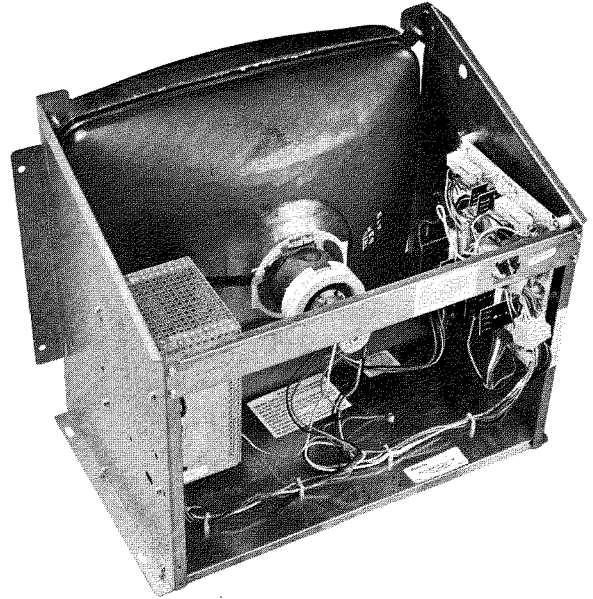
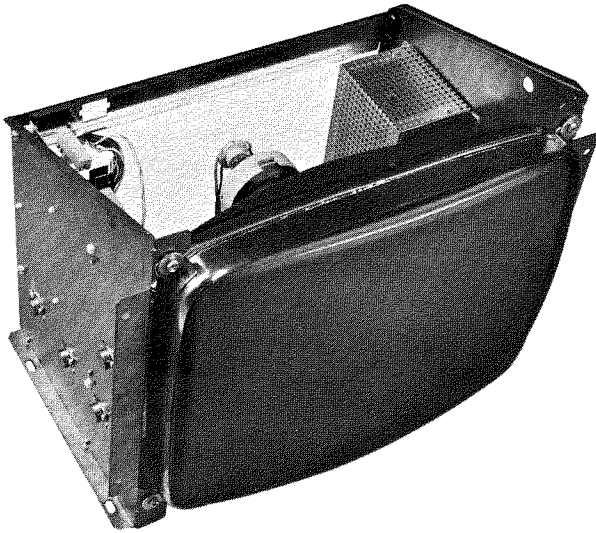




# WELLS-GARDNER ELECTRONICS CORPORATION

## GRAPHIC DISPLAY UNIT MODEL 19V2000



### ELECTRICAL SPECIFICATIONS

INPUT VOLTAGE ..... 30-0-30 VAC RMS center tapped @ nominal line for amplifier. 6.6 VAC RMS for filament.

I/P VOLT RANGE ..... + 10% to -10%

I/P POWER @ 60V AC ..... 122 Watts AC (Amplifiers at max. deflection)

SIGNAL INPUTS ..... "X" horizontal 20V P/P (+ 10V to -10V)  
(@ MAX. DEFLECTION) "Y" vertical 15V P/P (+ 7.5V to -7.5V)  
"Z" beam drive 4.0V max. brite 1.0V black level

INPUT IMPEDANCE ..... "X".....1.3K Ohm  
"Y".....1.3K Ohm  
"Z".....270 Ohm

JUMP SPEED ..... Deflection Amp.....60 usec. (+ 10V step "X" amp)

Z BANDWIDTH ..... 10 MHz @ -3DB point

HIGH VOLTAGE ..... 14.5KV @  $I_b = 0$   
Adjustable  $\pm 5\%$

HIGH VOLTAGE REGULATION 2.0% max.  
( $I_b$  0 TO 100  $\mu$ A)

FACTORY ADJUSTED ..... "X" & "Y" linearity  
CONTROLS H.V. adjust, Focus

CUSTOMER CONTROLS ..... Contrast, brightness

ENVIRONMENTAL ..... Operating ambient 0° to 55°C

## WELLS-GARDNER ELECTRONICS CORPORATION

2701 NORTH KILDARE AVENUE  
CHICAGO, ILLINOIS 60639

# SERVICE MANUAL AND PARTS CATALOG

## GENERAL INFORMATION

The Graphic Display unit is intended for the video game market. There are two models available and only differ in picture tube size and CRT mounting.

The main sections of the display are the H.V. Power Supply and Deflection Amplifier circuitry. A.C. power and X, Y, Z signals are fed to the display through a 12 pin receptacle located on the rear support strut. A major part of the circuitry is located on a plug-in circuit board. X-Y output transistors are mounted on side panel which also serves as a heat sink for these devices. H.V. regulator output and oscillator transistors are mounted on H.V. cage.

Component reference numbers and circuit legend are printed on the circuit board to aid in servicing. The picture tube is securely mounted to the chassis by brackets to create the complete unit. The picture tubes used all have implosion protection.

Side panel controls on right edge of Deflection P.C. Board include contrast, brightness, X linearity and Y linearity controls. Side panel control on H.V. cage at left includes focus control. H.V. adjust control is accessible through H.V. cover near center of H.V. cage front.

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## WARNINGS

### X-RADIATION

THIS CHASSIS HAS BEEN DESIGNED FOR MINIMUM X-RADIATION HAZARD. HOWEVER, TO AVOID POSSIBLE EXPOSURE TO SOFT X-RADIATION IT IS IMPERATIVE THAT THE H.V. CIRCUITRY IS NOT MODIFIED.

### HIGH VOLTAGE

THIS DISPLAY CONTAINS HIGH VOLTAGES DERIVED FROM POWER SUPPLIES CAPABLE OF DELIVERING LETHAL QUANTITIES OF ENERGY. TO AVOID DANGER TO LIFE, DO NOT ATTEMPT TO SERVICE THE CHASSIS UNTIL ALL PRECAUTIONS NECESSARY FOR WORKING ON HIGH VOLTAGE EQUIPMENT HAVE BEEN OBSERVED. IN ORDER TO PREVENT DAMAGE TO SOLID STATE DEVICES, DO NOT ARC PIX TUBE ANODE LEAD TO CHASSIS OR EARTH GROUND.

# PRODUCT SAFETY SERVICING GUIDELINES

## CAUTION

No modification of any circuit should be attempted. Service work should be performed only after you are thoroughly familiar with all of the following safety checks and service guidelines. To do otherwise increases the risk of potential hazards and injury to the user.

## SAFETY CHECKS

Subject: Fire and Shock Hazard

1. Do not install, remove, or handle the picture tube in any manner unless shatter-proof goggles are worn. People not so equipped should be kept away while picture tubes are handled. Keep the picture tube away from the body while handling.
2. When service is required, observe the original lead dress. Extra precaution should be given to assure correct lead dress in the high voltage circuitry area. Where a short circuit has occurred, replace those components that indicate evidence of overheating. Always use the manufacturer's specified replacement component. See parts list in the back of this manual.
3. Periodically check the high voltage for proper value ( $14.5 \text{ KV} \pm 5\%$  at 0 beam current) using a meter of known accuracy and calibration.
4. To prevent fire or shock hazard DO NOT EXPOSE THIS DISPLAY TO RAIN OR MOISTURE.
5. Check for frayed insulation on wires.

## OPERATING INSTRUCTIONS

1. Apply a suitable power and signal source to the deflection PCB P299 by means of input connector P100. (Refer to Assembly View Diagram, page 21)
2. **Brightness and Contrast**  
These controls are preset at the factory, but may be adjusted to suit program material. They are located on the right hand edge of the deflection amplifier PCB R517 is the brightness control and R514 is the contrast control. Both are finger adjustment controls.

Caution must be exercised when adjusting the brightness control. This control has more than 100% brightness range on most tubes. This control should be maintained below the point where a center spot appears on the CRT under normal input signal condition. Adjusting the control above this point may result in phosphor burn.

3. **Spot Killer Indicator**

A spot killer circuit is used to blank the CRT under a no signal condition. When the spot killer is active, the CRT will be extinguished and LED D504 will light indicating spot killer operation.

## IMPORTANT SERVICE NOTES

Work on these models should only be performed by those who are thoroughly familiar with precautions necessary when working on high voltage equipment.

Exercise care when servicing this chassis with power applied. Many B plus and high voltage RF terminals are exposed which, if carelessly contacted can cause serious shock or result in damage to the chassis. Maintain interconnecting ground lead connections between chassis and picture tube tag when operating chassis.

Certain HV failures can increase X-ray radiation. Units should not be operated with HV levels exceeding the specified rating for their chassis type. The maximum operating HV specified for the chassis used in these units is  $14.5\text{KV} \pm 500\text{V}$  at zero beam current with input voltage of  $60 \text{ VAC} \pm 10\%$ . Higher voltage may also increase possibility of failure in HV supply.

It is important to maintain specified values of all components in the high voltage circuits and anywhere else that could cause a rise in high voltage or operating supply voltages. Refer to the Parts List and use ONLY exact replacement parts; especially picture tubes, semiconductor devices, transformers, coils, fuses.

To determine the presence of high voltage, use an accurate high impedance HV meter connected between second anode lead and metal chassis frame only. When servicing the High Voltage System, remove static charge from it by connecting a 10K Ohm resistor in series with an insulated wire (such as a test probe) between picture tube tag and 2nd anode lead. (Input plug disconnected from chassis).

The picture tube used in this display unit employs integral implosion protection. Replace with tube of the same type number for continued safety. Do not lift picture tube by the neck. Handle the picture tube only when wearing shatterproof goggles and after discharging the high voltage completely. Keep others without shatterproof goggles away.

