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Patrick Jankowiak
Senior Engineer

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1120 Jupiter Rd., Ste. 190
Plano, TX 75074
972-702-8388
patrick@rdmproductions.com
www.rdmdrones.com

INSTRUCTION MANUAL

MODEL 1901C DISPLAY OSCILLOSCOPE

WAVETEK INDIANA INC.

66 N. FIRST AVENUE, P.O. BOX 190

BEECH GROVE, INDIANA 46107

317-783-3221

CONTENTS

LIST OF FIGURES AND TABLES

MANUAL CHANGE INFORMATION, if any, is located at the rear of this manual.

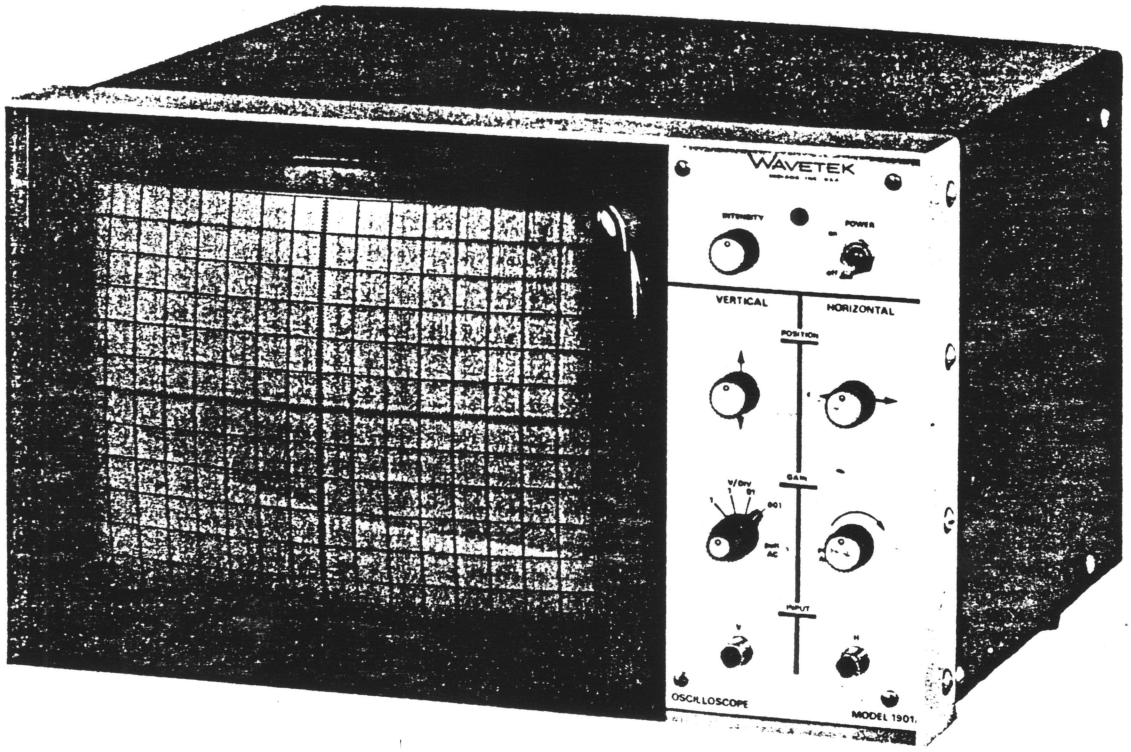


Figure i - Wavetek Display Oscilloscope

SECTION 1
GENERAL INFORMATION

1.1 INTRODUCTION

The Wavetek Display Oscilloscope is a low cost, large screen, solid state, X-Y display oscilloscope designed for production and laboratory test systems which employ sweep generator techniques.

For these applications several features have been incorporated in this large easy to read display.

1. Y-axis marker adder circuit.
2. Vertical polarity reversal.
3. Automatic spot blanking to prevent burning of the CRT phosphor.
4. Molded graticule for minimum paralax.

This instrument can also be used in many general purpose applications where a large screen X-Y display oscilloscope is required. Features important in the display for these applications are:

1. High frequency Z-axis amplifier for pulse marker or grey scale use.
2. Excellent full scan linearity.
3. High vertical sensitivity, up to 1 mV/division.
4. Ultra stable, low noise display.

The most outstanding features of this large-screen unit are its strength and reliability.

In the event servicing is required, maintenance personnel will find that the unit's p.c. board construction with convenient component layout plus a comprehensive instruction manual contribute to making this instrument easy to service.

1.2 SPECIFICATIONS

1.2.1 DISPLAY

CRT	12" diagonal (30 cm)
PHOSPHOR	P1 Medium persistence - Green
GRATICULE	12 vertical - 16 horizontal divisions (1.5 cm/div)
DEFLECTION	Magnetic
ACCELERATOR VOLTAGE	9kV nominal

1.2.2 VERTICAL

SENSITIVITY	4 position step attenuator for 1mV/div., 10 mV/div., 100mV/div., and 1V / div. Continuously variable vernier between steps.
INPUT IMPEDANCE	374K ohm
BANDWIDTH	DC to 15kHz (10 div. amplitude)
LINEARITY	5% (center 10 div.)
COUPLING	Switchable AC-DC (when AC coupled max DC voltage plus AC peak not to exceed 200V).
INPUT CONNECTOR	BNC, front panel
DRIFT	Less than ½ div/8 hr. (at a constant ambient after ½ hour warm up).

	POLARITY REVERSE	Vertical signal can be inverted with front panel switch.
1.2.3	MARKER ADDER	
	INPUT SIGNAL	Pulse or birdy
	SENSITIVITY (Max)	0.5 V/Division - continuously adjustable with rear panel control
	POLARITY	Rear panel polarity reversal switch
	INPUT IMPEDANCE	Approximately 15K ohm
1.2.4	HORIZONTAL	
	SENSITIVITY	Continuously adjustable from less than .1V Division to over 10V/Division.
	INPUT IMPEDANCE	Greater than 320K ohm
	BANDWIDTH	DC to 1.5KHz (14 div. amplitude)
	LINEARITY	3% (16 div.)
	COUPLING	Switchable AC-DC (when AC coupled max. DC voltage plus AC peak not to exceed 200V).
	INPUT CONNECTOR	BNC, front panel
	DRIFT	Less than ½ div/8 hr. (at a constant ambient temperature after ½ hour warm up)
1.2.5	INTENSITY MODULATION	
	SENSITIVITY	Adjustable from less than 1 V peak-to-peak to more than 10 V peak-to-peak for full modulation.
	INPUT IMPEDANCE	20 kΩ in parallel with 10 pF
	INPUT CONNECTOR	BNC, rear panel
	BANDWIDTH	Flat from DC to 1 MHz, 3 dB down at 3.5 MHz, 10 dB down at 10 MHz.
	POLARITY	Positive going voltage intensifies the trace. Internally changable for Positive Blanking
1.2.6	PROTECTION CIRCUIT	Prevents burning of the CRT by blanking the beam when the horizontal signal is less than approximately 4 divisions (60 Hz rate). When operating at a slower rate, or for servicing, a rear panel switch can be used to eliminate the protection circuit. May be changed internally to operate with vertical signal.
1.2.7	POWER	115/230 VAC ±10% 50/60 Hz (approximately 75 watts)
1.2.8	OPERATING TEMPERATURE	+10° to +50°C
1.2.9	MECHANICAL	
	DIMENSIONS	10 5/16" (262 mm) high x 14½" (368 mm) long x 16½" (419 mm) wide
	WEIGHT	26 pounds (11.8 Kg)

1.3 OPTIONS

OPT A	P4 phosphor, medium short persistence - white
OPT B	P7 phosphor, long persistence - blue
OPT C	clear face plate (no graticule)
OPT D	amber filter. Mounts between tube and face plate. (normally used with P7 phosphor.)

1.4 ACCESSORIES

INCLUDED	Operating Instruction Manual
AVAILABLE	Rack Mounting Kit
	Spare face plate without graticule
	Spare face plate with graticule

SECTION 2
INSTALLATION

2.1 INTRODUCTION

This section contains information for receiving and preparing the Display for use.

2.2 MECHANICAL INSTALLATION

2.2.1 INSPECTION AND DAMAGE CLAIMS

After unpacking, the instrument should be inspected for physical damage. A procedure for checking the electrical performance is given in Section 5. The shipping container and the packing material should be saved in case it becomes necessary to reship the unit.

If the unit is damaged or does not meet the electrical performance checks, notify the nearest Wavetek representative or the factory in Indiana. If the shipping container shows damage, notify the carrier. Retain the shipping container and packing material for the carrier's inspection. In either case, the factory or area representative will arrange for immediate repair or replacement of your instrument, without waiting for damage claim settlements.

2.2.2 OPERATING LOCATION

This unit can be used either on a bench or in an instrument rack. In either case insure that air flow is not restricted from passing through the rear panel heat sinks or ventillating holes.

Rack - Mounting kit, K107, enables the Display scope to be mounted in a standard 19" wide instrument rack. The kit consists of two aluminum brackets which fasten to the sides of the unit as shown in figure 2-1. Necessary screws are located in the pre-drilled holes provided for this accessory.

2.3 ELECTRICAL INSTALLATION

2.3.1 CONNECTION TO AC LINE

Before plugging in the instrument check the rear panel AC line voltage switch and the fuse to insure that the unit is prepared to operate with the available voltage. Fuse for 115V operation should be 2 A, for 230 V, 1 A.

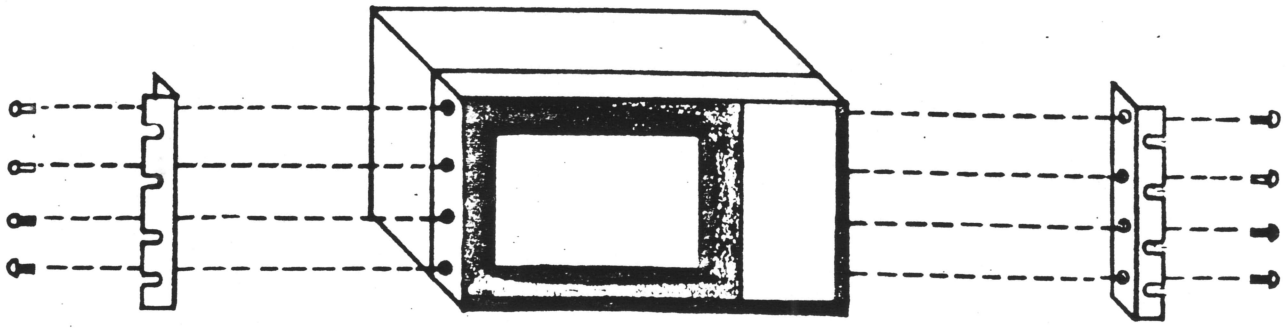


Figure 2-1. Rack Mounting Kit

2.3.2 PERFORMANCE

When the unit is turned on it is ready to use without warmup. For an electrical performance check of instrument refer to Section 5.3 of this manual.

2.3.3 Preliminary Operating Setup

There are three features of operation which are internally selectable by the customer.

1. Auto blanking axis (normally horizontal)
2. Auto blanking defeatability
3. Z-axis polarity (normally negative blanking)

To determine which operation is desired refer to description of rear panel controls, INTENSITY and AUTO BLANK, in Section 3.

AUTO BLANKING

A dual slide switch is located in the center of the main p.c. board. One half is for selecting either the horizontal or vertical signal to operate the Auto Blanking circuit. The other half is for defeating the operation of the rear-panel AUTO BLANK switch. The instructions for selecting the desired positions are in the upper left corner of the p.c. board. See Figure 5-5. In the ON position blanking will occur automatically and the rear-panel switch has no effect. In the OFF position the rear-panel AUTO BLANK switch can operate to allow or defeat automatic blanking. (Rear panel switch is normally ON.)

Z-Axis

To switch the polarity of the intensity modulation amplifier reverse the leads on the right side of the main p.c. board as shown in Figure 5-5.

SECTION 3
OPERATING INSTRUCTIONS

3.1 INTRODUCTION

This section includes descriptions of front and rear panel controls.

This instrument is ideal for use in conjuction with a Wavetek sweep generator. The vertical and horizontal amplifier specifications are very compatible with the signals that generate a demodulated RF response. The Y and Z marker inputs can be used conveniently with the various marker signals from the sweep generator. Consult the sweep generator manual for specific hookup instructions.

Applications for this instrument are certainly not limited to use with sweep generators. Any instrumentation requiring a large screen, X-Y display scope can include this unit.

3.2 DESCRIPTION OF FRONT PANEL

INTENSITY

Controls the brightness of the display.

POWER

Toggle switch applies primary power to the instrument. The LED Pilot light indicates an operating condition.

VERTICAL

POSITION..controls the vertical position of the trace. Pull to invert display.

GAIN...V/Div selects the vertical amplifier deflection factor. The vernier control provides a continuously variable adjustment between the ranges of the V/Div switch (Vernier must be fully clockwise to indicate a calibrated deflection factor). Input coupling of the vertical signal is normally DC. Pulling out on the vernier control will provide AC coupling of the input signal.

