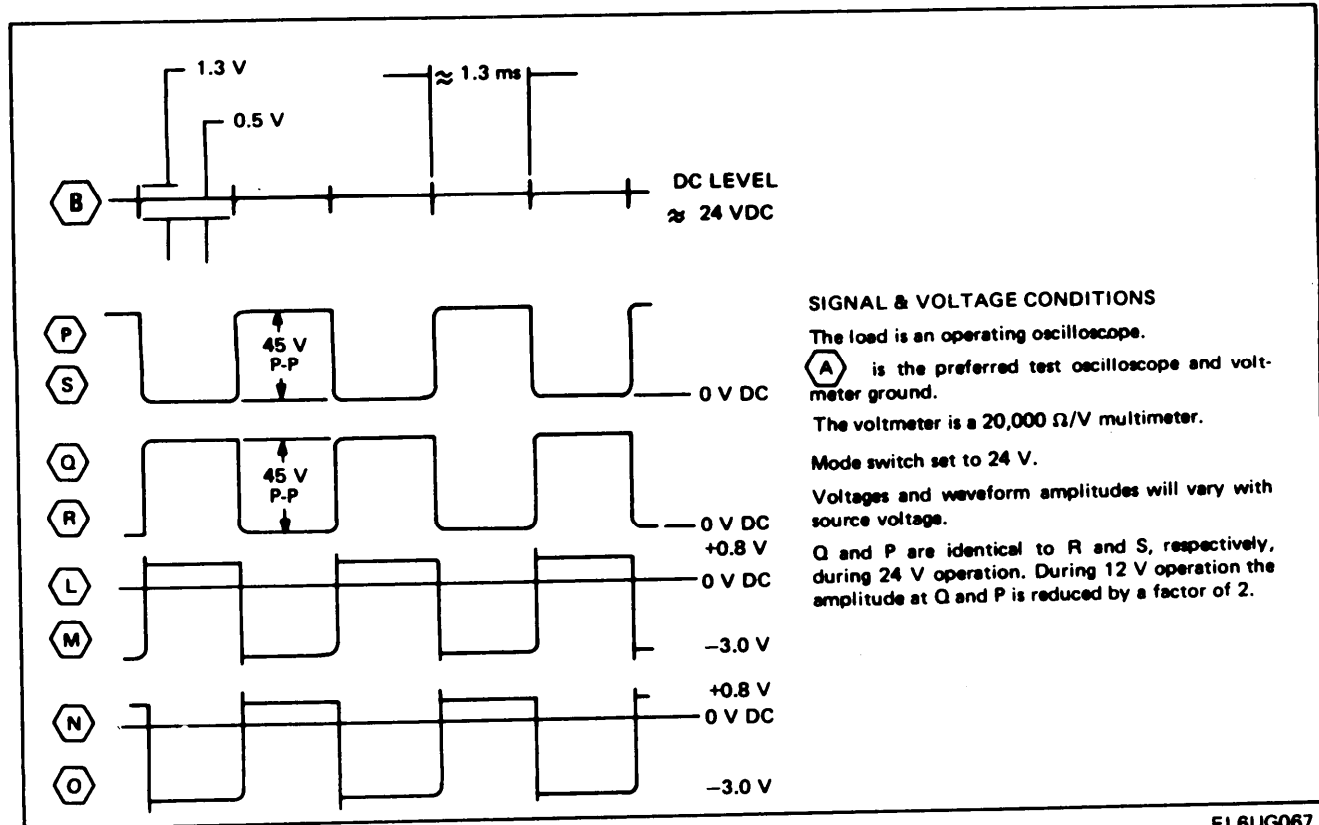
<sup>2</sup>To set the turn-off level, the battery is charged above the cut-off point (22 V). An oscilloscope is connected and the battery allowed to discharge while its voltage is being monitored. As it reaches 22 V the turn-off point is set to cut off Option 7. The turn-off point on Option 7 approximately coincides with the meter zero on the 1106.

<sup>3</sup>This does not permit accurate adjustment of the turn-off level. Ni Cd batteries can be used, following the technique used for item 3.



EL6UG066

Figure 6-6. Circuit board layout with test voltages.



EL6UG067

Figure 6-7. Typical idealized waveforms.

b. Change the dc source to 12 V. Operate the oscilloscope in the 12 V mode. Vary the dc source from 14 V to 11.5 V.

CHECK—Oscilloscope should operate over the voltage range.

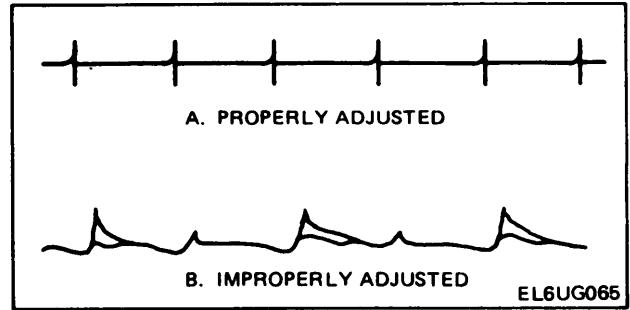
**Inverter Balance**

*NOTE*

*If the major oscilloscope use is with a 12-volt source, do this step while operating the oscilloscope and dc source on 12 volts.*

Operate the oscilloscope in the 24 V mode. Set the dc source to 24 V. Connect the test oscilloscope between C1801 (C) and the common negative return (A).

CHECK—Signal should be flat. See figure 6-8.



**Figure 6-8. Inverter Balance.**

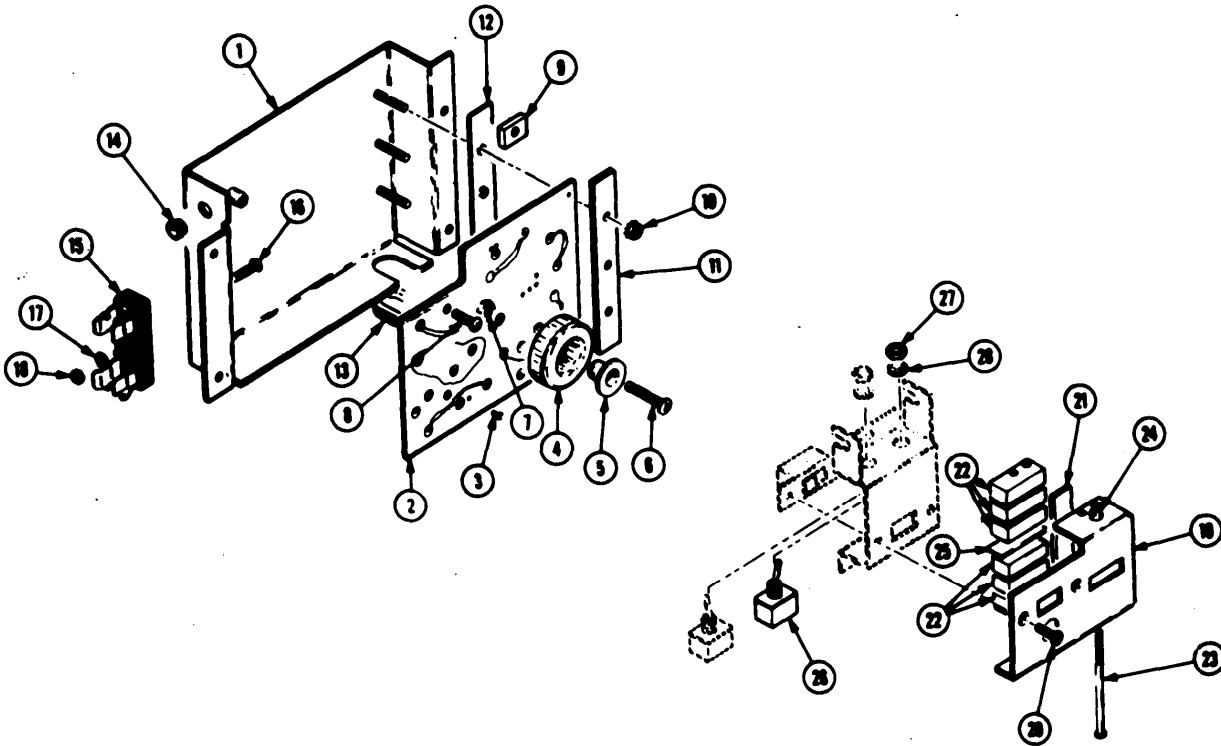


Figure 6-9. Option 07 Exploded View.

EL6UG088

OPTION 7

REPLACEABLE MECHANICAL PARTS

Fig. & Index No.	Qty	1 2 3 4 5	Name & Description	Fig. & Index No.	Qty	1 2 3 4 5	Name & Description
6-9-1	1		CHAS,ELEK EQUIP:DC INVERTER (ATTACHING PARTS)	6-9-19	1		BRACKET,SWITCH: (ATTACHING PARTS)
	2		SCREW,MACHINE:4-40 X 0.25 INCH,PNH STL	-20	2		SCREW,MACHINE:4-40 X 0.25" 100 DEG,FLH STL
	2		WASHER,FLAT:0.109 ID X 0.25 INCH OD,STL				-----
-2	1		CIRCUIT BOARD ASSY:INVERTER	-21	1		ACTUATOR,SWITCH:
-3	15		SOCKET,PIN TERM:0.188 INCH LONG	-22	6		SWITCH,SENS:10A,250V,SPDT,SNAP ACTION (ATTACHING PARTS)
-4	1		XFMR,TOROID:(SEE T1601 EPL) (ATTACHING PARTS)	-23	2		SCREW,MACHINE:2-56 X 1.75 INCH,PNH STL
			-----	-24	1		NUT,PLAIN,HEX.:2-56 X 0.188 INCH,BRS
-5	1		RETAINER,XFMR:				-----
-6	1		SCREW,MACHINE:8-32 X 0.750 INCH,FLH STL	-25	1		PLATE,ACT GUIDE:INVERTER
-7	1		NUT,PLAIN,HEX.:8-32 X 0.312 INCH,BRS				SPRING,SW ACT:POWER SOURCE
			-----	-26	1		SWITCH,TOGGLE:DPDT,5A,125VAC,0.25-40 THD (ATTACHING PARTS)
-8	2		SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS	-27	1		NUT,PLAIN,HEX.:0.25-40 X 0.312 INCH,BBS
			-----	-28	1		WASHER,LOCK:INTL,0.26 ID X 0.40" OD,STL
-9	4		TRANSISTOR:(SEE Q1652,Q1654,Q1662,Q1664 EPL) (ATTACHING PARTS)				-----
-10	3		NUT,PLAIN,EXT W:4-40 X 0.25 INCH,STL				WIRING HARNESS,:
-11	1		RETAINER,XSTR:				GROMMET,RUBBER:0.50 INCH DIA
-12	1		INSULATOR,PLATE:0.70 X 3 INCHES LONG				COVER,SCOPE:REAR
			-----				TERMINAL,LUG:0.146 INCH DIA DE,45 DEG BEND
-13	1		GROMMET,PLASTIC:U-SHP,0.625 X 0.658 INCH				MARKER,IDENT:
-14	1		GROMMET,PLASTIC:0.25 INCH DIA				CONNECTOR,RCPT,:POWER (ATTACHING PARTS)
-15	1		FUSEHOLDER:3AG FUSE (ATTACHING PARTS)				-----
-16	1		SCREW,MACHINE:6-32 X 0.312 INCH,PNH STL				SCREW,MACHINE:4-40 X 0.25" 100 DEG,FLH STL
-17	1		WASHER,LOCK:INTL,0.146 ID X 0.288 OD,STL				FOOT,CABINET:PLASTIC,W/LATCH GROOVE
-18	1		NUT,PLAIN,HEX.:6-32 X 0.25 INCH,BRS				ACCESSORIES
			-----				-----
	1		INSULATOR,FILM:1 X 2.55 INCH				CABLE ASSY,PWR,:3 WIRE,36 INCHES LONG

# REPLACEABLE MECHANICAL PARTS

## PARTS ORDERING INFORMATION

For complete part information refer to TM 11-6625-2735-24P-1.

*Detail Part of Assembly and/or Component  
Attaching parts for Detail Part*

---\*---

*Parts of Detail Part*

*Attaching parts for Parts of Detail Part*

---\*---

## SPECIAL NOTES AND SYMBOLS

X000 Part first added at this serial number  
00X Part removed after this serial number

## FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol ---\*--- indicates the end of attaching parts.

Attaching parts must be purchased separately, unless otherwise specified.

## INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

```

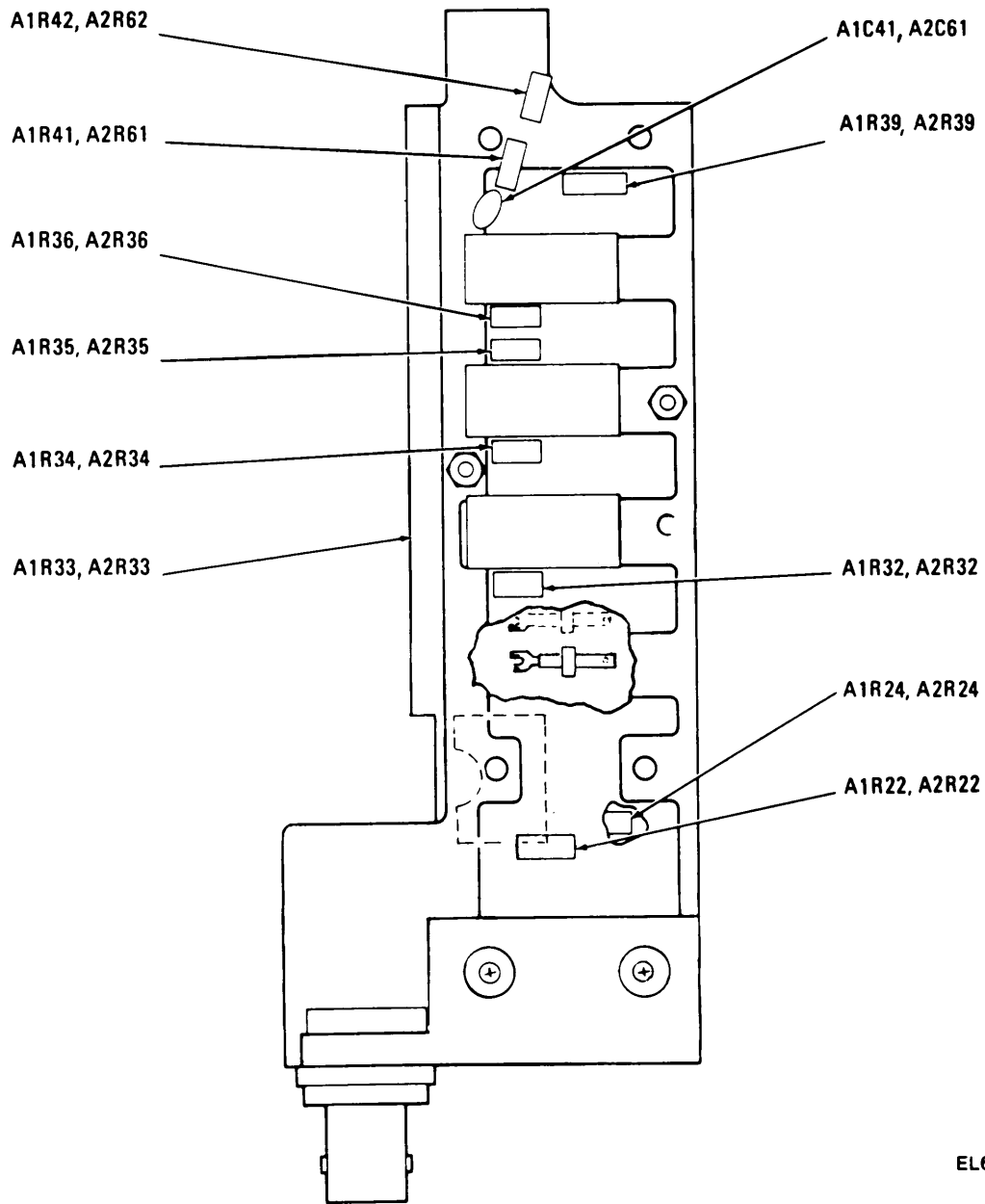
1 2 3 4 5           Name & Description
Assembly and/or Component
Attaching parts for Assembly and/or Component
---*---
```

## ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

## ABBREVIATIONS

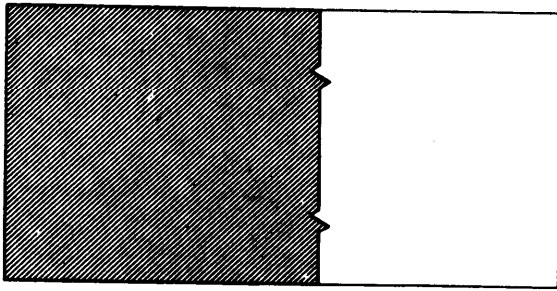
#	INCH NUMBER SIZE	ELCTRN	ELECTRON	IN	INCH	SE	SINGLE END
ACTR	ACTUATOR	ELEC	ELECTRICAL	INCAND	INCANDESCENT	SECT	SECTION
ADPTR	ADAPTER	ELCTLT	ELECTROLYTIC	INSUL	INSULATOR	SEMICOND	SEMICONDUCTOR
ALIGN	ALIGNMENT	ELEM	ELEMENT	INTL	INTERNAL	SHLD	SHIELD
AL	ALUMINUM	EPL	ELECTRICAL PARTS LIST	LPHLDR	LAMPHOLDER	SHLDR	SHOULDERED
ASSEM	ASSEMBLED	EQPT	EQUIPMENT	MACH	MACHINE	SKT	SOCKET
ASSY	ASSEMBLY	EXT	EXTERNAL	MECH	MECHANICAL	SL	SLIDE
ATTEN	ATTENUATOR	FIL	FILLISTER HEAD	MTG	MOUNTING	SLFLKG	SELF-LOCKING
AWG	AMERICAN WIRE GAGE	FLEX	FLEXIBLE	NIP	NIPPLE	SLVG	SLEEVING
BD	BOARD	FLH	FLAT HEAD	NON WIRE	NOT WIRE WOUND	SPR	SPRING
BRKT	BRACKET	FLTR	FILTER	OBD	ORDER BY DESCRIPTION	SQ	SQUARE
BRS	BRASS	FR	FRAME or FRONT	OD	OUTSIDE DIAMETER	SST	STAINLESS STEEL
BRZ	BRONZE	FSTNR	FASTENER	OVH	OVAL HEAD	STL	STEEL
BSHG	BUSHING	FT	FOOT	PH BRZ	PHOSPHOR BRONZE	SW	SWITCH
CAB	CABINET	FXD	FIXED	PL	PLAIN or PLATE	T	TUBE
CAP	CAPACITOR	GSKT	GASKET	PLSTC	PLASTIC	TERM	TERMINAL
CER	CERAMIC	HDL	HANDLE	PN	PART NUMBER	THD	THREAD
CHAS	CHASSIS	HEX	HEXAGON	PNH	PAN HEAD	THK	THICK
CKT	CIRCUIT	HEX HD	HEXAGONAL HEAD	PWR	POWER	TNSN	TENSION
COMP	COMPOSITION	HEX SOC	HEXAGONAL SOCKET	RCPT	RECEPTACLE	TPG	TAPPING
CONN	CONNECTOR	HLCPS	HELICAL COMPRESSION	RES	RESISTOR	TRH	TRUSS HEAD
COV	COVER	HLEXT	HELICAL EXTENSION	RGD	RIGID	V	VOLTAGE
CPLG	COUPLING	HV	HIGH VOLTAGE	RLF	RELIEF	VAR	VARIABLE
CRT	CATHODE RAY TUBE	IC	INTEGRATED CIRCUIT	RTNR	RETAINER	W/	WITH
DEG	DEGREE	ID	INSIDE DIAMETER	SCH	SOCKET HEAD	WSHR	WASHER
DWR	DRAWER	IDNT	IDENTIFICATION	SCOPE	OSCILLOSCOPE	XFMR	TRANSFORMER
		IMPLR	IMPELLER	SCR	SCREW	XSTR	TRANSISTOR



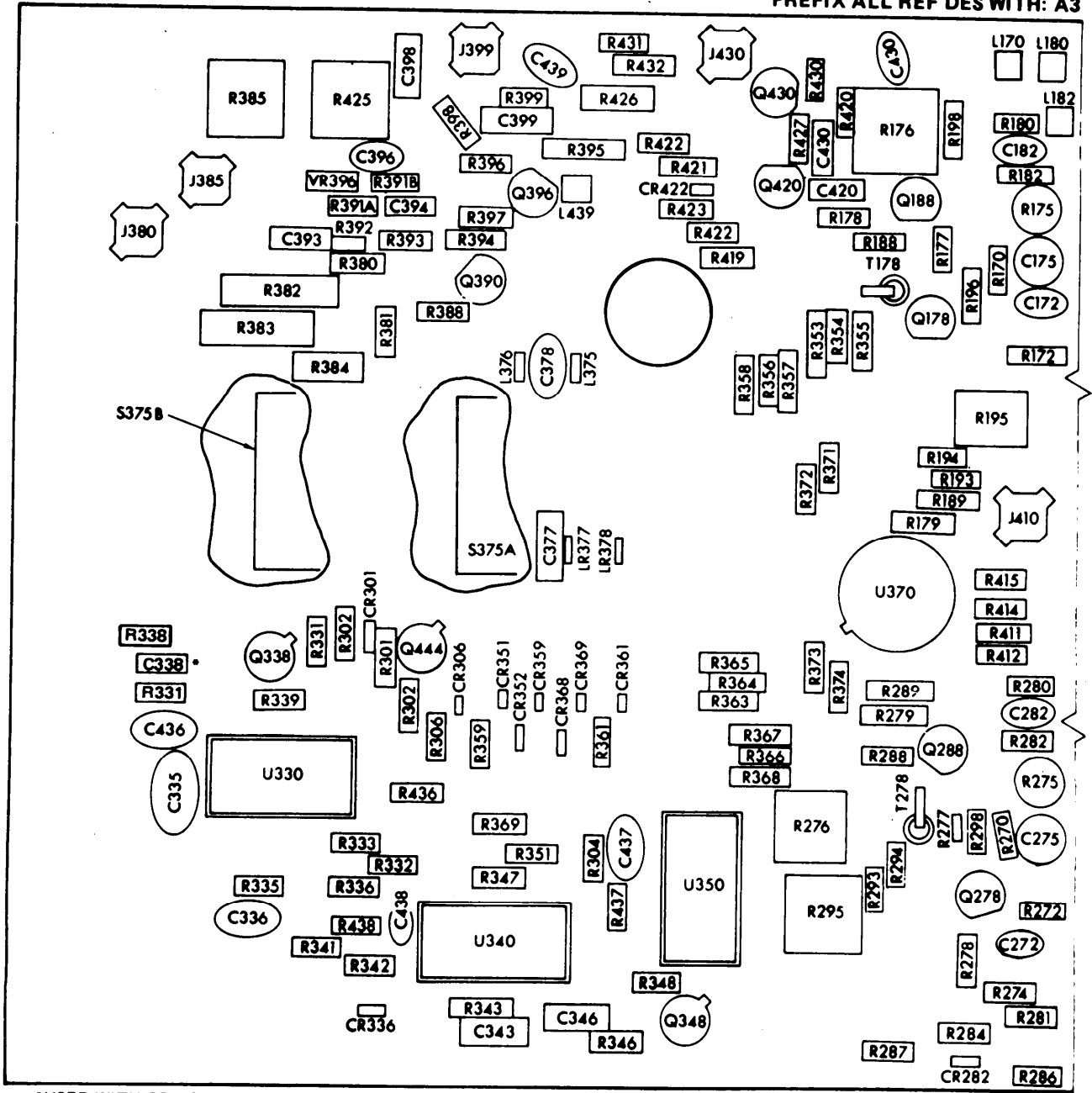
EL6UG002

Fig. 7-1. A1 and A2 boards component locations.





PREFIX ALL REF DES WITH: A3

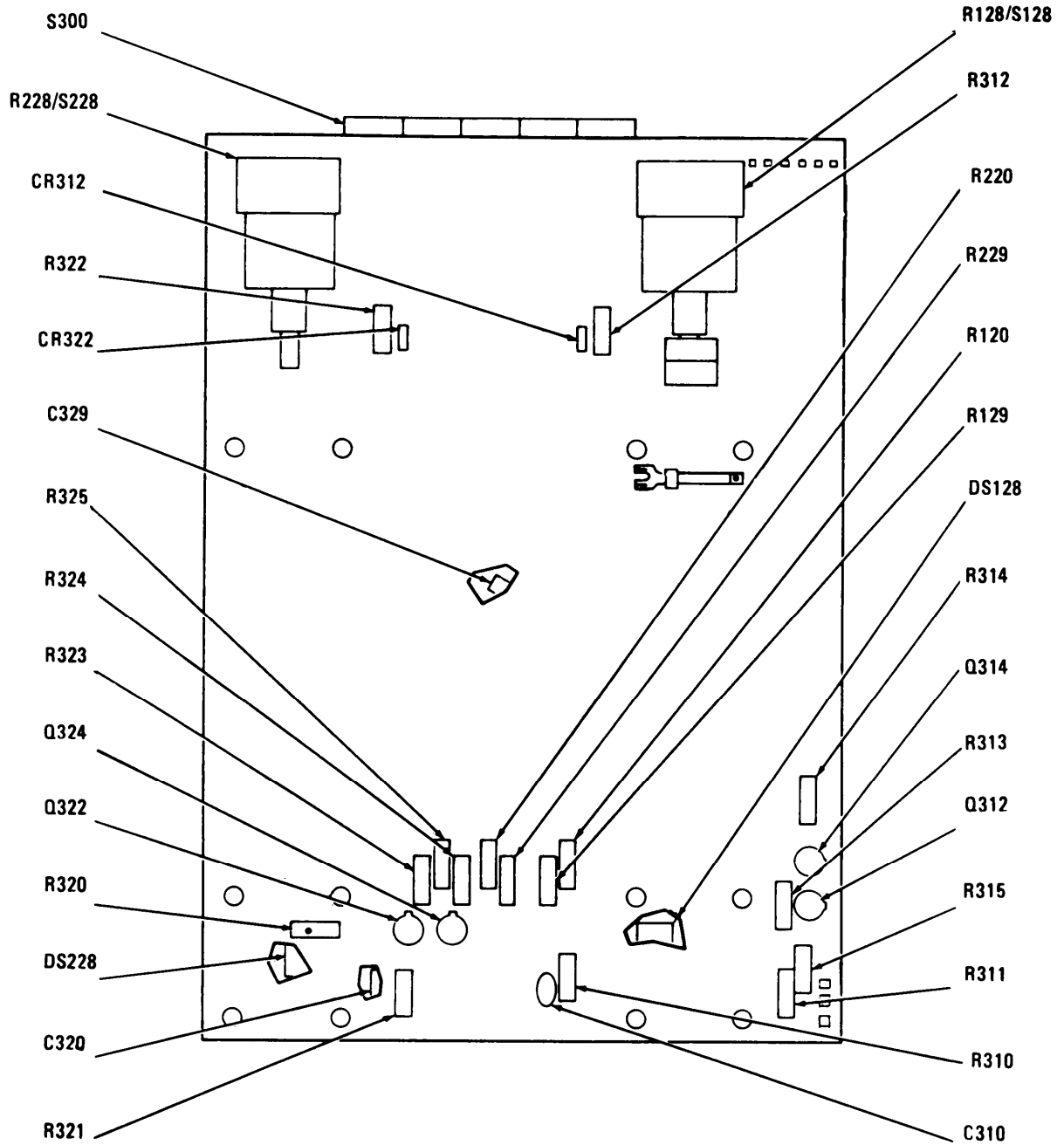


\*USED WITH OPTION 07

EL6UG003

Fig. 7-2. A3 board component locations. (Sheet 1 of 2)

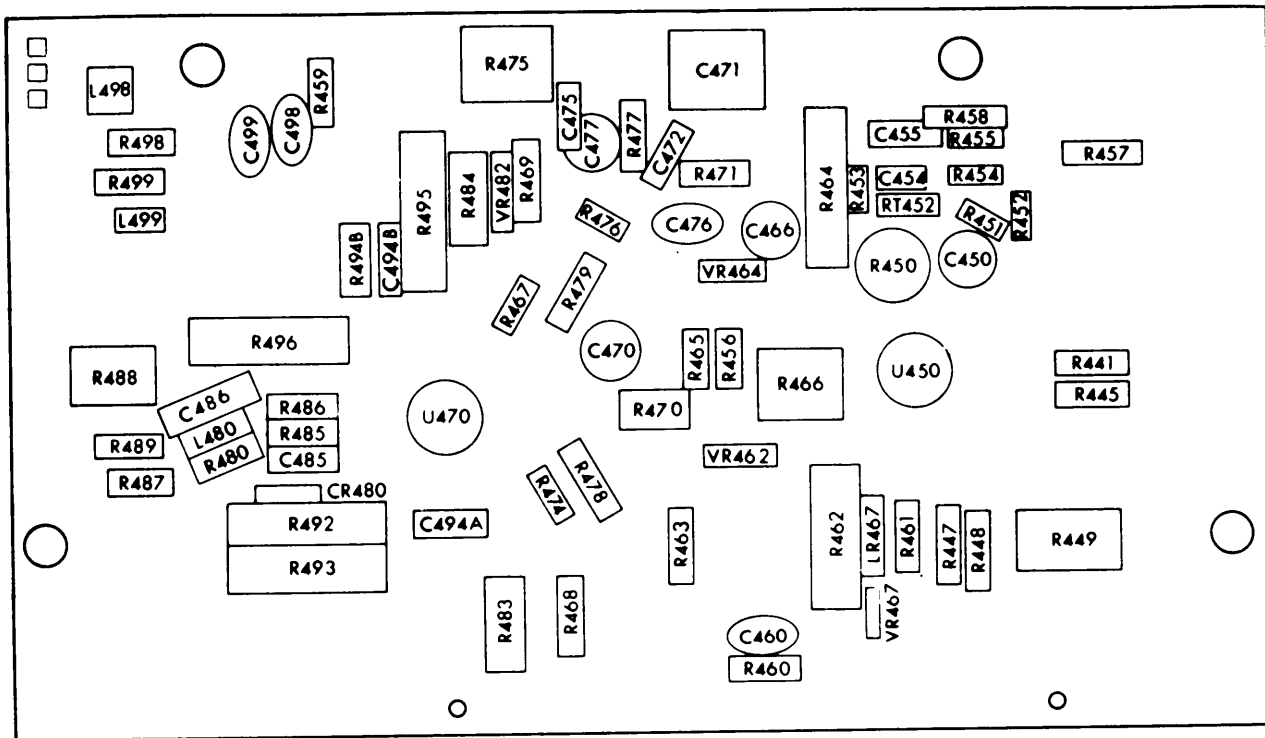




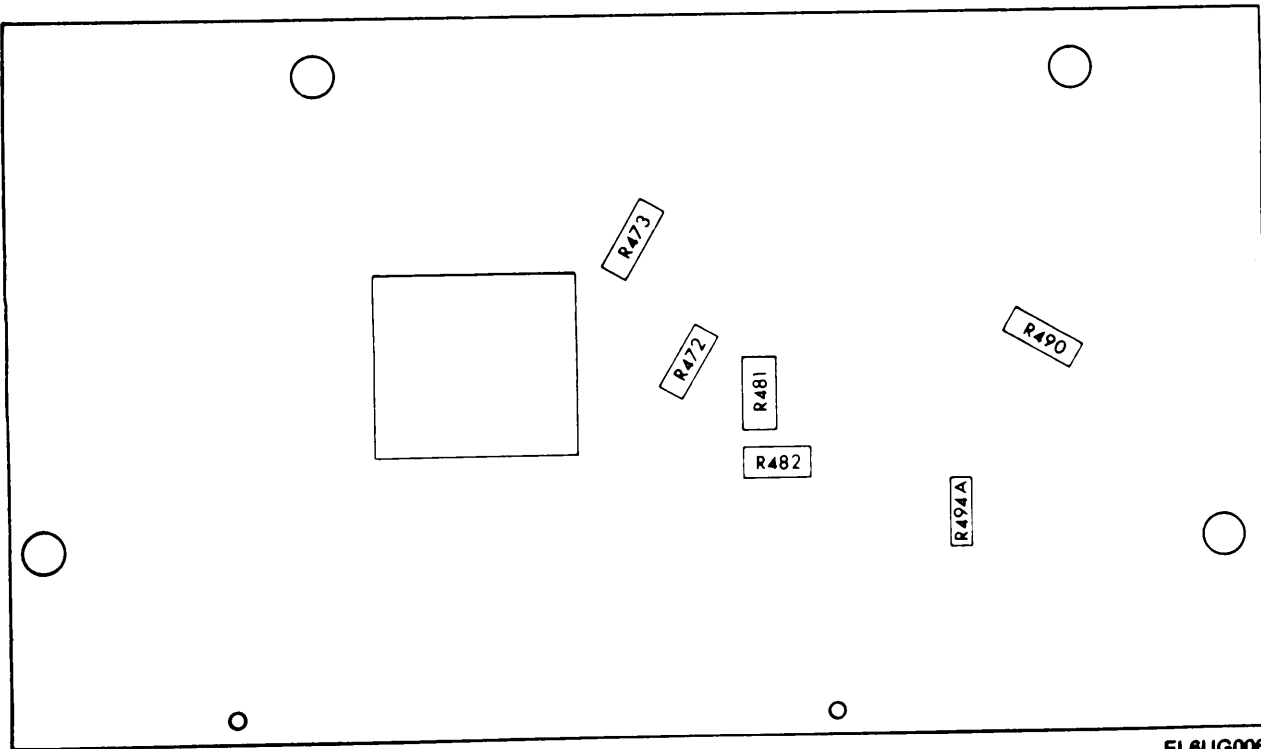
PREFIX ALL REF DES WITH: A4

EL6UG005

Fig. 7-3. A4 board component locations.