Before returning the display to user, perform the following safety checks:

1. Inspect all lead dress to make certain that leads are not pinched or that hardware is not lodged between the chassis and other metal parts in the display.
2. Replace all protective devices such as non-metallic control knobs, insulating fishpapers, adjustment and compartment covers or shields.
3. To be sure that no shock hazard exists, a check for the presence of leakage current should be made at each exposed metal part.

## SERVICE INFORMATION

### CIRCUIT TRACING

Component reference numbers are printed on top and bottom of the plug-in circuit board to facilitate circuit tracing. In addition, terminal numbers are also shown and referenced on the chassis schematic diagram in this manual.

Transistor elements are identified as follows:  
E - emitter, B - base, and C - collector.

### COMPONENT REMOVAL

Removing components from the etched board is facilitated by the fact that the circuitry (plating) appears on one side of the board only.

It is recommended that a solder extracting gun be used to aid in component removal. An iron with a temperature controlled heating element would be desirable since it would reduce the possibility of damaging the board due to over-heating.

The nozzle of the soldering gun is inserted directly over the component lead and when sufficiently heated, the solder is drawn away leaving the lead free from the copper plating. This method is particularly suitable in removing multi-terminal components.

### CRT REPLACEMENT

Use extreme care in handling the CRT, as rough handling may cause it to implode due to atmospheric pressure. Do not nick or scratch glass or subject it to any undue pressure in removal or installation. Use goggles and heavy gloves for protection.

1. Discharge CRT by shorting 2nd anode to ground through a 10k Ohm resistor. Remove CRT socket, yoke and 2nd anode lead.
2. Remove CRT from chassis by removing four screws at corners.

### POWER TRANSISTOR REPLACEMENT

When replacing any "Plug-in" transistor, please observe the following precautions:

1. The transistor sockets are not "captive", that is, the transistor mounting screws also secure the socket. When installing the transistor, the socket must be held in its proper location. This location is indicated by flanges on the socket which fit into the heat sink.
2. When replacing the output transistors, silicone grease should be applied evenly to both sides of the mica insulator.
3. All transistor mounting screws must be tight before applying power to the display. This insures proper cooling and electrical connections.

NOTE: Use caution when tightening transistor mounting screws. (Torque 7 to 10 inch lbs.) If the screw threads are stripped by excessive pressure, a poor electrical and mechanical connection will result.

## INDIVIDUAL CIRCUIT ANALYSIS

DC voltage measurements, using a meter with a 1 megohm or higher input, is useful in analyzing circuit faults in the H.V. Power Supply and Deflection Amplifier sections.

Scope waveforms are useful when checking the deflection amplifier and oscillator circuit. Waveforms can be compared to the scope photos in the service manual. (Refer to page 18) An ohm meter may be used to check for a shorted transistor or diode. In some cases, this can be done without removing the component from the circuit. When using an ohm meter, the AC power must be removed from the display.

### DEFLECTION AMPLIFIER

This board is held in place by mounting screws and a retaining bracket. There are three spacers and four mounting grommets underneath the board to keep board away from shorting it out with side panel. There is sufficient slack in the harness so that service may be performed with the set operating and this board removed from its mounting position. All of the plugs are keyed so improper termination would be difficult. P600 and P700 are interchangeable for trouble shooting purposes.

Deflection Amplifier Board (P299) contains "X", "Y" and "Z" amplifiers, 90V spot killer, "X" and "Y" spot killers, LED driver and DC low voltage power supply.

Before trouble shooting deflection amplifier board, visual inspection of board should be made to check a short circuit, broken lead or component overheating on board. Also observe the following when display is on.

1. D504 LED indicator will be on during a fault in the "X" or "Y" amplifier. The above condition will drive the CRT to cut off to prevent a CRT burn. Check "X", "Y" and "Z" signal inputs, before servicing deflection amplifier board.
2. An open 90V supply will drive the CRT into cut off. Check H.V. board for 90V supply, before troubleshooting Deflection Amplifier Board.

Should the sense resistors R720, R620 need replacement they must be replaced only with non-inductive resistors of the same value or display performance will be degraded.

Both output channels are fused. There must be replacement with similar fuses for continued protection of yoke and the T0-3 output devices.

The linearity controls R700, X channel, and R600, Y channel are factory set and do not normally require adjustment. These controls should not be used for Gain Controls. They are adjusted for best linearity.

Before making any adjustment on linearity controls, "X" and "Y" input signals should be checked for  $\pm 10V$  P/P and  $\pm 7.5$  P/P respectively while H.V. should be checked for  $14.5$  Kv  $\pm 500V$  @ zero beam current.

To check operation of the brightness and contrast controls, turn the contrast control (R514 green) to maximum. Adjust the brightness control (R517 grey) for a medium brightness display. Avoid high brightness levels which display retrace lines and a center spot.

## H.V. POWER SUPPLY

The CRT anode voltage is adjustable by means of R905. This control is accessible through the top perforated shield of the module. A hex tool 0.1 inch non-metallic composition should be used for this adjustment. Nominal H.V. is 14.5 KV @ 0 beam current.

Focusing may be set by means of R909. This control is accessible through the side shield of the module. It is a small flat blade (0.125") screwdriver adjustment. The focus voltage is adjustable over the range of 0 to +400 volts, and should be set for best overall definition.

When replacing the H.V. module, make certain that the CRT anode is safely discharged to ground through a 10k Ohm resistor before removing the anode cap.

Typical input current from the nominal 38V DC supply for a normal operating, unloaded H.V. module is 0.4 amp. Input current will increase with loading and higher than nominal 14.5 KV H.V. This line is fused by F102 located on Deflection Amplifier Board.

Under a load of 100 ua, H.V. should not change by more than 300 volts from 14.5 KV. Limit the brightness level on CRT such that beam current should not exceed 100 ua. To do otherwise will result in poor H.V. regulation.

The 90V line should be capable of supplying 25 ma output current with good regulation. The focus and G2 voltages are capable of only very low current drain; they are potential voltages only.

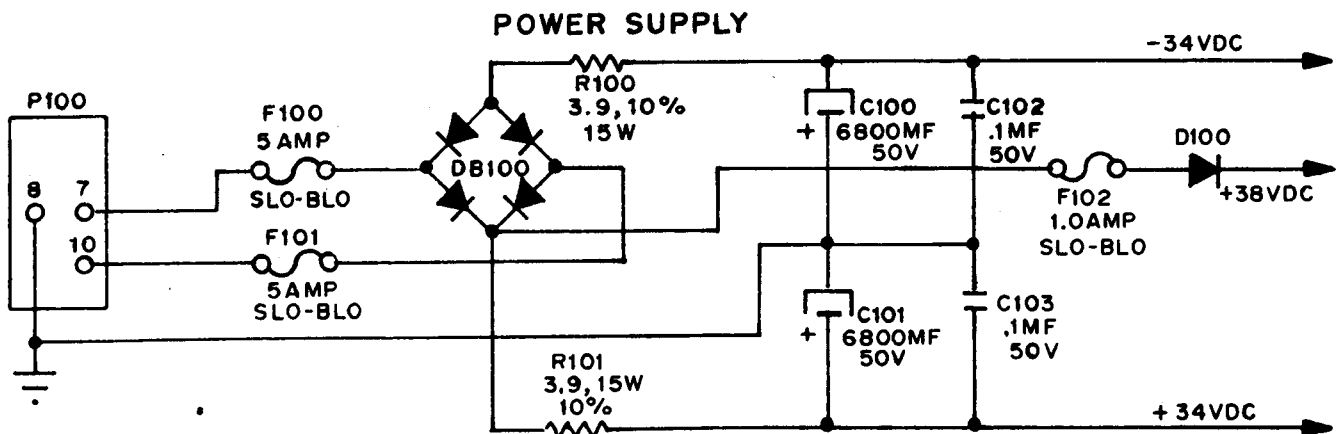
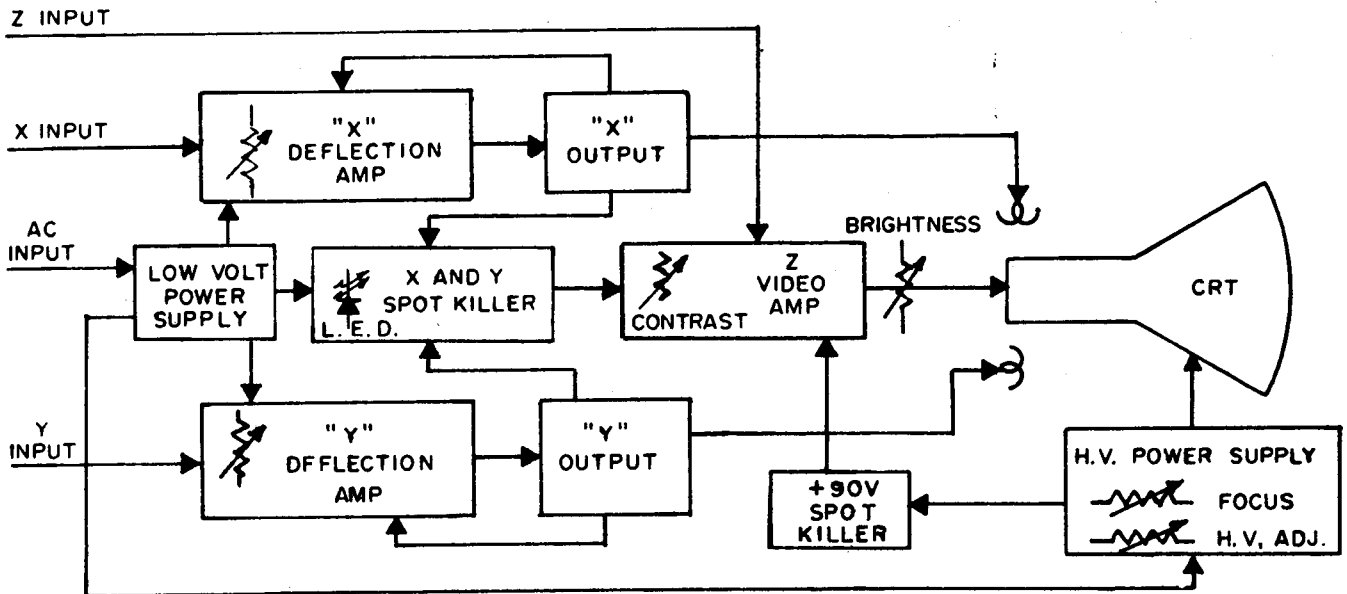
## CENTERING ADJUSTMENT