INPUT V...BNC connector for the vertical input signal. Maximum peak input should not exceed 200 V.

HORIZONTAL

POSITION...controls the horizontal position of the trace.

GAIN...vernier control provides a continuously variable adjustment of the horizontal input signal. Input coupling of the horizontal signal is normally DC. Pulling out on the vernier control will provide AC coupling of the input signal.

INPUT H..BNC connector for the horizontal input signal. Maximum peak input should not exceed 200 V.

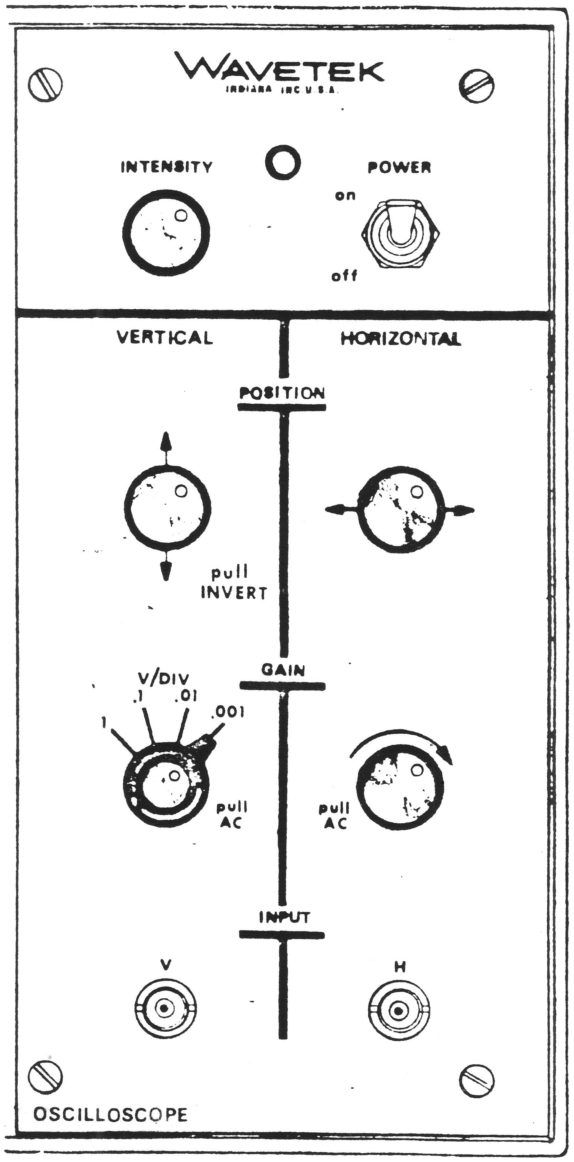


Figure 3-1. Front Panel

3.3 DESCRIPTION OF REAR PANEL

VERT MARKER

INPUT...BNC connector for applying pulse or birdy type markers to displayed signal. (100 V maximum input.)

SIZE...provides continuous adjustment of the marker size. Maximum sensitivity (fully clockwise) is 0.5 volts per division.

POLARITY...provides inversion of displayed pulse markers.

INTENSITY

INPUT...BNC connector for applying intensity modulation signals to display. A positive input intensifies and a negative input blanks the displayed signal. An internal wiring change can reverse the polarity of this Z axis amplifier. See Section 2.3.3.

CONTRAST...controls the difference in brightness between the X-Y display and the Z axis signal.

AUTO BLANK

In the ON position, the Auto Blanking circuit blanks the CRT beam in the absence of a horizontal signal in order to prevent burning of the CRT phosphor. In the OFF position, the blanking circuit is disabled to allow operation at slow sweep rates or to aid in servicing. Caution must be observed in the OFF position to prevent burning of the CRT phosphor.

Two internal switches are provided in this circuit. One disables the OFF position of the rear panel switch; the other switches the actuating signal from horizontal to vertical. For instructions see Section 2.3.3.

AC LINE

INPUT... three prong plug provides connection to AC mains.

VOLTAGE...Switch selects 115 or 230 VAC line voltage.

FUSE...3 AG type, Slo-Blo, 2 amp for 115 VAC or 1 amp for 230 VAC.

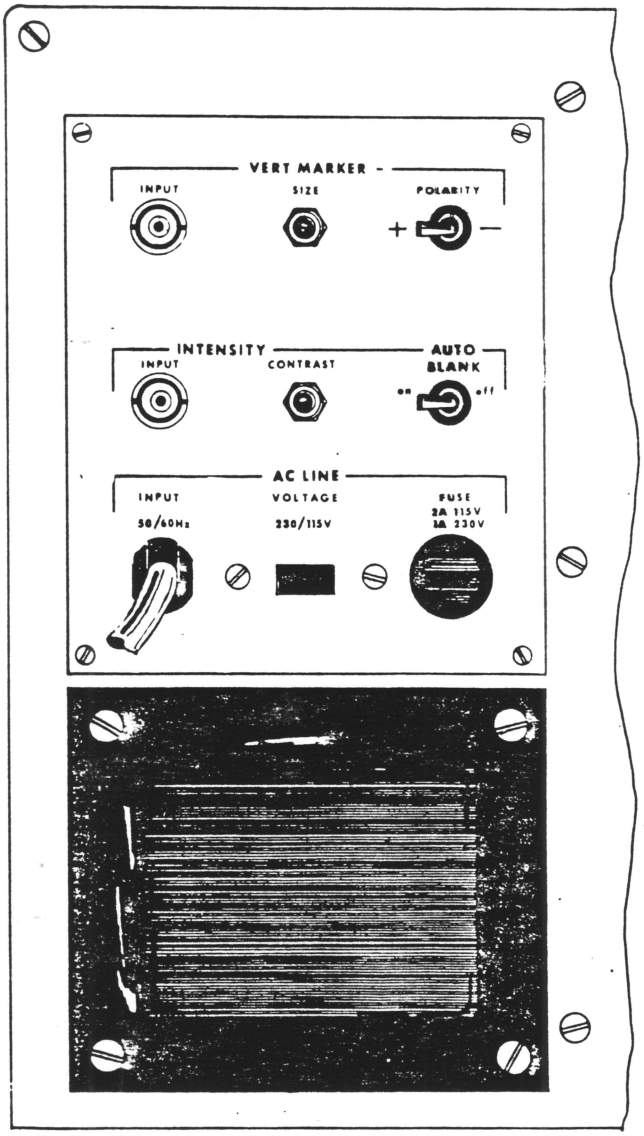


Figure 3-2. Rear Panel

SECTION 4
THEORY OF OPERATION

4.1 INTRODUCTION

This section first presents an overall block diagram analysis followed by a more detailed description of each block.

Figure 5-6 is a top view of the Display with the main sections labeled. This will serve as a physical reference corresponding to the circuit descriptions.

4.2 SIMPLIFIED BLOCK DIAGRAM

The block diagram of Figure 4-1 shows the relationship of each main section to the total operation of the unit. The CRT (Cathode Ray Tube) is the heart of the display. The composite signal of all the inputs to the unit is displayed on the face of the CRT.

The Power Supply provides the unit with five voltage sources. The +68 and ±15.5 volt supplies are regulated. The ±32 volt supplies are unregulated.

The High Voltage supply provides +9kV to the anode of the CRT. The power source for this section is the +32 volt supply. The High Voltage supply also provides positive voltages for G2 and G4 (the focusing electrode), of the CRT.

The Vertical Amplifiers convert the input voltage signal into a current signal for the Vertical-deflection Yoke. The pre-amp includes the front panel controls for adjusting the amplifier gain both in steps and continuously. Before the final stage of the vertical amplifier, the vertical marker signals are added to the main signal.

The Horizontal Amplifier converts the input voltage signal to a corresponding current signal for the Horizontal Yoke on the CRT. The Horizontal Amplifier has front panel controls for adjusting the GAIN and POSITION of the horizontal display on the CRT.

The Intensity Modulation circuit provides for front panel control of the brightness of the display. In addition, an external modulating signal can be amplified and applied to the CRT to produce markers or varying shades.

The Auto Blanking circuit prevents the CRT from burning when the beam is not being deflected with an alternating signal from either the Horizontal or Vertical Amp.

4.3 POWER SUPPLY

The outputs are +68 and ±15.5V regulated DC, as well as ±32V unregulated DC.

A dual primary transformer, T301, allows for a line voltage of either 115V or 230V AC. The 50V secondary is center tapped to allow for two full-wave rectified voltages. Unregulated +32 and -32 are filtered by C301 and C302 respectively. The +15.5 and -15.5 supplies are powered by the ±32 volt supplies. They are zener-diode regulated and have pass transistors for higher output current capability.

The source of the +68 supply is approximately +96 volts derived from a voltage doubler stacked on top of the +32V supply. The +68 volts is regulated by a zener diode (CR38).

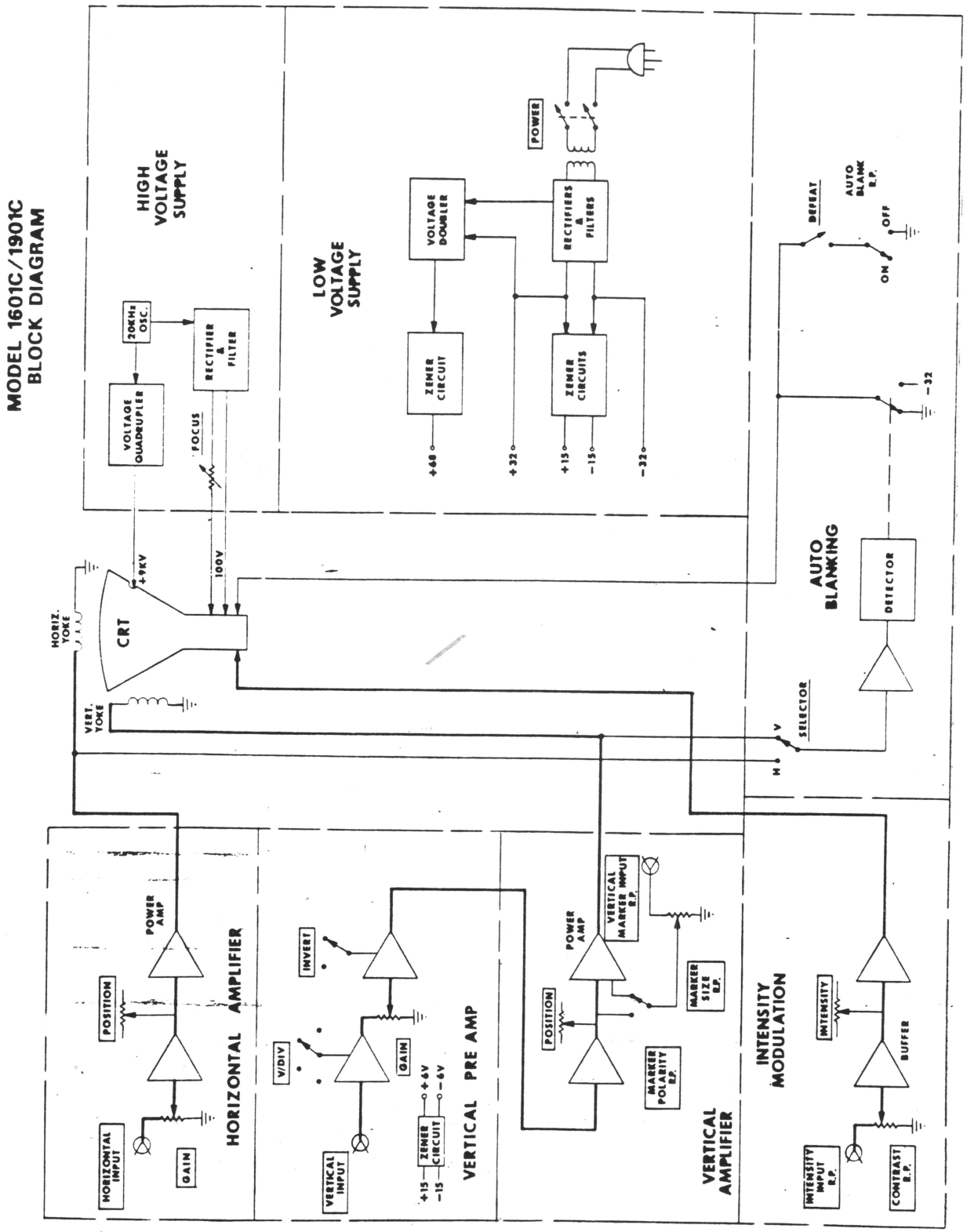


Figure 4-1. Display Block Diagram

4.4 HIGH VOLTAGE SUPPLY

The high voltage circuit is located away from the main printed-circuit board (See Figure 5-6) and housed in a steel enclosure to prevent 20 kHz radiation.

The high voltage circuit contains Q201, Q202, and Q203. It provides 9kV to the CRT anode as well as voltage for the focusing electrode (G4) and +100V for G2. Q203 is the heart of a ringing choke oscillator that develops a 20 kHz signal across T201. This voltage is coupled to the two different high voltage circuits. The oscillator signal is stepped up from 17 Vp to 2.25 kVp in the secondary connected to C208. It is then increased to +9kV DC by the cascade quadrupler. The oscillator signal is stepped up to 355Vp in the other secondary and rectified by CR202 and C207. The 355 volts is then fed to the focus control, R105, located on the Main Board. The 100 volt supply is derived from a voltage divider on the 355 volt output.