FRONT

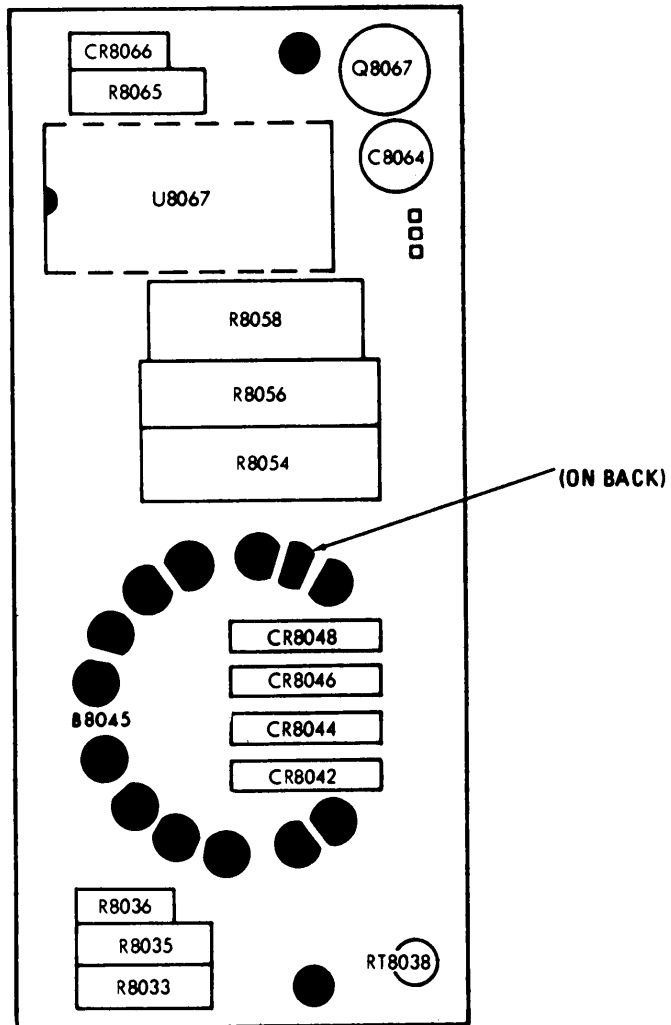


BACK

EL6UG006

PREFIX ALL REF DES WITH: A5

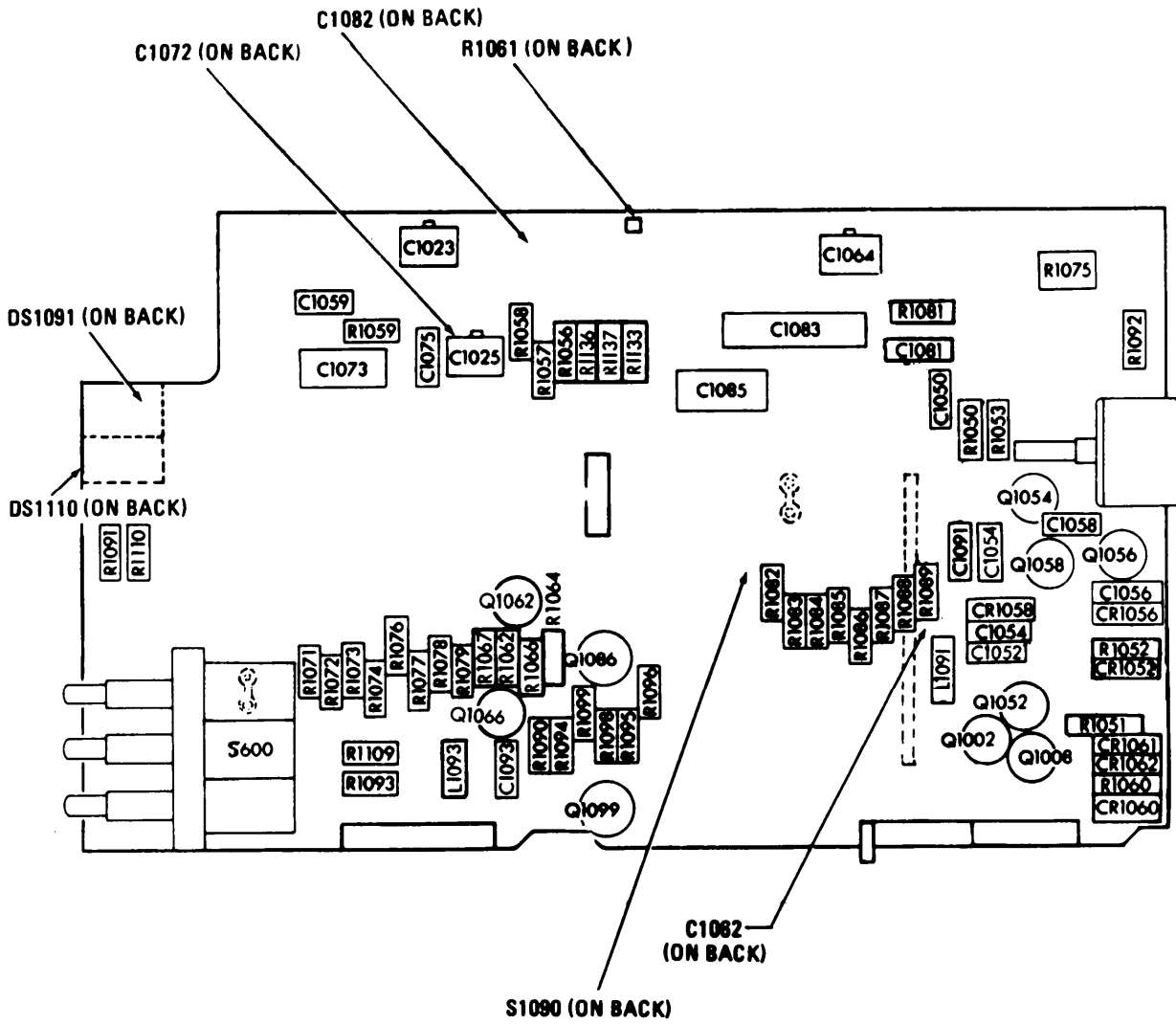
Fig. 7-4. A5 board component locations.



EL8UG007

PREFIX ALL REF DES WITH: A6

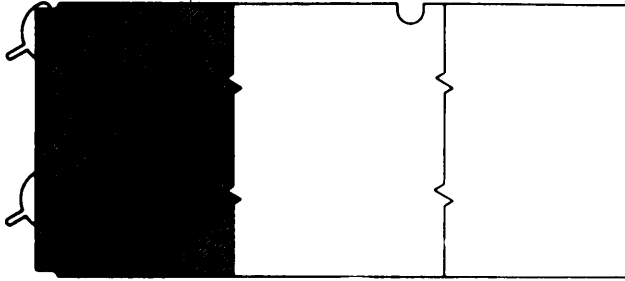
Fig. 7-5. A6 board component locations.



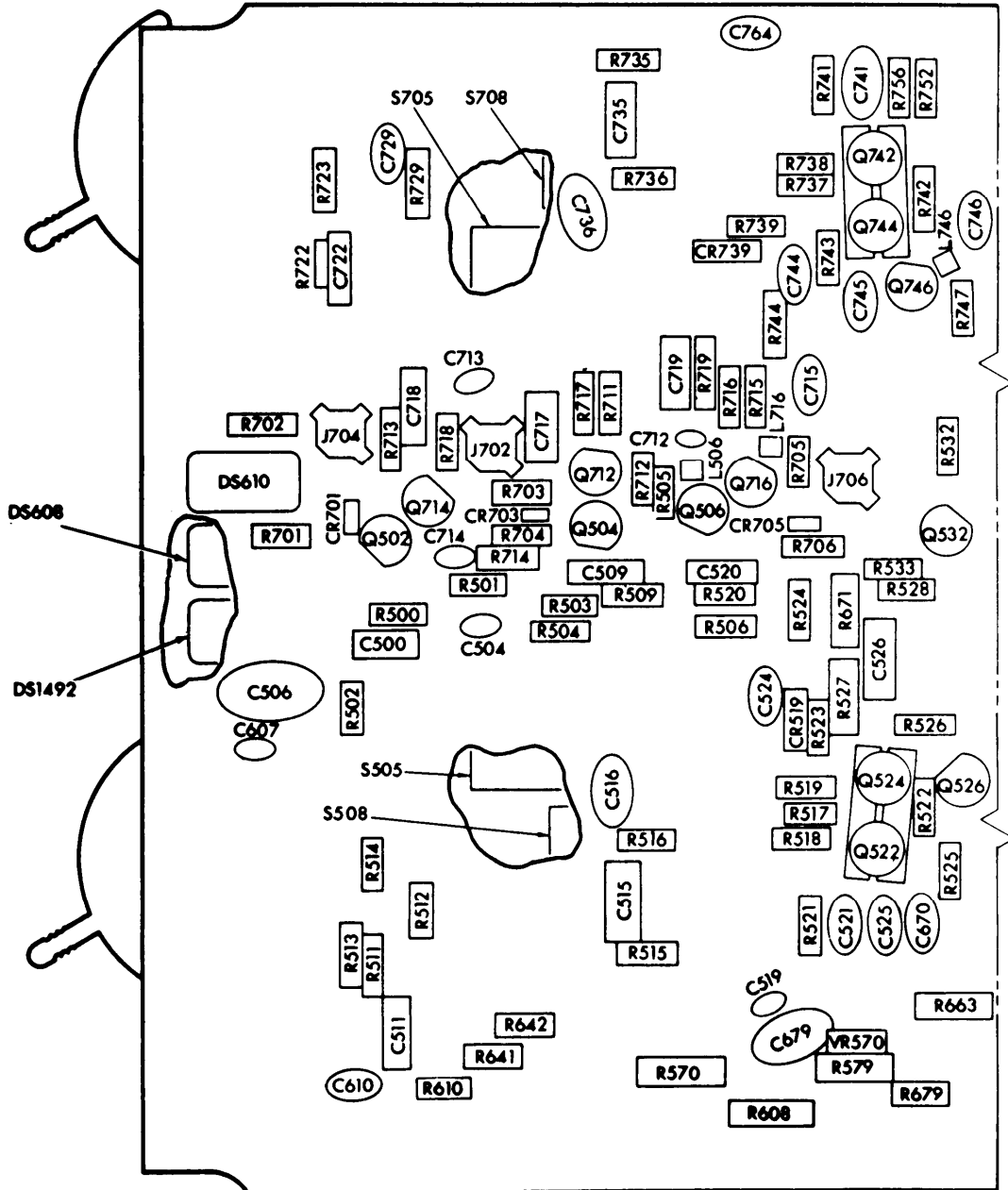
PREFIX ALL REF DES WITH: A7

EL6UG008

Fig. 7-6. A7 board component locations.

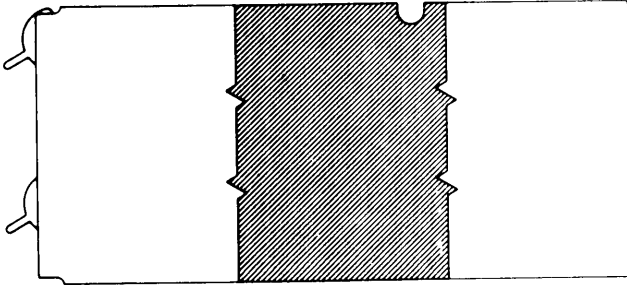


PREFIX ALL REF DES WITH: A8

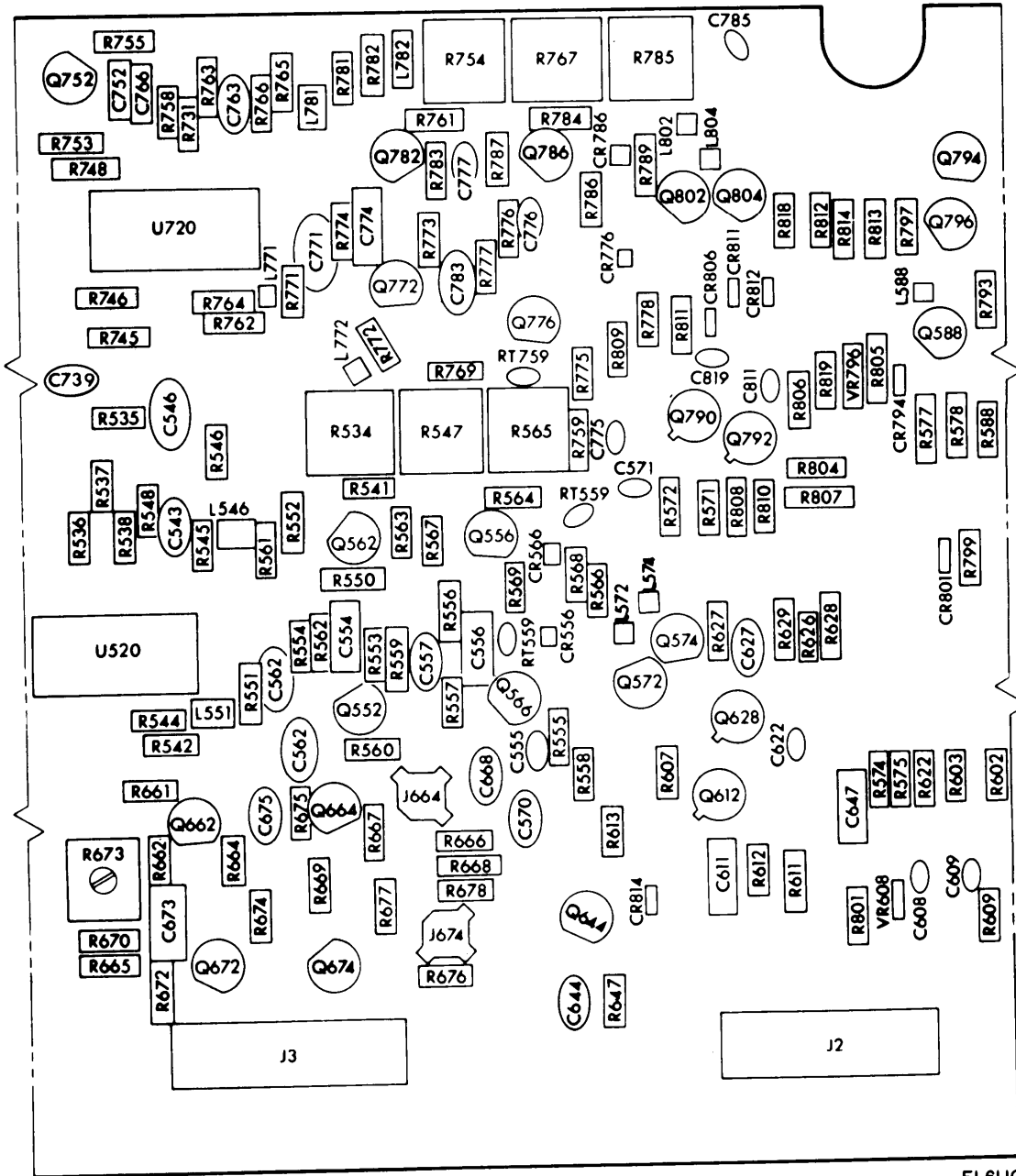


EL8UG009

Fig. 7-7. A8 board component locations. (Sheet 1 of 3)



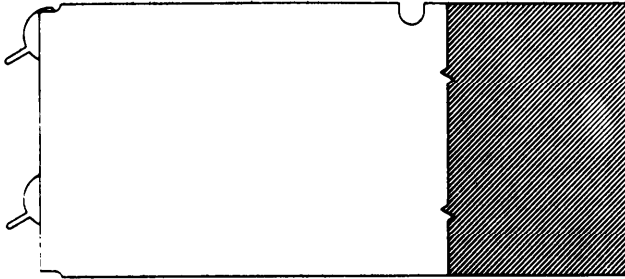
PREFIX ALL REF DES WITH: A8



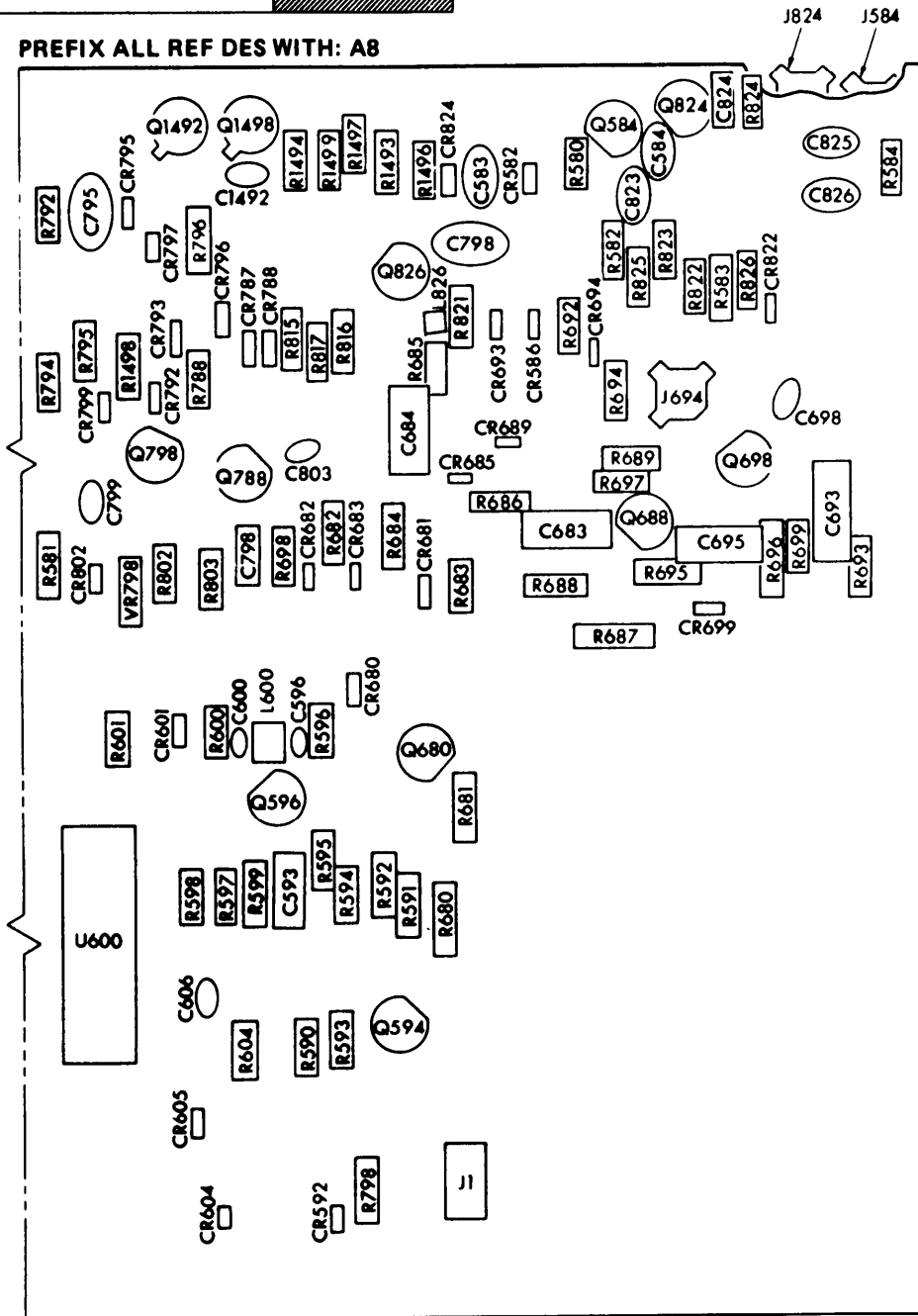
EL6UG010

Fig. 7-7. A8 board component locations. (Sheet 2 of 3)



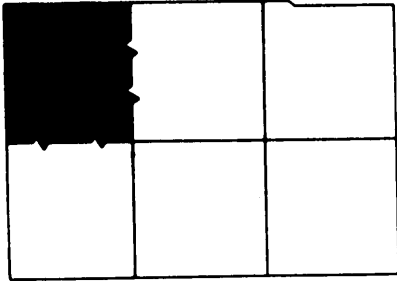


PREFIX ALL REF DES WITH: A8



EL6UG011

Fig. 7-7. A8 board component locations. (Sheet 3 of 3)



PREFIX ALL REF DES WITH: A9

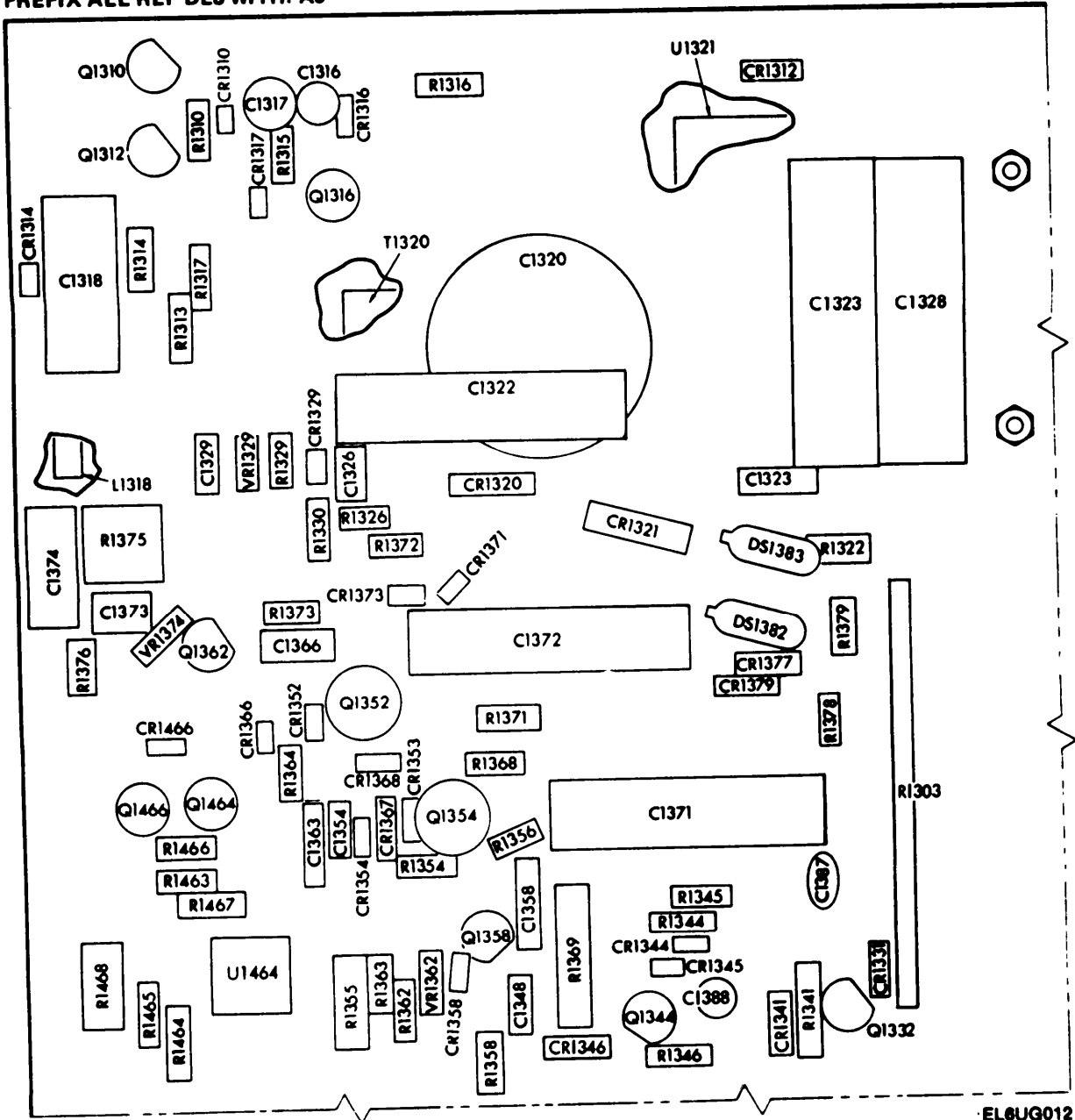
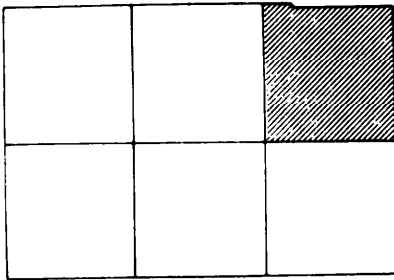
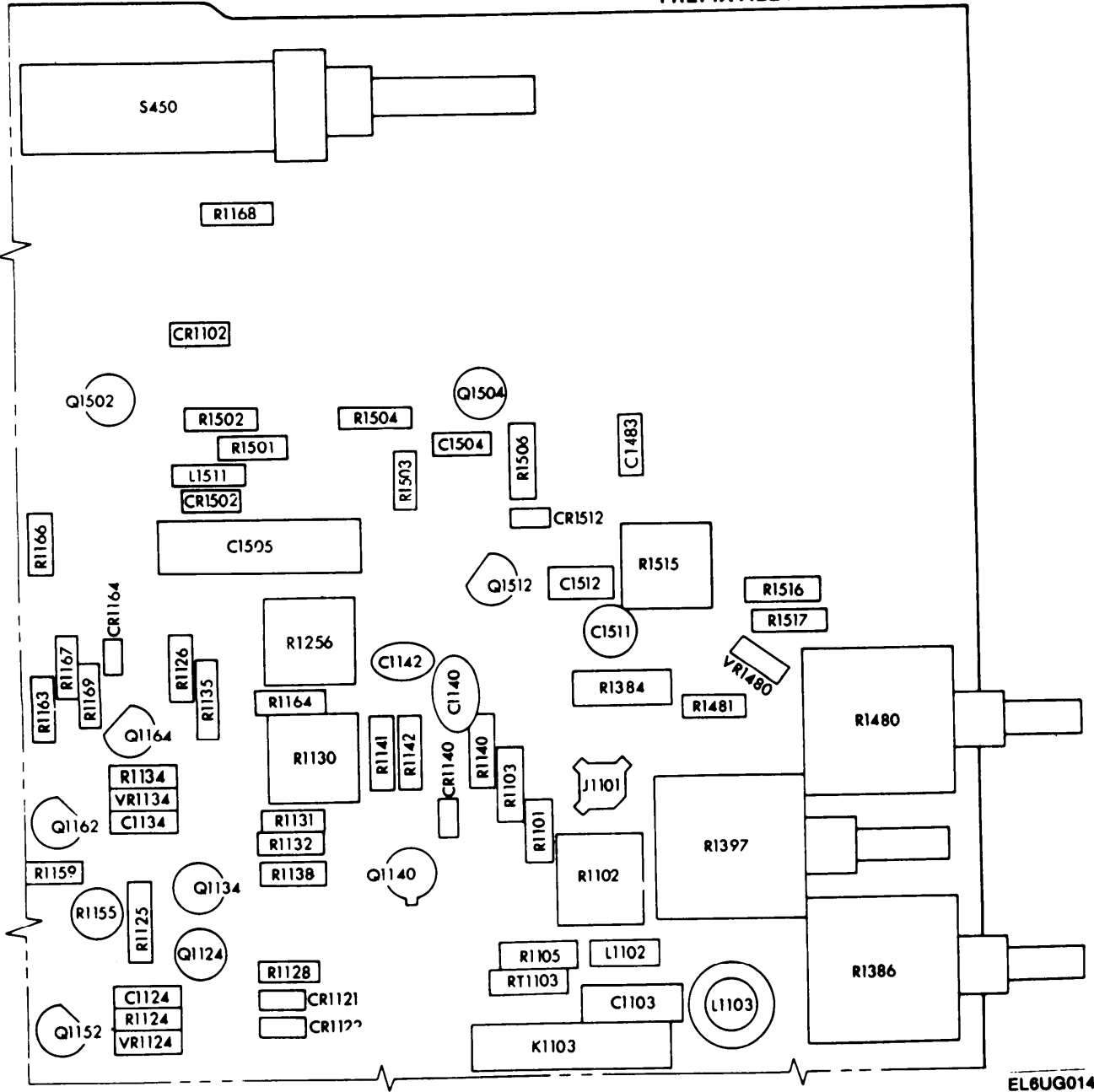


Fig. 7-8. A9 board component locations. (Sheet 1 of 8)





PREFIX ALL REF DES WITH: A9



EL6UG014

Fig. 7-8. A9 board component locations. (Sheet 3 of 6)