This is factory aligned and does not normally require any adjustment. However, in case of yoke replacement, proceed as follows:

Set the signal generator to display a rectangle of 10½" x 14" (Target Test Pattern). Adjust the brightness control for comfortable viewing of the display, keeping below the point where a no signal center spot appears on the CRT. Correct any yoke tilt and tighten the yoke clamp. Adjust the centering rings on yoke to align the center of target test pattern with geometric center of CRT.

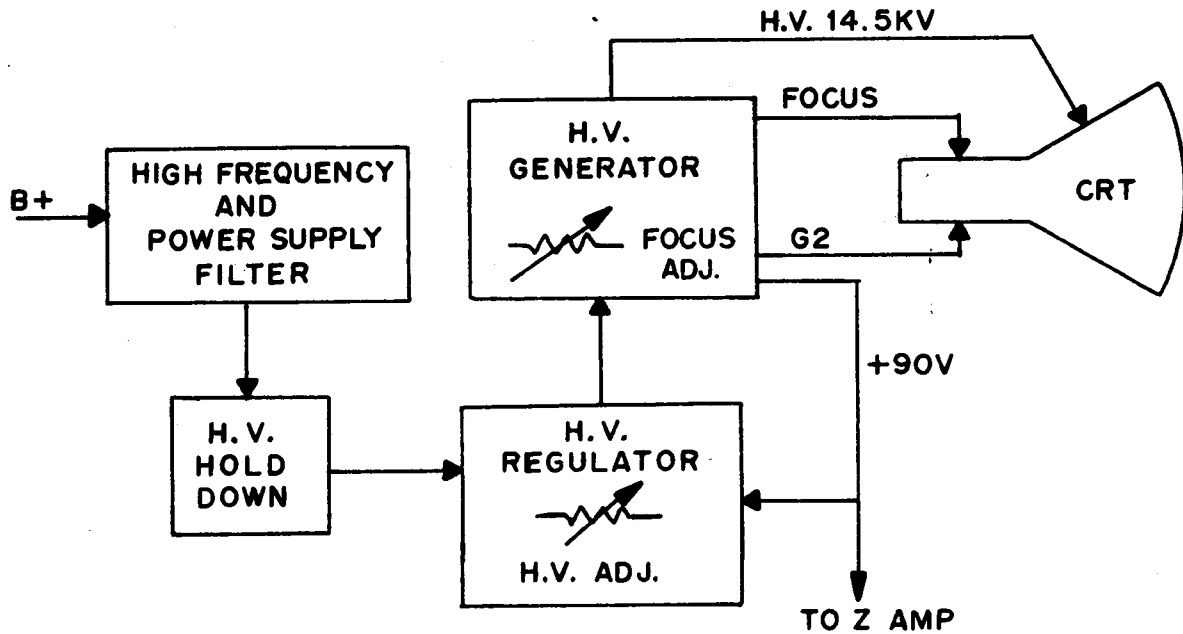
# THEORY OF OPERATION

## COMPLETE BLOCK DIAGRAM



A 30-0-30 VAC center tap is applied by means of P100-7, 8, 10 to bridge rectifier DB100 through F100 and F101. Output of DB100 is filtered by C100 and C101 to minimize ripple on power supply line of  $\pm 34V$  DC going to X and Y amplifier circuit on Deflection Board. R100 and R101 are used to limit rush current to the filters. B+ for H.V. circuit is taken off before limiting resistor. Typical ripple content on C100, C101 with a diagonal cross hatch pattern display is 1.0 volt P/P.

## H.V. SUPPLY BLOCK DIAGRAM

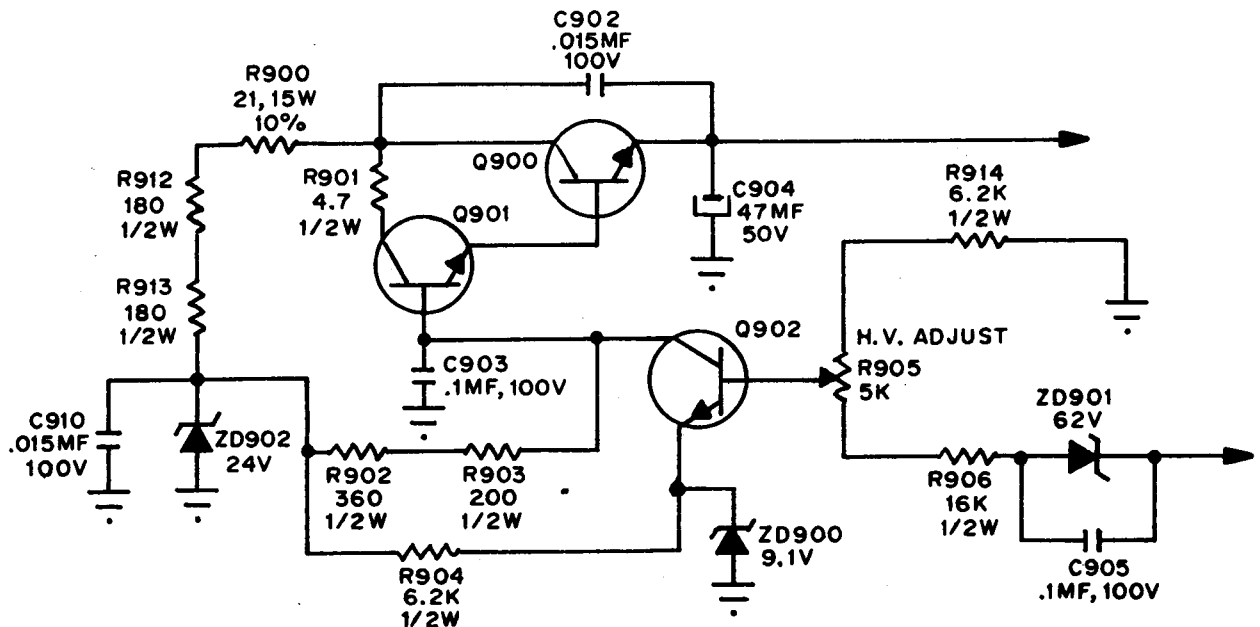


High voltage supply has been designed to operate over input supply voltage range of +33 to +42 volts, and an ambient temperature range of 0 to 55°C. This module produces nominal voltages of:

1.  $14.5 \pm 5\%$  KV @ beam current  $I_b = 0$
2.  $410 \pm 5\%$  volts @ 30 ua max. for G2
3. 0 to 410 volts for Focus
4.  $95 \pm 5\%$  volts for Z amplifier

The circuit can be broken down into 3 basic sub-systems; regulator, high voltage generator and high voltage hold down.