Q201 and Q202 provide the supply voltage to the oscillator. This voltage is controlled by a feedback signal in order to maintain a constant output level from the oscillator. The feedback is taken from R102 which is also the High Voltage adjustment. As the 9kV supply is loaded, a bigger load is seen by the oscillator. This temporarily lowers the oscillator supply voltage, consequently coupling less voltage to the 355V circuit. This results in a lower voltage at R102. This is inverted and amplified to provide a larger voltage supply to the oscillator, thus correcting for the additional loading.

4.5 VERTICAL AMPLIFIER

The Vertical Amplifier consists of two sections, the pre-amplifier and the power amplifier.

The Vertical pre-amplifier is mounted on a separate board and installed on the FRONT PANEL directly behind the vertical input jack. The power for this stage is ±6V. These voltages are derived from two zener-diode regulators connected to the +15.5 volts and -15.5 volts.

The vertical input impedance is 374 kΩ determined by R612. The signal first goes through one half of Q601, a dual FET. The vertical DC balance is adjusted at the gate of the other half. Q601 acts as a current offset compensation device for IC601. IC601 is an op. amp. with a gain which is determined by switched feedback resistors R601 through R604. S602 is the GAIN switch on the front panel which can select a sensitivity of 1, .1, .01 or .001 volts/division. The front panel vertical GAIN control, R615, adjusts the input amplitude to the next stage, IC602A.

IC602B is normally a non-inverting amplifier with a gain of about one. When pin 5 is grounded by the PULL INVERT switch, S403, this stage becomes an inverting amplifier with a gain of one. Thus the scope display will be inverted. The output of this stage then goes to the Power Amplifier.

The input to this stage is applied to R4 which is an internal pot for calibrating the vertical gain. The Vertical power amplifier consists of IC1, Q1 through Q6, Q301 and Q302. The inputs to this stage are the vertical preamplifier output and the "Y" marker input signals. These "Y" markers can be either pulse or birdy type markers. IC1A is a fixed-gain inverting op. amp; the input to which comes from the preamp. The output of IC1A is applied to the input to IC1B at which point are added the "Y" markers and the POSITION control voltage. IC1B is an inverting op. amp. Its feedback signal is the voltage across R30 which is proportional to the current signal through the vertical yoke. Q1, 2, 5, 6, 301 and 302 is a complementary symmetry, push-pull amplifier which provides high current gain for the vertical signal. Q3 and Q4 provide current limiting for Q301 and Q302. This prevents damage to the power transistors when the incoming signal is adequate to deflect the display off the face of the CRT.

The vertical yoke (L301A) provides the magnetic field which deflects the electron beam in the CRT up or down corresponding to changes in the voltage signal at the vertical input.

4.6 HORIZONTAL AMPLIFIER

The Horizontal Amplifier consists of IC2 and Q9 through Q14. The input is fed directly into the Horizontal GAIN pot, R402. A selected fraction of the input signal is then sent to one half of IC2. This op. amp. acts as a buffer for the horizontal input signal. The output of this goes to the other half of IC2. The other inputs at this point are the horizontal position signal from R403 and the feedback signal voltage from R64.

The circuit consisting of R47, R48, CR21, 22, 23 and 24 is designed to improve the display linearity during the furthest excursion of the signal.

The signal is then sent to a complementary symmetry, push-pull stage consisting of Q9, 10, 13, and 14. This provides the high current gain necessary for driving the yoke. Q11 and Q12 are current limiters which prevent damage to Q13 and Q14 when the incoming signal is adequate to deflect the display off the face of the CRT. The horizontal section of L301 provides the magnetic field for the horizontal deflection of the electron beam.

4.7 INTENSITY MODULATION

This two stage amplifier drives the cathode of the CRT. The first stage (Q22, 23 and 24) is a high impedance buffer for the intensity modulation input signal. The CONTRAST control varies the input level to this stage.

The second stage including Q17, 25 and 26 combines and amplifies the signals from the first stage and the front-panel INTENSITY control. The modulating signal from stage one can be applied to either the inverting or non-inverting input of stage two as shown on schematic.

4.8 AUTO BLANKING

This circuit consists of IC3 and Q19. The input to IC3 is an alternating signal from either the horizontal or vertical amplifier depending on setting of S1A. This AC signal is amplified in IC3 and an average negative value is detected by CR29 and C11. Q19 is biased on by this signal. When the horizontal deflection is less than approximately 2 scope divisions, the voltage on C11 is not sufficient to keep Q19 turned on. Turning Q19 off allows "G1" of the CRT to be biased with the -32 volt supply through R94 and CR42. This voltage will prevent electron flow to the CRT face thus preventing damage to the phosphor when there is no AC deflection signal. This circuit can be overriden with S502 and S1B allowing extremely slow sweep rates to be displayed.

4.9 CATHODE RAY TUBE (CRT)

It uses magnetic deflection and includes the following specifications: P1 phosphor (P4 or P7 phosphors are optional), electrostatic focusing (G4), 90° diagonal deflection, and 12.6V heater voltage. The face is raised to +9kV by the High Voltage circuit.

SECTION 5
MAINTENANCE

5.1 INTRODUCTION

This section provides information for performance testing, calibrating, and troubleshooting the Wavetek Display. The performance test is designed for incoming inspection and periodic evaluation. If performance is not to specifications, refer to calibration and troubleshooting, Sections 5.4 and 5.5.

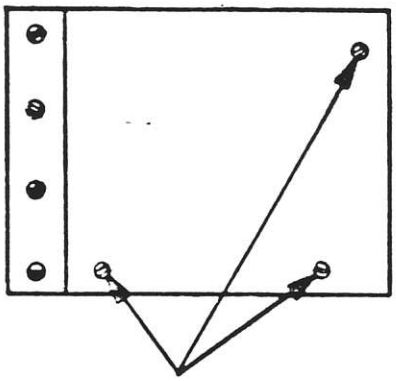
5.2 SERVICE INFORMATION

5.2.1 DISASSEMBLY

Most servicing can be done by simply removing the dust cover. Servicing the vertical pre-amp assembly can be facilitated by removing the front panel from the chassis. The high voltage circuit must be removed from can for servicing. Refer to Figure 5-6 for locations of assemblies.

DUST COVER REMOVAL

To remove the dust cover, remove the three screws on each side of the unit (Figure 5-1). Move cover back and up.



Dust Cover Screws

Figure 5-1. Display Side View

HIGH VOLTAGE ASSEMBLY REMOVAL

WARNING

There is an operating potential of +9000 volts on high-voltage connector.

First, turn unit off and remove dust cover. Slide a grounded screw driver under high-voltage connector cover. When voltage is discharged, remove connector from CRT by pushing connector sideways until one side of spring clip is released from receptacle on CRT then pulling other side of spring clip out. Next, disconnect 6-pin harness connector from main p.c. board. Finally, remove two screws from bottom of chassis which hold high-voltage box in place. To remove the high-voltage circuit from its metal box, remove horizontal screw from each side of lid. DO NOT remove screws or nuts on top of lid. The circuitry is mounted on the lid and will be removed from the box when the lid is lifted straight up.

FRONT PANEL REMOVAL

Turn unit off and remove dust cover. First, disconnect 15-pin connector from main p.c. board. Next, remove nut holding POWER switch to front panel. Finally, remove four screws in corners of panel and pull assembly forward and slightly to the right.

5.2.2 REASSEMBLY

Instrument can be reassembled by reversing the appropriate instructions in Section 5.2.1. When reinstalling a harness connector on a printed-circuit board, be sure connector is properly aligned with the board connector pins and that connector faces proper direction (See Figure 5-2).

CAUTION

Failure to properly orientate the connector can result in damage to circuitry.

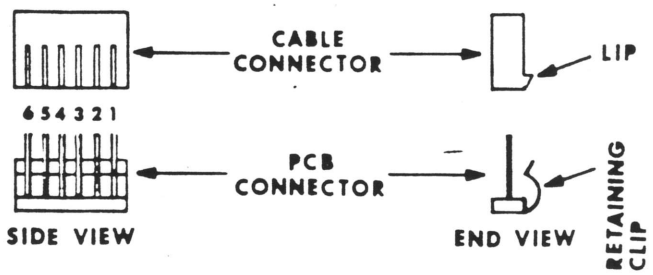


Figure 5-2. Connector Alignment

5.3 PERFORMANCE TESTS

The following procedure is intended to insure that the instrument meets its published specifications. Needed to perform the following tests are a Wavetek Model 144 function generator (or two independent signal sources) and a general-purpose lab-grade oscilloscope. See Table 5-1. Refer to Sections 3.2 and 3.3 for locations and descriptions of controls on Wavetek Display unit.

The Auto-Blanking circuit in most units is fed by the horizontal amplifier; therefore, the performance test procedures are based on this assumption. If the unit being tested is set for vertical auto-blanking, switch to horizontal before proceeding. Instructions for switching are in the upper-left corner of the main p.c. board. Before turning unit on, switch rear panel AUTO BLANK switch to the on position. Switch POWER on and allow a five minute warm up before proceeding.

TABLE 5-1. RECOMMENDED TEST EQUIPMENT FOR PERFORMANCE TESTS AND CALIBRATION

INSTRUMENT	CRITICAL REQUIREMENTS	RECOMMENDED
Oscilloscope	Lab Grade, D.C. coupled 10 MHz bandwidth	Tektronix 5403 main frame 5A48 Vertical Amp 5B42 Time Base
Voltmeter	10 Megohm input impedance	Weston Model 4440
Function Generator	2 independent frequency outputs	Wavetek Model 144
HV Probe	300 Megohm input impedance	Pomona Model 3157 High voltage test probe

5.3.1 VERTICAL POSITION CONTROL CHECK

1. Set Display controls as follows:

INTENSITY	minimum (fully ccw)
HORIZONTAL POSITION	mid range
VERTICAL POSITION	mid range
HORIZONTAL GAIN	mid range
VERTICAL GAIN (switch)	1V/div
VERTICAL GAIN (vernier)	fully cw

2. Apply an AC signal to the HORIZONTAL input. Approximately 4 Vpp will extend the full width of the scope face.

3. Turn INTENSITY up until trace appears.

4. Turn Vertical POSITION control alternately cw and ccw. Line should go off the screen in both directions.

5.3.2 HORIZONTAL POSITION CONTROL CHECK

1. Set display controls as follows:

INTENSITY	ccw
HORIZONTAL POSITION	mid range
VERTICAL POSITION	mid range
HORIZONTAL GAIN	mid range
VERTICAL GAIN (switch)	1V/div
VERTICAL GAIN (vernier)	cw

2. Apply an AC signal to the VERTICAL input. Twelve volts peak to peak will extend the full height of the scope face.

CAUTION

Do not turn AUTO BLANK off without a signal to the scope vertical. The result would be a bright dot which would burn the CRT phospher.

3. Switch AUTO BLANK off.

4. Turn up INTENSITY until trace appears.

5. Turn the Horizontal POSITION control alternately cw and ccw. Line should move off the screen in both directions.

6. Turn AUTO BLANK on. (Line will disappear)

5.3.3 VERTICAL GAIN CHECK

1. Set Display controls as follows:

INTENSITY	fully ccw
HORIZONTAL POSITION	mid range
VERTICAL POSITION	mid range
HORIZONTAL GAIN	mid range
VERTICAL GAIN (switch)	1V/div
VERTICAL GAIN (vernier)	fully cw

2. Make connections as shown in Figure 5-3.

3. Set function generator as follows:

Frequency	1 kHz
Output	10 Vpp (Set using calibrated lab scope)
Mode	continuous
Sweep Time	10 ms

(or set a second generator for 100 Hz)

4. Increase INTENSITY until trace is visible. Adjust the Horizontal GAIN control for a pattern width of 16 divisions. The vertical amplitude on the display should be 10 divisions ±1.

5.3.4 VERTICAL BANDWIDTH CHECK

1-4 Execute steps 1-4 of Vertical Gain check, Section 5.3.3. Set function generator for displayed amplitude of exactly 10 divisions.