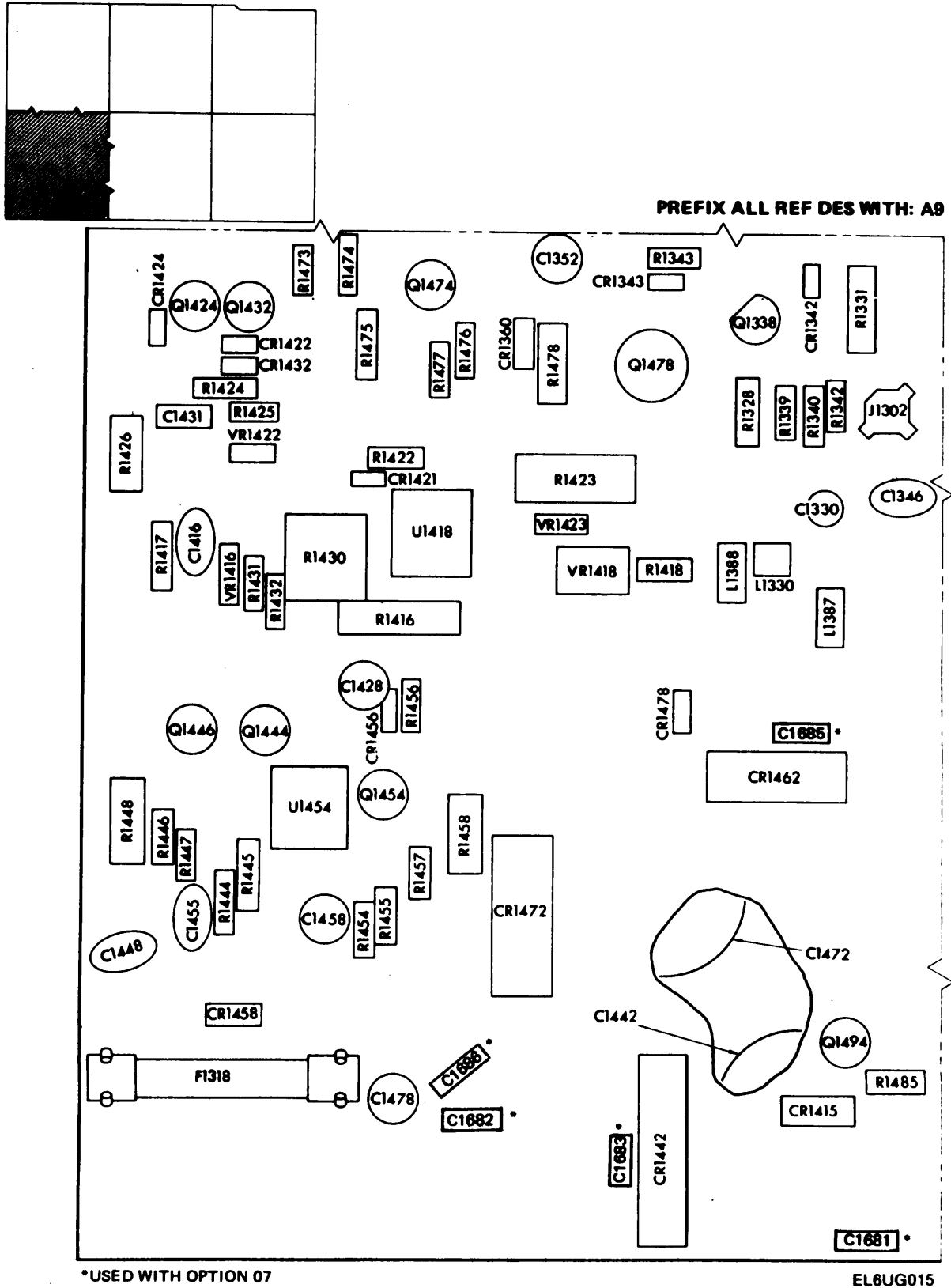


Fig. 7-8. A9 board component locations. (Sheet 4 of 6)



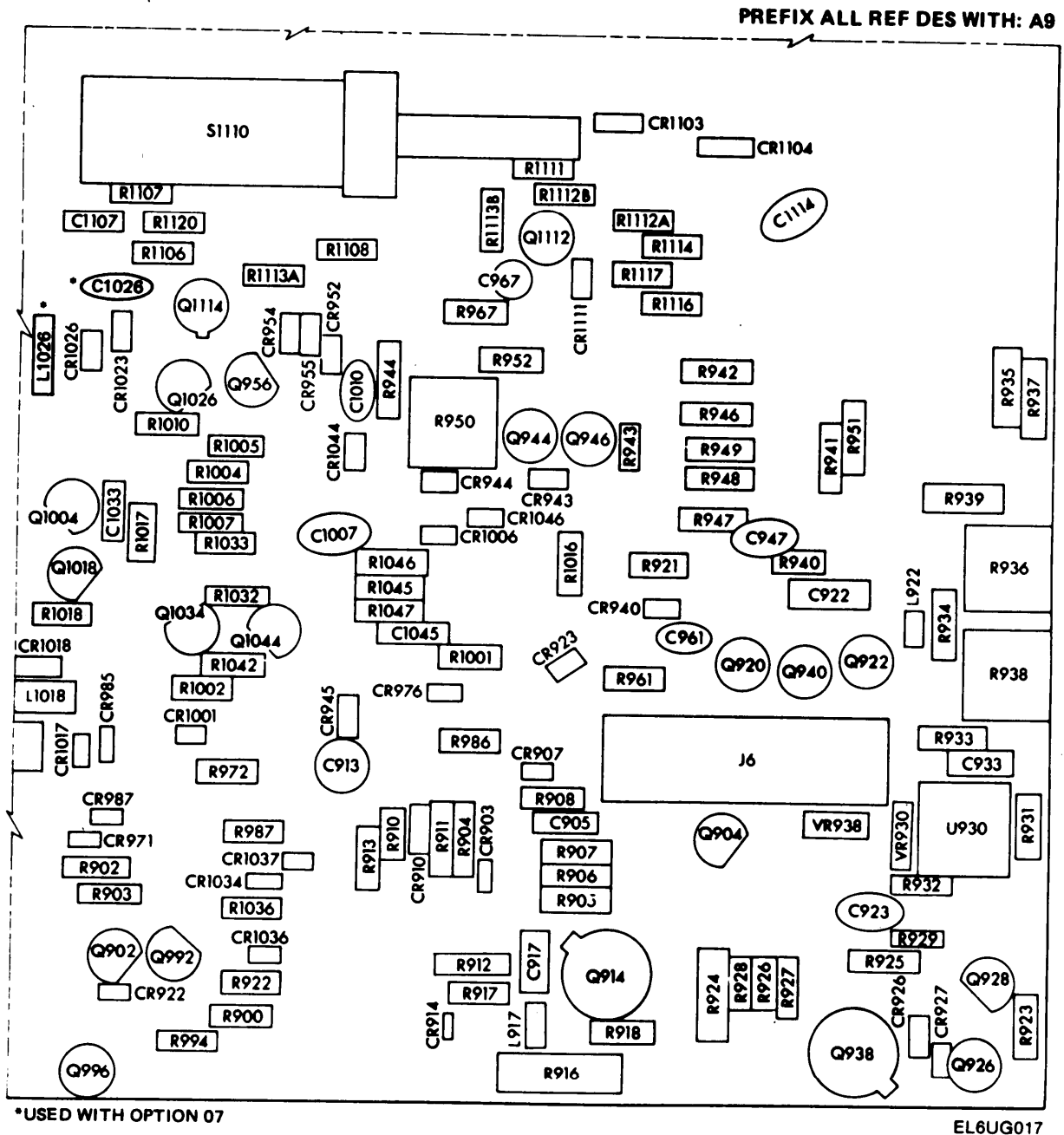
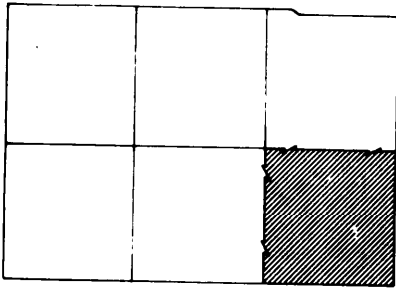


Fig. 7-8. A9 board component locations. (Sheet 6 of 6)





FO & Index No.	Qty	1	2	3	4	5	Name & Description
15-1	1						RTNR,IMPLOSION:5.422 X 4.743X 0.441,GRAY
-2	4						. THUMBSCREW:4-40 X 0.45 INCH,KNURLED
-3	1						SHLD,ELCTRN TUB:CRT
-4	2						KNOB:GRAY WITH SETSCREW
	1						. SETSCREW:5-40 X 0.125,STL BK OXD,HEX
-5	2						KNOB:RED-VAR
	1						. SETSCREW:5-40 X 0.125,STL BK OXD,HEX
-6	2						KNOB:GRAY--VOLTS/DI
	2						. SETSCREW:5-40 X 0.125,STL BK OXD,HEX
-7	2						KNOB:LEVER SWITCH
-8	1						PUSH BUTTON:GRAY--INVERT
-9	1						PUSH BUTTON:--BEAM FINDER
-10	1						PUSH BUTTON:GRAY--CH2
-11	1						PUSH BUTTON:GRAY--CHOP
-12	1						PUSH BUTTON:GRAY--ADD
-13	1						PUSH BUTTON:GRAY--ALT
-14	1						PUSH BUTTON:GRAY--CHI
-15	3						KNOB:GRAY
	1						. SETSCREW:5-40 X 0.125,STL BK OXD,HEX
-16	1						PUSH BUTTON:GRAY--X10
-17	1						KNOB:GRAY
	1						. SETSCREW:5-40 X 0.125,STL BK OXD,HEX
-18	1						KNOB:GRAY
	1						. SETSCREW:5-40 X 0.125,STL BK OXD,HEX
-19	1						KNOB:GRAY WITH SETSCREW
	1						. SETSCREW:5-40 X 0.125,STL BK OXD,HEX
-20	1						KNOB:RED
	1						. SETSCREW:5-40 X 0.125,STL BK OXD,HEX
-21	1						KNOB:GRAY--DLYD SWP
	2						. SETSCREW:5-40 X 0.25 INCH,HEX SOC STL
-22	1						RING,KNOB SKIRT:PLASTIC,1.45 INCH DIA
	2						. SETSCREW:6-32 X 0.188 INCH,HEX.SOC STL
	1						SHAFT,PUSH,ACTR:0.76 L X 0.065 STEPPED
-23	1						BRG,KNOB SKIRT:0.789 ID X 0.866"OD PLASTIC
-24	1						PUSH BUTTON:GRAY--A LOCK KNOBS
-25	1						PUSH BUTTON:GRAY--MIX
-26	1						PUSH BUTTON:GRAY--A INTEN
-27	1						PUSH BUTTON:GRAY--B DLY'D
-28	1						PUSH BUTTON:GRAY--AUTO
-29	1						PUSH BUTTON:GRAY--NORM
-30	1						PUSH BUTTON:GRAY--SNGL SWP
-31	2						KNOB:GRAY
	1						. SETSCREW:5-40 X 0.125,STL BK OXD,HEX
-32	2						KNOB:GRAY
	1						. SETSCREW:5-40 X 0.125,STL BK OXD,HEX
-33	9						BUSHING,SLEEVE:0.250 OD X 0.131 ID,PRESS MT
	3						BUSHING,SLEEVE:0.125 ID X 0.234 THK,PLSTC
	2						NUT,PLAIN,HEX.:0.312-18 X 0.50 INCH,STL
							(ATTACHING PARTS FOR EACH)
	1						NUT,PLAIN,HEX.:0.25-32 X 0.312 INCH,BRS
	1						WASHER,FLAT:0.25 ID X 0.375 INCH OD,STL
							- - - * - - -
-34	3						BUSHING,PLASTIC:0.257 ID X 0.412 INCI. OD
-35	2						LENS,LIGHT:CLEAR,ATTENUATOR
-36	16						FR,PUSH BUTTON:GRAY PLASTIC
-37	5						LENS,LIGHT:CLEAR
-38	1						RES.,VAR,WW: R930
							(ATTACHING PARTS)
-39	1						DIAL,CONTROL:10 TURN FOR 0.25 DIA SHAFT
	1						. SETSCREW:4-40 X 0.125 INCH,HEX SOC STL
							- - - * - - -

(FO-15 Located in Back of Manual)

FO & Index No.	Qty	1	2	3	4	5	Name & Description
15-40	4						LENS, LIGHT: WHITE
-41	1						EXTENSION SHAFT: 11.487 INCH LONG, W/KNOB
-42	1						RES., VAR, NONWIR: A TRIGGER (R530, S530)
-43	1						RES., VAR, NONWIR: B TRIGGER (R750, S750)
-44	1						RES., VAR, NONWIR: TRIG HOLDOFF (R644, S644)
-45	1						RES., VAR, NONWIR: POSITION (R1119A, B) (ATTACHING PARTS FOR EACH)
-46	1						NUT, PLAIN, HEX.: 0.25-32 X 0.312 INCH, BRS
-47	1						WASHER, FLAT: 0.25 ID X 0.375 INCH OD, STL - - - * - - -
-48	1						PANEL, FRONT:
-49	2						CONNECTOR, RCPT.: BNC, FEMALE, W/HARDWARE (ATTACHING PARTS FOR EACH)
-50	1						TERMINAL, LUG: 0.391" ID INT TOOTH - - - * - - -
-51	1						COIL, CAL: (ATTACHING PARTS)
-52	2						NUT, PLAIN, HEX.: 3-48 X 0.187 INCH, CD PL BRS
-53	2						WASHER, FLAT: 0.119 ID X 0.375 INCH OD, STL
-54	2						WSHR, SHOULDERED: 0.125 ID X 0.50 INCH OD
-55	1						SPACER, CUR LOOP: 1.094 X 0.344 X 0.125 INCH
-56	2						NUT, FINISHING: 0.25 HEX X 0.312" LONG, BRS - - - * - - -
-57	2						LAMPHOLDER: SCALE FACTOR (ATTACHING PARTS FOR EACH)
-58	1						SCREW, MACHINE: 2-56 X 0.25 INCH, PNH STL - - - * - - -
-59	FT						SHLD GSKT, ELEC: 0.026 OD NPRNW/WIRE NET CO
-60	1						CKT BOARD ASSY: CRT SCALE ILLUM (A10)
-61	1						. REFLECTOR, LIGHT: SCALE ILLUMINATION
-62	1						. LAMPHOLDER: SCALE ILLUMINATION
-63	FT						. WIRE, ELECTRICAL: 2 WIRE RIBBON
-64	2						. CONNECTOR, TERM.: 22-26 AWG, BRS & CU BE GOLD
-65	1						. CONN BODY, PL, EL: 2 WIRE RED
-66	4						SUPPORT, CRT: FRONT
-67	1						FRAME SECT, CAB.: FRONT (ATTACHING PARTS)
-68	4						SCR, TPG, THD FOR: 6-20 X 0.5 TYPE B, PNH, STL - - - * - - -
-69	1						SHLD, ELECTRICAL: HIGH VOLTAGE (ATTACHING PARTS)
-70	3						SCREW, MACHINE: 4-40 X 0.188 INCH, PNH STL - - - * - - -
-71	1						GROMMET, PLASTIC: U-SHP, 0.548 X 0.462 INCH
-72	1						CKT BOAD ASSY: FAN MOTOR (SEE A6 EPL) (ATTACHING PARTS)
-73	2						SCR, TPG, THD CTG: 4-24 X 0.25 INCH, PNH STL - - - * - - -
-74	1						. CKT BOARD ASSY INCLUDES:
-75	2						. SOCKET, PLUG-IN: 14 CONTACT, LOW CLEARANCE
-76	20						. SOCKET, PIN TERM: 0.188 INCH LONG
-77	1						SOCKET, PLUG-IN: 20 LEAD DIP, CKT BD MTG
-78	1						. SOCKET, PLUG-IN: 3 PIN, SQUARE
-79	1						. SOCKET, PLUG-IN: 3 PIN, LOW PROFILE
-80	1						. MOTOR, DC: (B1690)
-81	2						MOUNT, MOTOR: (ATTACHING PARTS)
-81	2						SCREW, MACHINE: 4-40 X 0.25 INCH, PNH STL - - - * - - -

FO & Index No.	Qty	1	2	3	4	5	Name & Description
15-82	1						TRANSISTOR:CHAS MTG(Q1318) (ATTACHING PARTS)
-83	2						SCREW,MACHINE:4-40 X 0.375 INCH,PNH STL
-84	1						TERMINAL,LUG:SE #8
-85	2						INSULATOR,BSHG:0.25 DIA X 0.188 INCH L - - - * - - -
-86	1						HEAT SINK,ELEC:TRANSISTOR
-87	1						BRACKET,XSTR:ALUMINUM (ATTACHING PARTS)
-88	2						NUT,PLAIN,EXT W:4-40 X 0.25 INCH,STL - - - * - - -
-89	4						FOOT,CABINET:W/CORD WRAP (ATTACHING PARTS FOR EACH)
-90	1						SCREW,MACHINE:8-32 X 1.0 INCH,PNH STL - - - * - - -
-91	FT						SHLD GSKT,ELEC:0.187 INCH DIA,2.75 FT L
-92	1						FR SECT.,CAB.:REAR (ATTACHING PARTS)
-93	2						SCREW,MACHINE:6-32 X 0.875 INCH,PNH STL - - - * - - -
-94	1						FILTER ELEM,AIR:2.5 X 2.5 X 0.25
-95	4						CONNECTOR,RCPT,:BNC,FEMALE,W/HARDWARE (ATTACHING PARTS FOR EACH)
-96	1						TERMINAL,LUG:0.391" ID INT TOOTH - - - * - - -
-97	2						CONN,RCPT,ELEC:4 CONT,QUICK DISCONNECT (ATTACHING PARTS FOR EACH)
-98	1						NUT,PLAIN,HEX.:9 MM X 0.437 INCH
-99	1						WASHER,LOCK:INTL,0.375 ID X 0.50" OD STL - - - * - - -
-100	1						PLATE,CONN MTG:ALUMINUM
-101	1						COVER,SCOPE:REAR (ATTACHING PARTS)
-102	2						SCREW,MACHINE:4-40 X 0.25" 100 DEG,FLH STL - - - * - - -
-103	1						. COVER INCLUDES: . COVER,FAN IMPLR: 1 . . STOP,FAN IMPLR:FAN
-104	1						. SCREEN,FAN:2.5 X 2.5 X 0.032,AL
-105	1						COV ASSY,LINE V:
-106	1						. FUSEHOLDER:0.262"ID TUBE FOR CRTG FUSE (ATTACHING PARTS)
-107	2						. SCREW,TPG,TF:4-20 X 0.312 PNH,STL,CD PL - - - * - - -
-108	1						BODY ASSY,LINE: (ATTACHING PARTS)
-109	2						NUT,PLAIN,HEX.:6-32 X 0.25 INCH,BRS
-110	2						WASHER,LOCK:#6 INTL,0.018THK,STL CD PL - - - * - - -
-111	1						. BODY,LINE VOLTGE INCLUDES: 1 . BUS,CONDUCTOR:  1 . CONT ASSY,ELEC:LINE V SEL,LOW/MED/HI 2 . RIVET,TUBULAR:0.188 L X 0.125 OD,BRS 2 . CLIP,ELECTRICAL:FUSE,CU BE ALBALOY PL
-111	1						CABLE ASSY,PWR,:3 WIRE,92 INCH LONG (ATTACHING PARTS)
-112	1						BSHG,STRAIN RLF:90 DEG,0.25 INCH DIA HOLE
-113	1						CABLE,NIP.,ELEC:0.265 ID X 0.38"OD W/FLG
-114	1						BSHG,STRAIN RLF:180 DEG,0.156" DIA HOLE - - - * - - -

FO & Index No.	Qty	1	2	3	4	5	Name & Description
15-115	1						PANEL, REAR: LINE VOLT (ATTACHING PARTS)
-116	1						SCREW, MACHINE: 4-40 X 0.188" 100 DEG, FLH STL
-117	1						SCREW, MACHINE: 4-40 X 0.312" 100 DEG, FLH STL
							SCREW, MACHINE: 4-40 X 0.438 INCH, FLH STL
							(OPTION 7 ONLY)
							NUT, PLAIN, HEX.: 4-40 X 0.25 INCH, STL
							(OPTION 7 ONLY)
-118	1						TERMINAL, LUG: SE #4
-119	1						NUT, PLAIN, EXT W: 4-40 X 0.25 INCH, STL
							- - - * - - -
	1						TERMINAL, LUG: 0.146 ID, LOCKING, BRZ TINNED (ATTACHING PARTS)
	1						NUT, PLAIN, EXT W: 6-32 X 0.312 INCH, STL
							- - - * - - -
	1						MARKER, IDENT: MARKED GROUND SYMBOL
-120	1						COVER, CRT: REAR (ATTACHING PARTS)
-121	2						SCREW, MACHINE: 4-40 X 0.25 INCH, PNH STL
							- - - * - - -
-122	1						SUPPORT, CRT: REAR
-123	1						GROMMET, PLASTIC: U-SHP, 1.0 X 0.42 INCH
-124	1						BRKT, CRT SHIELD: REAR, NYLON (ATTACHING PARTS)
-125	3						SCREW, MACHINE: 6-32 X 0.312 INCH, PNH STL
-126	1						WASHER, FLAT: 0.15 ID X 0.032 THK, STL CD PL
-127	1						TERMINAL, LUG: 0.146 ID, LOCKING, BRZ TINNED
-128	2						NUT, PLAIN, SQ: 6-32 X 0.312 INCH, STL
-129	1						NUT, PLAIN, EXT W: 6-32 X 0.312 INCH, STI
							- - - * - - -
-130	1						CLAMP, LOOP: 0.062 INCH DIA
-131	1						COIL, TUBE DEFLE: Y-AXIS (L1385) (ATTACHING PARTS)
-132	1						CLAMP, COIL: Y-AXIS
-133	2						SCREW, MACHINE: 4-40 X 0.25 INCH, PNH STL
-134	2						WASHER, FLAT: 0.125 ID X 0.25" OD, STL
-135	1						TERMINAL, LUG: SE #4
							- - - * - - -
-136	1						SHIELD, ELEC: CRT NECK
	1						SOCKET, PLUG-IN: CRT
-137	1						. SOCKET, PLUG-IN: 14 PIN
-138	4						. CONNECTOR, TERM.: 22-26 AWG, BRS& CU BE GOLD
-139	1						. HLDR, TERM CONN: 4 WIRE BLACK
	2						CONTACT, ELEC: FEMALE
-140	1						IMPLR, FAN, AXIAL: 2.60 INCH OD, PLASTIC
-141							
-142	3						GROMMET, PLASTIC: 0.375 INCH DIA
-143	1						GROMMET, PLASTIC: 1.24 X 0.739 X 0.108" OA
-144	2						GROMMET, PLASTIC: 0.50 INCH DIA
	2						GROMMET, PLASTIC: 0.625 INCH DIA
-145	1						CLIP, ELECTRICAL: COMPONENT MOUNTING (ATTACHING PARTS)
-146	1						SCREW, MACHINE: 4-40 X 0.25 INCH, PNH STL
-147	1						NUT, PLAIN, EXT W: 4-40 X 0.25 INCH, STL
							- - - * - - -
-148	1						DELAY LINE, ELEC: (DL380) (ATTACHING PARTS)
-149	1						BRKT, DELAY LINE: ALUMINUM
-150	1						NUT, PLAIN, EXT W: 6-32 X 0.312 INCH, STL
							- - - * - - -

FO & Index No.	Qty	1	2	3	4	5	Name & Description	
15-	-	. DELAY LINE INCLUDES:						
	1	. CONN, DELAY LINE:						
	1	. RETAINER, WIRE, E: DELAY LINE TERMINAL						
-151	1	SW, THERMOSTATIC: 10A, 240V, OPEN 75 DEG C (ATTACHING PARTS)						
-152	2	SCR, TPG, THD FOR: 5-32 X 0.188 INCH, PNH STL - - - * - - -						
-153	1	XFMR, PWR, STPDN: (SEE T1400 EPL) (ATTACHING PARTS)						
-154	2	SCREW, MACHINE: 6-32 X 0.312" 100 DEG, FLH STL						
-155	4	NUT, PLAIN, EXT W: 6-32 X 0.312 INCH, STL - - - * - - -						
	-	. TRANSFORMER INCLUDES:						
-156	4	. SCREW, MACHINE: 10-32 X 2.50", HEX HD STL						
-157	4	. WASHER, NONMETAL: #10, FIBER						
-158	4	. INSUL SLVG, ELEC: 0.19 ID X 1.875" LONG MYLAR						
-159	1	. COVER, XFMR: 3 L X 2.5 W X 0.65 INCH H						
-160	4	. WASHER, LOCK: SPLIT, 0.195 ID X 0.32" OD, P BRZ						
-161	4	. NUT, PLAIN, HEX.: 10-32 X 0.25 INCH, BRS						
-162	1	. BRACKET, XFMR: ALUMINUM						
-163	1	SHIELD, ELEC: TRANSFORMER						
-164	1	TRANSISTOR: CHAS MTG (Q1458)						
-165	1	TRANSISTOR: CHAS MTG (Q1426)						
-166	1	TRANSISTOR: CHAS MTG (Q1448) (ATTACHING PARTS FOR EACH)						
-167	1	SCREW, MACHINE: 4-40 X 0.375 INCH, PNH STL						
-168	1	WASHER, SPR TNSN: 0.146 ID X 0.323" OD, STL - - - * - - -						
-169	3	INSULATOR, PLATE: XSTR, 0.675 X 0.625 X 0.001"						
-170	1	COIL, DEFLE: TRACE ROTATION (L1386)						
-171	1	CHASSIS, SCOPE: MAIN						
-172	1	. CONTACT, SPRING: 1.188 X 0.375 X 0.25 INCH (ATTACHING PARTS)						
	1	. EYELET, METALLIC: 0.20 DIA X 0.093 INCH LONG - - - * - - -						
-173	FT	WIRE, ELECTRICAL: 2 WIRE RIBBON						
-174	FT	WIRE, ELECTRICAL: 3 WIRE RIBBON						
-175	FT	WIRE, ELECTRICAL: 4 WIRE RIBBON						
-176	FT	WIRE, ELECTRICAL: 5 WIRE RIBBON						
-177	FT	WIRE, ELECTRICAL: 6 WIRE RIBBON						
-178	FT	WIRE, ELECTRICAL: 7 WIRE RIBBON						
-179	FT	WIRE, ELECTRICAL: 10 WIRE RIBBON						
-180	2	HLDR, TERM CONN: 1 WIRE BLACK						
-181	2	HLDR, TERM CONN: 2 WIRE BLACK						
-182	4	HLDR, TERM CONN: 3 WIRE BLACK						
	4	HLDR, TERM CONN: 4 WIRE BLACK						
-183	2	CONN BODY, PL, EL: 5 WIRE BLACK						
-184	1	CONN BODY, PL, EL: 6 WIRE BLACK						
-185	1	CONN BODY, PL, EL: 7 WIRE BLACK						
-186	1	CONN BODY, PL, EL: 10 WIRE BLACK						
	64	CONNECTOR, TERM.: 22-26 AWG, BRS& CU BE GOLD						
-187	2	CONTACT, ELEC: FOR NO. 26 AWG WIRE						
-188	4	CONTACT, ELEC: FOR NO. 22-26 AWG WIRE						
-189	5	EYELET, METALLIC: 0.152 OD X 0.245 INCH L, BRS						
-190	5	EYELET, METALLIC: 0.126 OD X 0.23 INCH L, BRS						
	2	CLAMP, LOOP: 0.062 INCH DIA						



FO & Index No.	Qty	1	2	3	4	5	Name & Description
16-1	1						EXTENSION SHAFT:10.384 INCH LONG,W/KNOB
-2	1						ACTUATOR, SWITCH:POWER
-3	1						SWITCH, TOGGLE:POWER(S1401) (ATTACHING PARTS)
-4	1						NUT, PLAIN, HEX.:0.25-40 X 0.312 INCH, BBS
-5	1						WASHER, LOCK:INTL, 0.26 ID X 0.40" OD, STL - - - * - - -
-6	1						SWITCH, SLIDE:LINE SELECTOR(S1403) (ATTACHING PARTS)
-7	2						SCREW, MACHINE:4-40 X 0.25" 100 DEG, FLH STL - - - * - - -
-8	1						CON, INV SW HOLS:
-9	1						BRACKET, ELEC SW:ALUMINUM (ATTACHING PARTS)
-10	1						NUT, PLAIN, HEX.:4-40 X 0.188 INCH, BRS
-11	1						WASHER, FLAT:0.125 ID X 0.25" OD, STL
-12	1						SCR, ASSEM WSHR:4-40 X 0.312 INCH, PNH BRS
-13	1						NUT, PLAIN, HEX.:4-40 X 0.25 INCH, STL - - - * - - -
-14	1						SUPPORT, CKT BD:ACETAL
-15	1						CKT BOARD ASSY:TRIG GEN & Z AXIS LGC(A8) (ATTACHING PARTS)
-16	5						SCR, ASSEM WSHR:4-40 X 0.312 DOUBLE SEMS - - - * - - -
							. CKT BOARD ASSY INCLUDES:
-17	9						. TERM, TEST POINT:BRS CD PL
-18	9						. LINK, TERM. CONNE:0.086 DIA X 2.375 INCH L
-19	8						. CONN, RCPT, ELEC:CKT BD MT, 3 PRONG
-20							. SOCKET, PIN TERM:0.188 INCH LONG
							. SOCKET, PLUG-IN:3 PIN, SQUARE
							. SOCKET, PLUG-IN:3 PIN, LOW PROFILE
	1						. SOCKET, PLUG-IN:20 LEAD DIP, CKT BD MTG
-21	9						. TERMINAL, PIN:0.365 L X 0.25 PH, BRZ, GOLD PL
	1						. TERM. SET, PIN:36-0.525 L X 0.025 SQ
-22	1						. CONNECTOR, RCPT, :2 CONTACT
-23	1						. CONNECTOR, RCPT, :10 CONTACT
-24	1						. CONNECTOR, RCPT, :12 CONTACT
-25	1						. STUD, SELF-LKG:4-40 X 0.35 INCH LONG
-26	2						. COVER, HALF XSTR:FOR DUAL TO-18 CASE
	2						. COVER, HALF XSTR:FOR DUAL TO-18 CS, 2-56 THD (ATTACHING PARTS FOR EACH)
-27	1						. SCREW, MACHINE:2-56 X 0.312 INCH, RDH STL - - - * - - -
-28	3						. LAMPHOLDER:
	2						. ACTUATOR, SWITCH:COUPLING
-29	1						. . ACTUATOR, SWITCH:COUPLING
-30	2						. . SPRING, FLAT:RED COLORED
-31	2						. . ROLLER, DETENT:0.125 DIA X 0.125 INCH L
-32	1						. . GUIDE, SLIDE SW:
-33	1						. . ADPT, SHAFT, CPLG:SLIDE TO SHAFT
	1						. . SETSCREW:4-40 X 0.125 INCH, HEX SOC STL
	1						. ACTUATOR, SWITCH:A SOURCE
-34	1						. . ACTUATOR, SWITCH:A SOURCE
-35	2						. . SPRING, FLAT:GREEN COLORED
-36	2						. . ROLLER, DETENT:0.125 DIA X 0.125 INCH L
-37	1						. . GUIDE, SLIDE SW:
-38	1						. . ADPT, SHAFT, CPLG:SLIDE TO SHAFT
	1						. . SETSCREW:4-40 X 0.125 INCH, HEX SOC STL
	1						. ACTUATOR, SWITCH:B SOURCE
-39	1						. . ACTUATOR, SWITCH:B SOURCE
-40	2						. . SPRING, FLAT:GREEN COLORED
-41	2						. . ROLLER, DETENT:0.125 DIA X 0.125 INCH L
-42	1						. . GUIDE, SLIDE SW:
-43	1						. . ADPT, SHAFT, CPLG:SLIDE TO SHAFT

(FO-16 Located in Back of Manual)