## HIGH VOLTAGE REGULATOR

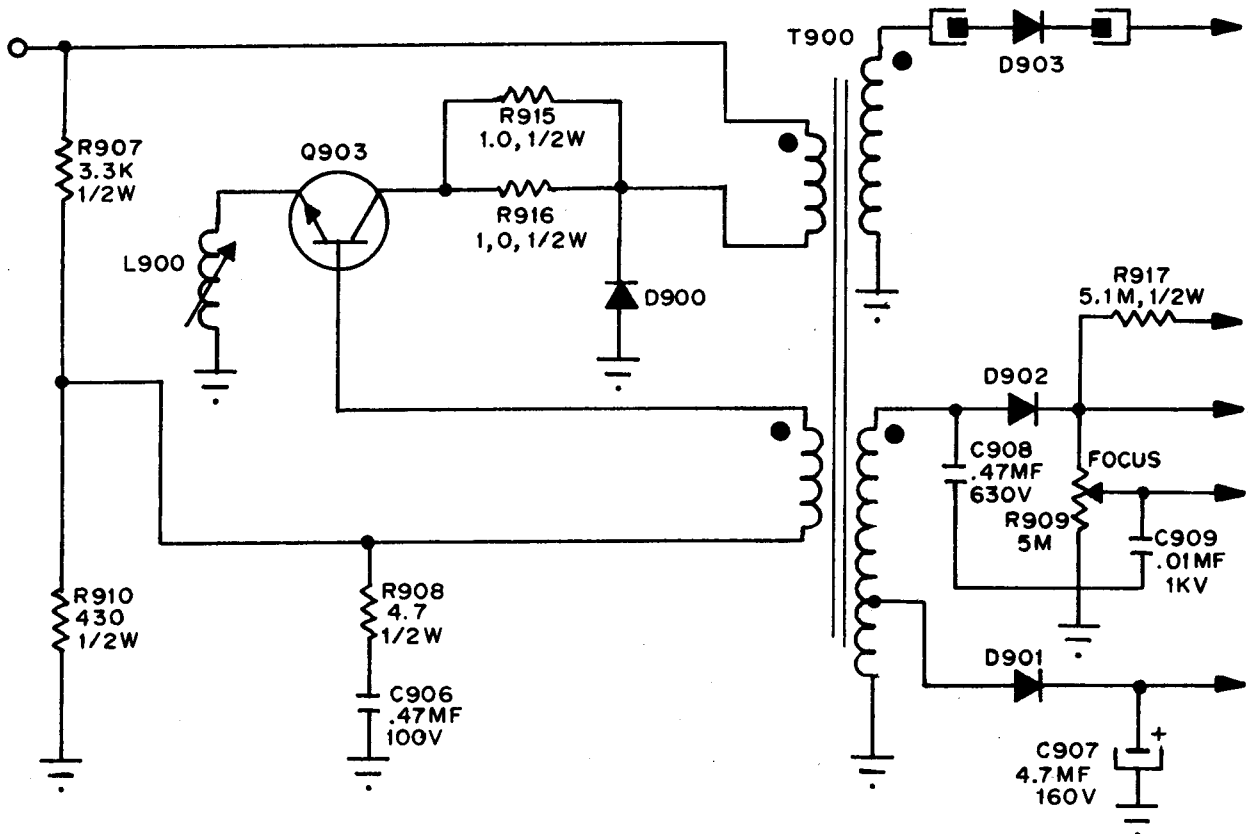


This is a series regulator with Q900 being the control element, Q901 a driver, and Q902 an error amp. ZD900 forms the emitter reference voltage source. Since the generated high voltage and other voltages are linked by means of the magnetic field of T900, any change in H.V. will be reflected back to all of the other voltages. This H.V. fluctuation is sensed on the 90V line and is used to control Q902. R906 and R914 are used to limit the range of H.V. adjustment by R905 to roughly 13.5 to 15.5 KV @ 0 beam current. ZD901 and C905 provide a means of dropping a large DC component without attenuating the error voltage that is needed to stabilize H.V. line. R904 provides a means of biasing ZD900 to insure a stable reference voltage for the error amp to work against. R902 and R903 is the collector load resistor for Q902 and biases Q900 and Q901 in the absence of an error signal.

The error amp. Q902, can only divert some of the base current from Q901 and shut the regulator down. It can not increase the conduction of the regulator above a level determined primarily by R902 and R903 and the current gain of Q900 and Q901. R901 is a buffer resistor to protect Q901.

C903 and C902 are used to suppress any tendency for high frequency oscillation that could generate radio frequency interference. C900, C901, C904 and R911 are filters and dampers to minimize ripple on power lines as well as to decouple 25 KHz pulses that are impressed onto the +38V line by a normally operating H.V. generator and prevent interference with other circuitry. L901 is a small high frequency filter choke to decouple the H.V. generator from the +VE supply rail and minimize line conducted radiation.

### HIGH VOLTAGE GENERATOR



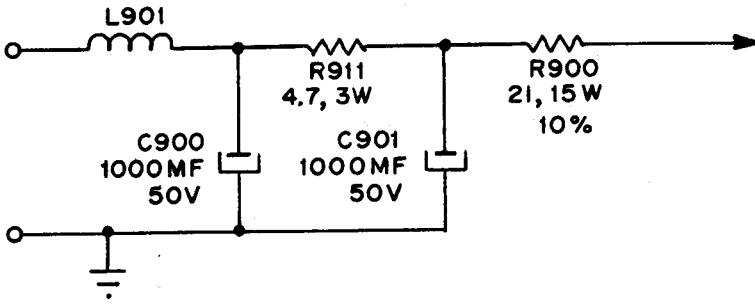
Q903, R907, R910, C906 and T900 form a free running Hartley Oscillator circuit that operates at approximately 25 KHz. The operating frequency is primarily determined by transformer and transistor characteristics. Feedback is established by the proper phasing of primary to feedback winding. AC feedback is determined by the turns ratio of primary to feedback winding as well as R908 and C906. The transistor must also be forward biased sufficiently to where oscillation can start when power is applied. This is controlled by R907 and R910. L900 is not essential to circuit operation but helps smooth out the AC waveform generated into a reasonable approximation of a sine wave. R915 and R916 are Safety resistors that

will burn out, and prevent damage to Q903, should the output circuitry come under excessive current drain. D900 is a surge diode.

There are two secondary windings. The H.V. winding delivers sufficient AC to the H.V. rectifier D903 to generate 14.5 KV anode voltage at a maximum current of 100 ua, and tapped lower voltage winding that is used to generate focus voltage of 0 to 410 VDC, and G<sub>2</sub> voltage of +410 VDC, and +90 volts for operation of the Z amp circuitry. D900, 901 and 902 are fast recovery diodes to operate @ high frequency of 25 KHz.

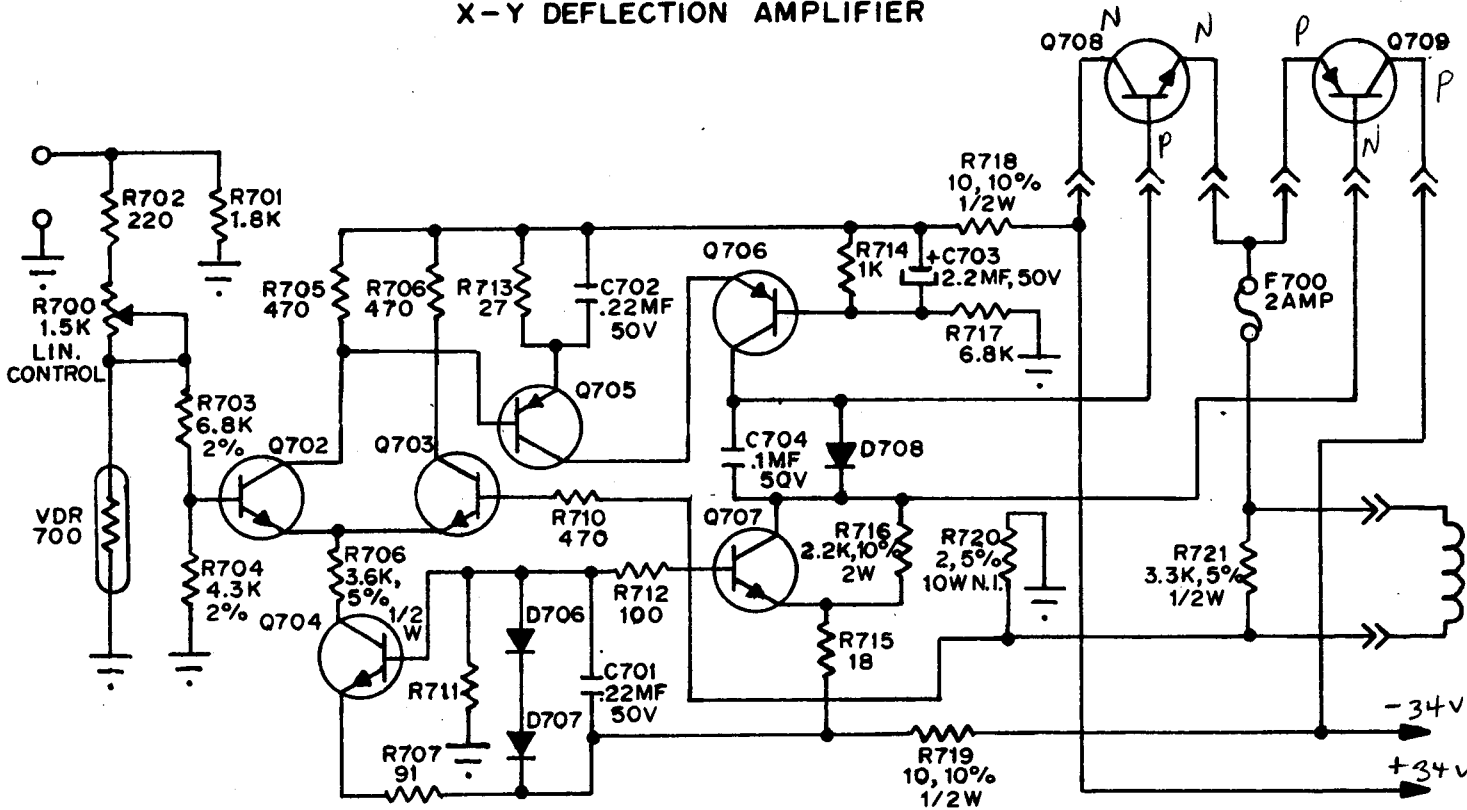


## H. V. HOLD DOWN



To comply with DHEW regulations it is necessary to insure that the H.V. may not rise to the point where soft x-rays are generated by CRT. This would occur at 22.5 KV when sufficient beam current is present. This is taken care by a limiter resistor R900 which supplies current to oscillator circuit. As H.V. increases, current in oscillator circuit will increase causing more voltage drop across R900. This will limit max. voltage supply to oscillator which in turn hold down H.V. from going up. R900 value has been selected such that H.V. will not exceed max. 21 KV under any regulator fault condition.