5. Increase function generator frequency to 15 kHz (3dB point).

6. Pattern should be at least seven divisions high.

5.3.5 VERTICAL LINEARITY CHECK

1. Set Display controls as follows:

INTENSITY	fully ccw
HORIZONTAL POSITION	mid range

VERTICAL POSITION	mid range
HORIZONTAL GAIN	mid range
VERTICAL GAIN (switch)	1V/div
VERTICAL GAIN (vernier)	fully clockwise

2. Make connections as shown in Figure 5-3.

3. Set function generator controls as follows:

Frequency	1 kHz
Output	1 Vpp
Mode	continuous
Sweep Time	10 ms

(or set a second generator for 100 Hz)

4. Increase INTENSITY until trace is visible. Adjust Horizontal GAIN control for a pattern 16 divisions wide.

5. Set vertical amplitude for one division (at vertical center of screen).

6. Using Vertical POSITION control move one-volt reference up and down. Amplitude should not vary more than .5 division.

5.3.6 HORIZONTAL GAIN CHECK

1. Set Display controls as follows:

INTENSITY	fully ccw
HORIZONTAL POSITION	mid range
VERTICAL POSITION	mid range
HORIZONTAL GAIN	mid range
VERTICAL GAIN (switch)	1V/div
VERTICAL GAIN (vernier)	fully cw

2. Make connections as shown in Figure 5-4.

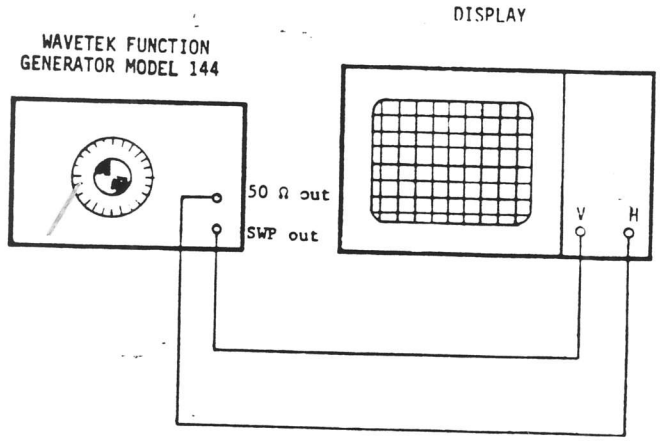


Figure 5-4. Horizontal Gain Check Setup

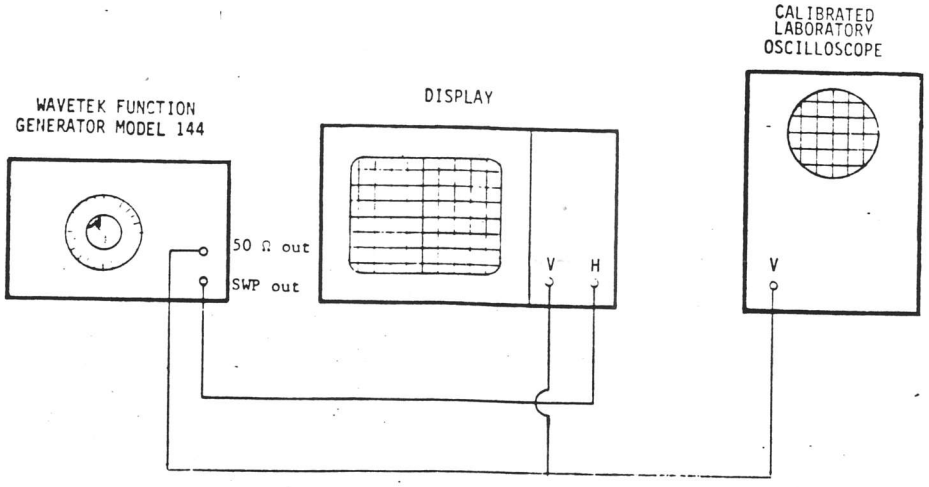


Figure 5-3. Vertical Gain Check Setup

3. Set the function generator as follows:

Frequency	100 Hz
Output Level	1 Vpp
Mode	continuous
Sweep Time	10 ms

(or set a second generator for 100 Hz)

4. Increase INTENSITY until trace is visible. Adjust Vertical GAIN for 12 division signal height.

5. Turn AUTO BLANK off.

6. Turn Horizontal GAIN control from min to max. The pattern should go from 0 to greater than 10 divisions.

5.3.7 HORIZONTAL BANDWIDTH CHECK

1-4 Execute steps 1-4 of 5.3.6 Horizontal Gain Check.

5. Adjust horizontal amplitude to 14 divisions by adjusting input level or Horizontal GAIN.

6. Increase function generator frequency to 1.5 kHz (3dB point). The horizontal amplitude should be at least 9.8 divisions wide.

5.3.8 HORIZONTAL LINEARITY CHECK

1-5 Execute steps 1-5 of 5.3.6 Horizontal Gain Check.

6. Adjust pattern width for 1 division and center it horizontally.

7. Move the displayed pattern from left to right over the full 16 divisions. Its amplitude should not vary more than .5 divisions.

8. Return AUTO BLANK switch to on position.

5.3.9 VERTICAL POLARITY CHECK

1. Apply an AC signal to the Display HORIZONTAL input and center line vertically.

2. Apply to the VERTICAL input a signal with a positive DC offset. The signal should appear in the upper half of the scope face.

3. Pull the Vertical POSITION knob. Signal should move to lower half of screen.

4. Push knob back in.

5.3.10 VERTICAL MARKER CHECK

1. Apply an AC signal of about 100 Hz to the HORIZONTAL input of the scope.

2. Apply a 5 kHz signal of approximately 5 volts p-p to the VERT MARKER input.

3. Rotate marker SIZE control. A signal should be displayed which is variable from 0 to 12 divisions.

5.3.11 INTENSITY MODULATION CHECK

1. Apply sweep output from function generator to Display HORIZONTAL input.

2. Set INTENSITY control for approximately half brightness.

3. Obtain rectangular signal from function generator. Set amplitude for 1 Vpp (±.5V). Set positive time much smaller than negative time.

4. Apply function generator signal to scope INTENSITY MODULATION INPUT on rear panel. The resulting bright areas should appear to be full brightness. The dark areas should be fully blanked.

CAUTION

If a signal is applied to the INTENSITY MODULATION INPUT without applying a Horizontal or Vertical input, the tube phosphor may be burned.

NOTE

If the polarity of this circuit has been internally reversed, change the function generator signal to provide a negative time much smaller than the positive time.

5.4 CALIBRATION PROCEDURE

This section provides the tests and adjustments necessary to align the unit and ensure that it meets its specifications. The procedure is written to be performed completely and in the sequence given. Names of external controls and connectors are written in all capital letters. Refer to Table 5-1 for list of equipment necessary for calibration.

Remove top cover by removing three screws on each side of unit (Figure 5-1) and lifting cover back and up.

Start calibration with controls in the following positions. To facilitate the calibration procedure, the control settings and hookups at the beginning of each step are assumed to be unchanged from the end of the previous step.

FRONT PANEL

INTENSITY	fully ccw (min)
HORIZONTAL POSITION	mid range
VERTICAL POSITION	mid range
HORIZONTAL GAIN	mid range
VERTICAL GAIN (switch)	1V/div
VERTICAL GAIN (vernier)	fully cw

REAR PANEL

AUTO BLANK	ON
VERT MARKER POLARITY	+
VERT MARKER SIZE	fully ccw
INTENSITY CONTRAST	fully cw (max)

Plug line cord into AC supply set for exactly 115 volts. Turn POWER on and allow a five minute warmup before calibrating.

Refer to Figure 5-5 for locations of test points and adjustments.

5.4.1 POWER SUPPLY CHECKS

With lab grade oscilloscope, check +32 V at TP 1 (Fig 5-5). Turn Vertical POSITION control fully clockwise; voltage should be +33 with less than 1 Vpp ripple. Turn control fully counterclockwise; Voltage should be +31 with less than 2 Vpp ripple.

With same scope check -32V at TP 2. Turn Vertical POSITION control fully clockwise; voltage should be -31 with less than 2 Vpp ripple. Turn control counterclockwise; voltage should be -33 with less than 1 Vpp ripple.

With voltmeter, check +15.5 V at TP 3. Reading should be between 14.7 and 16.3 V.

With voltmeter check -15.5 V at TP 4. Reading should be between -14.7 and -16.3 V.

With voltmeter check +68 V at TP 5. Reading should be between 61.2 and 74.8 V.

5.4.2 HIGH VOLTAGE ADJUSTMENT

Read DC voltage on TP 6 with high-impedance (10 Meg) meter. Set voltage for +355 V with High Voltage Adj. pot (see Fig 5.5). Check +9 kV with high-voltage probe by sliding probe under high-voltage connector cover on CRT anode (Figure 5-6). Reading should be between +8.5 kV and +9.5 kV.

5.4.3 INTENSITY LIMIT & FOCUS ADJUSTMENT

Apply square wave 10 Vpp to VERTICAL input and a ramp to HORIZONTAL input. Turn INTENSITY fully clockwise. Adjust horizontal amplitude for 12 divisions and frequency for a stable square-wave pattern.

Turn Intensity Limit control (Figure 5-5) fully counterclockwise. Return clockwise until blooming is 1%. One percent blooming can be determined by allowing the vertical amplitude to increase from 10 to 10.1 divisions. Decrease brightness as desired. Adjust Focus control