FO & Index No.	Qty	1	2	3	4	5	Name & Description
16-	1	.	.	.	.	.	SETSCREW:4-40 X 0.125 INCH,HEX SOC STL
-44	4	.	.	.	.	.	EXTENSION SHAFT:3 05 INCH LONG
-45	4	.	.	.	.	.	LEVER,SLIDE SW: (ATTACHING PARTS)
-46	2	.	.	.	.	.	RING,RETAINING:0.114 FREE IDX 0.025 INCH - - - * - - -
-47	23	.	.	.	.	.	CONTACT ASSY,EL:CAM SWITCH,TOP (ATTACHING PARTS)
-48	17	.	.	.	.	.	RIVET,TUBULAR:0.051 OD X 0.115 INCH LONG - - - * - - -
-49	1	.	.	.	.	.	PLATE,LEVER MTG:SLIDE SWITCH (ATTACHING PARTS)
-50	1	.	.	.	.	.	EYELET,METALLIC:0.089 OD X 0.218 INCH LONG - - - * - - -
-51	1	.	.	.	.	.	BRACKET,ELEC SW:ALUMINUM
	1	.	.	.	.	.	CKT BOARD ASSY:TIMING (ATTACHING PARTS)
-52	1	.	.	.	.	.	SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS
-53	1	.	.	.	.	.	POST,ELEC-MECH:HEX,1.593 INCH LONG - - - * - - -
	-	.	.	.	.	.	CKT BOARD ASSY INCLUDES:
-54	3	.	.	.	.	.	EXTENSION SHAFT:0.95 INCH LONG
-55	4	.	.	.	.	.	EXTENSION SHAFT:4.14 INCH LONG
-56	1	.	.	.	.	.	EXTENSION SHAFT:8.241 L X 0.081 INCH OD
-57	1	.	.	.	.	.	SWITCH,PUSH:MICRO(S1099) (ATTACHING PARTS)
-58	1	.	.	.	.	.	HOLDER,MICR:
-59	1	.	.	.	.	.	NUT,PLAIN,EXT W:4-40 X 0.25 INCH,STL
	2	.	.	.	.	.	SCREW,MACHINE:4-40 X 0.375"100DEG,FLH STL
	2	.	.	.	.	.	WASHER,LOCK:INTL,0.092 ID X 0.18"OD,STL
	2	.	.	.	.	.	NUT,PLAIN,HEX.:2-56 X 0.188 INCH,BRS - - - * - - -
-60	1	.	.	.	.	.	ACTUATOR,SWITCH:MICROSWITCH
	1	.	.	.	.	.	DRUM ASSY,CAM S:(S1050) (ATTACHING PARTS)
-61	8	.	.	.	.	.	SCREW,CAP:4-40 X 0.500,SCH,SST - - - * - - -
	-	.	.	.	.	.	ACTUATOR ASSY INCLUDES:
-62	1	.	.	.	.	.	COVER,CAM SW:18 & 25 ELEMENTS (ATTACHING PARTS)
-63	8	.	.	.	.	.	SCREW,MACHINE:4-40 X 0.25 INCH,PNH STL
-64	8	.	.	.	.	.	WASHER,LOCK:#4 INTL,0.015THK,STL CD PL - - - * - - -
-65	3	.	.	.	.	.	CONTACT,ELEC:GROUNDING
-66	2	.	.	.	.	.	NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS
-67	1	.	.	.	.	.	SPRING,FLAT:GREEN COLORED
	1	.	.	.	.	.	SPRING,FLAT:RED COLORED
-68	2	.	.	.	.	.	ROLLER,DETENT:0.125 DIA X 0.125 INCH L
	2	.	.	.	.	.	ROLLER,DETENT:
-69	1	.	.	.	.	.	BEARING,CAM SW:FRONT (ATTACHING PARTS)
-70	1	.	.	.	.	.	RING,RETAINING:0.338 ID X 0.025" THK,STL - - - * - - -
-71	1	.	.	.	.	.	ACTR ASSY,CAM S:TIME/CM,FRONT
-72	4	.	.	.	.	.	NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS
-73	1	.	.	.	.	.	BRACKET,COVER:ABS
-74	4	.	.	.	.	.	NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS
-75	.	.	.	.	.	.	DELETED
-76	.	.	.	.	.	.	DELETED



FO & Index No.	Qty	1	2	3	4	5	Name & Description
16-77	1	.	.	.	SPRING,HLCPS:0.125 OD X 0.3 INCH L		
	1	.	.	.	SPRING,HLCPS:0.176 OD X 0.835 INCH LONG		
-78	1	.	.	.	BEARING,CAM SW:0.428 ID,PLASTIC		
-79	1	.	.	.	ACTR ASSY,CAM S:TIME/CM,REAR (ATTACHING PARTS)		
-80	1	.	.	.	RING,RETAINING:0.338 ID X 0.025" THK,STL		
					- - - * - - -		
-81	1	.	.	.	NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS		
-82	1	.	.	.	SPRING,FLAT:GREEN COLORED		
	1	.	.	.	SPRING,FLAT:RED COLORED		
-83	2	.	.	.	ROLLER,DETENT:		
-84	1	.	.	.	BEARING,CAM SW:FRONT		
	1	.	.	.	SHAFT,CAM SW:W/DRIVER		
	1	.	.	.	WASHER,NONMETAL:0.109 ID X 0.25 INCH OD		
-85	1	.	.	.	RES.,VAR,NONWIR:(R1070)		
-86	1	.	.	.	SPACER,SWITCH:PLASTIC		
-87	1	.	.	.	CPLG,SHAFT,RDG:FOR 0.08 TO 0.125"DIA SHAFT		
	2	.	.	.	SETSCREW:3-48 X 0.062 INCH,HEX SOC STL		
	1	.	.	.	SETSCREW:4-40 X 0.094 INCH,HEX SOC STL		
-88	1	.	.	.	CKT BOARD ASSY:TIMING(A7)		
-89	-	.	.	.	SOCKET,PIN TERM:0.188 INCH LONG		
	-	.	.	.	SOCKET,PLUG-IN:3 PIN,SQUARE		
	-	.	.	.	SOCKET,PLUG-IN:3 PIN,LOW PROFILE		
-90	19	.	.	.	TERMINAL,PIN:0.365 L X 0.25 PH,BRZ,GOLD PL		
-91	43	.	.	.	CONTACT,ELEC:CKT BD SW,SPR,CU BE		
-92	32	.	.	.	CONTACT,ELEC:F-SHAPED		
-93	1	.	.	.	SW,PUSH BUTTON:TRIG MODE(S600)		
-94	4	.	.	.	SPACER,PUSH SW:0.13 W X 0.375 INCH L,PLSTC		
-95	2	.	.	.	LAMPHOLDER:		
-96	1	.	.	.	SW,PUSH BUTTON:HORIZ MODE(S1090)		
-97	4	.	.	.	SPACER,PB SW:0.164 INCH LONG		
-98	1	.	.	.	PLATE,ELEC SHLD:CKT BOARD MOUNT,BRS		
-99	1	.	.	.	SHIELD,ELEC:DELAY LINE (ATTACHING PARTS)		
					- - - * - - -		
-100	6	SCR,TPG,THD CTG:4-24 X 0.25 INCH,PNH STL					
-101	1	CKT BOARD ASSY:VERTICAL OUTPUT(A5) (ATTACHING PARTS)					
-102	2	SCR,ASSEM WSHR:4-40 X 0.312 DOUBLE SEMS					
-103	1	NUT,PLAIN,HEX.:6-32 X 0.25 INCH,STL					
-104	1	WASHER,FLAT:0.147 ID X 0.312" OD,BRS					
					- - - * - - -		
	-	.	.	.	CKT BOARD ASSY INCLUDES:		
-105	1	.	.	.	MICROCIRCUIT:(U470)		
-106	1	.	.	.	BRACKET,GND:MICROCIRCUIT,BRASS		
-107	3	.	.	.	TERMINAL,PIN:0.365 L X 0.25 PH,BRZ,GOLD PL		
-108	-	.	.	.	SOCKET,PIN TERM:0.188 INCH LONG		
	-	.	.	.	SOCKET,PLUG-IN:3 PIN,SQUARE		
	-	.	.	.	SOCKET,PLUG-IN:3 PIN,LOW PROFILE		
-109	3	SPACER,SLEEVE:0.11 ID X 0.25 OD X 0.28"H					



FO & Index No.	Qty	1	2	3	4	5	Name & Description
17-1	2						CONTACT,ELEC:GROUNDING CLIP (ATTACHING PARTS FOR EACH)
-2	1						SCREW,MACHINE:4-40 X 0.375 INCH,PNH STL
-3	1						SPACER,SLEEVE:0.25 OD X 0.188 INCH LONG - - - * - - -
	1						CKT BOARD ASSY:GAIN SWITCH(ATTENUATOR) (ATTACHING PARTS)
-4	2						SCR,ASSEM WSHR:4-40 X 0.312 DOUBLE SEMS - - - * - - -
							. ATTENUATOR ASSY INCLUDES:
-5	2						. COVER,CHASSIS:ATTENUATOR (ATTACHING PARTS FOR EACH)
-6	1						. SCR,TPG,THD FOR:2-32 X 0.156 INCH,PNH,STL
-7	1						. WASHER,FLAT:0.109 ID X 0.25 INCH OD,STL
-8	4						. SCREW,MACHINE:4-40 X 0.25 INCH,PNH STL
-9	4						. WASHER,FLAT:0.119 ID X 0.375 INCH OD,STL - - - * - - -
-10	2						. CONNECTOR,RCPT,:BNC,MALE,3 CONTACT (ATTACHING PARTS FOR EACH)
-11	1						. WASHER,LOCK:INT,0.521 ID X 0.625 INCH OD
-12	1						. WASHER,FLAT:0.500 ID X 0.625 INCH OD,STL
-13	1						. NUT,PLAIN,DODEC:0.500-28 X 0.90 INCH,BRS - - - * - - -
-14	2						. CHASSIS,SCOPE:ATTENUATOR (ATTACHING PARTS FOR EACH)
-15	4						. POST,ELEC-MECH:HEX,0.333 INCH LONG
-16	2						. SCREW,MACHINE:4-40 X 0.312 INCH,PNH STL
-17	6						. WASHER,LOCK:#4 INTL,0.015THK,STL CD BL
-18	2						. SCREW,MACHINE:2-56 X 0.25 INCH,PNH STL
-19	2						. WASHER,LOCK:INTL,0.092 ID X 0.175"OD,STL
-20	2						. WASHER,FLAT:0.09 ID X 0.188" OD,BRS
-21	2						. NUT,PLAIN,HEX.:2-56 X 0.188 INCH,BRS - - - * - - -
-22	2						. CKT BOARD ASSY:CH1,CH2 ATTEN(A1,A2)
-23	10						. CONT ASSY,ELEC:CAM SWITCH,BOTTOM
	10						. CONTACT ASSY,EL:CAM SWITCH,TOP (ATTACHING PARTS)
	10						. RIVET,TUBULAR:0.051 OD X 0.115 INCH LONG - - - * - - -
-24	36						. CONTACT,ELEC:0.178 INCH LONG
	2						. SOCKET,PIN TERM:0.138 INCH LONG
-25	1						. SHLD,ELECTRICAL:CAM CONTACTS
-26	2						. EXTENSION SHAFT:0.123 OD X 6.1 INCH LONG
-27	2						. ACTUATOR,SWITCH: (ATTACHING PARTS FOR EACH)
-28	1						. SCREW,CAP SCH:2-56 X 0.375"HEX HD STL - - - * - - -
	2						. CONTACT,ELEC:GROUNDING
							. (MAY BE REPL BY INDEXED PART NUMBERS -41 & 42 ON AVAILABILITY OF STOCK)
	2						. SW CAM ACTR AS:VOLTS/DIV (ATTACHING PARTS FOR EACH)
-29	6						. SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS - - - * - - -
							. EACH ACTUATOR ASSY INCLUDES:
-30	2						. CONTACT,ELEC:GROUNDING
-31	2						. SPRING,FLAT:RED COLORED
-32	2						. ROLLER,DETENT:
-33	2						. NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS
-34	1						. BEARING,CAM SW:FRONT (ATTACHING PARTS)
-35	1						. RING,RETAINING:0.338 ID X 0.025" THK,STL - - - * - - -
-36	1						. SHAFT,CAM SW:
-37	1						. ACTUATOR,CAM SW:DC,GND,AC

(FO-17 Located in Back of Manual)

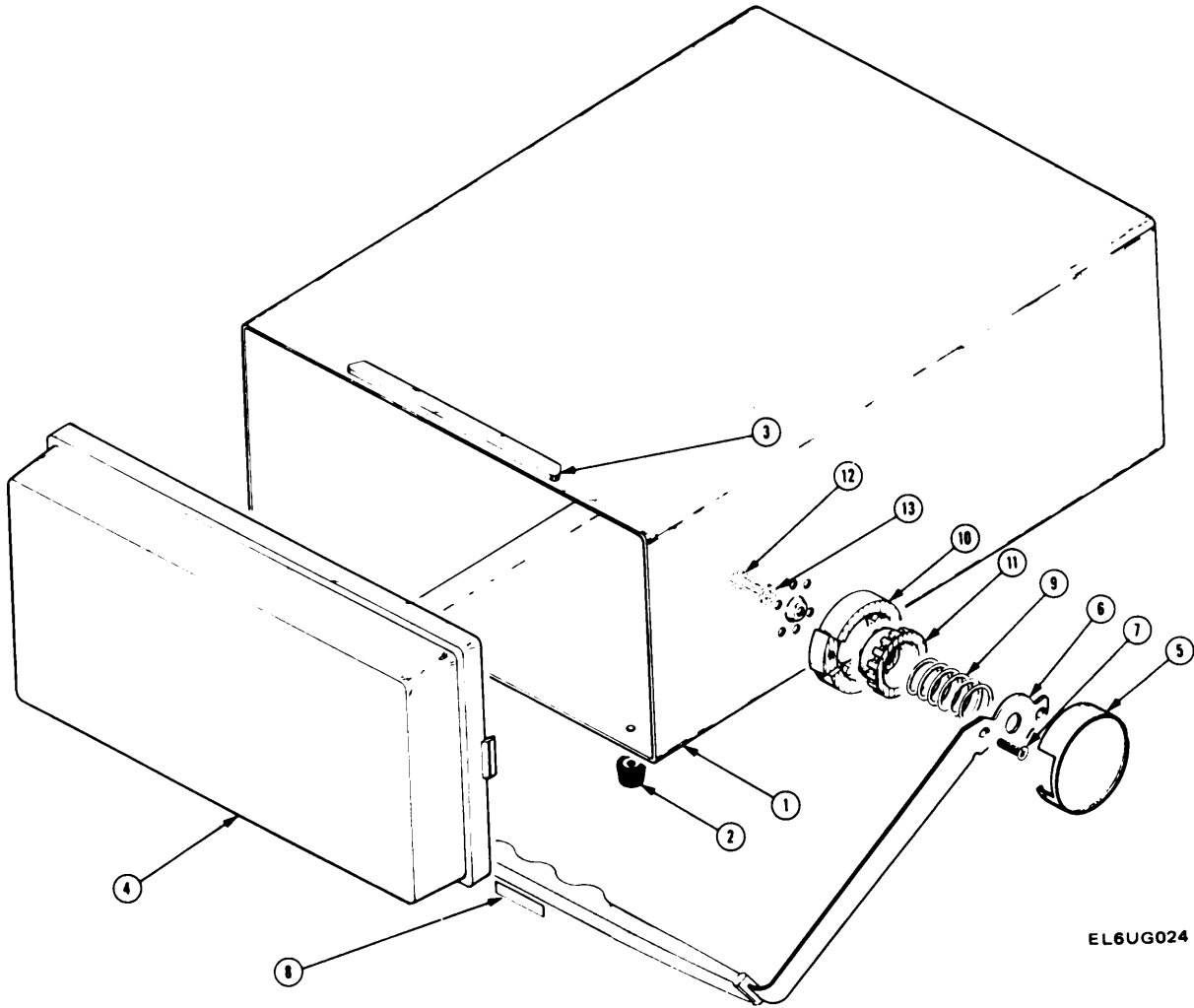
FO & Index No.	Qty	1	2	3	4	5	Name & Description
17-38	4	.	.	.	.	.	NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS
-39	1	.	.	.	.	.	BEARING,CAM SW:CENTER/REAR (ATTACHING PARTS)
-40	1	.	.	.	.	.	RING,RETAINING:0.328 FREE IDX 0.448 OD - - - * - - -
-41	1	.	.	.	.	.	WASHER,FLAT:0.195 ID X 0.367 INCH OD,BRS
-42	1	.	.	.	.	.	SPRING,HLCPS:CONICAL,0.20 INCH LONG
-43	1	.	.	.	.	.	ACTUATOR,CAM SW:ATTEN
-44	1	.	.	.	.	.	SHAFT,CAM SW:REAR
-45	4	.	.	.	.	.	NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS
-46	1	.	.	.	.	.	SPRING,FLAT:GREEN COLORED
	1	.	.	.	.	.	SPRING,FLAT:RED COLORED
-47	2	.	.	.	.	.	ROLLER,DETENT:
-48	1	.	.	.	.	.	BEARING,CAM SW:FRONT
-49	1	.	.	.	.	.	CKT BOARD ASSY:GAIN SWITCH( A4 )
-50	6	.	.	.	.	.	TERM,PIN:0.46 L X 0.025 SQ.PH BRZ GL
-51	29	.	.	.	.	.	TERMINAL,PIN:0.365 L X 0.25 PH,BRZ,GOLD PL
-52	10	.	.	.	.	.	CONTACT ASSY,EL:CAM SWITCH,TOP (ATTACHING PARTS FOR EACH)
-53	1	.	.	.	.	.	RIVET,TUBULAR:0.051 OD X 0.115 INCH LONG - - - * - - -
-54	-	.	.	.	.	.	SOCKET,PIN TERM:0.188 INCH LONG
	-	.	.	.	.	.	SOCKET,PLUG-IN:3 PIN,SQUARE
	-	.	.	.	.	.	SOCKET,PLUG-IN:3 PIN,LOW PROFILE
-55	2	.	.	.	.	.	CPLG,SHAFT,FLEX:FOR 0.125 INCH DIA SHAFTS
	4	.	.	.	.	.	SETSCREW:4-40 X 0.188 INCH,HEX SOC STL
-56	1	.	.	.	.	.	RES.,VAR,NONWIR:( R128/S128 )
-57	1	.	.	.	.	.	SPACER,SWITCH:PLASTIC
-58	1	.	.	.	.	.	RES.,VAR,NONWIR:( R228/S228 )
-59	1	.	.	.	.	.	SPACER,SWITCH:PLASTIC
-60	2	.	.	.	.	.	SHIELD,ELEC:CIRCUIT BOARD (ATTACHING PARTS FOR EACH)
-61	3	.	.	.	.	.	SCR,TPG,THD FOR:2-56 X 0.312 INCH,PNH STL
-62	3	.	.	.	.	.	WASHER,LOCK:INTL,0.092 ID X 0.175"OD,STL
-63	3	.	.	.	.	.	WASHER,FLAT:0.09 ID X 0.25 INCH OD,BRS - - - * - - -
-64	1	.	.	.	.	.	SW,PUSH BUTTON:VERT MODE(S300)
-65	4	.	.	.	.	.	SPACER,PUSH SW:0.13 W X 0.375 INCH L,PLSTC
-66	2	.	.	.	.	.	LAMPHOLDER:
-67	2	.	.	.	.	.	EXTENSION SHAFT:0.123 OD X 5.7 INCH LONG
-68	1	.	.	.	.	.	EXTENSION SHAFT:0.13 SQ X 6.215" LONG,PLSTC
	5	.	.	.	.	.	EXTENSION SHAFT:5.607 INCH LONG
-69	2	.	.	.	.	.	CPLG,SHAFT,RGD:0.128 ID X 0.312 OD X 0.5"L
	4	.	.	.	.	.	SETSCREW:4-40 X 0.188 INCH,HEX SOC STL
-70	2	.	.	.	.	.	CONTACT,ELEC:GROUNDING CLIP
	4	.	.	.	.	.	SETSCREW:4-40 X 0.094 INCH,HEX SOC STL (ATTACHING PARTS)
-71	1	.	.	.	.	.	SCREW,MACHINE:4-40 X 0.25 INCH,PNH STL
-72	1	.	.	.	.	.	WASHER,LOCK:SPLIT,0.118 ID X 0.212"OD STL
-73	1	.	.	.	.	.	WASHER,FLAT:0.125 ID X 0.25" OD,STL - - - * - - -
-74	1	.	.	.	.	.	CKT BOARD ASSY:VERT PREAMPL( A3 ) (ATTACHING PARTS)
-75	7	.	.	.	.	.	SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS
-76	1	.	.	.	.	.	POST,ELEC-MECH:0.538 INCH L - - - * - - -
	-	.	.	.	.	.	CKT BOARD ASSY INCLUDES:
-77	2	.	.	.	.	.	CONN,PLUG,ELEC:2 FEMALE BLADE CONT
-78	3	.	.	.	.	.	SOCKET,PLUG-IN:14 CONTACT,LOW CLEARANCE
-79	-	.	.	.	.	.	SOCKET,PIN TERM:0.188 INCH LONG
	-	.	.	.	.	.	SOCKET,PLUG-IN:3 PIN,SQUARE
	-	.	.	.	.	.	SOCKET,PLUG-IN:3 PIN,LOW PROFILE

FO & Index No.	Qty	1	2	3	4	5	Name & Description
17-80	4	.	TERM, TEST POINT: BRS CD PL				
-81	1	.	TERMINAL, PIN: 0.365 L X 0.25 PH, BRZ, GOLD PL				
-82	9	.	CONTACT ASSY, EL: CAM SWITCH, TOP				
	8	.	CONT ASSY, ELEC: CAM SWITCH, BOTTOM (ATTACHING PARTS)				
-83	9	.	RIVET, TUBULAR: 0.051 OD X 0.115 INCH LONG - - - * - - -				
-84	1	.	HEAT SINK, ELEC: TRANSISTOR				
-85	2	.	HEAT SINK, ELEC: TRANSISTOR				
-86	8	.	CONN, RCPT, ELEC: CKT BD MT, 3 PRONG				
-87	1	.	SW, PUSH BUTTON: INVERT( S225 )				
-88	1	.	SPACER, PUSH SW: 0.13 W X 0.375 INCH L, PLSTC				
	1	.	ACTUATOR, SWITCH: MOMENTARY				
-89	1	.	RES., VAR, NONWIR: ( R185 )				
-90	1	.	RES., VAR, NONWIR: ( R285 )				
-91	1	.	ACTUATOR, SWITCH: MOMENTARY				
-92	1	.	SPRING, HLCPS: 0.156 OD X 0.844 INCH LONG				
-93	1	.	GUIDE, SLIDE SW: 1 . ACTR ASSY, SL SW: OUTPUT ATTEN				
-94	1	.	CPLG, SHAFT, RGD: FOR 0.125 INCH DIA SHAFT				
	1	.	SETSCREW: 4-40 X 0.125 INCH, HEX SOC STL				
-95	1	.	ACTUATOR, SWITCH: SLIDE, BANDWIDTH LIMIT				
-96	1	.	SPRING, FLAT: GREEN COLORED				
-97	1	.	ROLLER, DETENT: 0.125 DIA X 0.125 INCH L				
-98	1	.	GUIDE, SLIDE SW:				
-99	1		GROMMET, PLASTIC: 1.24 X 0.739 X 0.108" OA				
-100	1		BRACKET, PREAMP: REAR, BRASS CU-SN-ZN PL (ATTACHING PARTS)				
-101	2		NUT, PLAIN, EXT W: 4-40 X 0.25 INCH, STL - - - * - - -				
-102	3		POST, ELEC-MECH: 0.250 HEX X 1.77 INCH LONG				
-103	1		RES., VAR, FILM: ( R1303A, B, C, D ) (ATTACHING PARTS)				
-104	2		SCREW, MACHINE: 6-32 X 0.312 INCH, PNH STL				
-105	1		TERMINAL, LUG: 0.146 ID, LOCKING, BRZ TINNED				
-106	2		NUT, PLAIN, EXT W: 6-32 X 0.312 INCH, STL - - - * - - -				
-107	1		BRACKET, RES: ALUMINUM (ATTACHING PARTS)				
-108	2		NUT, PLAIN, EXT W: 4-40 X 0.25 INCH, STL - - - * - - -				
-109	1		SHIELD, ELEC: HI VOLTAGE (ATTACHING PARTS)				
-110	4		SCREW, MACHINE: 4-40 X 0.25 INCH, PNH STL - - - * - - -				
-111	1		INSULATOR, FILM: 3.65 X 4.7, HIGH VOLTAGE				
-112	1		INSULATOR, FILM: 5.10 X 12.4 INCH				
-113	4		POST, ELEC-MECH: 0.538 INCH L (ATTACHING PARTS)				
-114	1		WASHER, FLAT: 0.125 ID X 0.25" OD, STL - - - * - - -				
-115	1		TRANSISTOR: CHAS MTG( Q1456 ) (ATTACHING PARTS)				
-116	1		SCREW, MACHINE: 2-56 X 0.312 INCH, RDH STL				
-117	1		WASHER, NONMETAL: 0.09 ID X 0.121" OD, NYLON				
-118	1		INSULATOR, PLATE: TRANSISTOR				
-119	1		HEAT SINK, ELEC: TRANSISTOR - - - * - - -				
-120	1		TRANSISTOR: CHAS MTG( Q1482 ) (ATTACHING PARTS)				
-121	1		SCR, ASSEM WSHR: 2-56 X 0.312 INCH, PNH, STL				
-122	1		WASHER, NONMETAL: 0.09 ID X 0.121" OD, NYLON - - - * - - -				

FO & Index No.	Qty	1	2	3	4	5	Name & Description
17-123	1						INSULATOR, PLATE: TRANSISTOR
-124	1						CLAMP, LOOP: 0.062 INCH DIA
-125	2						EXTENSION SHAFT: 4.14 INCH LONG
-126	1						EXTENSION SHAFT: 0.123 OD X 5.7 INCH LONG
-127	2						CPLG, SHAFT, RGD: 0.128 ID X 0.312 OD X 0.5" L
	2						. SETSCREW: 4-40 X 0.094 INCH, HEX SOC STL
-128	1						EXTENSION SHAFT: 9.312 INCH LONG
-129	1						EXTENSION SHAFT: 0.125 OD X 1.45 INCH LONG
-130	1						EXTENSION SHAFT: 0.125 OD X 1.7 INCH LONG
-131	1						EXTENSION SHAFT: 0.125 OD X 1.05 INCH L
-132	2						CPLG, SHAFT, FLEX: FOR 0.125 INCH DIA SHAFTS
	4						. SETSCREW: 4-40 X 0.188 INCH, HEX SOC STL
	1						CPLG, SHAFT, FLEX: FOR 0.125 INCH DIA SHAFTS
	4						. SETSCREW: 4-40 X 0.125 INCH, HEX SOC STL
-133	1						CKT BOARD ASSY: INTERFACE(A9) (ATTACHING PARTS)
-134	7						SCR, ASSEM WSHR: 4-40 X 0.312 DOUBLE SEMS
	1						TERMINAL, LUG: 0.14 ID, PLAIN, BRASS
							- - - * - - -
							. CKT BOARD ASSY INCLUDES:
-135	4						. CONN, RCPT, ELEC: CKT BD MT, 3 PRONG
-136	7						. LINK, TERM. CONNE: 0.086 DIA X 2.375 INCH L
-137	-						. SOCKET, PIN TERM: 0.188 INCH LONG
	-						. SOCKET, PLUG-IN: 3 PIN, SQUARE
	-						. SOCKET, PLUG-IN: 3 PIN, LOW PROFILE
-138	2						. WASHER, NONMETAL: 0.312 ID X 0.875" OD, RBR
-139	2						. CONNECTOR, RCPT, : 10 CONTACT
-140	1						. CONNECTOR, RCPT, : 12 CONTACT
-141	2						. CLIP, ELECTRICAL: FOR 0.25 INCH DIA FUSE
-142	26						. TERM, TEST POINT: BRS CD PL
-143	25						. TERMINAL, PIN: 0.365 L X 0.25 PH, BRZ, GOLD PL
-144	24						. CONTACT, ELEC: F-SHAPED
-145	1						. HEAT SINK, ELEC: XSTR, 0.72 OD X 0.375" H
-146	1						. TERMINAL BOARD: 5 NOTCH CERAMIC, CLIP MTD
	2						. . MOUNT, TERM. BD: 0.577 INCH H
-147	1						. TERMINAL BOARD: 3 NOTCH, CERAMIC, CLIP MTD
	1						. . MOUNT, TERM. BD: 0.577 INCH H
-148	1						. TERMINAL BOARD: 1 NOTCH, CERAMIC, CLIP MTD
	1						. . MOUNT, TERM. BD: 0.577 INCH H
-149	1						. TERMINAL, STUD: 0.812 L, INSULATED (ATTACHING PARTS)
-150	1						. NUT, PLAIN, EXT W: 4-40 X 0.25 INCH, STL - - - * - - -
-151	11						. INSULATOR, BSHG: 0.25 DIA X 0.188 INCH L
-152	-						. RES., VAR, NONWIR: FOCUS(R1380) (ATTACHING PARTS)
-153	1						. NUT, PLAIN, HEX.: 0.25-32 X 0.312 INCH, BRS
-154	1						. WASHER, FLAT: 0.25 ID X 0.375 INCH OD, STL
-155	1						. WASHER, LOCK: INTL, 0.26 ID X 0.40" OD, STL - - - * - - -
-156	1						. SUPPORT, VAR RES: CIRCUIT CARD MOUNTING
-157	1						. SEMICOND DEVICE: VOLT MULTIPLIER(U1321) (ATTACHING PARTS)
-158	2						. NUT, PL, EXT WSHR: 8-32 X 0.344 HEX, NYLON - - - * - - -
-159	1						. SW, PUSH BUTTON: X10 MAG(S1110)
-160	2						. SPACER, PB SW: 0.133 INCH LONG
-161	1						. SW, PUSH BUTTON: BEAM FINDER(S450)
-162	2						. SPACER, PB SW: 0.164 INCH LONG
-163	1						. RES., VAR, NONWIR: INTENSITY(R1335A, B)
-164	1						. SPACER, SWITCH: PLASTIC
-165	1						. RES., VAR, NONWIR: SCALE ILLUM(R1480)
	1						. SPACER, SWITCH: PLASTIC

FO & Index No.	Qty	1	2	3	4	5	Name & Description
17-166	1	.	RES., VAR, NONWIR: ASTIG(R1397)				
	1	.	SPACER, SWITCH: PLASTIC				
-167	1	.	RES., VAR, NONWIR: TRACE ROT(R1386)				
	1	.	SPACER, SWITCH: PLASTIC				
-168	1		WIRING HARNESS, : TRIGGER				
-169	5	.	EYELET, METALLIC: 0.152 OD X 0.245 INCH L, BRS				
-170	5	.	EYELET, METALLIC: 0.126 OD X 0.23 INCH L, BRS				
	1		WIRING HARNESS, : MAIN				
-171	2	.	CONNECTOR, TERM.: 22-26 AWG, BRS& CU BE GOLD				
-172	2	.	HLDR, TERM CONN: 1 WIRE BLACK				
	10	.	EYELET, METALLIC: 0.152 OD X 0.245 INCH L, BRS				
	10	.	EYELET, METALLIC: 0.126 OD X 0.23 INCH L, BRS				
	1		WIRING HARNESS, : PROBE POWER				
	8	.	CONNECTOR, TERM.: 22-26 AWG, BRS& CU BE GOLD				
-173	4	.	HLDR, TERM CONN: 2 WIRE BLACK				

**CABINET**



EL6UG024

**Fig. 7-9. Cabinet exploded view.**

Fig. & Index No.	Qty	1	2	3	4	5	Name & Description	
7-9-1	1	CABINET, SCOPE:						
-2	4	. FOOT, CABINET: BOTTOM						
-3	1	. HLDR, POUCH ASSY:						
-4	1	COVER, SCOPE: FRONT						
-5	1	COVER, HDL LATCH: 2.12 DIA X 0.7, ACETAL						
-6	1	HANDLE, CARRYING: (ATTACHING PARTS)						
-7	4	SCR, TPG, THD FOR: 6-32 X 0.50 DEG, FLH ST -----*-----						
-8	1	PLATE, IDENT:						
-9	2	SPRING, HLCPS: 0.959 DIA X 1.250 INCH LONG						
-10	2	INDEX, HDL RING:						
-11	2	HUB, HDL INDEX: 1.42 DIA X 0.565 THK, AL CD (ATTACHING PARTS FOR EACH)						
-12	1	SCR, CAP, HEX HD: 10-24 X 0.375 INCH LONG						
-13	1	WSHR, SPR TNSN: 0.218 ID X 0.69 INCH OD -----*-----						



**APPENDIX A**

**REFERENCES**

The following is a list of applicable references that are available to the operator and maintenance personnel.