## X-Y DEFLECTION AMPLIFIER



X-CHANNEL SCHEMATIC

Both X and Y channels are practically identical with only minor differences in input signal levels of  $\pm 10V$  and  $\pm 7.5V$  respectively to accommodate the 4/3 aspect ratio of the CRT. Because of this, we will investigate only the X channel.

The amplifier is a direct coupled voltage to current converter. It is current through the yoke that will produce the magnetic field to deflect the electronic beam. The small signal response of the amplifier is DC to approximately 2 MHz with the large signal being limited mainly by yoke inductance and available supply voltage to a maximum slew rate of approximately 120 usec. for full deflection.

The input signal of  $\pm 10V$  is applied to P100-3 by a generator that is capable of delivering this voltage into a 1.3K Ohm load.

R702, R700, R703, R704 and VDR700 has been used to make correction and to compensate inherent non-linearity characteristics of CRT for deflection. VDR700 is used to produce a closer 1st order approximate to the desire pre-distortion necessary to correct for the CRT deflection non-linearity and controlled by R700.

The pre-distorted signal is applied to the input transistor of a differential amplifier comprised of Q702, Q703 and constant current source Q704. The current supplied by Q704 is split almost equally between Q702 and Q703 resulting in similar no signal collector voltages within 5% of the supply level. Very heavy negative feedback is applied to the base of Q703 from across R720, a non-inductive current sensing resistor. The voltage across which supplies an accurate representation of yoke current and forces the amplifier to correct any distortion present.

The signal present at the collector of Q702 is current amplified by Q705 and this in turn is used to drive Q706 which then drives the output transistors Q708 and Q709 forcing current through the x-winding of the yoke and producing beam deflection.

The output transistors are current driven with the actual driver transistor being Q706 and its constant current source being Q707. D708 is used to hold the bases of Q708 and Q709 separate by 0.6 of a volt. This results in output transistors that are biased class B. Because of push pull arrangement of output transistors, and the

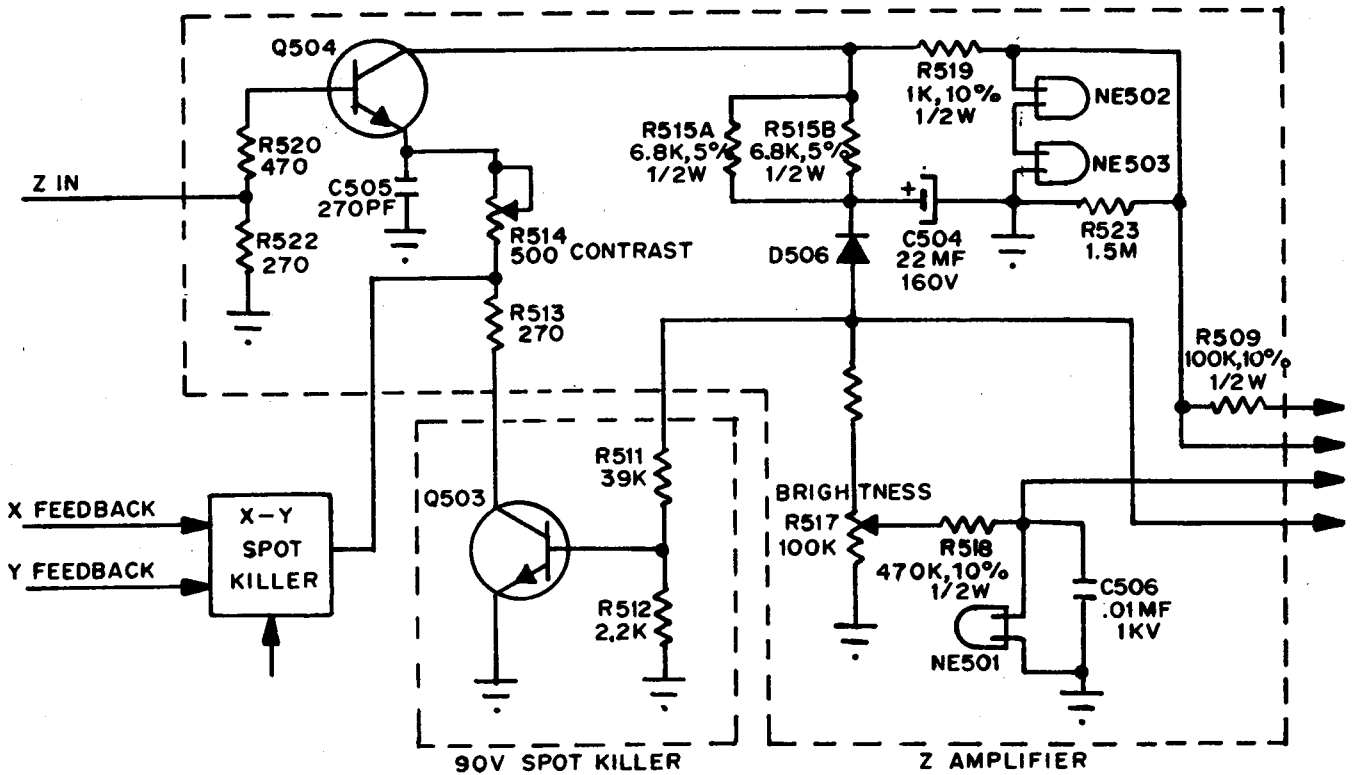
cancelling effect of such a stage on any common ripple component considerable amount of power supply ripple can be tolerated. Any small amount of crossover distortion that may result from class B operation is removed by means of the very heavy negative feedback present. C704 is used to maintain a low impedance path across D708. Q704 is a constant current source with fixed bias voltage maintained by D706 and D707 with R711 allowing current to flow through them from -ve rail to ground.

Q707 works exactly the same way as Q704 except R716 has been added to dissipate more power where total current flowing through both Q707 and R716 is constant. R712 is a suppressing resistor to prevent spontaneous oscillation of Q707. C701 is an H.F. bypass.

R721 is a resistor critically selected to damp the yoke and minimize any tendency for ringing.

In case of a failure of an output device or an extreme excursion of the electron beam, F700 will open and prevent damage to the yoke or sense resistor as well as remove all loading from Q708 and Q709, thus protecting those from potential failure also.

## Z AMPLIFIER



The Z amplifier provides intensity modulation of the electron beam. A minimum 8 steps are discernable. The driving generator must be capable of the following outputs into a 270 ohm load:

- 1.0 volt black level
- 4.0 volts full beam intensity

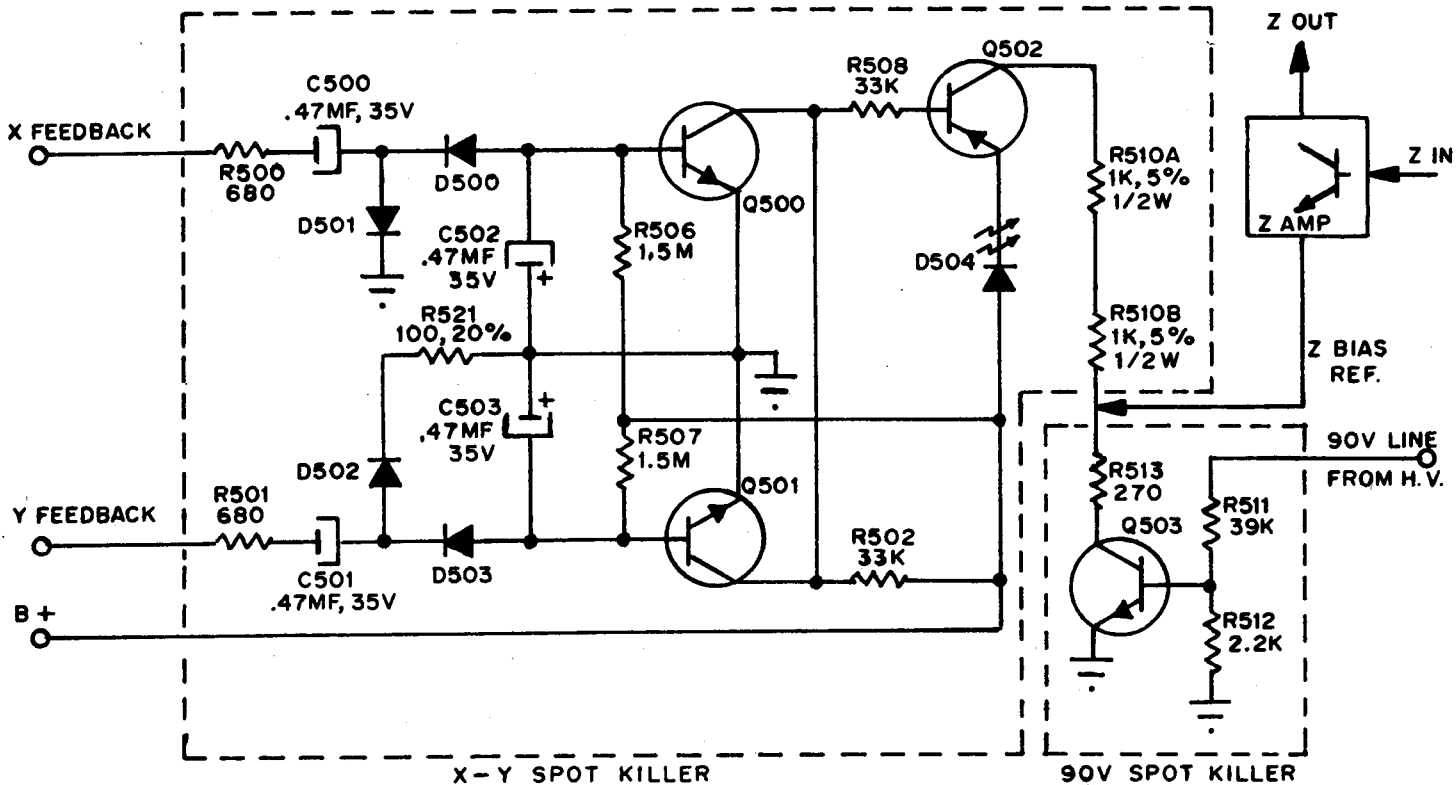
Q504 is a single stage common emitter amplifier with a 3 dB point of 10 MHz capable of sufficient amplification to control the electron beam, typically 30V P-P of signal may be found on the cathode of the CRT. R514 is a contrast control and varies the AC gain over a range of 3/1. C505 is a peaking capacitor selected for good high frequency response with minimum overshoot.