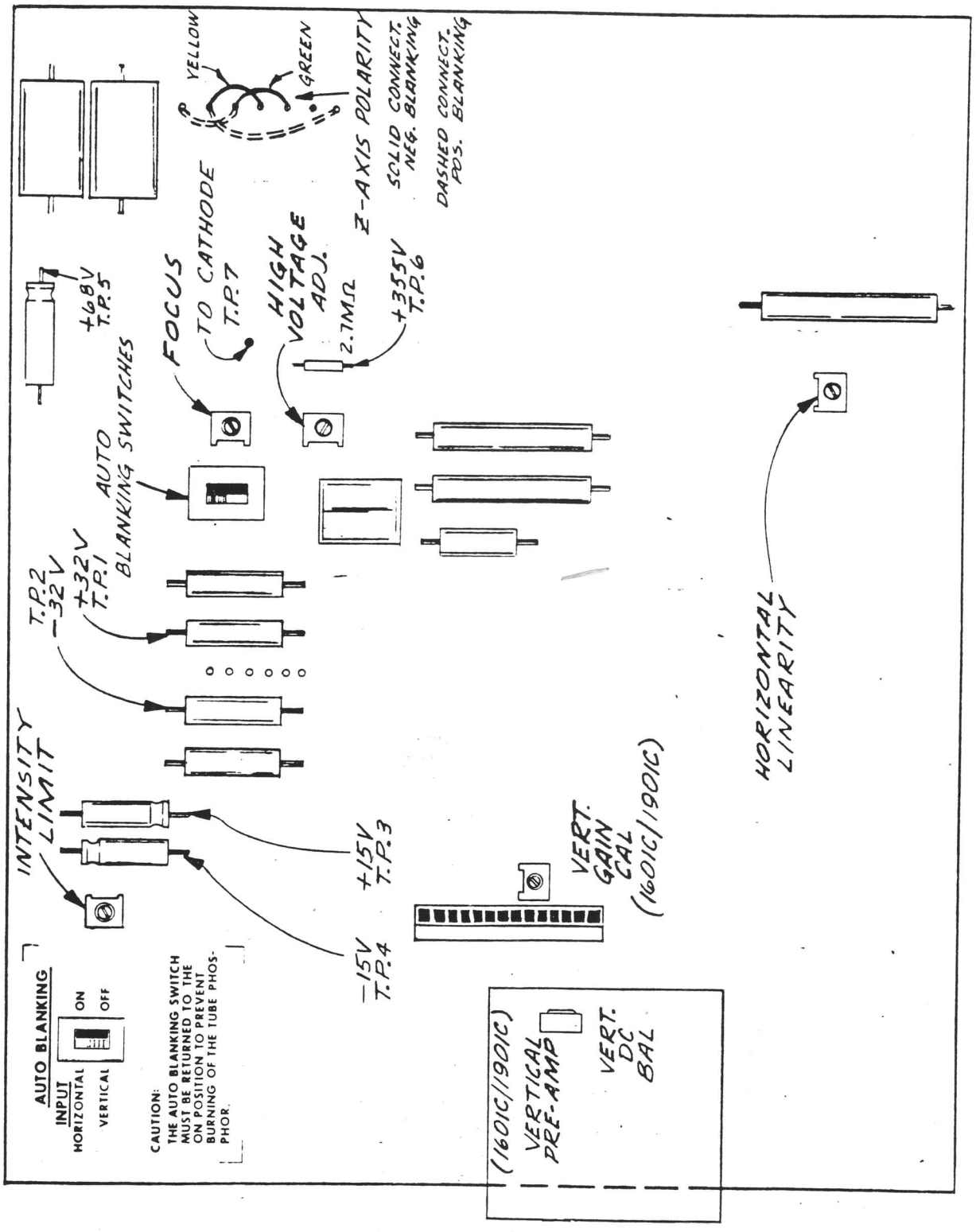


Figure 5-5. Test Points and Adjustments

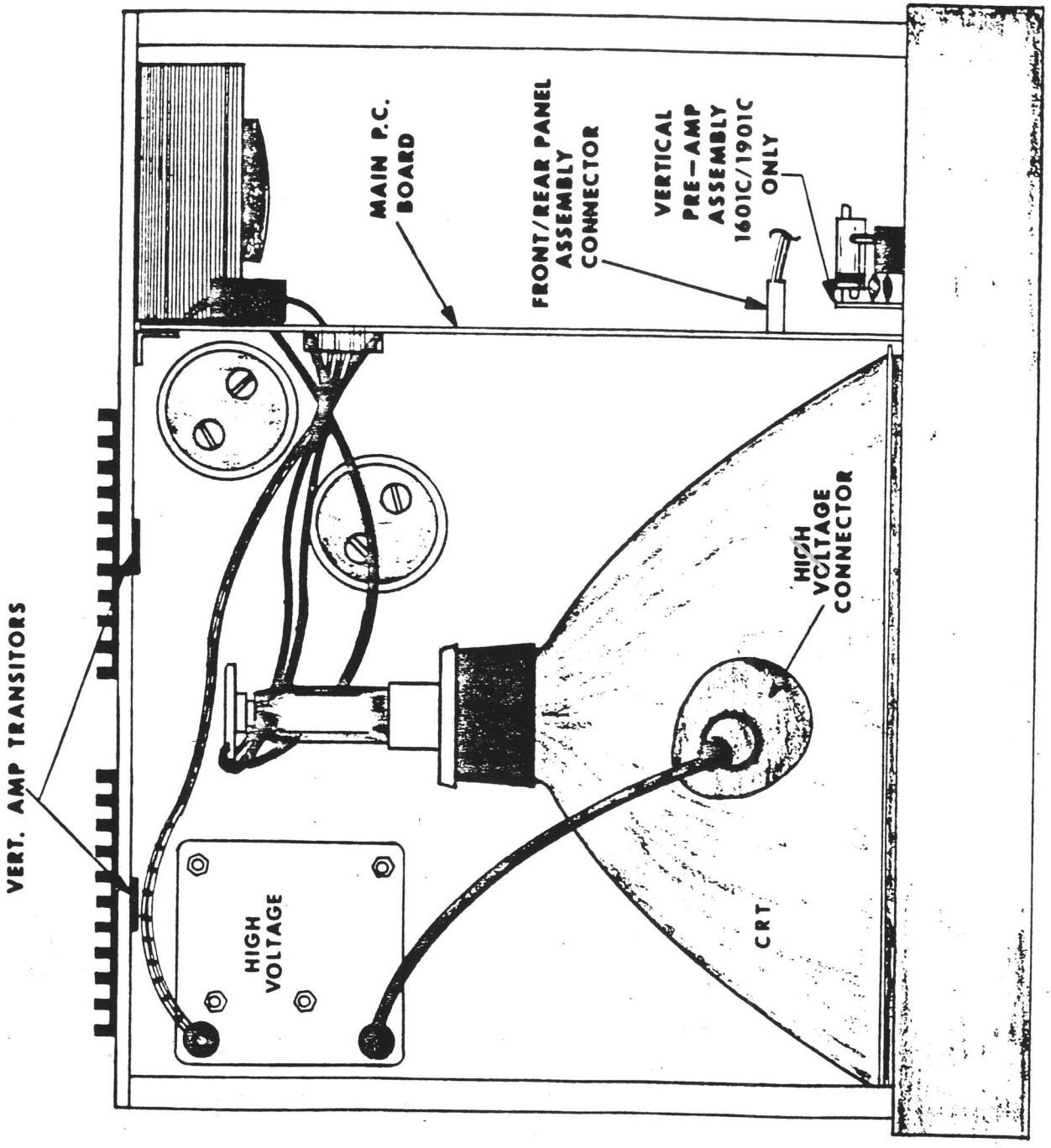


Figure 5-6. Display Top View

(Figure 5-5) for sharpest display. Disconnect vertical signal.

5.4.4 VERTICAL D.C. BALANCE

Increase Horizontal GAIN for 16 division trace. Turn Vertical GAIN vernier fully counterclockwise. Position horizontal line at center graticule with Vertical POSITION control.

Turn Vertical GAIN vernier fully clockwise. With Vert DC Bal (Figure 5-5) return line to center graticule. Start procedure again by turning Vertical GAIN vernier fully counterclockwise. Repeat procedure until there is minimum movement of the line when the Vertical GAIN vernier is turned from one extreme to the other.

5.4.5 VERTICAL GAIN CALIBRATION

Turn Vertical GAIN vernier fully clockwise. Apply a 1 kHz sine wave simultaneously to the VERTICAL input and the vertical input of lab grade scope. Adjust signal generator to 8 Vpp according to the lab scope. Adjust Vert Gain Cal (Figure 5-5) for 8 divisions on Display face.

5.4.6 YOKE ADJUSTMENT

Disconnect vertical signal. Move tabs on yoke until bowing (curvature) is eliminated from horizontal line. Loosen yoke clamp screw until yoke is free to rotate. Rotate yoke until the horizontal line is exactly parallel to the center horizontal graticule. Tighten screw and recheck trace alignment.

5.4.7 VERTICAL LINEARITY CHECK

Set Sweep Time of horizontal signal to 10 ms. Apply a 1 kHz signal to the vertical input. Reduce the amplitude of the signal from the function generator to one division on the scope face. Using the Vertical POSITION control, move this one volt reference up and down. Its amplitude should not vary more than .5 divisions.

5.4.8 HORIZONTAL LINEARITY ADJUSTMENT

Reverse horizontal and vertical inputs. Set frequency of horizontal signal to 100 Hz. Center the display with Vertical and Horizontal POSITION controls. Set vertical amplitude for 5 divisions. Set horizontal amplitude for six divisions. With the Horizontal POSITION control, move the displayed signal to the right until left edge of signal is on the second line to the right of center. The right edge of the signal should fall exactly on the far right (8th) graticule line. Set the position of the right edge of the signal with Horizontal Linearity pot shown in Figure 5-5.

Reduce the horizontal amplitude to one division. (Switch Auto-Blanking selector to the vertical position if trace disappears.) Move the displayed pattern from left to right over the full 16 divisions. Its amplitude should not vary more than .5 divisions. Return Auto-Blanking selector to horizontal position. Disconnect horizontal input.

5.4.9 Z-AXIS GAIN CHECK

Move 10 ms signal from VERTICAL to HORZONTAL input. Feed 100 kHz from the function generator into INTENSITY input. Monitor CRT cathode voltage using Lab Scope with a low-capacity probe. The cathode is connected by the grey wire from the tube to TP 7 on Figure 5-5. Adjust function generator output for 18 Vpp (at cathode). Move probe to INTENSITY input. The input signal should be less than 1 Vpp. Return the probe to the cathode.

Turn CONTRAST fully counterclockwise. Increase function generator input to provide 10 Vpp at cathode. Move probe to input. Signal should be greater than 20 Vpp. Decrease input signal level to 1 Vpp and turn CONTRAST control to max (cw).

5.4.10 Z-AXIS BANDWIDTH

Return probe to cathode. Adjust signal level for 10 Vpp at cathode. Increase input frequency to 1 MHz. Voltage should be 10 ±.2 Vpp. Increase input frequency to 3.5 MHz. Voltage should be greater than 7.1 Vpp. Increase frequency to 10 MHz. Voltage should be greater than 3.2 Vpp.

5.4.11 VERTICAL MARKER CHECK

Apply a 5 kHz signal of approximately 5 volts p-p to the VERT MARKER input. Signal should be about 12 divisions high. Rotate the VERT MARKER SIZE control counterclockwise. Signal should decrease to zero volts. Disconnect signal from MARKER input.

5.4.12 VERTICAL POLARITY CHECK

Center the line with Vertical POSITION control. Apply a signal to the VERTICAL input which has a positive DC offset. The signal should appear on the upper half of the scope face. Pull the Vertical POSITION knob. The signal should move to the lower portion of the screen. Push knob back in.

5.5 TROUBLESHOOTING

5.5.1 GENERAL

A thorough understanding of the block diagram and the theory of operation located in Section 4 may enable the trouble symptom to be associated with a particular circuit or component. Refer to Section 6 for schematic diagrams and to Section 5.2 for disassembly procedure.

5.5.2 PRELIMINARY CHECKS

Equipment troubles are frequently due simply to improper front or rear panel control settings. Refer to the operating instructions in Section 3 for complete explanation of each control's function.

5.5.3 CALIBRATION

After verifying that trouble is not improper setting of the controls or test setup, make a thorough check of the

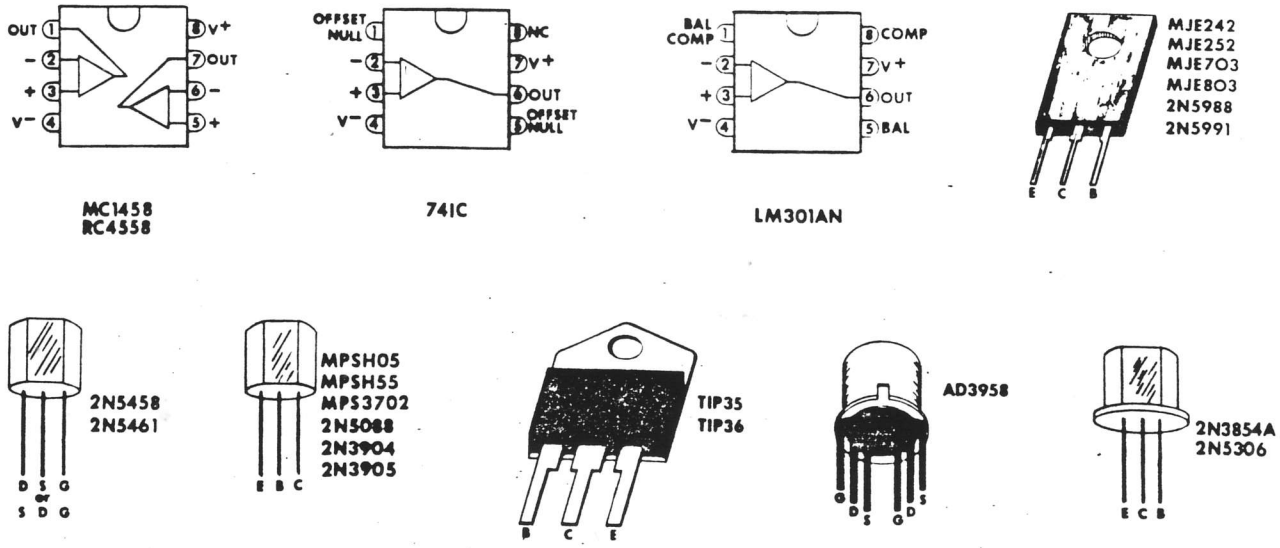


Figure 5-7. Lead Configurations

instrument's calibration by following the procedure in Section 5.4. By performing the calibration procedure, a trouble can be localized to a specific circuit.

5.5.4 VISUAL INSPECTION

After localizing a trouble to a specific area of the unit, make a good visual check of the area. Check for burned or broken components, loose wires or circuit-board connections.

5.5.5 VOLTAGE AND RESISTANCE CHECKS

After localizing the problem, voltage and resistance checks will help find the defective component. See Figure 5-7 for identification of transistor and IC leads. See Figure 5-8 for locations of major components on the main board.

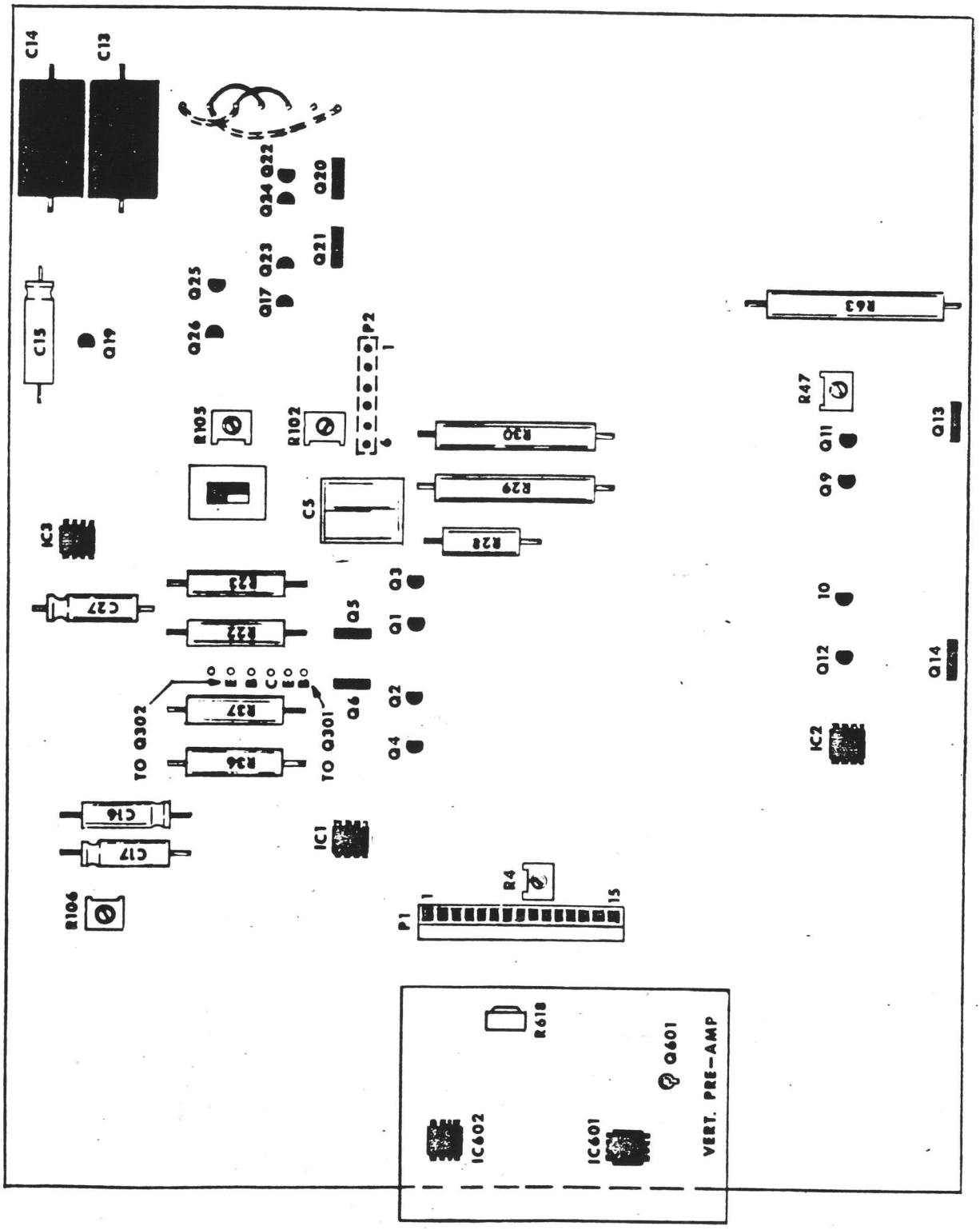
When troubleshooting, care must be taken not to short one of the higher voltage supplies to the ±15.5 volt supplies in order to prevent damage to the op. amps. If trouble is suspected in the high-voltage circuit, the assembly can be disconnected from main board and another high-voltage assembly substituted for the suspected defective one.