DA Pam 310-1	Consolidated Index of Army Publications and Blank Forms.
DA Pam 738-750	The Army Maintenance Management System (TAMMS).
SB 38-100	Preservation, Packaging, Packing and Marking Materials, Supplies, and Equipment Used by the Army.
TB 434118	Field Instructions for Painting and Preserving Electronics Command Equipment (Including Camouflage Pattern Painting of Electrical Equipment Shelters).
TB 43-180	Calibration Requirements for the Maintenance of Army Materiel.
TM 750-244-2	Procedures for Destruction of Electronics Materiel to Prevent Enemy Use (Electronics Command).
TM 11-6625-2735-14 NAVELEX 0969-LP-170-1090 TO 33A1-13-498-1	Operator's, Organizational, Direct Support, and General Support Maintenance Manual (Including Depot Maintenance) for Oscilloscope OS-261/U (NSN 6625-00-127-0079).
TM 11-6625-2735-24P NAVELEX 0967-LP-170-1100 TO 33A1-13-498-4	Organizational, Direct Support, and General Support Maintenance Repair Parts and Special Tools Lists (Including Depot Maintenance Repair Parts and Special Tools) for Oscilloscope OS-261/U (NSN 6625-00-127-0079).
TM 11-6625-2735-24P-1	Organizational, Direct Support, and General Support Maintenance Repair Parts and Special Tools Lists (Including Depot Maintenance Repair Parts and Special Tools) for Oscilloscope OS-261B(V)1/U (NSN 6625-01-101-1318).



## APPENDIX B

## COMPONENTS OF END ITEM LIST AND BASIC ISSUE ITEMS LISTS

## Section I. INTRODUCTION

**B-1. SCOPE**

This appendix lists integral components of and basic issue items for Oscilloscope 0S-261B(V)1/U and 03-261C(V)1/U to help you inventory items required for safe and efficient operation.

**B-2. GENERAL**

This Components of End Item List is divided into the following sections:

*a. Section II. Integral Components of the End Item.* These items, when assembled, comprise the oscilloscope and must accompany it whenever it is transferred or turned in. The illustrations will help you identify these items.

*b. Section III. Basic Issue Items.* These are the minimum essential items required to place the oscilloscope in operation, to operate it, and to perform emergency repairs. Although shipped separately packaged, BII must be with the oscilloscope during operation and whenever it is transferred between property accounts. The illustrations will assist you with hard-to-identify items. This manual is your authority to request/requisition replacement BII, based on TOE/MTOE authorization of the end item.

**B-3. EXPLANATION OF COLUMNS**

*a. Illustration.* This column is divided as follows:

*(1) Figure Number.* Indicates the figure number of the illustration on which the item is shown.

*(2) Item Number.* The number used to identify item called out in the illustration.

*b. National Stock Number.* Indicates the National stock number assigned to the item and which will be used for requisitioning.

*c. Part Number.* Indicates the primary number used by the manufacturer, which controls the design and characteristics of the item by means of its engineering drawings, specifications, standards, and inspection requirements to identify an item or range of items.

*d. Description.* Indicates the Federal item name and, if required, a minimum description to identify the item.

*e. Location.* The physical location of each item listed is given in this column. The lists are designed to inventory all items in one area of the major item before moving on to an adjacent area.

*f. Quantity Required (Qty Reqd).* This column lists the quantity of each item required for a complete major item.

*g. Quantity.* This column is left blank for use during an inventory. Under the Rcvd column, list the quantity you actually receive on your major item. The Date column is for your use when you inventory the major item at a later date; such as for shipment to another site.

SECTION II. INTEGRAL COMPONENTS OF END ITEM

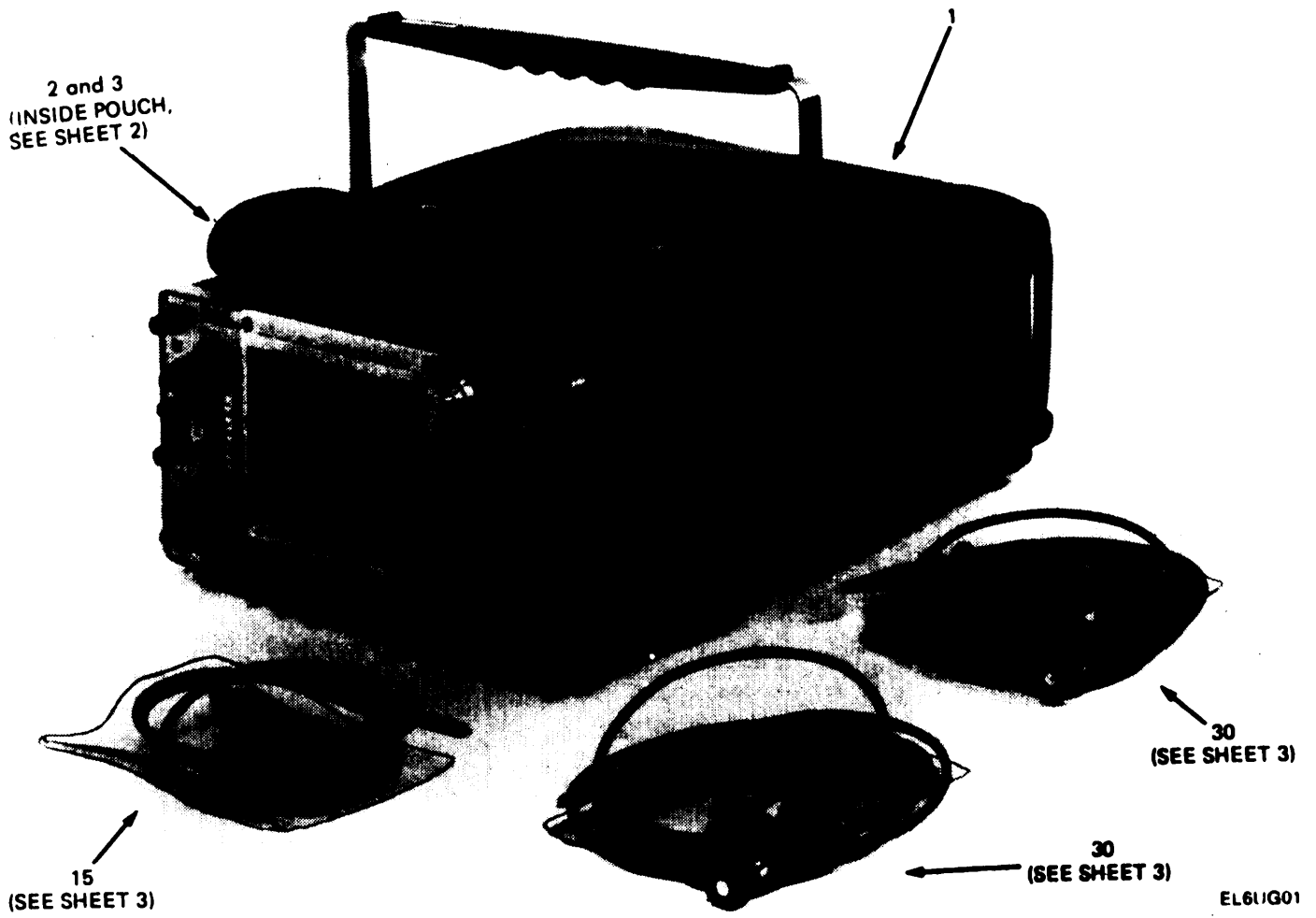
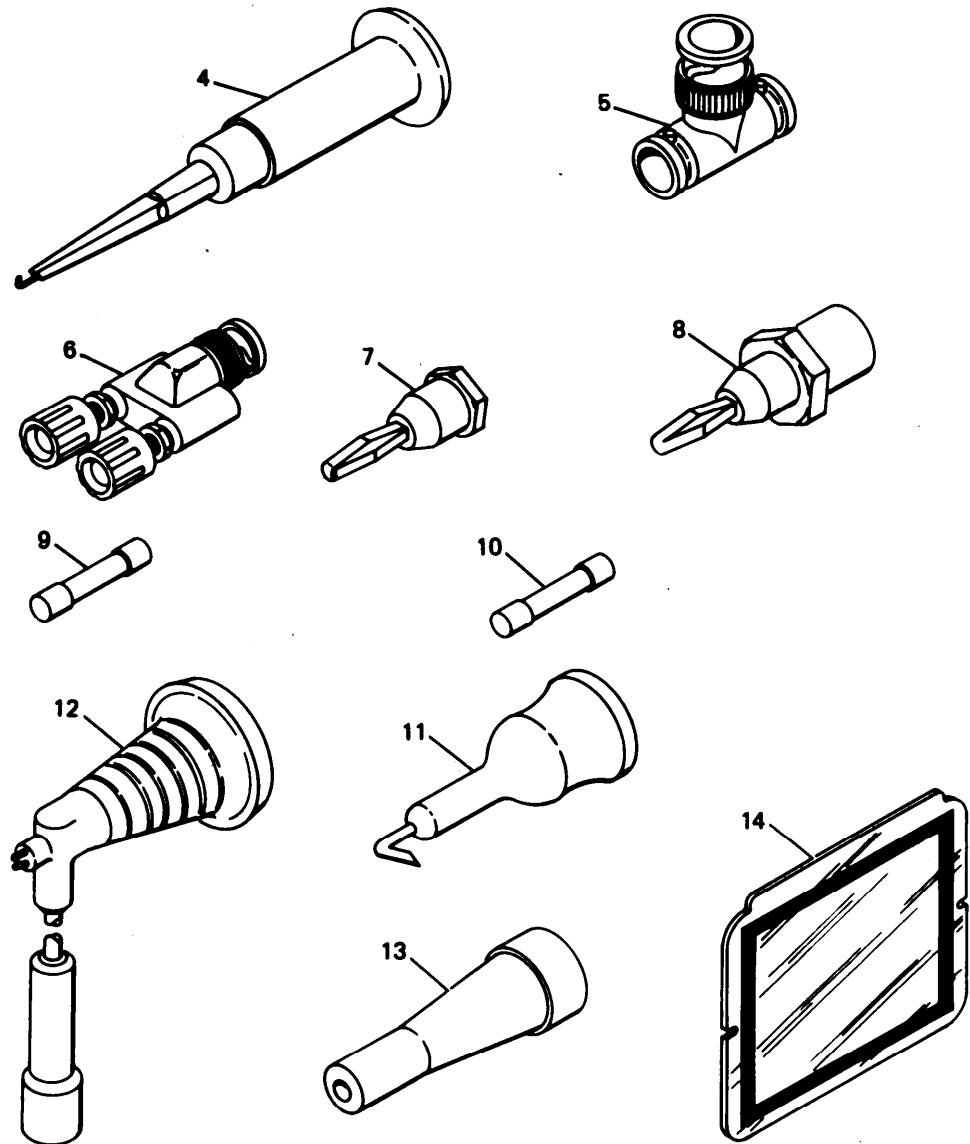


Fig. B-1. Oscilloscope OS-261B(V)1/U and OS-261C(V)1/U. (Sheet 1 of 3)

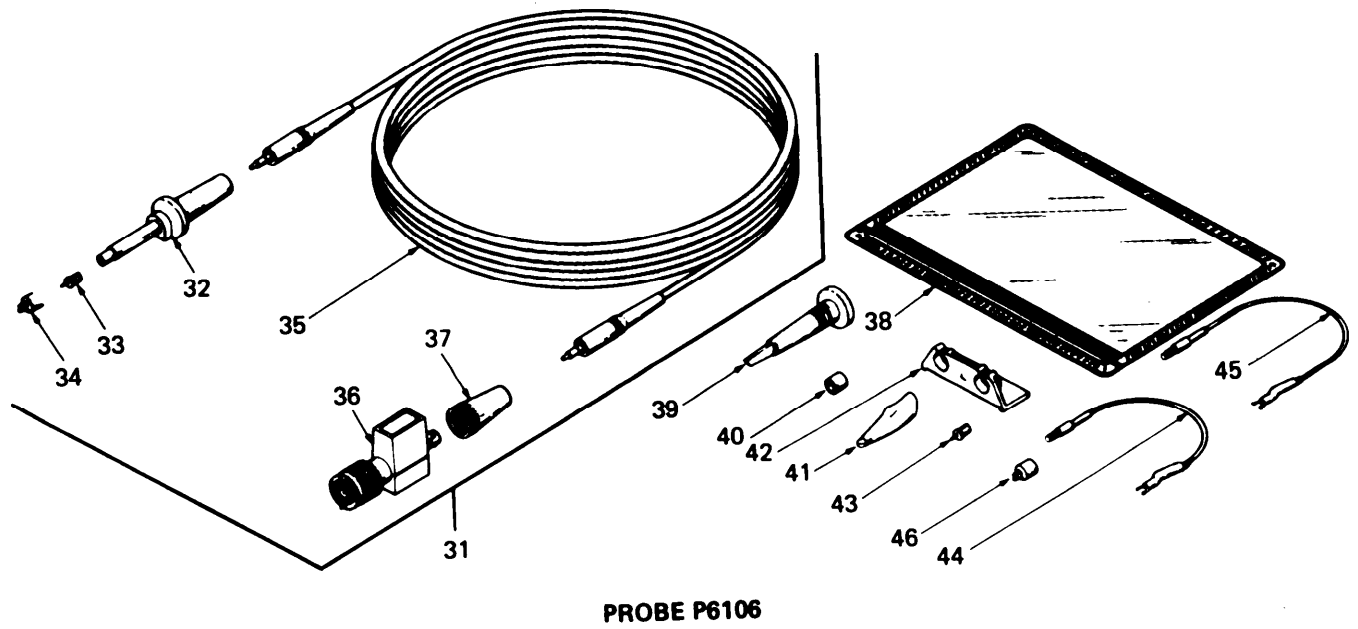
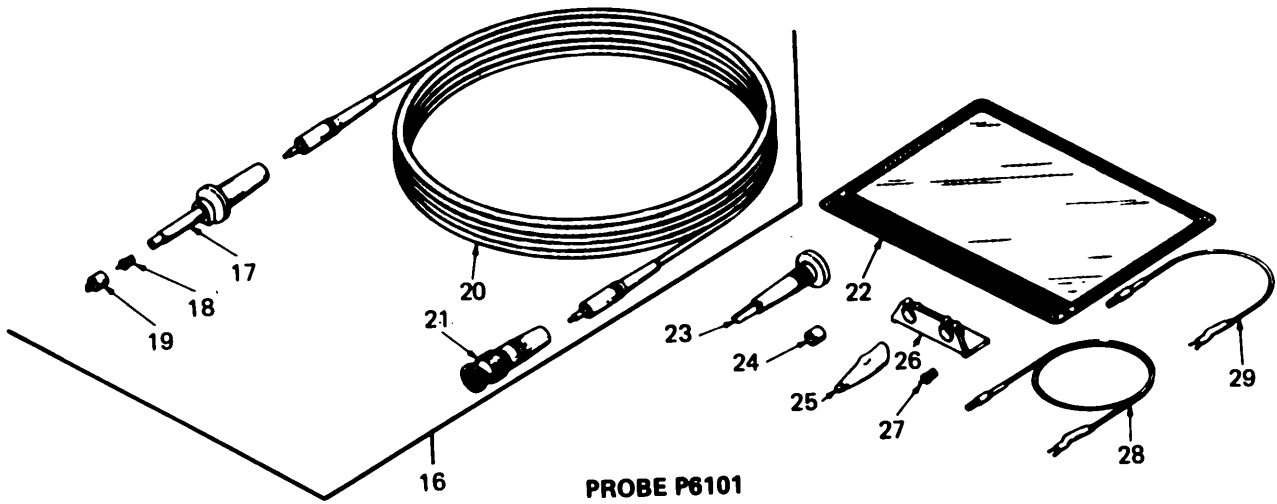
SECTION II. INTEGRAL COMPONENTS OF END ITEM



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Fig. B-1. Oscilloscope OS-261B(V)1/U and OS-261C(V)1/U. (Sheet 2 of 3)

SECTION II. INTEGRAL COMPONENTS OF END ITEM



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Fig. B-1. Oscilloscope OS-261B(V)1/U and OS-261C(V)1/U. (Sheet 3 of 3)

SECTION II. INTEGRAL COMPONENTS OF END ITEM

(1) ILLUSTRATION		(2) NATIONAL STOCK NUMBER	(3) DESCRIPTION  PART NUMBER (FSCM)	(4) LOCATION	(5) USED ON CODE	(6) QTY REQD	(7) QUANTITY		
							RCVD	DATE	
1		6625-00-127-0079	OSCILLOSCOPE OS-261B(V)1/U and OS-261C(V)1/U (80008) Consisting of:			1			
1	1		POUCH 016-0535-02 (80009)	Top of oscilloscope			1		
1	2		ACCESSORY PACKAGE 020-0580-00 (80009) Consisting of:	In pouch			1		
1	3		ACCESSORY BAG 016-0537-00	In pouch			1		
1	4		HOOK TIP 013-0071-00 (80009)	In pouch			1		
1	5		CONNECTOR, UG274C/U BNC T 103-0030-00 (80008)	In pouch			1		
1	6		CONNECTOR, UG1035/U dual banana to male BNC 103-0035-00 (80009)	In pouch			1		
1	7		BANANA TIP 134-0013-00 (80009)	In pouch			1		
1	8		ADAPTER, Plug tip 134-0016-01 (80009)	In pouch			1		
1	9		FUSE AGC3/4 (71400)	In pouch			1		
1	10		FUSE AGC 1-1/2 (71400)	In pouch			2		
1	11		HOOK TIP 206-0105-00 (80009)	In pouch			1		
1	12		PEN TIP 206-0134-03 (80009)	In pouch			1		
1	13		SPRING CLIP 206-0168-00 (80009)	In pouch			1		
1	14	IMPLOSION SHIELD 337-1674-01 (80009)	In pouch			1			

SECTION II. INTEGRAL COMPONENTS OF END ITEM

(1) ILLUSTRATION		(2) NATIONAL STOCK NUMBER	(3) DESCRIPTION  PART NUMBER (FSCM)	(4) LOCATION	(5) USED ON CODE	(5) QTY REQD	(7) QUANTITY	
A FIG. NO.	B ITEM NO.						RCVD	DATE
1	15		PROBE WITH ACCESSORIES 010-61-1-01 (80009) Consisting of:	In pouch		1		
1	16		PROBE 010-6101-00 (80009) Consisting of:	In pouch		1		
1	17		PROBE HEAD 206-0223-00 (80009) Consisting of:	On probe		1		
1	18		PROBE TIP 208-0191-01 (80009)	On probe		1		
1	19		PROBE TIP 0150201-01 (80009)	On probe		1		
1	20		CABLE ASSEMBLY 175-1661-01 (80009)	On probe		1		
1	21		ADAPTER 103-0189-00 (80009)	On probe		1		
1	22		POUCH OBD (05006)	In pouch		1		
1	23		TIP 013-0107-03 (80009)	In pouch		1		
1	24		SLEEVE 166-0404-01 (80009)	In pouch		1		
1	25		CLIP 344-0046-00 (80009)	In pouch		2		
1	26		HOLDER 352-0351-00 (80009)	In pouch		1		
1	27		TIP 206-0191-01 (80009)	In pouch		2		
1	28		LEAD 175-0125-01 (80009)	In pouch		1		
1	29		LEAD 175-0124-01 (80009)	In pouch		1		



SECTION II. INTEGRAL COMPONENTS OF END ITEM

ILLUSTRATION		(2) NATIONAL STOCK NUMBER	(3) DESCRIPTION  PART NUMBER (FSCM)	(4) LOCATION	(5) USED ON CODE	(6) QTY REQD	(7) QUANTITY	
A FIG NO.	B ITEM NO.						RCVD	DATE
1	30		PROBE WITH ACCESSORIES 010-6106-01 (80009) Consisting of:	In pouch		2		
1	31		PROBE 010-6106-00 (80009) Consisting of:	In pouch		1		
1	32		PROBE HEAD 206-0216-00 (80009) Consisting of:	On probe		1		
1	33		PROBE TIP 206-0191-01 (80009)	On probe		1		
1	34		PROBE TIP 015-0201-01 (80009)	On probe		1		
1	35		CABLE ASSEMBLY 175-1661-00 (80009)	On probe		1		
1	36		COMPENSATION BOX 206-0237-00 (80009)	On probe		1		
1	37		RETAINER 343-0570-00 (80009)	On probe		1		
1	38		POUCH OBD (05006)	In pouch		1		
1	39		TIP 013-0107-03 (80009)	In pouch		1		
1	40		SLEEVE 166-0404-01 (80009)	In pouch		1		
1	41		CLIP 344-0046-00 (80009)	In pouch		2		
1	42		HOLDER 352-0351-00 (80009)	In pouch		1		
1	43		TIP 206-0191-01 (80009)	In pouch		2		
1	44		LEAD 175-0263-01 (80009)	In pouch		1		
1	45		LEAD 175-0124-01 (80009)	In pouch		1		
1	46		TIP 015-0201-01 (80009)	In pouch		1		

SECTION III. BASIC ISSUE ITEMS

(1) Illus number	(2) National Stock number	(3) Description FSCM and Part number	(4) Usable On Code U/M	(5) Qty rqr
		TECHNICAL MANUAL: TM 11-6025-2735-14-1	EA	1

## APPENDIX D

## MAINTENANCE ALLOCATION

## Section I. INTRODUCTION

**D-1. General**

This appendix provides a summary of the maintenance operations for the OS-261B(V)1/U and OS-261C(V)1/U. It authorizes categories of maintenance for specific maintenance functions on repairable items and components and the tools and equipment required to perform each function. This appendix may be used as an aid in planning maintenance operations.

**D-2 Maintenance Function**

Maintenance functions will be limited to and defined as follows:

*a. Inspect.* To determine the serviceability of an item by comparing its physical, mechanical, and/or electrical characteristics with established standards through examination.

*b. Test.* To verify serviceability and to detect incipient failure by measuring the mechanical or electrical characteristics of an item and comparing those characteristics with prescribed standards.

*c. Service.* Operations required periodically to keep an item in proper operating conditions, i.e., to clean (decontaminate), to preserve, to drain, to paint, or to replenish fuel, lubricants, hydraulic fluids, or compressed air supplies.

*d. Adjust.* To maintain, within prescribed limits, by bringing into proper or exact position, or by setting the operating characteristics to the specified parameters.

*e. Align.* To adjust specified variable elements of an item to bring about optimum or desired performance.

*f. Calibrate.* To determine and cause corrections to be made or to be adjusted on instruments or test measuring and diagnostic equipments used in precision measurement.

Consists of comparisons of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared.

*g. Install.* The act of emplacing, seating, or fixing into position an item, part, module (component or assembly) in a manner to allow the proper functioning of the equipment or system.

*h. Replace.* The act of substituting a serviceable like type part, subassembly, or module (component or assembly) for an unserviceable counterpart.

*i. Repair.* The application of maintenance services (inspect, test, service, adjust, align, calibrate, replace) or other maintenance actions (welding, grinding, riveting, straightening, facing, remachining, or resurfacing to restore serviceability to an item by correcting specific damage, fault, malfunction, or failure in a part, subassembly, module (component or assembly), end item, or system.

*j. Overhaul.* That maintenance effort (service/action) necessary to restore an item to a completely serviceable/operational condition as prescribed by maintenance standards (i.e., DMWR) in appropriate technical publications. Overhaul is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like new condition.

*k. Rebuild.* Consists of those services actions necessary for the restoration of unserviceable equipment to a like new condition in accordance with original manufacturing standards. Rebuild is the highest degree of material maintenance applied to Army equipment. The rebuild operation includes the act of returning to zero those age measurements (hours, miles, etc.) considered in classifying Army equipments/components.

**D-3. Column Entries**

*a. Column 1, Group Number.* Column 1 lists group numbers, the purpose of which is to identify components, assemblies, subassemblies, and modules with the next higher assembly.

*b. Column 2, Component/Assembly.* Column 2 contains the noun names of components, assemblies, subassemblies, and modules for which maintenance is authorized.

*c. Column 3, Maintenance Functions.* Column 3 lists the functions to be performed on the item listed in column 2. When items are listed without maintenance functions, it is solely for purpose of having the group numbers in the MAC and RPSTL coincide.

*d. Column 4, Maintenance Category.* Column 4 specifies, by the listing of a "worktime" figure in the appropriate subcolumn(s), the lowest level of maintenance authorized to perform the function listed in column 3. This figure represents the active time required to perform that maintenance function at the indicated category of maintenance. If the number or complexity of the tasks within the listed maintenance function vary at different maintenance categories, appropriate "worktime" figures will be shown for each category. The number of task-hours specified by the "worktime" figure represents the average time required to restore an item (assembly, subassembly, component, module, end item or system) to a serviceable condition under typical field operating conditions. This time includes preparation time, troubleshooting time, and quality assurance/quality control time in addition to the time required to perform the specific tasks identified for the maintenance functions authorized in the maintenance allocation chart. Subcolumns of column 4 areas follows:

- C** – Operator/Crew
- O** – Organizational
- F** – Direct Support
- H** – General Support
- D** – Depot

*e. Column 5, Tools and Equipment.* Column 5 specifies by code, those common tool sets (not individual tools) and special tools, test, and support equipment required to perform the designated function.

*f. Column 6, Remarks.* Column 6 contains an alphabetic code which leads to the remark in section IV, Remarks, which is pertinent to the item opposite the particular code.

**D-4. Tool and Test Equipment Requirement (Section III)**

*a. Tool or Test Equipment Reference Code.* The numbers in this column coincide with the numbers used in the tools and equipment column of the MAC. The numbers indicate the applicable tool or test equipment for the maintenance functions.

*b. Maintenance Category.* The codes in this column indicate the maintenance category allocated the tool or test equipment.

*c. Nomenclature.* This column lists the noun name and nomenclature of the tools and test equipment required to perform the maintenance functions.

*d. National/NATO Stock Number.* This column lists the National/NATO stock number of the specified tool or test equipment.

*e. Tool Number.* This column lists the manufacturer's part number of the tool followed by the Federal Supply Code for manufacturers (5-digit) in parentheses.

**D-5. Remarks (Section IV)**

*a. Reference Code.* This code refers to the appropriate item in section II, column 6.

*b. Remarks.* This column provides the required explanatory information necessary to clarify items appearing in section II.