Brightness is controlled by the DC bias voltage between cathode and G<sub>1</sub> of CRT, with G<sub>1</sub> being the most negative with respect to cathode. It is set by a divider network comprised of R516 and brightness control R517. In order

to accommodate the large differences in turn on characteristics of CRT, brightness control range should be about 25% or more. This means that on most tubes it is now possible to turn this control up to the point where an undeflected beam may be seen on the screen. Care must be used when adjusting this control because should this occur, the probability is high that phosphor will burn and irreversible CRT damage will result in short order.

R518, C506 and NE501 are a spark suppression network to keep any transient voltage spikes that may be generated inside the CRT due to internal arcing from damaging the Z amp by routing them to ground. R519, NE502 and NE503 are also arc suppression components. The two neons have a combined firing voltage of approximately 130 volts. Any voltage spike greater than 130 volts will trigger the neons and provide a very low impedance path to ground.

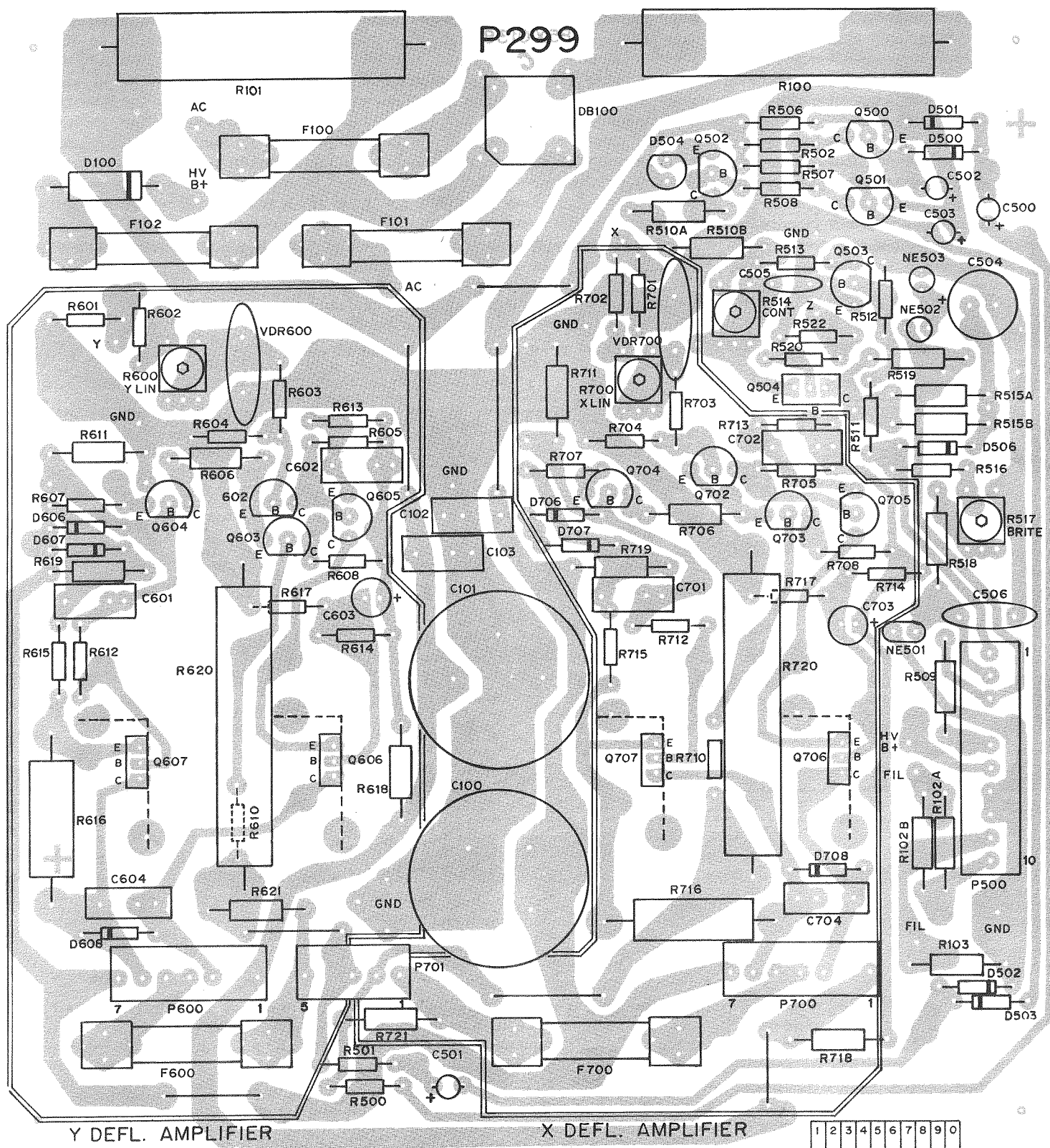
## X-Y-90V SPOT KILLER



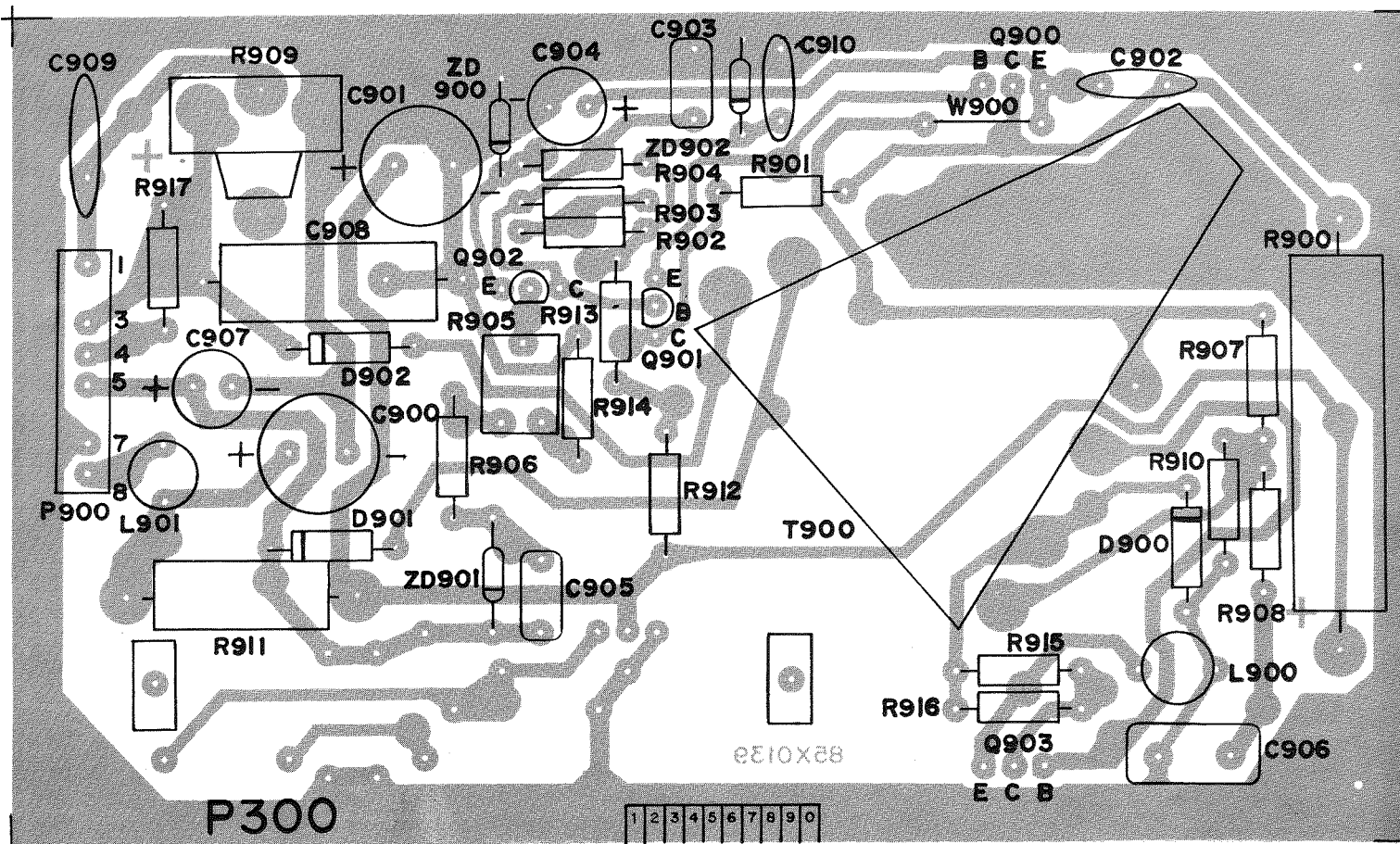
It is important to protect CRT from phosphor burn by an undeflected brite spot on screen under different fault conditions. This can be done by cutting off electron beam (Z amplifier) and also by allowing the CRT heater to cool down before the cathode to  $G_1$  bias voltage becomes small enough to turn on the electron beam on screen depending upon different fault conditions. A typical cathode to  $G_1$  voltage for a just visible display is 60 volts. D506 is an isolation diode to prevent discharge of C504 through any resistance path in H.V. supply and brightness control circuitry. Following are examples of typical fault conditions.