5.5.6 REPAIR

When removing components from the printed-circuit board, do not use excessive heat. This can damage the lands on the printed circuit board.

WARNING

If the defective component is the CRT, use extreme care in replacing it. To prevent personal injury, always wear a face mask or goggles and protective gloves.



Figures 5-8. PC Board Component Locations

SECTION 6
SCHEMATICS AND PARTS LISTS

6.1 INTRODUCTION

This section contains schematics and a list of replaceable electronic parts for the instrument. Also included is the Wavetek code for component manufacturers, a list of abbreviations used in the text, and an explanation of schematic symbols.

6.2 PARTS LIST NOTES

The instrument parts list is divided to separate the various assemblies. The assembly three-digit circuit reference on the schematic is represented in the REFERENCE SYMBOL column by the last one or two digits. The first digit represents the assembly on which the part is located. The assembly (200, 300...) is indicated next to the reference symbol heading on the parts list.

The following code is used on the parts list to identify the manufacturer.

A-B	Allen-Bradley	Milwaukee, Wisconsin
ACI	Advance Components Inc.	Centerbrook, Connecticut
A-D	Analog Devices.	Norwood, Massachusetts
AER	AVX	Myrtle Beach, South Carolina
A-I	Alan Industries	Columbus, Indiana
ALC	Alco Electronics Products, Inc.	Lawrence, Massachusetts
AMP	AMP, Inc.	Harrisburg, Pennsylvania
APL	Amphenol.	Danbury, Connecticut
A-P	American Plasticraft (APCO)	Chicago, Illinois
APX	Amperex	Slatersville, Rhode Island
ARC	ARCO Electronics.	Great Neck, New York
ASE	Airco Speer Electronics	Nogales, Arizona
BEK	Beckman Instruments, Inc.	Fullerton, California
BEL	Belden.	Chicago, Illinois
BOU	Bourns.	Riverside, California
BUS	Bussman	St. Louis, Missouri
CAM	Cambion	Cambridge, Massachusetts
CAR	Carling Electric, Inc.	West Hartford, Connecticut
C-D	Cornell Dubilier.	Newark, New Jersey
C-E	Clinton Electronics	Rockford, Illinois
CGW	Corning Glass Works	Corning, New York
CHE	Cherry Electrical Products, Prod.	Waukegan, Illinois
C-H	Cutler-Hammer	Milwaukee, Wisconsin
C-I	Components Incorporated	Biddeford, Maine
C-J	Cinch Jones	Elk Grove Village, Illinois
C-K	C & K Components.	Watertown, Massachusetts
C-L	Centralab	Milwaukee, Wisconsin
CLA	Clairex Electronics	Mount Vernon, New York
CTS	Chicago Telephone Systems	Elkhart, Indiana
C-W	Continental Wire.	Philadelphia, Pennsylvania
DEL	Delevan	East Aurora, New York
DIO	Diodes, Inc.	Chatsworth, California

DRA	Drake Mfg. Company	Harwood Heights, Illinois
ETP	Erie Technological Prod., Inc.	Erie, Pennsylvania
FCD	Fairchild	Mountain View, California
G-E	General Electric	Syracuse, New York
G-H	Grayhill	La Grange, Illinois
G-I	General Instrument Semi., Comp.	Hicksville, New York
HEL	Helipot	Anaheim, California
HEY	Heyman Mfg. Company	Kenilworth, New Jersey
HHS	Herman H. Smith Inc.	Brooklyn, New York
HIT	Hitachi America LTD.	Chicago, Illinois
H-P	Hewlett-Packard	Palo Alto, California
INT	Intersil Inc.	St. Palos Heights, Illinois
IRC	International Resistance Co.	Philadelphia, Pennsylvania
ITT	International Telephone & Telegraph	West Palm Beach, Florida
JEF	Jeffers	Dubois, Pennsylvania
JEW	Jewell Electrical Instruments	Manchester, New Hampshire
JON	E.F. Johnson Company	Waseca, Minnesota
KEM	Kemtron Electron Products, Inc.	Newburyport, Massachusetts
KID	Kidco, Inc.	Medford, New Jersey
LIT	Littelfuse	Des Plaines, Illinois
M-A	Microwave Associates	Burlington, Massachusetts
MAL	Mallory	Indianapolis, Indiana
M-E	Mepco/Electra	Mineral Wells, Texas
M-O	Marko-Oak	Anaheim, California
MOL	Molex	Downers Grove, Illinois
MOT	Motorola	Phoenix, Arizona
NAT	National Semiconductor Corp.	Santa Clara, California
N-T	National Teltronics	Laredo, Texas
OHM	Ohmite Mfg. Company	Skokie, Illinois
P-B	Potter & Brumfield	Princeton, Indiana
POM	Pomona Electronics Co., Inc.	Pomona, California
Q-C	Quality Components	St. Marys, Pennsylvania
RAY	Raytheon	Burlington, Massachusetts
RCA	RCA	Harrison, New Jersey
RMC	Radio Material Company	Chicago, Illinois
S-C	Specialty Connector	Indianapolis, Indiana
SCC	Stackpole Carbon Co.	St. Marys, Pennsylvania
SEL	Sealectro	Mamaroneck, New York
SEM	Semtech	Newbury Park, California
S-G	Standard Grigsby	Aurora, Illinois
SGM	Sigma	Braintree, Massachusetts
S-I	Switchcraft, Inc.	Chicago, Illinois
SIG	Signetics Corporation	Sunnyvale, California
SPE	Spectrol	City of Industry, California
SPR	Sprague	North Adams, Massachusetts
SSS	Solid State Scientific	Montgomeryville, Pennsylvania
S-T	Sarkes Tarzian	Bloomington, Indiana
STR	Stettner Trush	Cazenovia, New York
SYL	Sylvania	Woburn, Massachusetts
SYS	Syscon International	South Bend, Indiana
THR	Thermalloy, Co.	Dallas, Texas
T-I	Texas Instruments	Dallas, Texas
TRW	TRW Capacitor Division	Ogallala, Nebraska
VAC	VACTEC	Maryland Heights, Missouri
VAR	Varadyne Capacitor Division	Santa Monica, California
W-E	Wells Electronics	South Bend, Indiana
W-I	Wavetek Indiana, Inc.	Beech Grove, Indiana
WSD	Wavetek, San Diego	San Diego, California

6.3 ABBREVIATION CODE

The following abbreviations are used on the parts lists, schematics and throughout the text of the manual.

A	assembly	IC	integrated circuit	mW	milliwatt
A	ampere	IF	intermediate frequency	Ω	ohm
AC	alternating current	J	jack	OC	opto-coupler
C	capacitor	K	relay	P	plug
CR	diode	kHz	kilohertz	p-p	peak-to-peak
CW	continuous wave	Kohm	kilohm	pF	picofarad
cw	clockwise	kV	kilovolt	Q	transistor
ccw	counterclockwise	kW	kilowatt	R	resistor
dB	decibel	L	inductor	RF	radio frequency
dBm	decibel referred to 1 mW	MHz	megahertz	rms	root-mean-square
dBmV	decibel referred to 1 mV	Mohm	megohm	R.P.	rear panel
DC	direct current	µF	microfarad	S	switch
DS	indicating device, lamp	µA	microampere	T	transformer
F	farad	µH	microhenry	T.P.	test point
F	fuse	M	meter	V	vacuum tube
F.P.	front panel	mA	milliampere	V	volt
H	henry	mH	millihenry	VA	voltampere
Har	harmonic	mV	millivolt	W	watt
Hz	hertz			X	crystal

6.4 SCHEMATIC NOTES

The following notes pertain to the schematics. Additional notes pertaining to specific schematics are included on each schematic if required.

All values are shown in the following units unless otherwise specified:

Component	Units
Resistor	ohms
Capacitor	picofarads
Inductor	microhenries

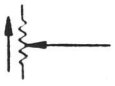
Denotes DC voltage reading in volts unless otherwise specified.

Denotes high impedance crystal detector reading in volts unless otherwise specified.

Denotes 50 ohm crystal detector reading in volts unless otherwise specified.

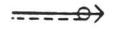
Signal or voltage source.

Connect to indicated signal or voltage source.



Arrow indicates clockwise rotation of wiper.

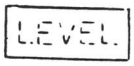
Coaxial jack



Coaxial plug

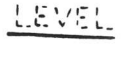
Coaxial cable

Factory adjusted part.

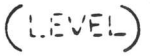


Denotes a front panel device.

Denotes a rear panel device.



Denotes a P.C. board adjustment or accessible module adjustment.



Denotes an internal module adjustment not accessible without removing module cover.

6.5 SCHEMATICS AND PARTS LIST

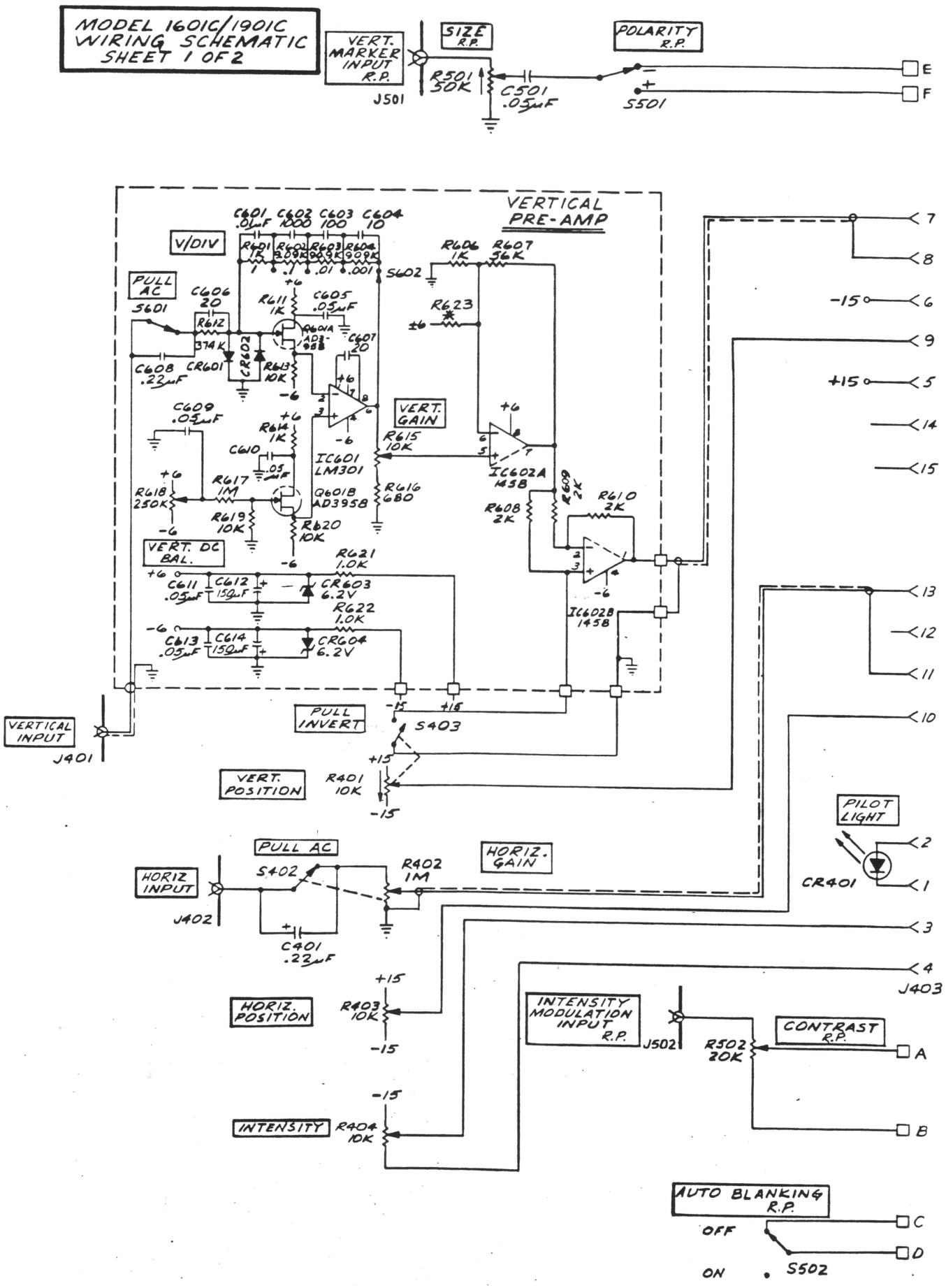
The 1601C/1901C schematic is on two sheets. Sheet one contains the front-panel and rear-panel assembly parts. Sheet two includes the high voltage, chassis and main p.c. board parts.