**SECTION II. MAINTENANCE ALLOCATION CHART  
FOR  
OSCILLOSCOPE OS-261B(V)1/U AND OS-261C(V)1/U**

(1) GROUP NUMBER	(2) COMPONENT/ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE CATEGORY					(5) TOOLS AND EQPT.	(6) REMARKS
			C	O	F	H	D		
00	OSCILLOSCOPE OS-261B(V)1/U AND OS-261C(V)1/U	Impact Test		0.1		1.0		Visual External Simple Opera- tional	
		Calibrate				1.5		1 thru 29	A
		Repair		0.1		0.5		1 thru 29	
		Repair					24.0	1 thru 29	
		Overhaul						1 thru 25	
01	ELECTRONIC COMPONENTS ASSEMBLY (MP179)	Inspect				0.1		27	
		Test				0.5		1 thru 29	
		Repair				0.5		1 thru 29	
0101	CIRCUIT CARD ASSY (A4)	Inspect				0.1		23	
		Test				0.5		2,3,6,27,28,29	
		Replace				0.2		27	
		Repair				0.5		27	
0102	CIRCUIT CARD ASSY (A1)	Inspect				2.7		27	
		Test				0.5		1 thru 29	
		Replace				0.2		27	
		Repair				0.5		27	
02	CIRCUIT CARD ASSY (A3)	Inspect				0.1		27	
		Test				0.5		1 thru 29	
		Replace				0.2		27	
		Repair				0.5		27	
03	CIRCUIT CARD ASSY (A5)	Inspect				0.1		27	
		Test				0.5		1 thru 29	
		Replace				0.2		27	
		Repair				0.5		27	
04	CIRCUIT CARD ASSY (A6)	Inspect				0.1		27	
		Test				0.5		1,3,6,27,28	
		Replace				0.2		27	
		Repair				0.5		27	
05	CIRCUIT CARD ASSY (A7)	Inspect				0.1		27	
		Test				0.5		1 thru 29	
		Replace				0.2		27	
		Repair				0.5		27	
0501	CIRCUIT CARD ASSY (A7A1)	Inspect				0.1		27	
		Test				0.5		1 thru 29	
		Replce				0.2		27	
		Repair				0.5		27	
06	CIRCUIT CARD ASSY (A8)	Inspect				0.1		27	
		Test				0.5		1 thru 29	
		Replace				0.2		27	
		Repair				0.5		27	

**SECTION II. MAINTENANCE ALLOCATION CHART  
FOR  
OSCILLSCOPE OS-201B(V)1/U AND OS-201C(V)1/U**

(1) GROUP NUMBER	(2) COMPONENT/ASSEMBLY	(3) MAINTENANCE	(4) MAINTENANCE CATEGORY					(5) TOOLS AND EQPT.	(6) REMARKS
			C	O	F	H	D		
07	CIRCUIT CARD ASSY (A9)	Inspect				0.1		27 1 thru 29	
		Test				0.5			
		Replace				0.2			
		Repair				0.5			
08	CIRCUIT CARD ASSY (A10)	Inspect				0.2		27 28 27 27	
		Test				0.5			
		Replace				0.2			
		Repair				0.5			
09	DC TO AC INVERTER (OPTION 07)	Inspect				0.1		27 1 thru 29	
		Test				0.5			
		Replace				0.2			
		Repair				0.5			

**SECTION III. TOOL AND TEST EQUIPMENT REQUIREMENTS  
FOR  
OSCILLOSCOPE 0S-61B(V)1/U AND OS-261C(V)1/U**

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/NATO STOCK NUMBER	TOOL NUMBER
1	H,D	AUTOTRANSFORMER, VARIABLE, TF 510/U, EQUIVALENT TO GENERAL RADIO W10MT3VM VARIAC AUTOTRANSFORMER	6120-00-054-7794	
2	H,D	VOLTMETER, DC, PRECISION, EQUIVALENT TO FLUKE 893A	6625-00-488-4093	
3	H,D	VOLTMETER, DC, (VOM), AN/USM-210, EQUIVALENT TO SIMPSON 269	6625-00-019-0815	
4	H,D	OSCILLOSCOPE, TEST, OS-261B(V)1/U, EQUIVALENT TO TEKTRONIX TYPE 475	6625-00-127-0079	
5	H,D	AMPLITUDE CALIBRATOR, AN/USM-360, STANDARD, EQUIVALENT TO TEKTRONIX 06741502-01 CAL. GEN.	6625-00-192-0866	
6	H,D	POWER SUPPLY, PP 7208/U, EQUIVALENT TO LAMBDA LPD-422A-FM	6130-00-175-0832	
7	H,D	GENERATOR, MEDIUM-FREQUENCY CONSTANT-AMPLITUDE SIGNAL, EQUIVALENT TO TEKTRONIX TYPE SG 503	6625-00-520-5143	
8	H,D	GENERATOR, TIME-MARK, EQUIVALENT TO TEKTRONIX TYPE TG 501 TIME-MARK GENERATOR	6625-00-520-5199	
9	H,D	GENERATOR, AN/USM-269, LOW-FREQUENCY, SINE-WAVE, EQUIVALENT TO GEN. RADIO 1310 A	6625-00-054-3476	
10	H,D	GENERATOR, SQUARE-WAVE, EQUIVALENT TO TEKTRONIX TYPE PG 506	6625-00-520-5158	
11	H,D	PULSER, TUNNEL DIODE, EQUIVALENT TO TEKTRONIX PART No. 067-0681-01	4831-01-018-6735	
12	H,D	SIGNAL PICKOFF, EQUIVALENT TO TEKTRONIX PART No. 017-0061-00	6625-00-374-8193	
13	H,D	PROBE, CURRENT, EQUIVALENT TO TEKTRONIX TYPE P6022 935 Hz-200 MHz	6625-00-124-9355	
14	H,D	CABLE, COAXIAL, 2 EA, 50 OHMS, RG-58/U, 42 IN., EQUIVALENT TO TEKTRONIX PART No. 012-0057-01	6625-00-495-4831	
15	H,D	CABLE, COAXIAL, 2 EA, 50 OHMS, RG-58/U, 18 IN., EQUIVALENT TO TEKTRONIX PART No. 012-0076-00	6145-00-916-8025	
16	H,D	ADAPTER, GR TO BNC FEMALE, EQUIVALENT TO TEKTRONIX PART No. 017-0063-00	5835-00-765-5481	
17	H,D	ADAPTER, CONNECTOR, GR874 TO BNC MALE EQUIVALENT TO TEKTRONIX PART No. 017-0064-00	5935-00-984-5563	

**SECTION III. TOOL AND TEST EQUIPMENT REQUIREMENTS  
FOR  
OSCILLOSCOPE OS-261B(V)1/U AND OS-261C(V)1/U**

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/NATO STOCK NUMBER	TOOL NUMBER
18	H,D	ADAPTER, CONNECTOR, BNC FEMALE TO BNC FEMALE, EQUIVALENT TO TEKTRONIX PART No. 103-0028-00	5935-01-033-1478	
19	H,D	ADAPTER, CONNECTOR, ELBOW, BNC MALE TO BNC FEMALE, EQUIVALENT TO TEKTRONIX PART No. 103-0031-00		
20	H,D	T-CONNECTOR, BNC, EQUIVALENT TO TEKTRONIX PART No. 103-0030-00	5935-00-284-1962	
21	H,D	ATTENUATOR, X10 (20dB), BNC, EQUIVALENT TO TEKTRONIX PART No. 011-0059-02	5985-00-572-7438	
22	H,D	ATTENUATOR, X5 (14dB), BNC, EQUIVALENT TO TEKTRONIX PART No. 011-060-02	6625-00-009-4694	
23	H,D	ATTENUATOR, X2 (6dB), BNC, EQUIVALENT TO TEKTRONIX PART No. 011-0069-02	5805-00-103-1875	
24	H,D	TERMINATION (50 OHM FEED THRU), 2 EA, EQUIVALENT TO TEKTRONIX PART No. 011-0049-01	5985-00-087-4954	
25	H,D	FILTER, 500 MHz, EQUIVALENT TO TEKTRONIX PART No. 067-0684-00		
26	H,D	ADAPTER, CONNECTOR, BNC MALE TO MINIATURE PROBE TIP, EQUIVALENT TO TEKTRONIX PART No. 013-0084-01	5935-00-482-1776	
27	H,D	TOOL KIT, ELECTRONIC EQUIPMENT TK-100/G	5180-00-605-0079	
28	H,D	MULTIMETER AN/USM-223	6625-00-999-7465	
29	H,D	TEST SET, TRANSISTOR TS-1836 D/U	6625-00-138-7320	
*THE NATIONAL STOCK NUMBERS THAT ARE MISSING FROM THIS LIST HAVE BEEN REQUESTED AND WILL BE ADDED BY A CHANGE TO THE LIST UPON RECEIPT.				



SECTION IV. REMARKS

REFERENCE CODE	REMARKS
A	Replace lamps and knobs.



**APPENDIX E**  
**EXPENDABLE SUPPLIES AND MATERIALS LIST**

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**Section I. INTRODUCTION**

**E-1 . SCOPE**

This appendix lists expendable supplies and materials you will need to operate and maintain the oscilloscope. These items are authorized to you by CTA 50-970, Expendable Items (Except Medical, Class V, Repair Parts, and Heraldic Items).

**E-2. EXPLANATION OF COLUMNS**

a. Column(1)- Item number. Not used.

b. Column(2)- Level. This column identifies the lowest level of maintenance that requires the listed item.

(enter as applicable)

C – Operator/Crew

O – Organizational Maintenance

F – Direct Support Maintenance

H – General Support Maintenance

c. Column(3)- National Stock Number. This is the National stock number assigned to the item; use it to request or requisition the item.

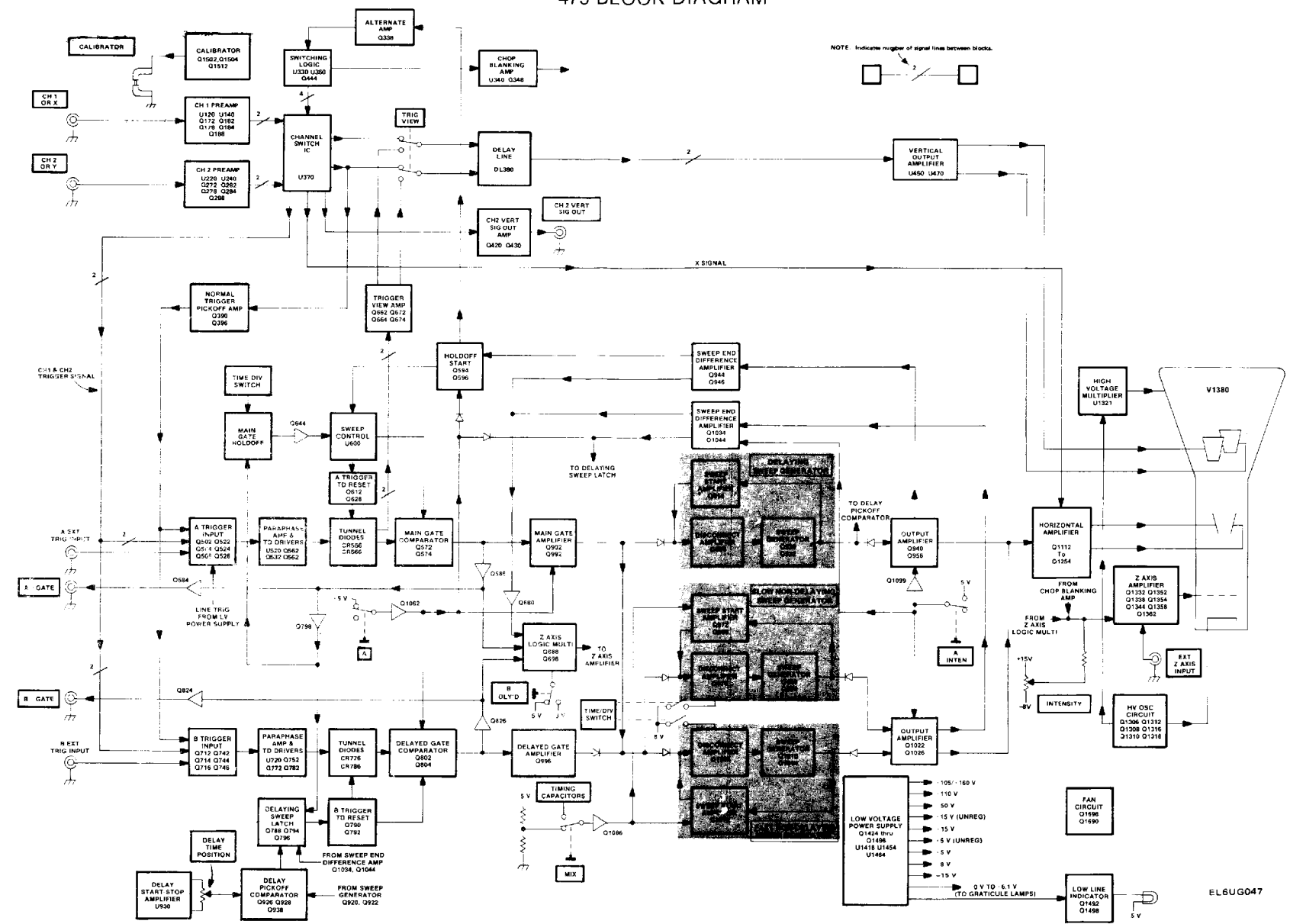
d. Column(4)- Description. Indicates the Federal item name and, if required, a description to identify the item. The last line for each item indicates the Federal Supply Code for Manufacturer (FSCM) in parentheses followed by the part number.

e. Column(5)- Unit of Measure (U/M). Indicates the measure used in performing the actual maintenance function. This measure is expressed by a two-character alphabetical abbreviation (e g., ea, in, pr). If the unit of measure differs from the unit of issue, requisition the lowest unit of issue that will satisfy your requirements.

SECTION II. EXPENDABLE SUPPLIES AND MATERIALS

(1) ITEM NUMBER	(2) LEVEL	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION	(5) U/M
	0	8020-00-721-9657	Brush, paint	ea
	0	7920-00-862-6710	Cloth, lint-free	yd
	0		Paint	oz
	0		Sandpaper	sh
	0		Detergent	oz
	0	6850-00-105-3084	Trichlorotrifluoroethane	qt

### 475 BLOCK DIAGRAM



EL6UG047

FO-1. Block diagram.

**VOLTAGES AND WAVEFORMS**

The voltages and waveforms shown on this diagram were obtained by using the recommended test equipment and test set-ups listed below.

RECOMMENDED TEST EQUIPMENT		
ITEM	SPECIFICATIONS	RECOMMENDED TYPE
Test oscilloscope	Frequency response DC to 75 MHz Deflection factor 1 mV to 5 V/Div Input impedance 1 MΩ 20 pF Sweep rate 50 ns	Tektronix 7603 equipped with 7A13 Amplifier and 7B50 Time-base units, or equivalent.
Probe	Fast-rise 10X attenuation probe compatible with vertical amplifier of test oscilloscope.	Tektronix P6035B, or equivalent
Voltmeter (Non-loading Digital Multimeter)	Input Impedance 10 MΩ Range 0 to 500 V	Tektronix DM 501 Digital Multimeter or equivalent.

**475 Control Settings**

Display Controls		Sweep Controls	
INTENSITY	Midrange	TIME/DIV	0.1 ms
FOCUS	Midrange	VAR TIME/DIV	Calibrated detent
SCALE ILLUM	Midrange	DELAY TIME	
		POSITION	Full counterclockwise
		HORIZ DISPLAY	A
		X10 MAG	Off (button out)
		POSITION (Horiz)	Midrange
		FINE	Midrange

Vertical Controls (CH 1 and CH 2)	
POSITION	Center trace on graticule
VOLTS/DIV	2 mV for dc voltages 100 mV for waveforms
VAR VOLTS/DIV	Calibrated detent
AC-GND-DC	DC
INVERT	Off (button out)
VERT MODE	CH
100 or 20 MHz BW	Full bandwidth (Push in, then release)

Trigger Controls (A and B)	
COUPLING	AC
LEVEL	0
SLOPE	-
SOURCE	NORM
TRIG MODE	AUTO
A TRIGGER HOLDOFF	NORM

**Voltage Measurements**

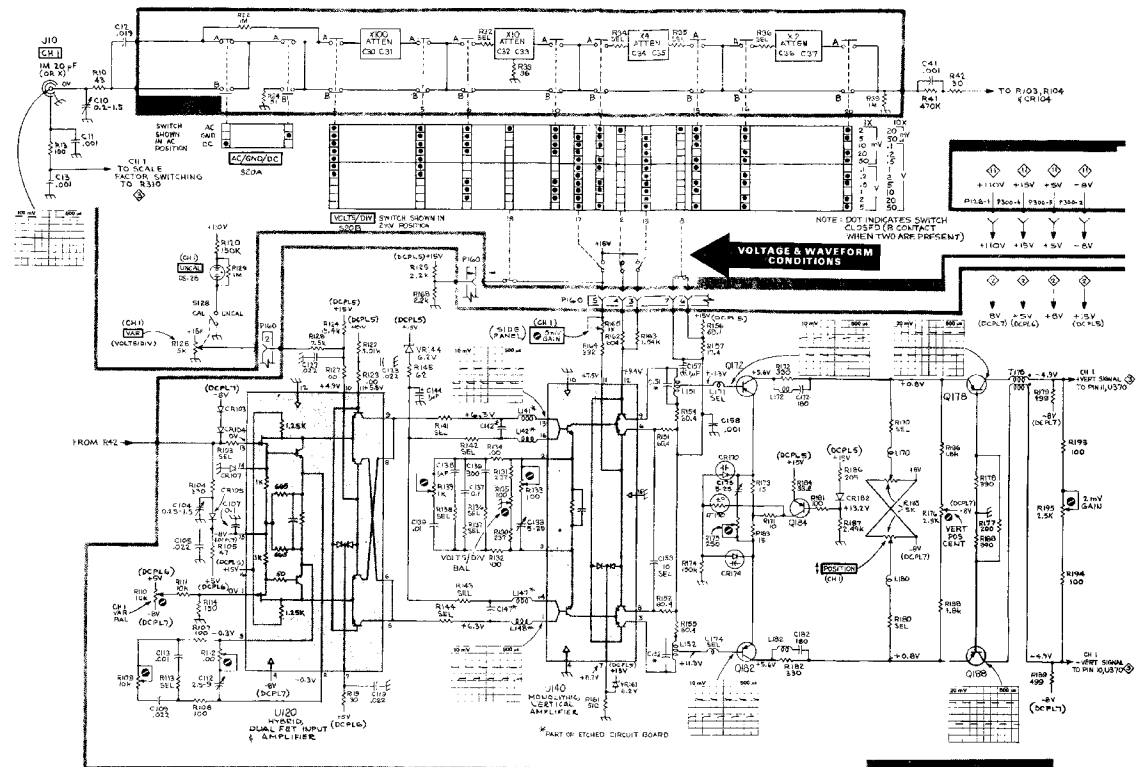
Voltage measurements are taken with no signal applied and the trace positioned to the center horizontal graticule line. The voltmeter common is connected to chassis ground.

**Waveform Conditions**

Apply the 475 calibrator signal to CH 1 input through a P6075 10X probe (supplied with 475). Connect 475 A: GATE (rear panel) through a 49-inch 50-ohm BNC cable to test oscilloscope external trigger input. Set test oscilloscope trigger source to external and set vertical input for ac coupling.

Set test oscilloscope VOLTS/DIV and TIME/DIV controls as indicated on readout symbols on each waveform.

Tolerance of voltages and waveforms shown are 20%.



CH 1 VERTICAL PREAMP

FO-2. Channel 1 vertical preamplifier schematic diagram.

## VOLTAGES AND WAVEFORMS

The voltages and waveforms shown on this diagram were obtained by using the recommended test equipment and test set-ups listed below.

RECOMMENDED TEST EQUIPMENT		
ITEM	SPECIFICATIONS	RECOMMENDED TYPE
Test oscilloscope	Frequency response DC to 75 MHz Deflection factor 1 mV to 5 V/Div Input impedance 1 MQ 20 pF Sweep rate 50 ns	Tektronix 7603 equipped with 7A13 Amplifier and 7B50 Time-base units, or equivalent.
Probe	Fast-rise 10X attenuation probe compatible with vertical amplifier of test oscilloscope.	Tektronix P6053B, or equivalent.
Voltmeter (Non-loading Digital Multimeter)	Input impedance 10 MD Range 0 to 500 V	Tektronix DM 501 Digital Multimeter or equivalent.

### 475 Control Settings

Display Controls  
INTENSITY Midrange  
FOCUS Midrange  
SCALE ILLUM Midrange

### Vertical Controls (CH 1 and CH 2)

POSITION Center trace on graticule  
VOLTS/DIV 2 mV for dc voltages  
100 mV for waveforms  
VAR VOLTS/DIV Calibrated detent  
AC-GND-DC DC  
INVERT Off (button out)  
VERT MODE CH 1  
100 or 20 MHz BW Full bandwidth (Push in, men release)

### Trigger Controls (A and B)

COUPLING AC  
LEVEL 0  
SLOPE +  
SOURCE NORM  
TRIG MODE AUTO  
A TRIGGER HOLDOFF NORM

Sweep Controls  
TIME/DIV 0.1 ms  
VAR TIME/DIV Calibrated detent  
DELAY TIME Full counterclockwise  
HORIZ DISPLAY A  
X10 MAG Off (button out)  
POSITION (Horiz) Midrange  
FINE Midrange

### Voltage Measurements

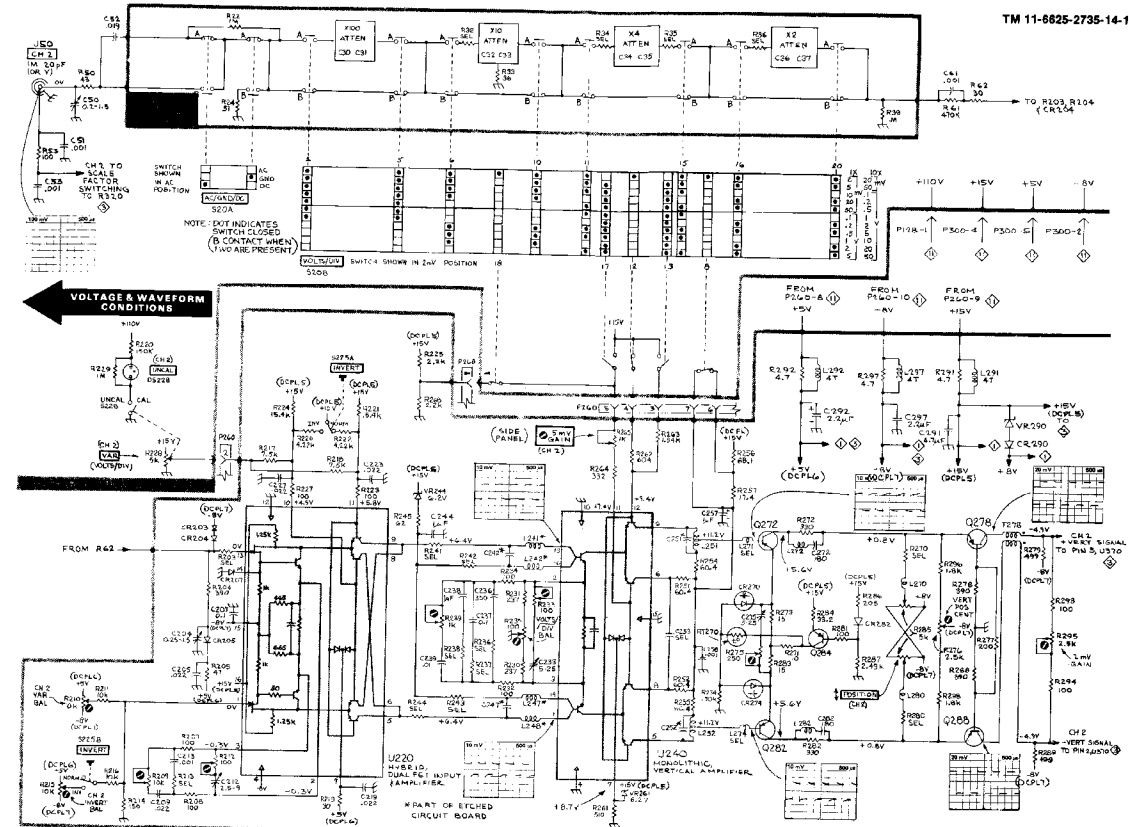
Voltage measurements are taken with no signal applied and the trace positioned to the center horizontal graticule line. The voltmeter common is connected to chassis ground.

### Waveform Conditions

Apply the 475 calibrator signal to CH 1 input through a P6075 10X probe (supplied with 475). Connect 475 A - GATE (rear panel) through a 42-inch 50-ohm BNC cable to test oscilloscope external trigger input. Set test oscilloscope trigger source to external and set vertical input for ac coupling.

Set test oscilloscope VOLTS/DIV and TIME/DIV controls as indicated on readout symbols on each waveform.

Tolerance of voltages and waveforms shown are 20%.



CH 2 VERTICAL PREAMP  
FO-3. Channel 2 vertical preamplifier schematic diagram.

**VOLTAGES AND WAVEFORMS**

The voltages and waveforms shown on this diagram were obtained by using the recommended test equipment and test set-ups listed below.

RECOMMENDED TEST EQUIPMENT		
ITEM	SPECIFICATIONS	RECOMMENDED TYPE
Test oscilloscope	Frequency response DC to 75 MHz Deflection factor 1 mV to 5 V/Div Input impedance 1 MΩ 20 pF Sweep rate 50 ns	Tektronix 7603 equipped with 7A13 Amplifier and 7B50 Time-base units, or equivalent.
Probe	Fast-rise 10X attenuation probe compatible with vertical amplifier of test oscilloscope.	Tektronix P6053B, or equivalent.
Voltmeter (Non-loading Digital Multimeter)	Input impedance 10 MΩ Range 0 to 500 V	Tektronix DM 501 Digital Multimeter or equivalent.

**475 Control Settings**

Display Controls	TIME/DIV MIDRANGE	SWEEP CONTROLS TIME/DIV MIDRANGE	0.1 ms Calibrated detent
INTENSITY	MIDRANGE	VAR TIME/DIV DELAY TIME POSITION	Full counterclockwise
FOCUS	MIDRANGE	HORIZ DISPLAY X10 MAG	A Off (button out)
SCALE ILLUM	MIDRANGE	POSITION (Horiz) FINE	MIDRANGE

**Vertical Controls (CH 1 and CH 2)**

POSITION	Center trace on graticule
VOLTS/DIV	2 mV for dc voltages 100 mV for waveforms
VAR VOLTS/DIV	Calibrated detent
AC-GND-DC	DC
INVERT	Off (button out)
VERT MODE	CH 1
100 or 20 MHz BW	Full bandwidth (Push in, then release)

**Trigger Controls (A and B)**

COUPLING	AC
LEVEL	D
SLOPE	+
SOURCE	NORM
TRIG MODE	AUTO
A TRIGGER HCLDOFF	NORM

**Voltage Measurements**

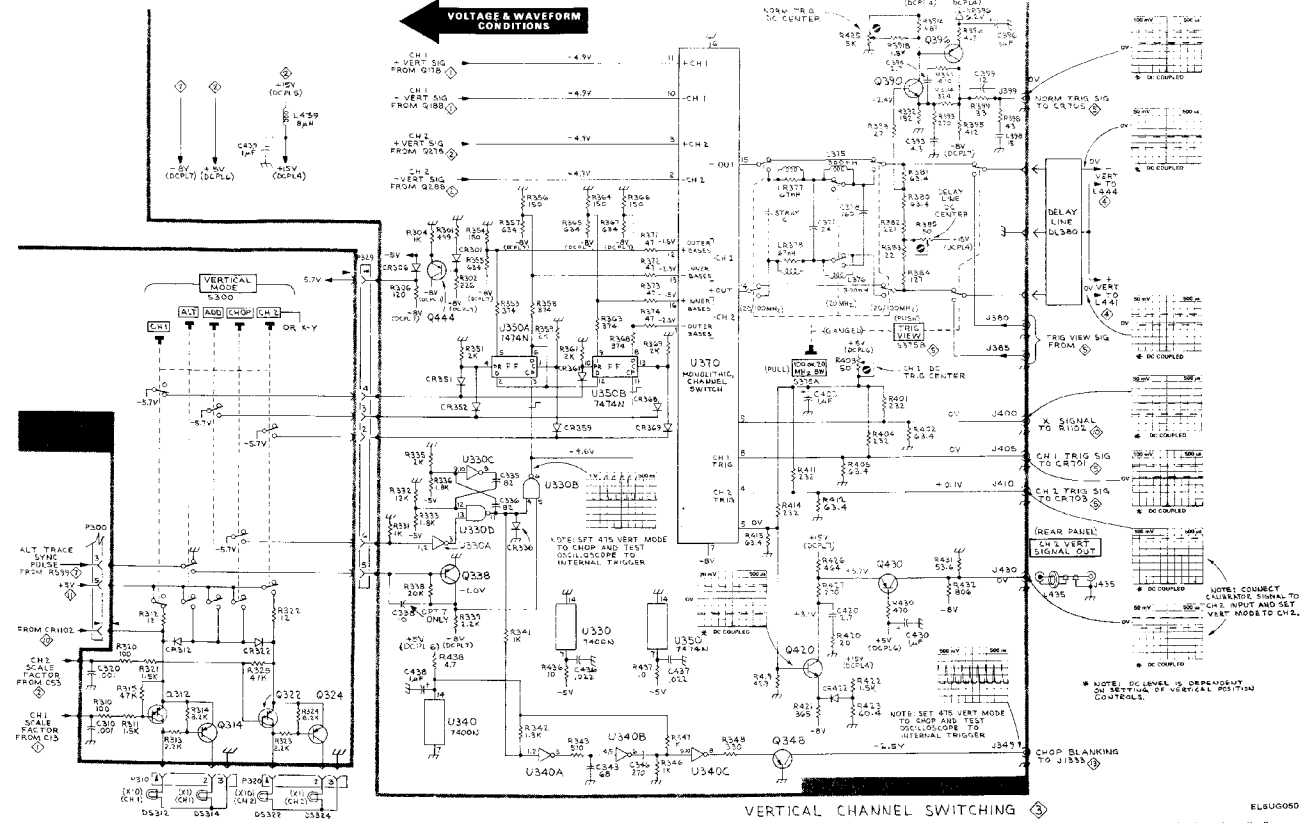
Voltage measurements are taken with no signal applied and the trace positioned to the center horizontal graticule line. The voltmeter common is connected to chassis ground.

**Waveform Conditions**

Apply the 475 calibrator signal to CH 1 input through a P8075 10X probe (supplied with 475). Connect 475 A - GATE (rear panel) through a 42-inch 50-ohm BNC cable to test oscilloscope external trigger input. Set test oscilloscope trigger source to external and set vertical input for ac coupling. For waveforms which have the horizontal centerline labeled 0 V, set the test oscilloscope vertical input for dc coupling.

Set test oscilloscope VOLTS/DIV and TIME/DIV controls as indicated on readout symbols on each waveform.

Tolerance of voltages and waveforms shown are 20%.





**VOLTAGES AND WAVEFORMS**

The voltages and waveforms shown on this diagram were obtained by using the recommended test equipment and test set-ups listed below.

RECOMMENDED TEST EQUIPMENT		
ITEM	SPECIFICATIONS	RECOMMENDED TYPE
Test oscilloscope	Frequency response DC to 75 MHz Deflection factor 1 mV to 5 V/Div Input impedance 1 MΩ 20 pF Sweep rate 50 ns	Tektronix 7603 equipped with 7A13 Amplifier and 7B50 Time-base units, or equivalent.
Probe	Fast-rise 10X attenuation probe compatible with vertical amplifier of test oscilloscope.	Tektronix P6053B, or equivalent.
Voltmeter (Non-loading Digital Multimeter)	Input Impedance 10 MΩ Range 0 to 500 V	Tektronix DM 501 Digital Multimeter or equivalent.

**475 Control Settings**

Display Controls  
 INTENSITY Midrange  
 FOCUS Midrange  
 SCALE ILLUM Midrange

Vertical Controls (CH 1 and CH 2)  
 POSITION Center trace on graticule  
 VOLTS/DIV 2 mV for ac voltages  
 100 mV for waveforms  
 VAR VOLTS/DIV Calibrated detent  
 AC-GND-DC DC  
 INVERT OFF (button out)  
 VERT MODE CH 1  
 100 or 20 MHz BW Full bandwidth (Push in, then release)

Trigger Controls (A and B)  
 COUPLING AC  
 LEVEL 0  
 SLOPE -  
 SOURCE NORM  
 TRIG MODE AUTO  
 A TRIGGER HOLDOFF NORM

Sweep Controls  
 TIME/DIV 0.1 ms  
 VAR TIME/DIV Calibrated detent  
 DELAY TIME  
 POSITION Full counterclockwise  
 HORIZ DISPLAY A  
 X10 MAG Off (button out)  
 POSITION (Horiz) Midrange  
 FINE Midrange

**Voltage Measurements**

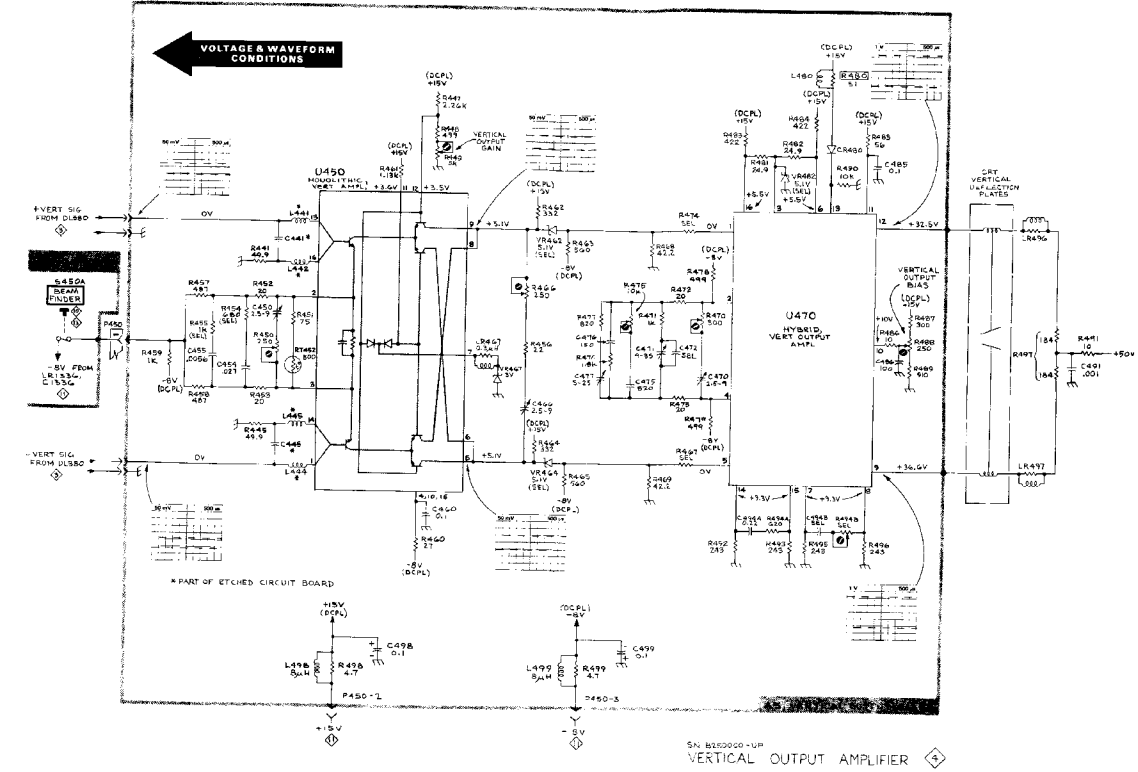
Voltage measurements are taken with no signal applied and the trace positioned to the center horizontal graticule line. The voltmeter common is connected to chassis ground.