- A. On power down, Z is cut off as Q503 and Q504 are not conducting, while D506 blocks discharge path of C504 long enough to hold cathode voltage until heater filament cools down.
- B. On +90 volts failure, Q503 is turned off, which in turn cuts off Q504 while the cathode of the CRT will reach the 95V supply potential. Since Z is cut off and cathode is at 95V supply potential, this will eliminate any phosphor burn on CRT.

- C. Spot killer circuit is also intended to protect CRT in case of X or Y or both amplifier circuits fail. Q500 and Q501 are X and Y spot killer amplifiers. Since both work same way, only Q500 circuit has been analyzed here. Under normal operating condition feedback input signals of approximately 2.8V P/P from yoke are being rectified by D500, D501 to  $-4.7$  volts. This will overcome comparatively small +ve bias from R506 and reverse bias Q500. Under fault condition, there will be no input signal and -ve supply on base of Q500. Positive bias will take over and turns on Q500, Q502. LED D504 will come on and indicate fault condition in amplifier circuit. Collector current of Q502 will develop sufficient voltage across R513 to reverse bias, the emitter base junction of Q504. With Q504 in cutoff, the cathode of the CRT will reach the 95V supply potential. Since Z is cut off and cathode is at 95V supply potential, this will eliminate phosphor burn on CRT.



NOTE: ONLY THE BRIGHTNESS CONTROL (R517) AND THE CONTRAST CONTROL (R514) ON THE DEFLECTION AMPLIFIER PCB ARE "FIELD ADJUSTABLE." X AND Y LINEARITY CONTROLS HAVE BEEN FACTORY ADJUSTED AND SHOULD NOT BE TAMPERED WITH.



NOTE: FOCUS AND HIGH VOLTAGE CONTROLS HAVE BEEN FACTORY ADJUSTED AND SHOULD NOT BE TAMPERED WITH.

# SERVICE NOTES

# 19V2000 GRAPHIC DISPLAY UNIT

## REPLACEMENT PARTS

When ordering replacement parts give complete Part Number stamped on part. If Part Number shipped does not agree with Part Number ordered it is either the equivalent or an improved part.

Use only GENUINE factory tested parts to insure service jobs you can depend on and to obtain original set performance.

## P299 DEFLECTION BOARD

Ref. No.	Part No.	Description	Ref. No.	Part No.	Description
<b>RESISTORS</b>			<b>CAPACITORS</b>		
R100	43X0401-351	3.9 Ohm, $\pm 10\%$ , 15W WW	C100	45X0559-001	6800 pF, 50V Electrolytic
R101	43X0401-351	3.9 Ohm, $\pm 10\%$ , 15W WW	C101	45X0559-001	6800 pF, 50V Electrolytic
R102A	340X3033-934	3.3 Ohm, $\pm 5\%$ , 1/2W Carbon	C102	80X0099-193	0.1 uF, 50V Disc
R102B	340X3033-934	3.3 Ohm, $\pm 5\%$ , 1/2W Carbon	C103	80X0099-193	0.1 uF, 50V Disc
R103	340X3102-244	1k Ohm, $\pm 10\%$ , 1/2W Carbon	C500	45X0525-003	.47 uF, 35V Electrolytic
R500	340X2681-934	680 Ohm, $\pm 5\%$ , 1/4W Carbon	C501	45X0525-003	.47 uF, 35V Electrolytic
R501	340X2681-934	680 Ohm, $\pm 5\%$ , 1/4W Carbon	C502	45X0525-003	.47 uF, 35V Electrolytic
R502	340X2333-934	33k Ohm, $\pm 5\%$ , 1/4W Carbon	C503	45X0525-003	.47 uF, 35V Electrolytic
R506	340X2155-934	1.5M Ohm, $\pm 5\%$ , 1/4W Carbon	C504	45X0524-055	22 uF, 160V Electrolytic
R507	340X2155-934	1.5M Ohm, $\pm 5\%$ , 1/4W Carbon	C505	80X0099-144	270 pF, 500V Disc
R508	340X2333-934	33k Ohm, $\pm 5\%$ , 1/4W Carbon	C506	80X0099-061	0.01 uF, 1KV Z5U Disc
R509	340X3104-244	100k Ohm, $\pm 10\%$ , 1/2W Carbon	C601	47X0786-006	0.22 uF, 50V Molded
510A	340X3102-934	1k Ohm, $\pm 5\%$ , 1/4W Carbon	C602	47X0786-006	0.22 uF, 50V Molded
510B	340X3102-934	1k Ohm, $\pm 5\%$ , 1/4W Carbon	C603	45X0524-054	2.2 uF, 50V Electrolytic
R511	340X2393-934	39k Ohm, $\pm 5\%$ , 1/4W Carbon	C604	80X0099-193	0.1 uF, 50V Disc
R512	340X2222-934	2.2k Ohm, $\pm 5\%$ , 1/4W Carbon	C701	47X0786-006	0.22 uF, 50V Molded
R513	340X2271-934	270 Ohm, $\pm 5\%$ , 1/4W Carbon	C702	47X0786-006	0.22 uF, 50V Molded
R514	40X0637-002	500 Ohm, Contrast Control	C703	45X0524-054	2.2 uF, 50V Electrolytic
R515A	340X3682-934	6.8k Ohm, $\pm 5\%$ , 1/2W Carbon	C704	80X0099-193	0.1 uF, 50V Disc
R515B	340X3682-934	6.8k Ohm, $\pm 5\%$ , 1/2W Carbon	<b>SEMICONDUCTORS</b>		
R516	340X2104-934	100k Ohm, $\pm 5\%$ , 1/4W Carbon	D100	66X0073-001	Diode, (SI) 3A
R517	40X0637-003	100k Ohm, Brightness Control	D500	66X0070-001	Diode, IN914
R518	340X3474-244	470k Ohm, $\pm 10\%$ , 1/2W Carbon	D501	66X0070-001	Diode, IN914
R519	340X3102-244	1k Ohm, $\pm 10\%$ , 1/2W Carbon	D502	66X0070-001	Diode, IN914
R520	340X2471-934	470 Ohm, $\pm 5\%$ , 1/4W Carbon	D503	66X0070-001	Diode, IN914
R521	340X2101-851	100 Ohm $\pm 20\%$ 1/4W Carbon	D504	7A0363-001	LED
R522	340X2271-934	270 Ohm $\pm 5\%$ , 1/4W Carbon	D506	66X0069-001	Diode 250V HS
R523	304X2155-934	1.5M Ohm $\pm 5\%$ , 1/4W Carbon	D606	66X0070-001	Diode, IN914
R600	40X0637-001	1.5k Ohm, Linearity Control	D607	66X0070-001	Diode, IN914
R601	340X2182-934	1.8k Ohm, $\pm 5\%$ , 1/4W Carbon	D608	66X0071-001	Diode, IN4001
R602	340X2221-934	220 Ohm, $\pm 5\%$ , 1/4W Carbon	D706	66X0070-001	Diode, IN914
R603	340X2682-924	6.8k Ohm, $\pm 2\%$ , 1/4W Carbon	D707	66X0070-001	Diode, IN914
R604	340X2432-924	4.3k Ohm, $\pm 2\%$ , 1/4W Carbon	D708	66X0071-001	Diode, IN4001
R605	340X2471-934	470 Ohm, $\pm 5\%$ , 1/4W Carbon	Q500	86X0127-001	Transistor (NPN) TPS 98
R606	340X3362-934	3.6k Ohm, $\pm 5\%$ , 1/2W Carbon	Q501	86X0127-001	Transistor (NPN) TPS 98
R607	340X2910-934	91 Ohm, $\pm 5\%$ , 1/4W Carbon	Q502	86X0072-001	Transistor (PNP) MPSA56
R608	340X2471-934	470 Ohm, $\pm 5\%$ , 1/4W Carbon	Q503	86X0113-001	Transistor (NPN) 2N3904
R610	340X2471-934	470 Ohm, $\pm 5\%$ , 1/4W Carbon	Q504	86X0115-001	Transistor (NPN) D40P3
R611	340X3472-934	4.7k Ohm, $\pm 5\%$ , 1/4W Carbon	Q602	86X0127-001	Transistor (NPN) TPS 98
R612	340X2101-934	100 Ohm, $\pm 5\%$ , 1/4W Carbon	Q603	86X0127-001	Transistor (NPN) TPS 98
R613	340X2270-934	27 Ohm, $\pm 5\%$ , 1/4W Carbon	Q604	86X0127-001	Transistor (NPN) TPS 98
R614	340X2102-934	1k Ohm, $\pm 5\%$ , 1/4W Carbon	Q605	86X0114-001	Transistor (PNP) 2N3906
R615	340X2180-934	18 Ohm, $\pm 5\%$ , 1/4W Carbon	Q606	38A5578-000	Transistor Assy (PNP)
R616	340X5222-743	2.2k Ohm, $\pm 10\%$ , 2W Carbon	Q607	38A5577-000	Transistor Assy (NPN)
R617	340X2682-934	6.8k Ohm, $\pm 5\%$ , 1/4W Carbon	Q608	86X0123-001	Transistor (NPN) 2N3716
R618	340X3100-944	10 Ohm, $\pm 10\%$ , 1/2W Carbon	Q609	86X0124-001	Transistor (PNP) 2N3792
R619	340X3100-944	10 Ohm, $\pm 10\%$ , 1/2W Carbon	Q702	86X0127-001	Transistor (NPN) TPS 98
R620	43X0401-053	2 Ohm, $\pm 5\%$ , 10W WW	Q703	86X0127-001	Transistor (NPN) TPS 98
R621	340X3332-934	3.3k Ohm, $\pm 5\%$ , 1/2W Carbon	Q704	86X0127-001	Transistor (NPN) TPS 98
R700	40X0637-001	1.5k Ohm, Linearity Control	Q706	38A5578-000	Transistor Assy (PNP)
R701	340X2182-934	1.8k Ohm, $\pm 5\%$ , 1/4W Carbon	Q707	38A5577-000	Transistor Assy (NPN)
R702	340X2221-934	220 Ohm, $\pm 5\%$ , 1/4W Carbon	Q708	86X0123-001	Transistor (NPN) 2N3716
R703	340X2682-924	6.8k Ohm, $\pm 2\%$ , 1/4W Carbon	Q709	86X0124-001	Transistor (PNP) 2N3792
R704	340X2432-924	4.3k Ohm, $\pm 2\%$ , 1/4W Carbon			
R705	340X2471-934	470 Ohm, $\pm 5\%$ , 1/4W Carbon			
R706	340X3362-934	3.6k Ohm, $\pm 5\%$ , 1/2W Carbon			
R707	340X2910-934	91 Ohm, $\pm 5\%$ , 1/4W Carbon			
R708	340X2471-934	470 Ohm, $\pm 5\%$ , 1/4W Carbon			
R710	340X2471-934	470 Ohm, $\pm 5\%$ , 1/4W Carbon			
R711	340X3472-934	4.7k Ohm, $\pm 5\%$ , 1/2W Carbon			
R712	340X2101-934	100 Ohm, $\pm 5\%$ , 1/4W Carbon			
R713	340X2270-934	27 Ohm, $\pm 5\%$ , 1/4W Carbon			
R714	340X2102-934	1k Ohm, $\pm 5\%$ , 1/4W Carbon			
R715	340X2180-934	18 Ohm, $\pm 5\%$ , 1/4W Carbon			