The two sheets face each other for ease of comprehension and circuit tracing. The main board is enclosed by the dashed line. Hard wired connections are indicated by squares along the dashed line. Discrepancies between the 1601C/1901C and 1944 (R4 and T301) are incicated on sheet two.

There are eight pages of parts lists including:

1601C, 1901C, 1944 MAIN BOARD (3 pages)
A309-1 High Voltage
1601C, 1901C, 1944 Chassis
1601C/1901C Front Panel
1601C/1901C Rear Panel
B329-1 Vertical Pre-Amp

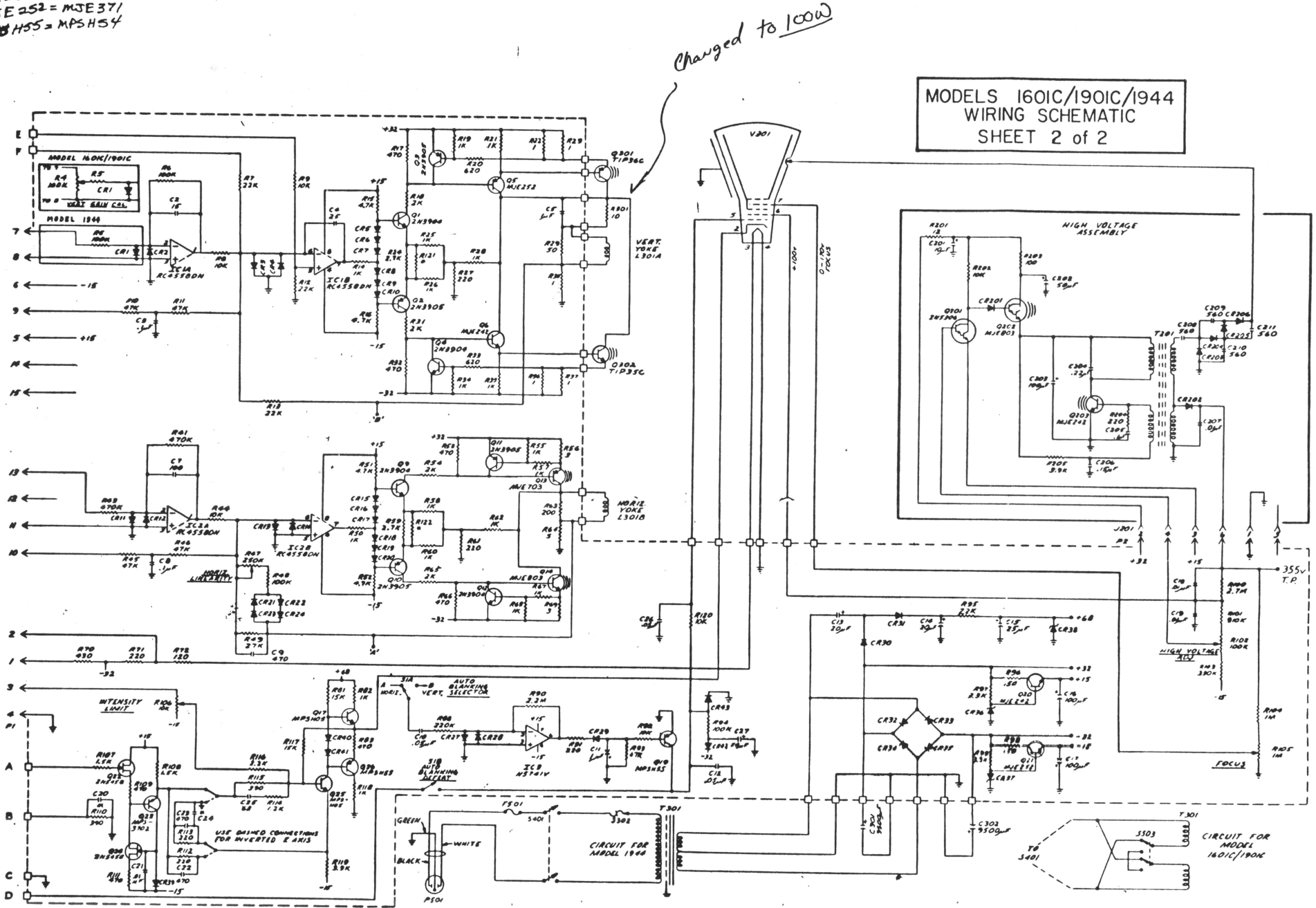
MODEL 1601C/1901C WIRING SCHEMATIC SHEET 1 OF 2



MJE 242 = MJE 243
MJE 252 = MJE 371
MPS H55 = MPS H54

changed to 100W

MODELS 1601C/1901C/1944 WIRING SCHEMATIC SHEET 2 of 2



Q22 + Q24 2N3958 or Tek 151-1054

PARTS LIST 1601C, 1901C, 1944 Main Board

REV B

REFERENCE SYMBOL	DESCRIPTION	WAVETEK PART NO.	MANUFACTURER CODE	MANUFACTURER NUMBER	TQ
"C "	CAPACITORS				
2	Cer disc, 15 pF ±5%, 1 kV	CD101-015	SPR	10TCC-Q15	1
4	Cer disc, 25 pF ±5%, 1 kV	CD101-025	SPR	10TCC-Q25	1
5	Flm, 1 µF ±10%, 100 V	CP103-510	SPR	225P	1
7	Cer disc, 100 pF ±5%, 1 kV	CD104-110	SPR	10TCU-T10	1
8,3	Cer disc, .1 µF ±20%, 100 V	CD103-410	SPR	TG-P10	2
9,22,23	Cer disc, 470 pF ±20%, 1 kV	CD102-147	SPR	5GA-T47	3
10,12,26	Cer disc, .05 µF ±20%, 100 V	CD103-350	SPR	TG-S50	3
11	Ta, 1.0 µF ±10%, 25 V	CE120-001	ACI	100DE105	1
13,14	Elect, 20 µF, 250 V	CE109-020	C-D	BR20-250	2
15	Elect, 25 µF, 100 V	CE121-025	MAL	TT100X25	1
16,17	Elect, 100 µF +150%-10%, 25 V	CE105-110	SPR	TE-1211	2
18,19,21	Cer disc, .01 µF ±20%, 1 kV	CD102-310	SPR	5GA-S10	3
24	Cer disc, 200 pF ±20%, 1 kV	CD102-120	SPR	5GA-T20	1
25	Cer disc, 68 pF ±5%, 1 kV	CD104-068	SPR	10TCU-Q68	1
27	Elect, 50 µF +150%-10%, 50 V	CE107-050	SPR	TE-1307	1
"CR "	DIODES				
1 thru 20, 27,28,39, 40,41	Si, Computer Diode	DG109-140	G-E	1N914	25
21,22,23,24, 29,30,31, 42,43	Si, Junction 100 PIV 3/4 A	DR000-001	DIO	1N4004	9
32,33,34,35	Si, Junction 200 PIV 3 A	DR000-009	G-E	1N5624	4
36,37	Zener, 16 V ±5%, 1 W	DB000-012	C-L	1N4745A	2
38	Zener, 68 V ±10%, 1 W	DB000-004	C-L	ZD68A	1
"IC "	INTEGRATED CIRCUITS				
1,2	Dual Op. Amp. RC4558DN RAY only	IC000-027	W-I	IC000-027	2
3	Operational Amplifier, 8 pin, DIP	IC000-002	SIG	N5741V	1
"P "	CONNECTORS (PLUGS)				
1	15 pin locking plug	MC000-080	MOL	09-65-1151	1
2	6 pin locking plug	MC000-075	MOL	09-65-1061	1
"Q "	TRANSISTORS				
1,4,9,12	NPN, Si	QA039-040	NAT	2N3904	4
2,3,10,11	PNP, Si	QA039-050	MOT	2N3905	4
5,21	PNP, Si, Power	QB000-022	MOT	MJE252	2
6,20	NPN, Si, Power	QB000-023	MOT	MJE242	2
13	PNP, Si, Power, Darlington	QB000-024	MOT	MJE703	1
14	NPN, Si, Power, Darlington	QB000-025	MOT	MJE803	1
17,25	NPN, Si	QB000-032	MOT	MPSH05	2
19,26	PNP, Si	QB000-027	MOT	MPSH55	2
22,24	N-Channel JFET, matched pair (2N5458)	QB000-017	W-I	QB000-017	1
23	PNP, Si	QB000-009	MOT	MPS3702	1

PARTS LIST

160IC, 190IC, 1944 Main Board

REV B

REFERENCE SYMBOL	DESCRIPTION	WAVETEK PART NO.	MANUFACTURER CODE	MANUFACTURER NUMBER	TQ
"R "	RESISTORS				
5,6,48,94	Comp, 100 KΩ ±10%, ¼ W	RC104-410	A-B	CB1041	4
7,12,13	Comp, 22 KΩ ±10%, ¼ W	RC104-322	A-B	CB2231	3
8,9,44,92, 120	Comp, 10 KΩ ±10%, ¼ W	RC104-310	A-B	CB1031	5
10,11,45,46, 93	Comp, 47 KΩ ±10%, ¼ W	RC104-347	A-B	CB4731	5
14,21,35,50, 82,118	Comp, 1 KΩ ±10%, ¼ W	RC104-210	A-B	CB1021	6
15,16,51,52	Comp, 4.7 KΩ ±10%, ¼ W	RC104-247	A-B	CB4721	4
17,32,53,66	Comp, 470 Ω ±5%, ¼ W	RC103-147	A-B	CB4715	4
18,31,54,65	Comp, 2 KΩ ±5%, ¼ W	RC103-220	A-B	CB2225	4
19,25,26,34, 55,57,58, 60,67,68	Comp, 1 KΩ ±5%, ¼ W	RC103-210	A-B	CB1025	10
20,33	Comp, 620 Ω ±5%, ¼ W	RC103-162	A-B	CB6215	2
22,23,36,37	WW, 1 Ω ±5%, 5 W	RM104-R10	SPR	243E1R05	4
24,59	Comp, 2.7 KΩ ±5%, ¼ W	RC103-227	A-B	CB2725	2
27,61	Comp, 220 Ω ±5%, ½ W	RC105-122	A-B	EB2215	2
28,62	Comp, 1 KΩ ±10%, 2 W	RC110-210	A-B	HB1021	2
29	WW, 50 Ω ±5%, 10 W	RM103-050	SPR	247E5005	1
30	WW, 1 Ω ±5%, 10 W	RM103-R10	SPR	247E1R05	1
41	Comp, 470 KΩ ±10%, ¼ W	RC104-447	A-B	CB4741	1
43	Comp, 470 KΩ ±10%, ½ W	RC106-447	A-B	EB4741	1
47	Var cermet, 250 KΩ	RP131-425	CTS	360T254	1
49	Comp, 27 KΩ ±10%, ¼ W	RC104-327	A-B	CB2731	1
56,69	Comp, 3 Ω ±5%, 1 W	RC107-R30	A-B	CB30G5	2
63	WW, 200 Ω ±5%, 10 W	RM103-120	SPR	247E2015	1
64	WW, 5 Ω ±5%, 3 W	RM102-R50	SPR	242E5R05	1
70	Comp, 430 Ω ±5%, ½ W	RC105-143	A-B	EB4315	1
71	Comp, 220 Ω ±5%, 2 W	RC109-122	A-B	HB2215	1
72	Comp, 120 Ω ±5%, 2 W	RC109-112	A-B	HB1215	1
81	Comp, 15 KΩ ±10%, 2 W	RC110-315	A-B	HB1531	1
83,109,111	Comp, 470 Ω ±10%, ¼ W	RC104-147	A-B	CB4711	3
88	Comp, 220 KΩ ±10%, ¼ W	RC104-422	A-B	CB2241	1
90	Comp, 2.2 MΩ ±10%, ¼ W	RC104-522	A-B	CB2251	1
91,112,113	Comp, 220 Ω ±10%, ¼ W	RC104-122	A-B	CB2211	3
95	Comp, 2.2 KΩ ±10%, ½ W	RC106-222	A-B	EB2221	1
96,98	Comp, 150 Ω ±10%, 2 W	RC110-115	A-B	HB1511	2
97,99	Comp, 3.3 KΩ ±10%, ¼ W	RC104-233	A-B	CB3321	2
100	Comp, 2.7 MΩ ±5%, ¼ W	RC105-527	A-B	EB2755	1
101	Comp, 910 KΩ ±5%, ¼ W	RC103-491	A-B	CB9145	1
102	Var cermet, 100 KΩ	RP131-410	CTS	360T104	1
103	Comp, 330 KΩ ±5%, ¼ W	RC103-433	A-B	CB3345	1
104	Comp, 1 MΩ ±10%, ½ W	RC106-510	A-B	EB1051	1
105	Var cermet, 1 MΩ	RP131-510	CTS	360T105	1
106	Var cermet, 10 KΩ	RP131-310	CTS	360T103B	1
107,108	Comp, 1.5 KΩ ±10%, ¼ W	RC104-215	A-B	CB1521	2
110,115	Comp, 390 Ω ±10%, ¼ W	RC104-139	A-B	CB3911	2
114	Comp, 1.2 kΩ ±10%, ¼ W	RC104-212	A-B	CB1221	1