**Waveform Conditions**

Apply the 475 calibrator signal to CH 1 input through a P6075 10X probe (supplied with 475). Connect 475 A 1 GATE (rear panel) through a 42-inch 50-ohm BNC cable to test oscilloscope external trigger input. Set test oscilloscope trigger source to external and set vertical input for ac coupling.

Set test oscilloscope VOLTS/DIV and TIME/DIV controls as indicated on readout symbols on each waveform.

Tolerance of voltages and waveforms shown are 20%.



SN 1850000-UP  
 VERTICAL OUTPUT AMPLIFIER

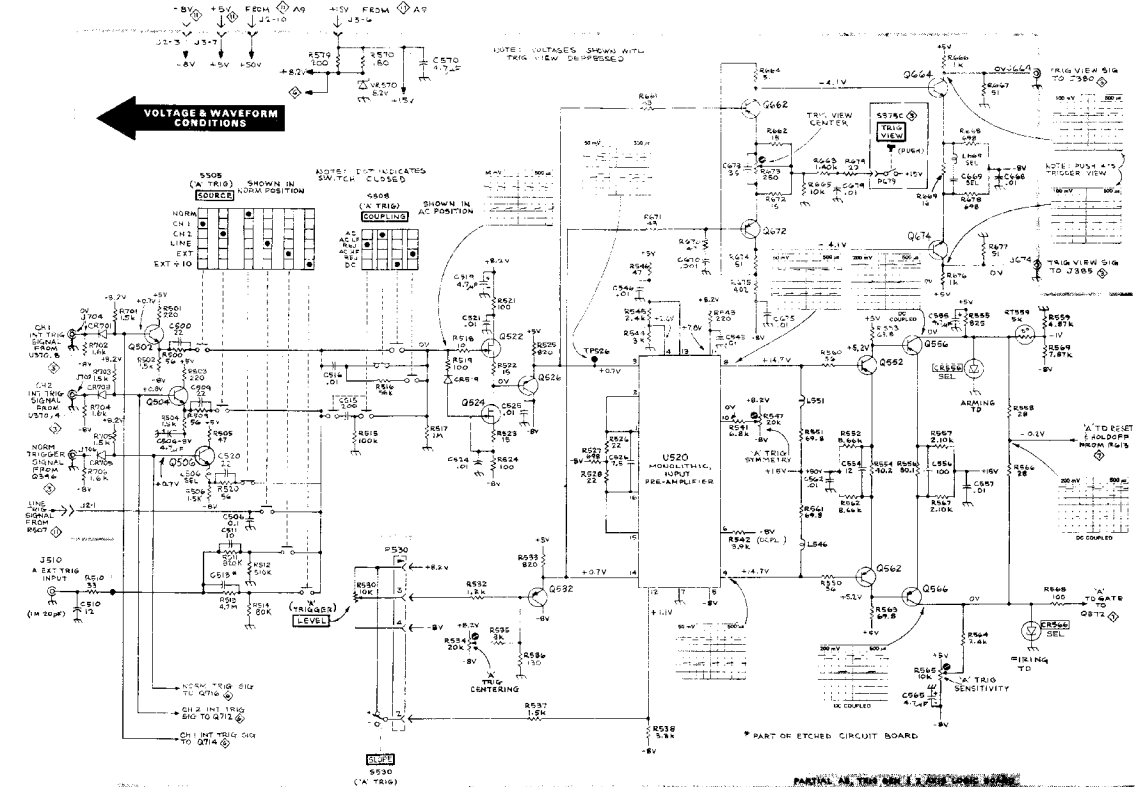
**VOLTAGES AND WAVEFORMS**

The voltages and waveforms shown on this diagram were obtained by using the recommended test equipment and test set-ups listed below.

RECOMMENDED TEST EQUIPMENT		
ITEM	SPECIFICATIONS	RECOMMENDED TYPE
Test oscilloscope	Frequency response: DC to 75 MHz Deflection factor: 1 mV to 5 V/Div Input impedance: 1 MΩ, 20 pF Sweep rate: 50 ns	Tektronix 7603 equipped with 7A3 Amplifier and 7B50 Time-base units, or equivalent
Probe	Fast-rise 10X attenuation probe compatible with vertical amplifier of test oscilloscope.	Tektronix P6053B, or equivalent
Voltmeter (Non-loading Digital Multimeter)	Input Impedance: 10 MΩ Range: 0 to 500 V	Tektronix DM 501 Digital Multimeter or equivalent.

**475 Control Settings**

- |  |   |   |  |   |   |
|--|---|---|--|---|---|
| <p><b>Display Controls</b></p> <p>INTENSITY Midrange</p> <p>FOCUS Midrange</p> <p>SCALE ILLUM Midrange</p> | <p><b>Vertical Controls (CH 1 and CH 2)</b></p> <p>POSITION Center trace on graticule</p> <p>VOLTS/DIV 2 mV for dc voltages</p> <p>VAR VOLTS/DIV 100% for waveforms</p> <p>AC-GND-DC DC</p> <p>INVERT Off (button out)</p> <p>VERT MODE CH</p> <p>100 or 20 MHz BW Full bandwidth (Push in, to release)</p> | <p><b>Trigger Controls (A and B)</b></p> <p>COUPLING AC</p> <p>LEVEL 0</p> <p>SLOPE -</p> <p>SOURCE NORM</p> <p>TRIG MODE AUTO</p> <p>A TRIGGER HILOFF NORM</p> | <p><b>Sweep Controls</b></p> <p>TIME/DIV 0.1 ms</p> <p>VAR TIME/DIV Calibrated detent</p> <p>DELAY TIME POSITION</p> <p>HORIZ DISPLAY Full counterclockwise</p> <p>X10 MAG A</p> <p>POSITION (Horiz) Off (button out)</p> <p>FINE Midrange</p> | <p><b>Voltage Measurements</b></p> <p>Voltage measurements are taken with no signal applied and the trace positioned to the center horizontal graticule lines. The voltmeter common is connected to chassis ground.</p> | <p><b>Waveform Conditions</b></p> <p>Apply the 475 calibrator signal to CH 1 input through a P6075 10X probe (supplied with 475). Connect 475 A-GATE (rear panel) through a 42-inch 50-ohm BNC cable to test oscilloscope external trigger input. Set test oscilloscope trigger source to external and set vertical input for ac coupling. For waveforms which have the horizontal centerline labeled 0 V, set the test oscilloscope vertical input for dc coupling.</p> <p>Set test oscilloscope VOLTS/DIV and TIME/DIV controls as indicated on readout symbols on each waveform.</p> <p>Tolerance of voltages and waveforms shown are 20%.</p> |
|--|---|---|--|---|---|



**VOLTAGES AND WAVEFORMS**

The voltages and waveforms shown on this diagram were obtained by using the recommended test equipment and test set-ups listed below.

RECOMMENDED TEST EQUIPMENT		
ITEM	SPECIFICATIONS	RECOMMENDED TYPE
Test oscilloscope	Frequency response DC to 75 MHz Deflection factor 1 mV to 5 V/Div Input impedance 1 MΩ 20 pF Sweep rate 50 ns	Tektronix 7603 equipped with 7A13 Amplifier and 7B60 Time-base units, or equivalent.
Probe	Fast-rise 10X attenuation probe compatible with vertical amplifier of test oscilloscope.	Tektronix P6053B, or equivalent
Voltmeter (Non-loading Digital Multimeter)	Input Impedance 10 MΩ Range 0 to 500 V	Tektronix DM 501 Digital Multimeter or equivalent

**475 Control Settings**

Display Controls  
 INTENSITY Midrange  
 FOCUS Midrange  
 SCALE ILLUM Midrange

Vertical Controls (CH 1 and CH 2)  
 POSITION Center trace on graticule  
 VOLTS/DIV 2 mV for dc voltages  
 100 mV for waveforms  
 VAR VOLTS/DIV Calibrated detent  
 AC-GND-DC DC  
 INVERT Off (button out)  
 VERT MODE CH 1  
 100 or 20 MHz BW Full bandwidth (Push in, then release)

Trigger Controls (A and B)  
 COUPLING AC  
 LEVEL 0  
 SLOPE -  
 SOURCE NORM  
 TRIG MODE AUTO  
 A TRIGGER HOLD OFF NORM

Sweep Controls  
 TIME DIV 0.1 ms  
 VAR TIME/DIV Calibrated detent  
 DELAY TIME A  
 POSITION Full counterclockwise  
 X10 MAG Off (button out)  
 POSITION (Horiz) Midrange  
 FINE Midrange

**Voltage Measurements**

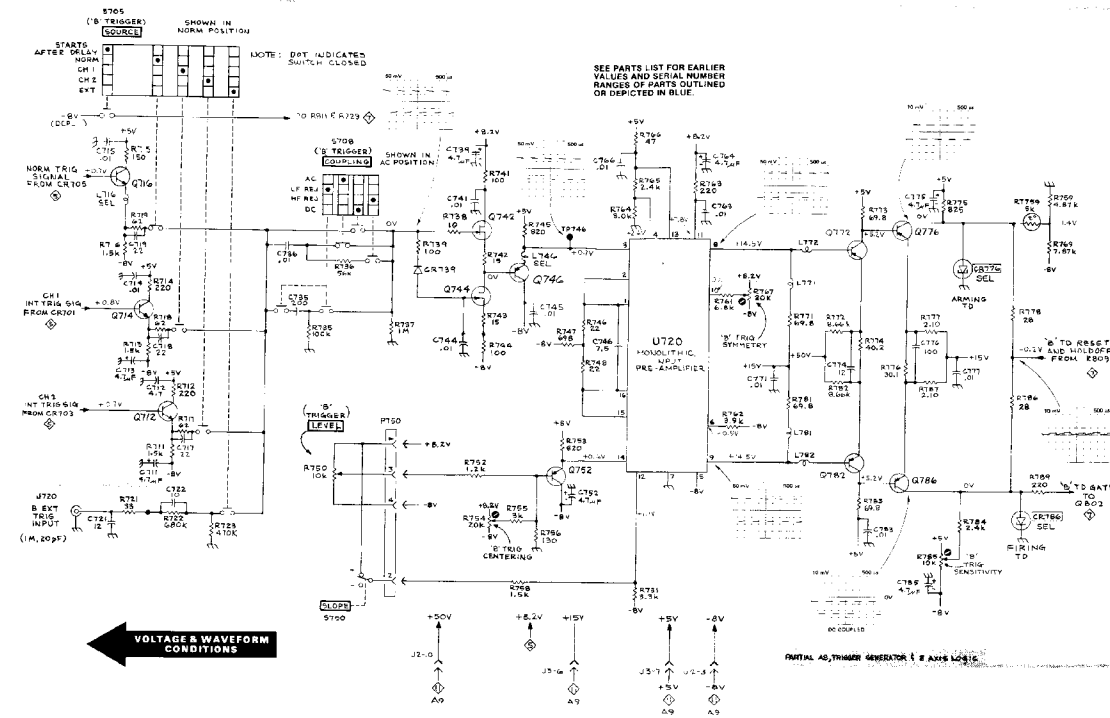
Voltage measurements are taken with no signal applied and the trace positioned to the center horizontal graticule line. The voltmeter common is connected to chassis ground.

**Waveform Conditions**

Apply the 475 calibrator signal to CH 1 input through a P6075 10X probe (supplied with 475). Connect 475 A-GATE (rear panel) through a 42-inch 50-ohm BNC cable to test oscilloscope external trigger input. Set test oscilloscope trigger source to external and set vertical input for ac coupling. For waveforms which have the horizontal centerline labeled 0 V, set the test oscilloscope vertical input for dc coupling.

Set test oscilloscope VOLTS/DIV and TIME/DIV controls as indicated on readout symbols on each waveform.

Tolerance of voltages and waveforms shown are 20%.



**B TRIGGER GENERATOR**

ELEU0053

FIG. 7. B Trigger generator schematic diagram.

### VOLTAGES AND WAVEFORMS

The voltages and waveforms shown on this diagram were obtained by using the recommended test equipment and test set-ups listed below.

RECOMMENDED TEST EQUIPMENT		
ITEM	SPECIFICATIONS	RECOMMENDED TYPE
Test oscilloscope	Frequency response DC to 75 MHz Deflection factor 1 mV to 5 V/Div Input impedance 1 MΩ 20 pF Sweep rate 50 ns	Tektronix 7603 equipped with 7A13 Amplifier and 7B50 Time-base units, or equivalent.
Probe	Fast-rise 10X attenuation probe compatible with vertical amplifier of test oscilloscope.	Tektronix P6053B or equivalent.
Voltmeter (Non-loading Digital Multimeter)	Input Impedance 10 MΩ Range 0 to 500 V	Tektronix DM 501 Digital Multimeter or equivalent.

#### 475 Control Settings

Display Controls		Swamp Controls	
INTENSITY	Midrange	TIME/DIV	0.1 ms
FOCUS	Midrange	VAR TIME/DIV	Calibrated detent
SCALE ILLUM	Midrange	DELAY TIME	A
		POSITION	Full counterclockwise
		HORIZ DISPLAY	A (button out)
		OFF (button out)	Midrange
		POSITION (Horiz)	Midrange
		FINE	Midrange

Vertical Controls (CH 1 and CH 2)		Voltage Measurements	
POSITION	Center trace on graticule	Voltage measurements are taken with no signal applied and the trace positioned to the center horizontal graticule line. The voltmeter common is connected to chassis ground.	
VOLTS/DIV	2 mV for dc voltages 100 mV for waveforms		
VAR VOLTS/DIV	Calibrated detent		
AC-GND-DC	DC		
INVERT	Off (button out)		
VERT MODE	CH 1		
	Full bandwidth (Push in, then release)		

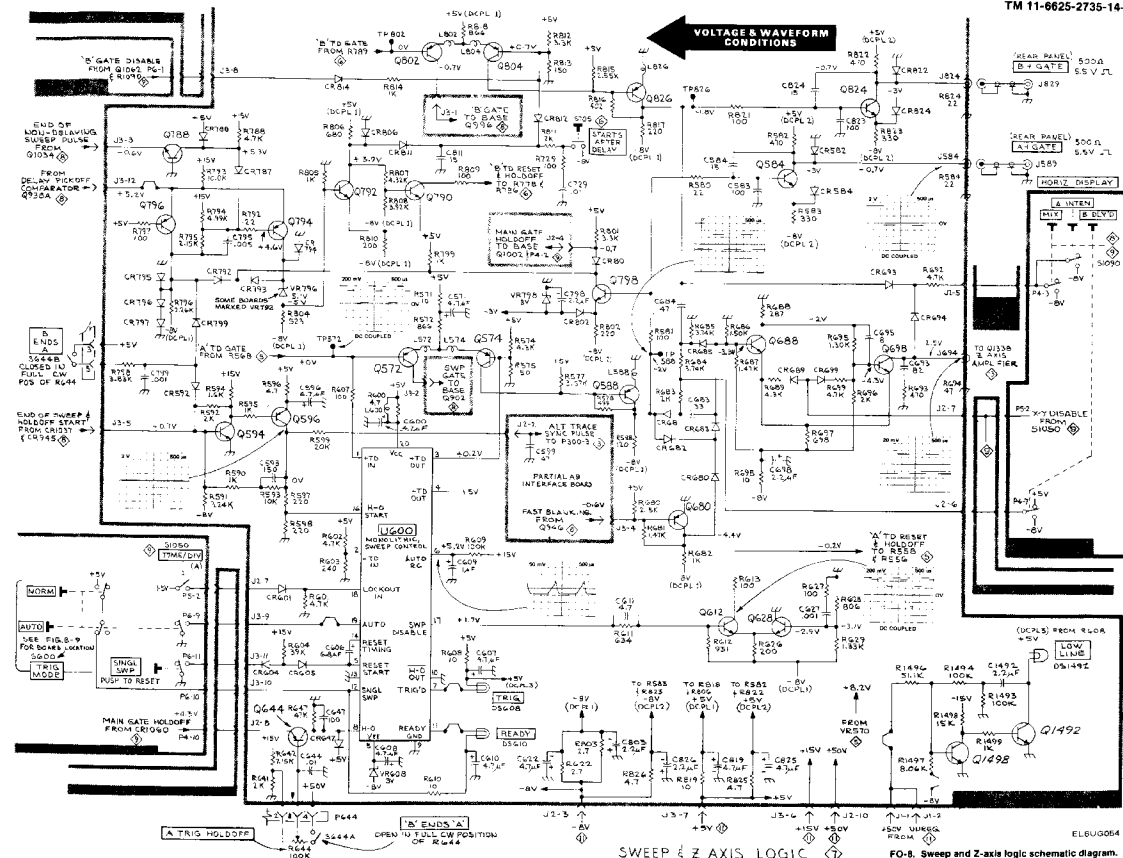
#### Trigger Controls (A and B)

COUPLING	AC
LEVEL	0
SLOPE	+
SOURCE	NORM
TRIG MODE	AUTO (for waveforms) SINGL SWP (for dc voltages READY light off)
A TRIGGER HOLD OFF	NORM

#### Waveform Conditions

Apply the 475 calibrator signal to CH 1 input through a P607B 10X probe (supplied with 475). Connect 475 A - GATE (rear panel) through a 42-inch 50-ohm BNC cable to test oscilloscope external trigger input. Set test oscilloscope trigger source to external and set vertical input for ac coupling. For waveforms which have the horizontal center line labeled 0 V DC, set the test oscilloscope vertical input for dc coupling.

Set test oscilloscope VOLTS/DIV and TIME/DIV controls as indicated on readout symbols on each waveform. Tolerance of voltages and waveforms shown are 20%.



**VOLTAGES AND WAVEFORMS**

The voltages and waveforms shown on this diagram were obtained by using the recommended test equipment and test set-ups listed below.

RECOMMENDED TEST EQUIPMENT		
ITEM	SPECIFICATIONS	RECOMMENDED TYPE
Test oscilloscope	Frequency response DC to 75 MHz Deflection factor 1 mV to 5 V/Div Input impedance 1 MΩ 20 pF Sweep rate 50 ns	Tektronix 7603 equipped with 7A13 Amplifier and 7D50 Time-base units, or equivalent.
Probe	Fast-rise 10X attenuation probe compatible with vertical amplifier of test oscilloscope	Tektronix P6053B, or equivalent
Voltmeter (Non-loading Digital Multimeter)	Input impedance 10 MΩ Range 0 to 500 V	Tektronix DM 501 Digital Multimeter or equivalent.

**475 Control Settings**

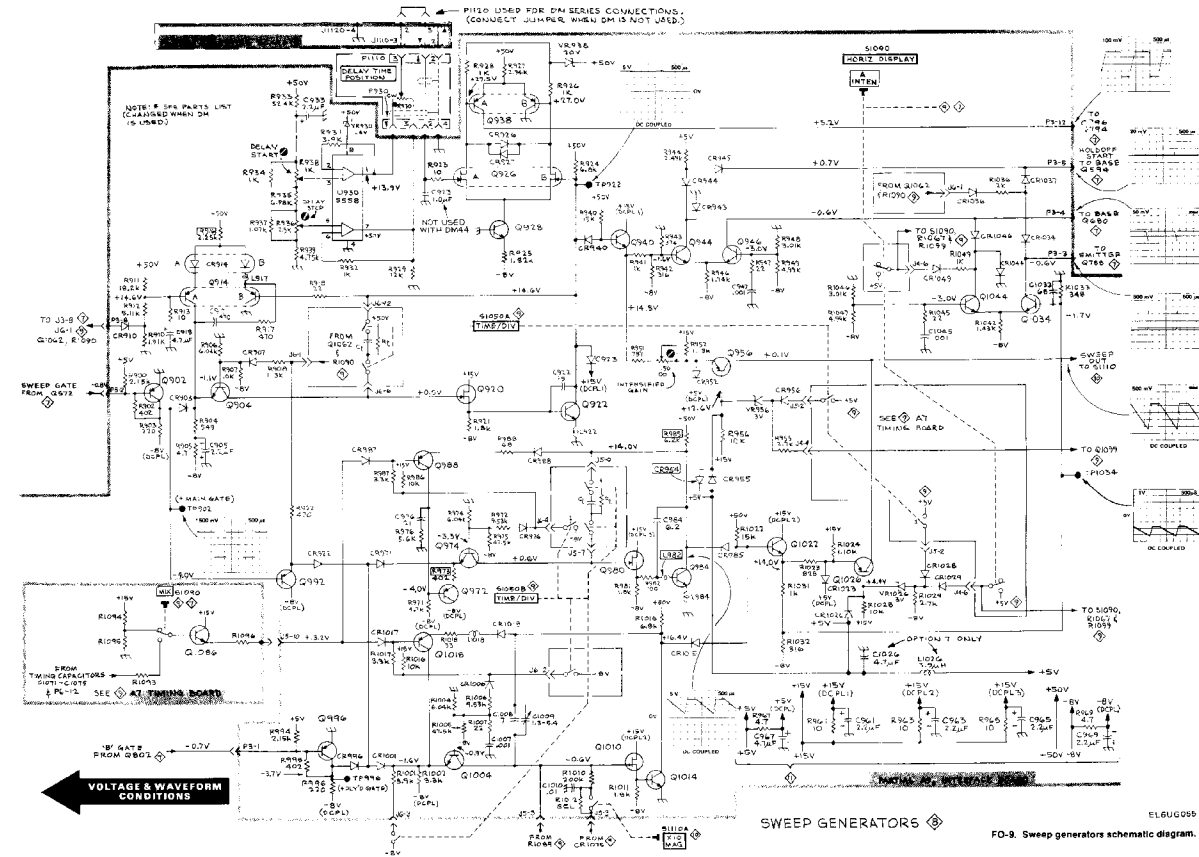
Display Controls		
INTENSITY	Midrange	
FOCUS	Midrange	
SCALE ILLUM	Midrange	
Vertical Controls (CH 1 and CH 2)		
POSITION	Center trace on graticule	
VOITS/DIV	2 mV for dc voltages 100 mV for waveforms	
VAR VOLTS/DIV	DC	
AC-GND-DC	DC	
INVERT	Off (button out)	
VERT MODE	CH 1	
	100 or 20 MHz BW	
	Full bandwidth (Push in, then release)	
Trigger Controls (A and B)		
COUPLING	AC	
LEVEL	0	
SLOPE	-	
SOURCE	NORM	
TRIG MODE	AUTO (for waveforms) SINGL SWP (for dc voltages. READY light off)	
A TRIGGER HOLDOFF	NORM	

**Sweep Controls**  
 TIME/DIV 0.1 ms  
 VAR TIME/DIV Calibrated detent  
 DELAY TIME Full counterclockwise  
 POSITION A  
 HORIZ DISPLAY Off (button out)  
 POSITION (Horiz) Midrange  
 FINE Midrange

**Voltage Measurements**  
 Voltage measurements are taken with no signal applied and the trace positioned to the center horizontal graticule line. The voltmeter common is connected to chassis ground.

**Waveform Conditions**  
 Apply the 475 calibrator signal to CH 1 input through a P6075 10X probe (supplied with 475). Connect 475 A GATE (rear panel) through a 42-inch 50-ohm BNC cable to test oscilloscope external trigger input. Set test oscilloscope trigger source to external and set vertical input for ac coupling. For waveforms which have the horizontal centerline labeled 0 VDC, set the test oscilloscope vertical input for dc coupling.

Set test oscilloscope VOLTS/DIV and TIME/DIV controls as indicated on readout symbols on each waveform. Tolerance of voltages and waveforms shown are 20%.



FO-9. Sweep generators schematic diagram.

### VOLTAGES AND WAVEFORMS

The voltages and waveforms shown on this diagram were obtained by using the recommended test equipment and test set-ups listed below.

RECOMMENDED TEST EQUIPMENT		
ITEM	SPECIFICATIONS	RECOMMENDED TYPE
Test oscilloscope	Frequency response: DC to 75 MHz Deflection factor: 1 mV to 5 V/Div Input impedance: 1 MΩ 20 pF Sweep rate: 50 ns	Iektronix 7803 equipped with 7A13 Amplifier and 7R50 Time-base units, or equivalent.
Probe	Fast-rise 10X attenuation probe compatible with vertical amplifier of test oscilloscope	Tektronix P6053B or equivalent.
Voltmeter (Non-loading Digital Multimeter)	Input Impedance: 10 MΩ Range: 0 to 500 V	Iektronix DM 501 Digital Multimeter or equivalent.

#### 475 Control Settings

Display Controls  
 INTENSITY Midrange  
 FOCUS Midrange  
 SCALE ILLUM Midrange

Vertical Controls (CH 1 and CH 2)  
 POSITION Center trace on graticule  
 VOLTS/DIV 2 mV for dc voltages  
 100 mV for waveforms  
 VAR VOLTS/DIV Calibrated detent  
 AC-GND-DC DC  
 INVERT Off (button out)  
 VERT MODE CH 1  
 100 or 20 MHz BW Full bandwidth (Push in, then release)

Trigger Controls (A and B)  
 COUPLING AC  
 LEVEL 0  
 SLOPE +  
 SOURCE NORM  
 TRIG MODE AUTO (for waveforms)  
 SINGL SWP (for dc voltages, READY light off).  
 A TRIGGER HOLDOFF NORM

Sweep Controls  
 TIME/DIV 0.1 ms  
 VAR TIME/DIV Calibrated detent  
 DELAY TIME  
 POSITION Full counterclockwise  
 HORIZ DISPLAY A  
 X10 MAG Off (button out)  
 POSITION (Horiz) Midrange  
 FINE Midrange

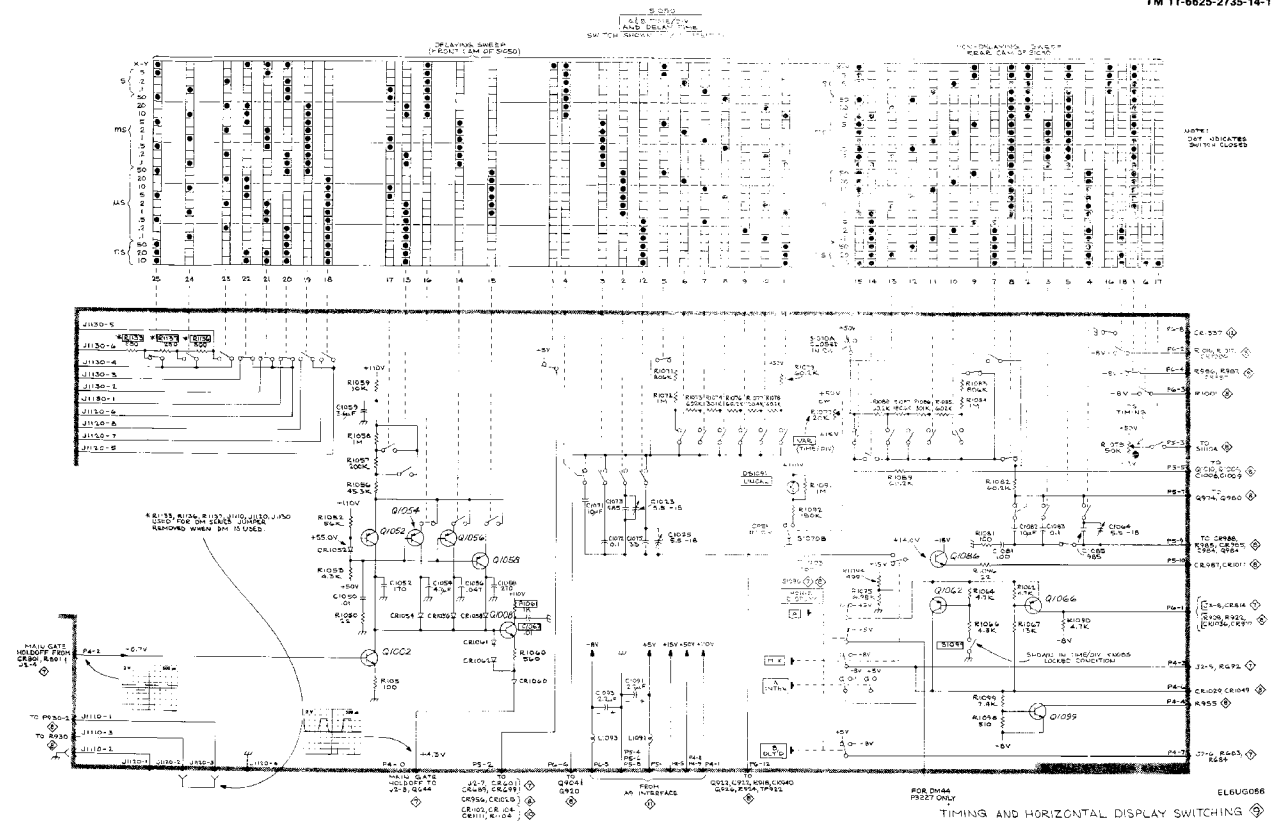
#### Voltage Measurements

Voltage measurements are taken with no signal applied and the trace positioned to the center horizontal graticule line. The voltmeter common is connected to chassis ground.

#### Waveform Conditions

Apply the 475 calibrator signal to CH 1 input through a P6075 10X probe (supplied with 475). Connect 475 A - GATF (rear panel) through a 42-inch 50-ohm BNC cable to test oscilloscope external trigger input. Set test oscilloscope trigger source to external and set vertical input for ac coupling. For waveforms which have the horizontal centerline labeled 0 V DC, set the test oscilloscope vertical input for dc coupling.

Set test oscilloscope VOLTS/DIV and TIME/DIV controls as indicated on readout symbols on each waveform. Tolerance of voltages and waveforms shown are 20%.



**VOLTAGES AND WAVEFORMS**

The voltages and waveforms shown on this diagram were obtained by using the recommended test equipment and test set-ups listed below.

ITEM	RECOMMENDED TEST EQUIPMENT	
	SPECIFICATIONS	RECOMMENDED TYPE
Test oscilloscope	Frequency response DC to 75 MHz Deflection factor 1 mV to 5 V/Div Input impedance 1 MΩ 20 pF Sweep rate 50 ns	Tektronix 7603 equipped with 7A13 Amplifier and 7B50 Time-base units, or equivalent.
Probe	Fast-rise 10X attenuation probe compatible with vertical amplifier of test oscilloscope.	Tektronix P6053B or equivalent
Voltmeter (Non-loading Digital Multimeter)	Input Impedance 10 MΩ Range 0 to 500 V	Tektronix DM 501 Digital Multimeter or equivalent.

**475 Control Settings**

Display Controls	Midrange	Sweep Controls	0.1 ms
INTENSITY	Midrange	TIME/DIV	Calibrated detent
FOCUS	Midrange	VAR TIME/DIV	Calibrated detent
SCALE ILLUM	Midrange	DELAY TIME	Full counter-clockwise
		POSITION	A
		HORIZ DISPLAY	Off (button out)
		X10 MAG	Midrange
		POSITION (Horiz)	Midrange
		FINE	Midrange

**Vertical Controls (CH 1 and CH 2)**

POSITION	Center trace on graticule
VOLTS/DIV	2 mV for dc voltages
VAR VOLTS/DIV	100 mV for waveforms
AC-GND-DC	DC
INVERT	Off (button out)
VER1 MODE	CH 1
100 or 20 MHz BW	Full bandwidth (Push in, then release)

**Trigger Controls (A and B)**

COUPLING	AC
LEVEL	0
SLOPE	1
SOURCE	NORM
TRIG MODE	AUTO
A TRIGGER HOLDOFF	NORM

**Voltage Measurements**

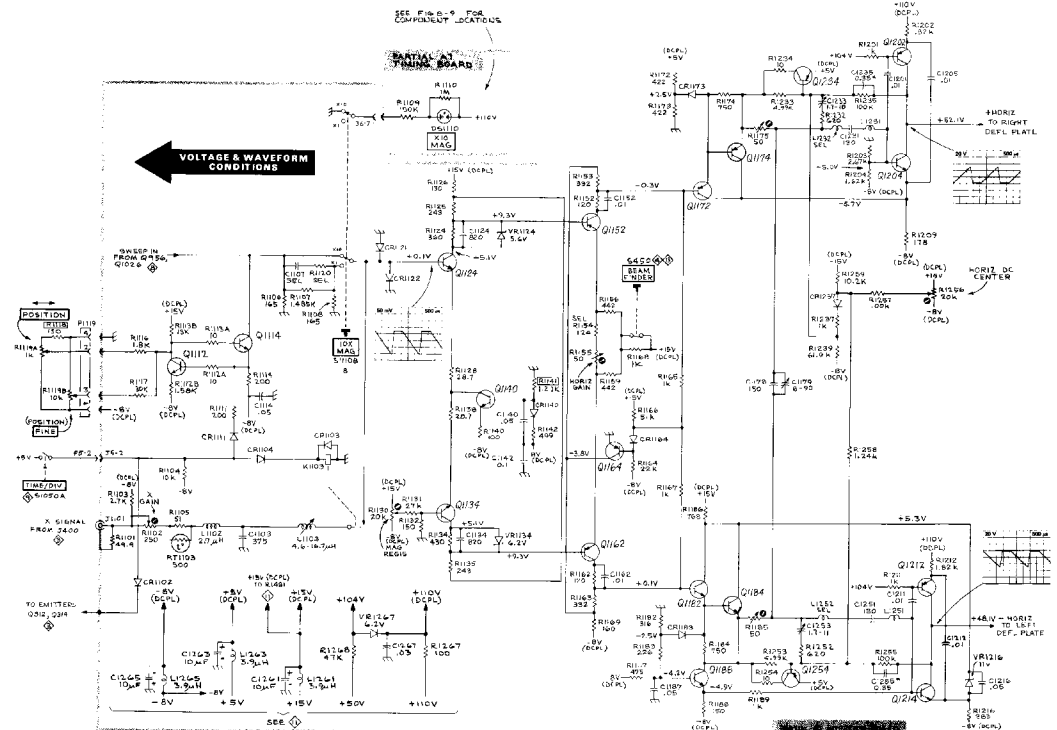
Voltage measurements are taken with no signal applied and the trace positioned to the center horizontal graticule line. The voltmeter common is connected to chassis ground.

**Waveform Conditions**

Apply the 475 calibrator signal to CH 1 input through a P6075 10X probe (supplied with 475). Connect 475 A - GATE (rear panel) through a 42-inch 50-ohm BNC cable to test oscilloscope external trigger input. Set test oscilloscope trigger source to external and set vertical input for ac coupling. For waveforms which have the horizontal centerline labeled 0 V, set the test oscilloscope vertical input for dc coupling.

Set test oscilloscope VOLTS/DIV and TIME/DIV controls as indicated on readout symbols on each waveform.

Tolerance of voltages and waveforms shown are 20%.



**HORIZONTAL AMPLIFIER**  
FO-11. Horizontal amplifier schematic diagram.

RL8U-0057

**VOLTAGES AND WAVEFORMS**

The voltages and waveforms shown on this diagram were obtained by using the recommended test equipment and test set-ups listed below

RECOMMENDED TEST EQUIPMENT		
ITEM	SPECIFICATIONS	RECOMMENDED TYPE
Test oscilloscope	Frequency response DC to 75 MHz Deflection factor 1 mV to 5 V/Div Input impedance 1 MΩ 20 pF Sweep rate 50 ns	Tektronix 7603 equipped with 7A13 Amplifier and 7B50 Time-base units, or equivalent.
Probe	Fast-rise 10X attenuation probe compatible with vertical amplifier of test oscilloscope	Tektronix P6053B, or equivalent.
Voltmeter (Non-loading Digital Multimeter)	Input Impedance 10 MΩ Range 0 to 500 V	Tektronix DM 501 Digital Multimeter or equivalent.

**475 Control Settings**

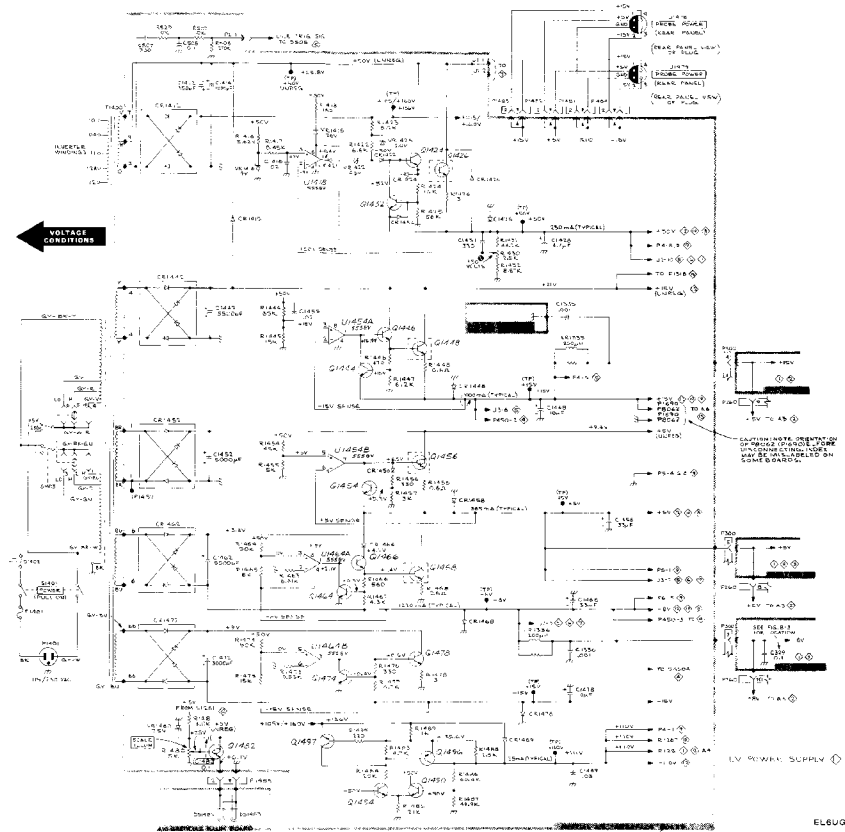
Display Controls		Sweep Controls	
INTENSITY	Midrange	TIME/DIV	0.1 ms
FOCUS	Midrange	VAR TIME/DIV	Calibrated detent
SCALE ILLUM	Midrange	DELAY TIME	
		POSITION	Full counterclockwise
		HORIZ DISPLAY	A
		X10 MAG	Off (button out)
		POSITION (Horiz)	Midrange
		FINE	Midrange

**Vertical Controls (CH 1 and CH 2)**

POSITION	Center trace on graticule	<b>Voltage Measurements</b>	Voltage measurements are taken with no signal applied and the trace positioned to the center horizontal graticule line. The voltmeter common is connected to chassis ground.
VOLTS/DIV	2 mV for dc voltages 100 mV for waveforms		
VAR VOLTS/DIV	Calibrated detent	<b>Waveform Conditions</b>	Apply the 475 calibrator signal to CH 1 input through a P6075 10X probe (supplied with 475). Connect 475 A-GATE (rear panel) through a 42-inch 50-ohm BNC cable to test oscilloscope external trigger input. Set test oscilloscope trigger source to external and set vertical input for ac coupling.
AC-GND-DC	DC		
INVERT	Off (button out)		
VERT MODE	CH 1		
100 or 20 MHz BW	Full bandwidth (Push in, then release)		Set test oscilloscope VOLTS/DIV and TIME/DIV controls as indicated on readout symbols on each waveform.

**Trigger Controls (A and B)**

COUPLING	AC	Tolerance of voltages and waveforms shown are 20%.
LEVEL	0	
SLOPE	-	
SOURCE	NORM	
TRIG MODE	AUTO	
A TRIGGER HOLDOFF	NORM	



FD-12. Low voltage power supply schematic diagram.



**VOLTAGES AND WAVEFORMS**

The voltages and waveforms shown on this diagram were obtained by using the recommended test equipment and test set-ups listed below.

RECOMMENDED TEST EQUIPMENT		
ITEM	SPECIFICATIONS	RECOMMENDED TYPE
Test oscilloscope	Frequency response DC to 75 MHz Collection factor 1 mV to 5 V/Div Input impedance 1 MΩ 20 pF Sweep rate 50 ns	Tektronix 7603 equipped with 7A13 Amplifier and 7B50 Time-base unit, or equivalent.
Probe	Fast-rise 10X attenuation probe compatible with vertical amplifier of test oscilloscope.	Tektronix P6053B or equivalent.
Voltmeter (Non-loading Digital Multimeter)	Input impedance 10 MΩ Range 0 to 500 V	Tektronix DM 501 Digital Multimeter or equivalent.

**475 Control Settings**

Display Controls		Sweep Controls	
INTENSITY	Midrange	TIME/DIV	0.1 ms
FOCUS	Midrange	VAR TIME/DIV	Calibrated detent
SCALE ILLUM	Midrange	DELAY TIME	
		POSITION	Full counterclockwise
		HORIZ DISPLAY	A
		X10 MAG	Off (button out)
		POSITION (Horiz)	Midrange
		FINE	Midrange

**Vertical Controls (CH 1 and CH 2)**

POSITION	Center trace on graticule
VOLTS/DIV	2 mV for dc voltages 100 mV for waveforms
VAR VOLTS/DIV	Calibrated detent
AC-GND-DC	DC
INVERT	Off (button out)
VERT MODE	CH 1
100 or 20 MHz BW	Full bandwidth (Push in, then release)

**Trigger Controls (A and B)**

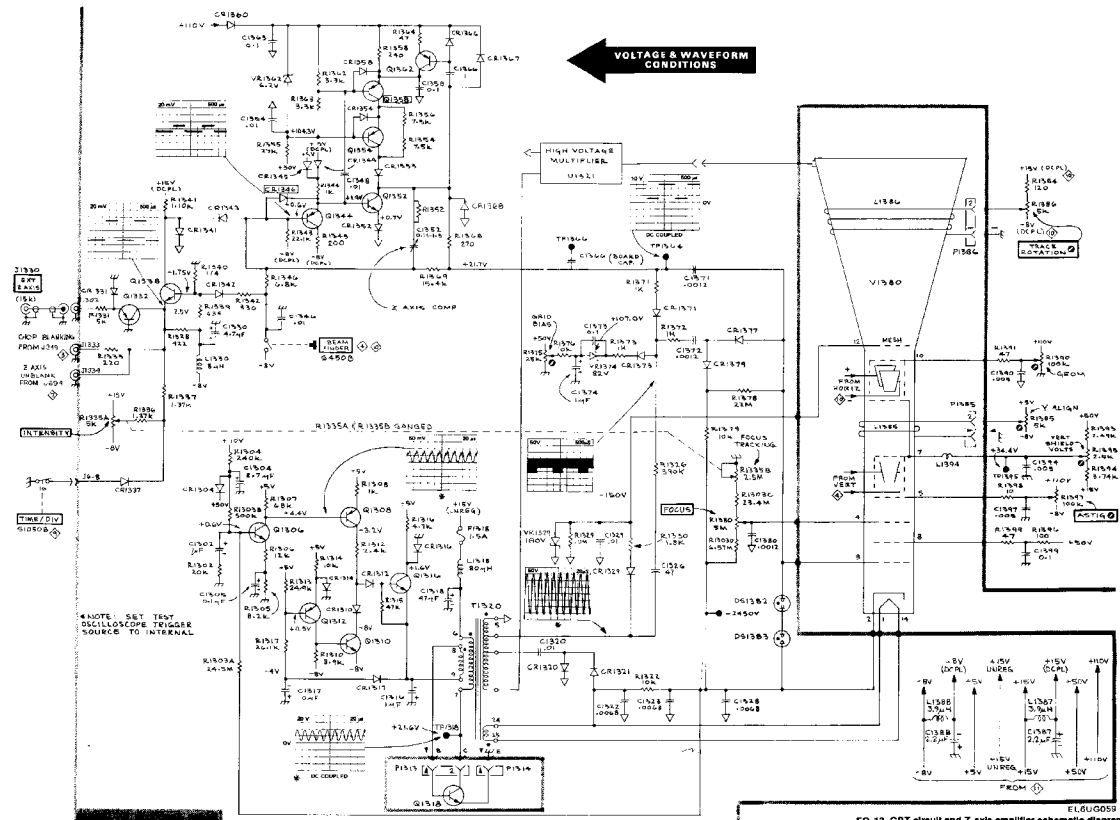
COUPLING	AC
LEVEL	0
SLOPE	↑
SOURCE	NORM
TRIG MODE	AUTO
A TRIGGER HOLDOFF	NORM

**Voltage Measurements**  
Voltage measurements are taken with no signal applied and the trace positioned to the center horizontal graticule line. The voltmeter common is connected to chassis ground.

**Waveform Conditions**  
Apply the 475 calibrator signal to CH 1 input through a P6075 10X probe (supplied with 475). Connect 475 A - GATE (rear panel) through a 42-inch 50-ohm BNC cable to test oscilloscope external trigger input. Set test oscilloscope external trigger input. Set test oscilloscope trigger source to external and set vertical input for ac coupling. For waveforms which have the horizontal centerline labeled 0 V, set the test oscilloscope vertical input for dc coupling.

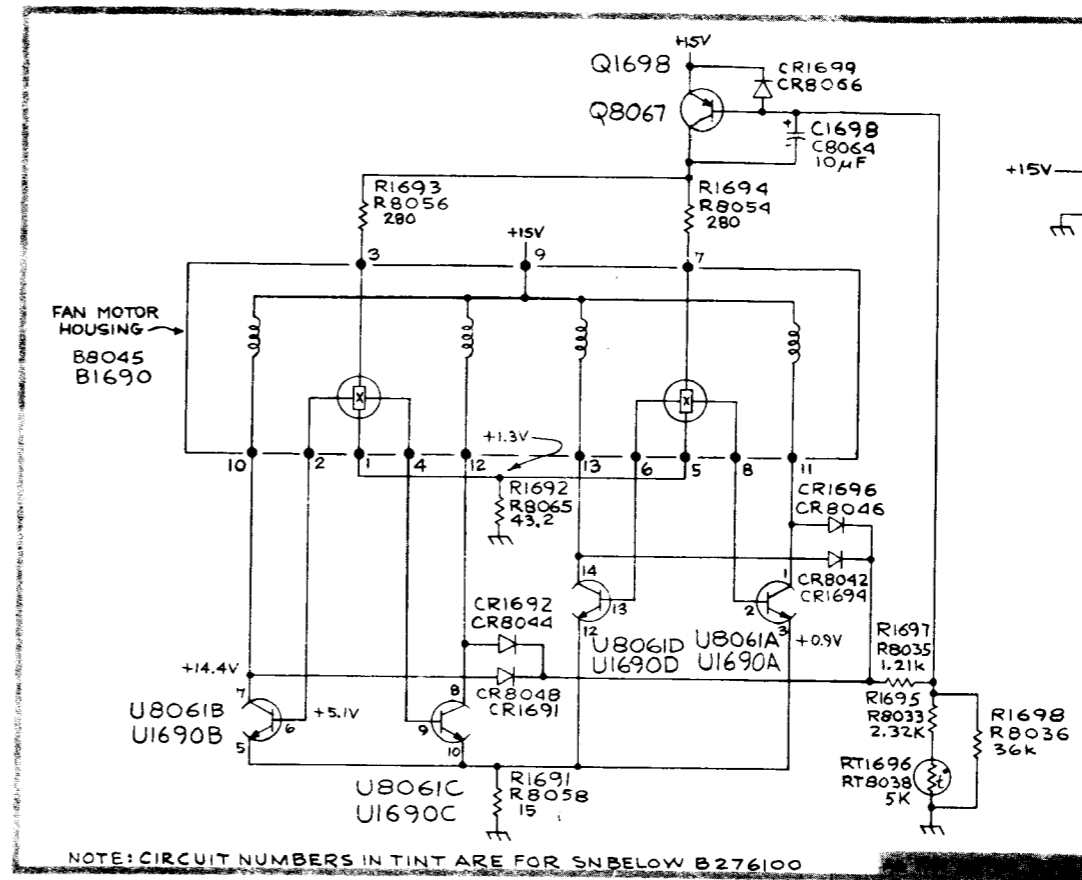
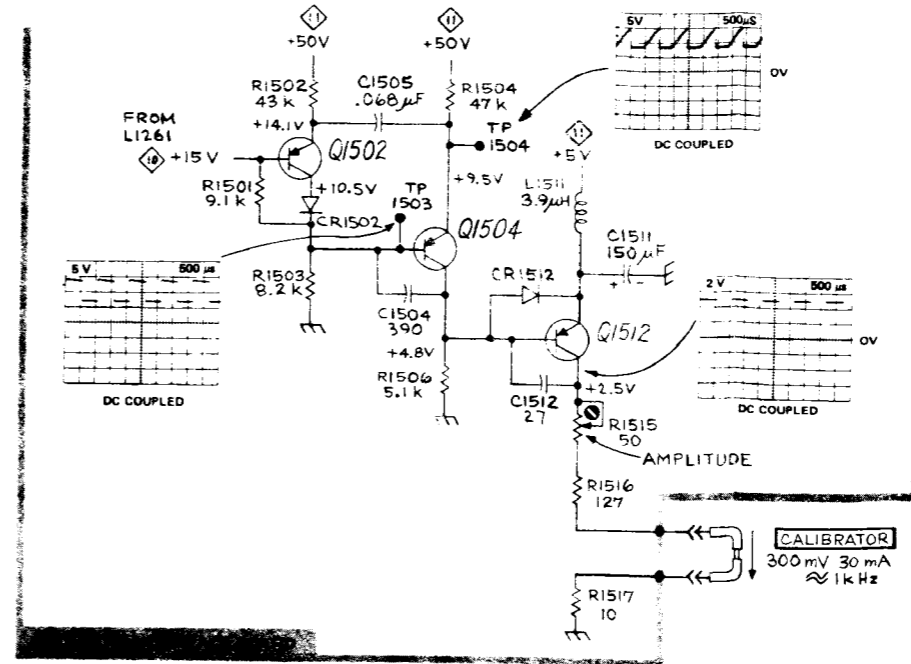
Set test oscilloscope VOLTS/DIV and TIME/DIV controls as indicated on readout symbols on each waveform.

Tolerance of voltages and waveforms shown are 20%.



CRT CIRCUIT & Z-AXIS AMPLIFIER

EQ-13. CRT circuit and Z-axis amplifier schematic diagram.

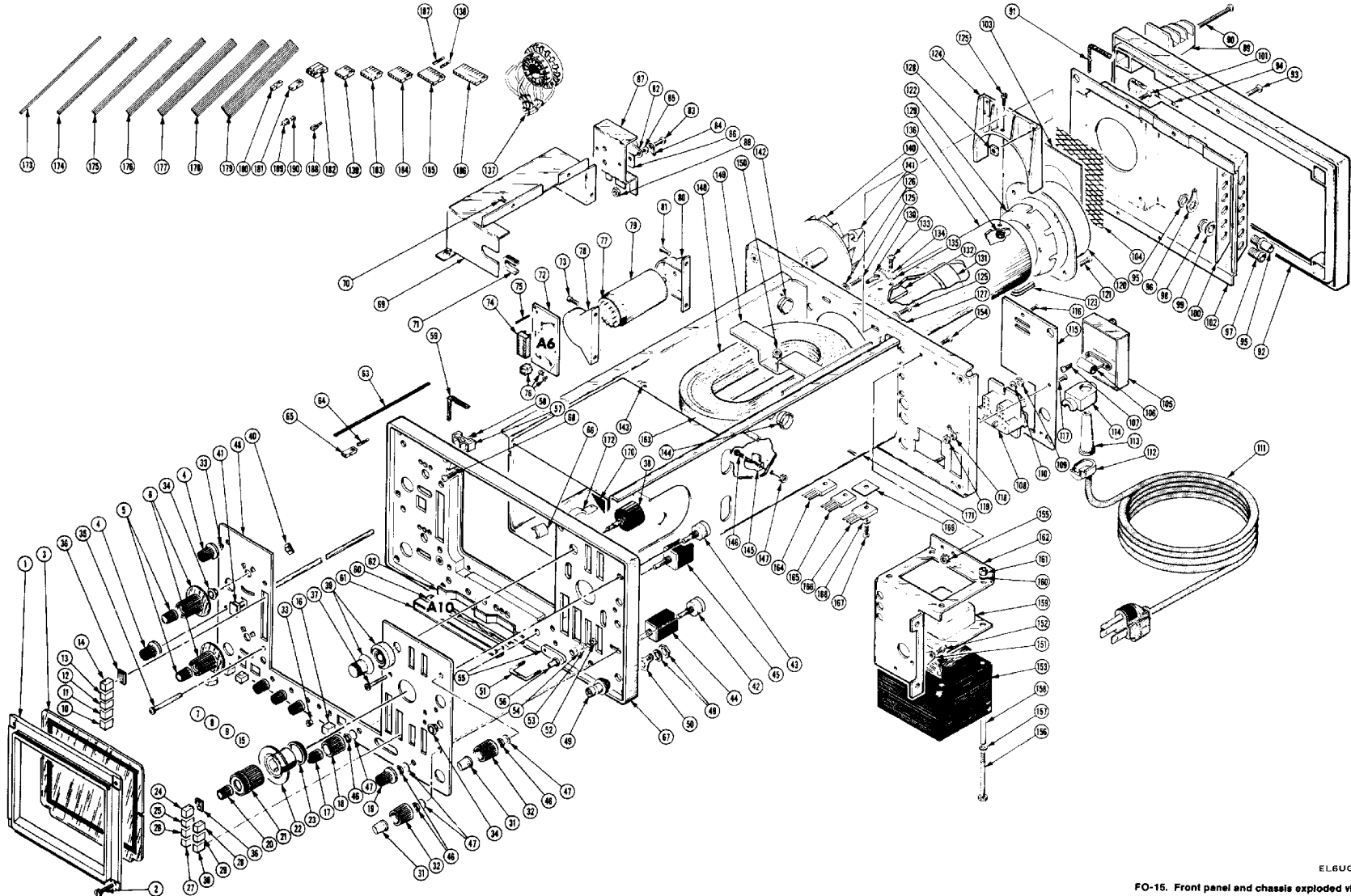


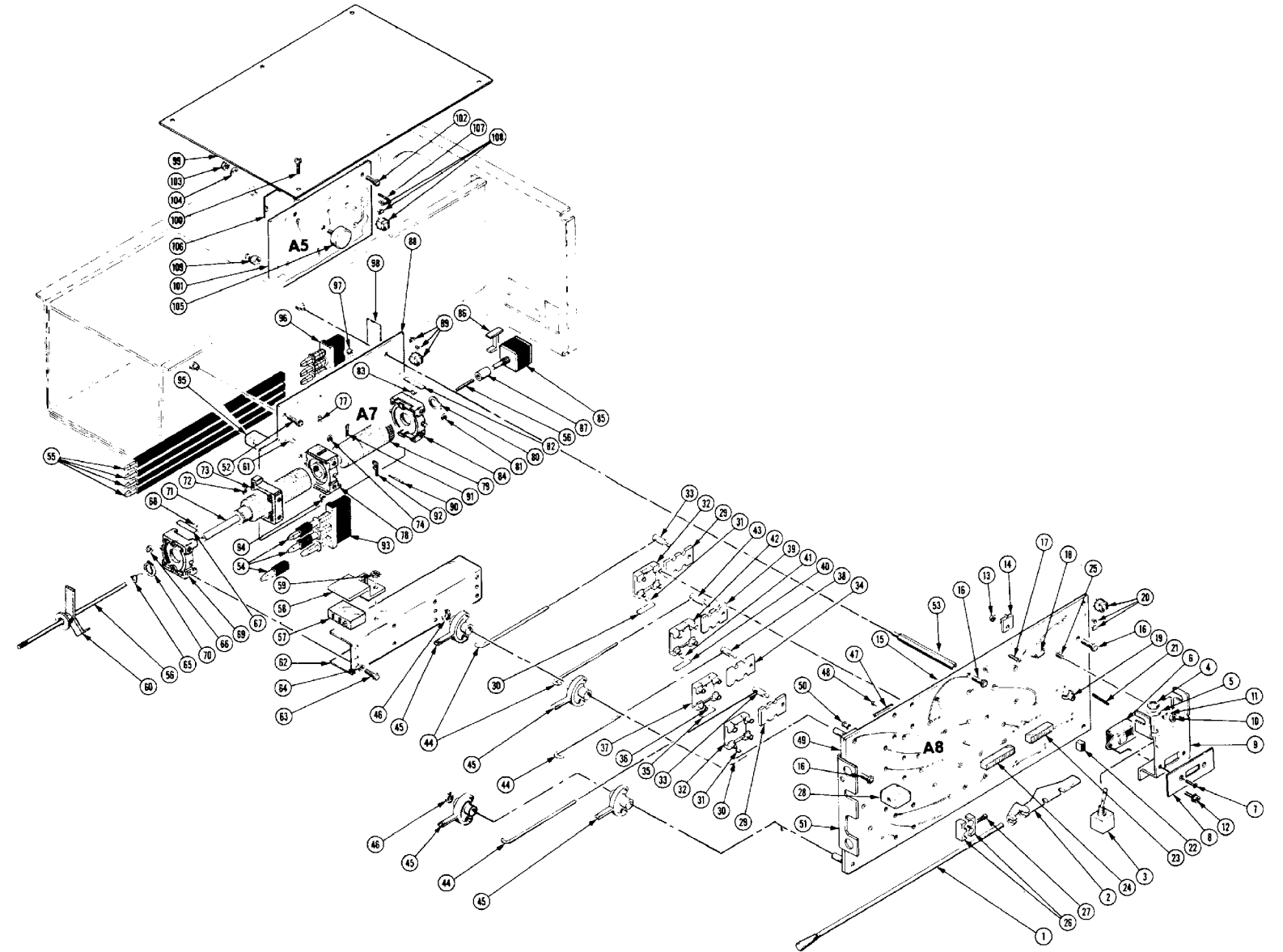
P1690  
P8062

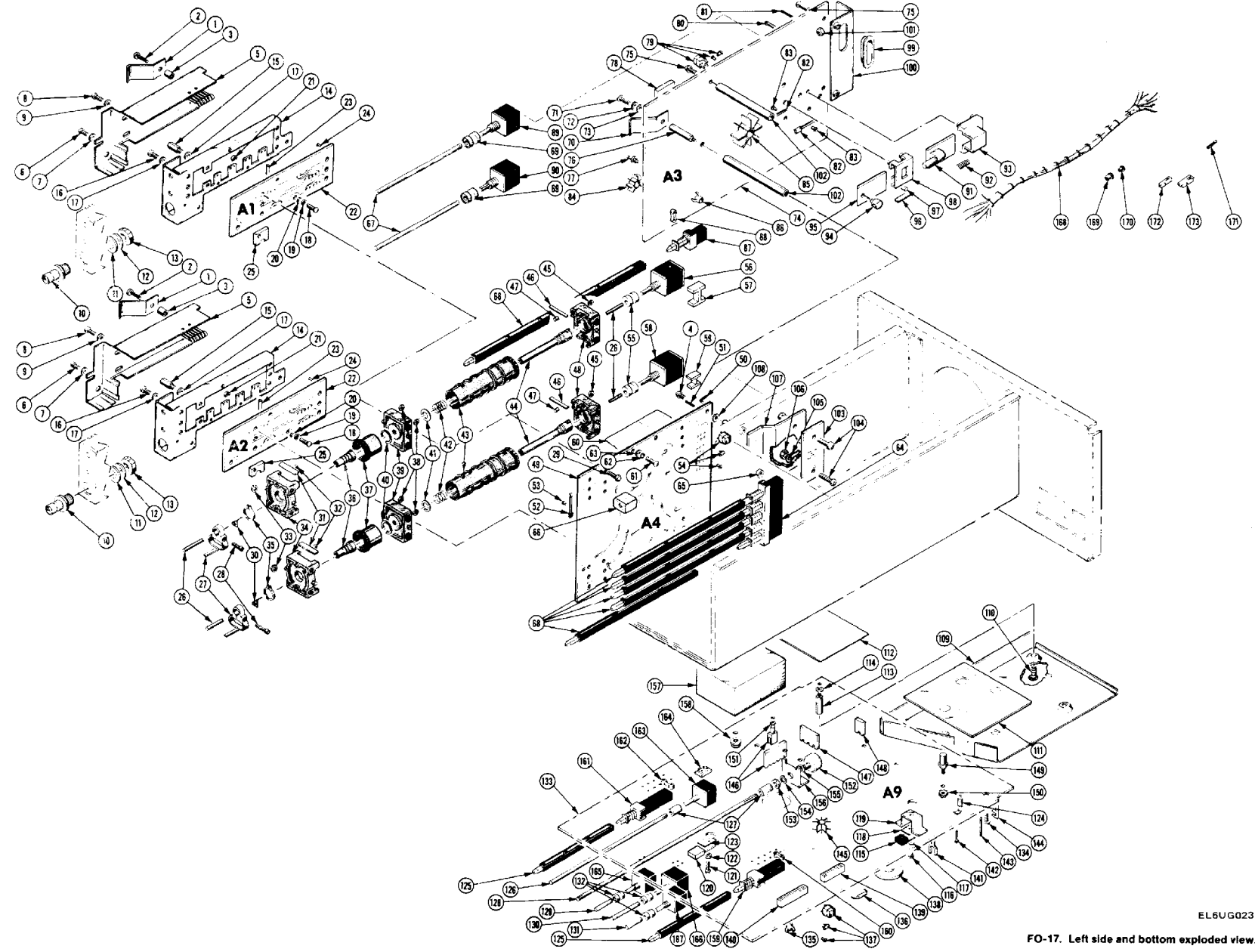
+15V A9

A9

CAUTION: NOTE ORIENTATION OF P8062 (P1690) BEFORE DISCONNECTING. INDEX MAY BE MISLABELED ON SOME BOARDS.







FO-17. Left side and bottom exploded view.

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PAGE NO	PARA-GRAPH	FIGURE NO	TABLE NO
2-25	2-28		
3-10	3-3		3-1
5-6	5-8		
		FO3	

IN THIS SPACE TELL WHAT IS WRONG AND WHAT SHOULD BE DONE ABOUT IT:

Recommend that the installation antenna alignment procedure be changed throughout to specify a 2° IFF antenna lag rather than 1°.

REASON: Experience has shown that with only a 1° lag, the antenna servo system is too sensitive to wind gusting in excess of 25 knots, and has a tendency to rapidly accelerate and decelerate as it hunts, causing strain to the drive train. Hunting is minimized by adjusting the lag to 2° without degradation of operation.

Item 5, Function column. Change "2 db" to "3db."

REASON: The adjustment procedure the the TRANS POWER FAULT indicator calls for a 3 db (500 watts) adjustment to light the TRANS POWER FAULT indicator.

Add new step f.1 to read, "Replace cover plate removed in step e.1, above."

REASON: To replace the cover plate.

Zone C 3. On J1-2, change "+24 VDC to "+5 VDC."

REASON: This is the output line of the 5 VDC power supply. +24 VDC is the input voltage.

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