PARTS LIST

1601C, 1901C, 1944 Main Board

REV B

REFERENCE SYMBOL	DESCRIPTION	WAVETEK PART NO.	MANUFACTURER CODE	MANUFACTURER NUMBER	TQ
"R"	RESISTORS (Cont'd)				
116	Comp, 2.2 KΩ ±10%, ¼ W	RC104-222	A-B	CB2221	1
117	Comp, 15 KΩ ±10%, ½ W	RC106-315	A-B	EB1531	1
119	Comp, 3.9 KΩ ±10%, ¼ W	RC104-239	A-B	CB3921	1
121,122	Comp, factory selected	---------	---	------	2
"S"	SWITCHES				
1	Dual, slide, SPDT	SS000-005	SCC	SS191-21	1
	MISCELLANEOUS				
	pc board	Z333A/Z335	W-I	Z333A/Z335	1
	Terminals	HT123-000	W-I	HT123-000	82
	for Model 1601C/1901C Add				
"R"	RESISTORS				
4	Var cermet, 100 KΩ	RP131-410	CTS	360T104	1

PARTS LIST

1115-00-0006 $264.10

A309-1 HIGH VOLTAGE REV

REFERENCE SYMBOL	DESCRIPTION	WAVETEK PART NO.	MANUFACTURER CODE	MANUFACTURER NUMBER	TQ
"C 200"	CAPACITORS				
1	Elect, 10 µF +150%-10%, 50 V	CE107-010	SPR	TE-1304	1
2	Elect, 50 µF +150%-10%, 50 V	CE107-050	SPR	TE-1307	1
3	Elect, 100 µF +150%-10%, 25 V	CE105-110	SPR	TE-1211	1
4	Mylar, .22 µF ±10%, 200 V	CP101-422	C-D	WMF-2P22	1
5	Mylar, .1 µF ±10%, 200 V	CP101-410	C-D	WMF-2P1	1
6	Mylar, .15 µF ±10%, 100 V	CP103-415	C-D	WMF-1P15	1
7	Cer disc, .01 µF ±20%, 1 kV	CD102-310	SPR	5GA-S10	1
8,9,10,11	Cer disc, 560 pF ±20%, 6 kV	CD111-156	A-E	6CCD561	4
"CR 200"	DIODES				
1	Si, Junction, 100 PIV	DR000-001	DIO	1N4004	1
2,3,4,5,6	Si, High Voltage, 7000 PIV 10 mA	DR000-010	SEM	SCM70	5
"J 200"	CONNECTORS (JACKS)				
1	6 pin harness connector	MC000-076	MOL	09-50-3061	1
	Contacts	MC000-068	MOL	08-50-0107	5
"Q 200"	TRANSISTORS				
1	NPN, Si, Darlington	QA053-060	G-E	2N5306	1
2	NPN, Si, Darlington	QB000-025	MOT	MJE803	1
3	NPN, Si	QB000-023	MOT	MJE242	1
"R 200"	RESISTORS				
1	Comp, 12 Ω ±10%, ½ W	RC106-012	A-B	EB1201	1
2	Comp, 10 KΩ ±10%, ¼ W	RC104-310	A-B	CB1031	1
3	WW, 100 Ω ±5%, 5 W	RM104-110	SPR	243E1015	1
4	Comp, 220 Ω ±10%, ¼ W	RC104-122	A-B	CB2211	1
5	Comp, 3.9 KΩ ±10%, ¼ W	RC104-239	A-B	CB3921	1
"T 200"	TRANSFORMERS				
1	High Voltage 5610-00-0025 $69.25 ≈ 5days	TT002-028	W-I	TT002-028	1
	MISCELLANEOUS				
	High Voltage Lead Assembly	MC000-060	N-T	239-12	1
	Turret Terminal	HT115-000	SEL	RST-SM-21-TUR	5

PARTS LIST

1601C, 1901C, 1944 Chassis REV

REFERENCE SYMBOL	DESCRIPTION	WAVETEK PART NO.	MANUFACTURER CODE	MANUFACTURER NUMBER	TQ
"C 300"	CAPACITORS				
1,2	Elect, 9500 µF, 50 V	CE117-295	MAL	CG952U-050EFH3	2
"J 300"	CONNECTORS (JACKS)				
	CRT Socket	MC000-061	A-P	321-7 pin	1
"L 300"	INDUCTORS				
1	Yoke	LY000-001	W-I	LY000-001	1
"Q 300"	TRANSISTORS				
1	PNP, Si, Power 125 W, 25 A	QB000-030	T-I	TIP36C	1
2	NPN, Si, Power 125 W, 25 A	QB000-029	T-I	TIP35C	1
"R 300"	RESISTORS				
1	WW, 10 Ω ±5%, 50 W	RM105-010	OHM	0400B	1
"S 300"	SWITCHES				
1	Thermal Switch (Part of TT000-031)	--------	---	-------	-
"T 300"	TRANSISTORS				
1	Power, 115 V pri, w/thermal cutout for Model 1944	TT000-031	W-I	TT000-031	1
	Power, 115/230 dual pri, for 1601C/1901C	TT000-026	W-I	TT000-026	1
"V 300"	TUBES				
1	Cathode Ray Tube, P1 phosphor	VV001-004	C-E	CE387-M12P1	1

PARTS LIST 1601C/1901C Front Panel REV

REFERENCE SYMBOL	DESCRIPTION	WAVETEK PART NO.	MANUFACTURER CODE	MANUFACTURER NUMBER	TQ
"C 400"	CAPACITORS				
1	Mylar, .22 µF ±10%, 200 V	CP101-422	C-D	WMF-2P22	1
"CR 400"	DIODES				
1	Red LED with mounting kit	DL000-001	NAT	NSL5046	1
"J 400"	CONNECTORS (JACKS)				
1,2	BNC Receptacle	JB106-250	APL	UG625/U	2
3	15-Pin Harness Connector	MC000-081	MOL	09-50-3151	1
	Contacts for Above	MC000-068	MOL	08-50-0106	12
"R 400"	RESISTORS				
1	Var carbon, 10 kΩ & pull-close switch	RP135-310	W-I	RP135-310	1
2	Var carbon, 1 MΩ & pull-open switch	RP134-510	W-I	RP134-510	1
3,4	Var carbon, 10 kΩ	RP102-310	W-I	RP102-310	2
"S 400"	SWITCHES				
1	Toggle, DPST	ST000-009	C-H	7561K4	1
2	Part of R402 Assembly	----------	----	---------	-
3	Part of R401 Assembly	----------	----	---------	-

PARTS LIST

1601C/1901C Rear Panel REV

REFERENCE SYMBOL	DESCRIPTION	WAVETEK PART NO.	MANUFACTURER CODE	MANUFACTURER NUMBER	TQ
"C 500"	CAPACITORS				
1	Cer disc, .05 µF ±20%, 100 V	CD103-350	SPR	TG-S50	1
"F 500"	FUSES				
1	Fuse, 2 A, 125 V Slo-Blo	MF000-002	BUS	MDL2	1
"J 500"	CONNECTORS (JACKS)				
1,2	BNC Receptacle	JB106-250	APL	UG625/U	2
"P 500"	CONNECTORS (PLUGS)				
1	AC Plug/Cord Assembly	WL009-088	BEL	17405-S	1
"R 500"	RESISTORS				
1	Var, 50 kΩ ±10%	RP124-350	A-B	WA2G032S-503MA	1
2	Var, 20 kΩ ±20%	RP124-320	A-B	WA2G032S-203MA	1
"S 500"	SWITCHES				
1,2	Toggle, SPDT	ST000-003	ALC	MST105D	2
3	Slide, DPDT	SS000-003	S-I	46256LFE	1
	MISCELLANEOUS				
	Fuse holder	MF000-001	LIT	345001	1

PARTS LIST

B329-1
VERTICAL PRE-AMP

REV

REFERENCE SYMBOL	DESCRIPTION	WAVETEK PART NO.	MANUFACTURER CODE	MANUFACTURER NUMBER	TQ
"C 600"	CAPACITORS				
1	Film, .01 µF ±10%, 80 V	CP104-310	SPR	192P1039R8	1
2	Sil mica, 1000 pF ±5%, 500 V	CM101-210	ARC	DM19-102J	1
3	Cer disc, 100 pF ±5%, 1 kV	CD104-110	SPR	10TCU-T10	1
4	Cer disc, 10 pF ±5%, 1 kV	CD101-010	SPR	10TCC-Q10	1
5,9,10,11,13	Cer disc, .05 µF ±20%, 100 V	CD103-350	SPR	TG-S50	5
6,7	Cer disc, 20 pF ±5%, 1 kV	CD101-020	SPR	10TCC-Q20	2
8	Film, .22 µF ±10%, 200 V	CP101-422	C-D	WMF-2P22	1
12,14	Elect, 150 µF 10 V	CE115-115	SPR	503D-1576-010CB	2
"CR 600"	DIODES				
1,2	Si, Computer Diode	DG109-140	G-E	1N914	2
3,4	Zener, 6.2 V ±10%, 1 W	DB000-011	C-L	1N4735	2
"IC 600"	INTEGRATED CIRCUITS				
1	Operational Amplifier, 8 pin, DIP	IC000-008	NAT	LM301AN	1
2	Dual Operational Amplifier, 8 pin, DIP	IC000-005	MOT	MC1458P1	1
"Q 600"	TRANSISTORS				
1	Dual N-channel, JFET	QB000-026	A-D	AD3958	1
"R 600"	RESISTORS				
1	Met flm, 1.00 kΩ ±1%, 1/8 W	RF212-100	CGW	RN55D	1
2	Met flm, 9.09 kΩ ±1%, 1/8 W	RF212-909	CGW	RN55D	1
3	Met flm, 90.9 kΩ ±1%, 1/8 W	RF213-909	CGW	RN55D	1
4	Met flm, 909 kΩ ±1%, 1/8 W	RF214-909	CGW	RN55D	1
6,11,14,21, 22	Comp, 1.0 kΩ ±10%, ¼ W	RC104-210	A-B	CB1021	5
7	Comp, 56 kΩ ±10%, ¼ W	RC104-356	A-B	CB5631	I
8,9,10	Comp, 2 kΩ ±5%, ¼ W	RC103-220	A-B	CB2025	3
12	Met flm, 374 kΩ ±1%, 1/8 W	RF214-374	CGW	RN55D	1
13,20	Met flm, 10.0 kΩ ±1%, 1/8 W	RF213-100	CGW	RN55D	2
15	Var Carbon, 10 kΩ Part of S602 Assembly	---------	---	-----	-
16	Comp, 680 Ω ±10%, ¼ W	RC104-168	A-B	CB6811	1
17	Comp, 1 MΩ ±10%, ¼ W	RC104-510	A-B	CB1051	1
18	Var cermet, 250 kΩ ±20%	RP129-425	CTS	360S254B	1
19	Comp, 10 kΩ ±10%,	RC104-310	A-B	CB1031	1
23*	Factory selected value, if used	---------	---	-------	-
"S 600"	SWITCHES				
1	SPST, pull-open, part of S602 Assembly	---------	---	------	-
2	Rotary, 1 Pole, 4 Position (plus S601 and R615)	SR000-027	W-I	SR000-027	1

MANUAL CHANGES

All Ocilloscopes

WAVETEK'S product improvement program incorporates the latest electronic developments into these instruments as rapidly as development and testing permit. Due to the time required to document and print these instruction manuals, it is not always possible to include the change information in the current printing. The following changes should be made to this manual:

CHANGES

1). Due to vendor changes, the wire connecting the CRT cathode and TP7 may be either a grey or a yellow wire. If a grey wire is used, no yellow wire will be present. If a yellow wire is used, no grey wire will be present.

2). On the CRT itself, pins 1 and 5 are internally shorted together, and either may be used to connect the CRT grid to the blanking cirucit.