# (P299 DEFLECTION BOARD CONT'D)

Ref. No.	Part No.	Description	Ref. No.	Part No.	Description
<b>MISCELLANEOUS</b>					
F100	16X0180-001	Fuse, 5 Amp, Slo-Blo	NE502	7A0334-001	Lamp, Neon (GE) 5 Amp.
F101	16X0180-001	Fuse, 5 Amp, Slo-Blo	NE503	7A0334-001	Lamp, Neon (GE) 5 Amp.
F102	16X0183-001	Fuse, 1 Amp, Slo-Blo	P100	6A0391-002	Connector, 12 Pin
F600	16X0181-001	Fuse, 2 Amp, NB	P500	6A0394-010	Connector, 10 Pin
F700	16X0181-001	Fuse, 2 Amp, NB	P600	6A0394-007	Connector, 7 Pin
J500	3A0629-010	Receptacle, 10 Pin	P700	6A0394-001	Connector, 7 Pin
J600	3A0629-007	Receptacle, 7 Pin	P701	6A0394-005	Connector, 5 Pin
J700	3A0629-007	Receptacle, 7 Pin	VDR600	43X0468-001	VDR
DB100	38A5576-000	Bridge, Rectifier Assy	VDR700	43X0468-001	VDR
NE501	7A0334-001	Lamp, Neon (GE) 5 Amp.			

## P300 HIGH VOLTAGE BOARD

### RESISTORS

R900	43X0401-052	21 Ohm, $\pm 10\%$ 15W WW
R901	340X3047-934	4.7 Ohm, $\pm 5\%$ , 1/2W Carbon
R902	340X3361-934	360 Ohm, $\pm 5\%$ , 1/2W Carbon
R903	340X3201-934	200 Ohm, $\pm 5\%$ , 1/2W Carbon
R904	340X3622-934	6.2k Ohm, $\pm 5\%$ , 1/2W Carbon
R905	40X0637-004	5k Ohm, H.V. Adj.
R906	340X3163-934	16k Ohm, $\pm 5\%$ , 1/2W Carbon
R907	340X3332-934	3.3k Ohm $\pm 5\%$ , 1/2W Carbon
R908	340X3047-934	4.7 Ohm $\pm 5\%$ , 1/2W Carbon
R909	40X0638-001	5M Ohm Focus Control
R910	340X3431-934	430 Ohm, $\pm 5\%$ , 1/2W Carbon
R911	340X6047-631	4.7 Ohm, $\pm 5\%$ , 3W Carbon
R912	340X3181-934	180 Ohm, $\pm 5\%$ , 1/2W Carbon
R913	340X3181-934	180 Ohm, $\pm 5\%$ , 1/2W Carbon
R914	340X3622-934	6.2k Ohm, $\pm 5\%$ , 1/2W Carbon
R915	340X3010-934	1.0 Ohm, $\pm 5\%$ , 1/2W Carbon
R916	340X3010-934	1.0 Ohm, $\pm 5\%$ , 1/2W Carbon
R917	340X3515-834	5.1M Ohm, $\pm 5\%$ , 1/2W Carbon

### CAPACITORS

C900	45X0524-056	1000 uF, 50V Electrolytic
C901	45X0524-056	1000 uF, 50V Electrolytic
C902	80X0099-134	.0015 uF, 100V Ceramic
C903	349X1044-109	0.1 uF, 100V Mylar
C904	45X0524-027	47 uF, 50V Electrolytic
C905	349X1044-109	0.1 uF, 100V Mylar
C906	349X4742-109	.47 uF, 100V Mylar
C907	45X0524-057	4.7 uF, 160V Electrolytic
C908	46X0540-001	0.47 uF, 630V Met. Poly
C909	80X0099-061	.01 uF, 1KV Ceramic
C910	80X0099-134	.015 uF, 100V Ceramic

### SEMICONDUCTORS

Q900	86X0128-001	Transistor BU409
Q901	86X0071-001	Transistor MPSA06
Q902	86X0071-001	Transistor MPSA06
Q903	86X0129-001	Transistor 2SD525R
D900	66X0069-001	Diode, 250V, HS
D901	66X0069-001	Diode, 250V, HS
D902	66X0068-002	Diode, ERC27-13
D903	66X0067-002	H.V. Rectifier H 1809
ZD900	66X0040-020	Diode, Zener 9.1V, 1/2W
ZD901	66X0040-021	Diode, Zener 62V, 1/2W
ZD902	66X0040-007	Diode, Zener 24V, 1W

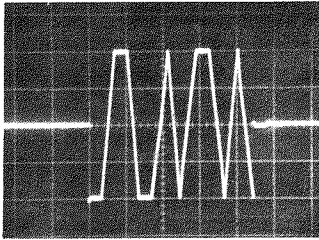
### TRANSFORMERS & COILS

L900	9A2797-001	Inductor, Adj L 1.5 uH
L901	9A2796-001	Inductor, Fixed 11.5 uH
T900	53X0480-001	HV Transformer

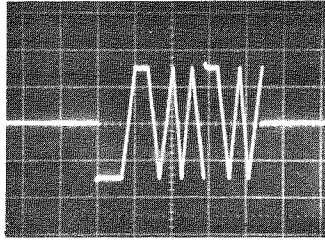
### FINAL ASSEMBLY PARTS

V500	88X0122-506	Pix Tube 19VARP4/M50—102W
	13X1207-001	Pix Tube Socket
	28X0793-001	Dag Spring, Grounding
	9A2794-001	Deflection Yoke
	74X0004-001	Magnet, Red
	74X0004-014	Magnet, Green
	74X0004-018	Magnet, Yellow
	10A1241-001	Knob, Green (Contrast)
	10A1241-002	Knob, Grey (Brightness)

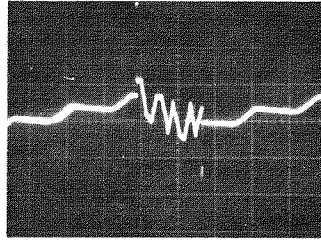
## CHASSIS VOLTAGE WAVEFORMS



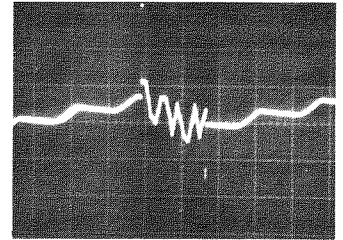
1. Vert. 20V P/P



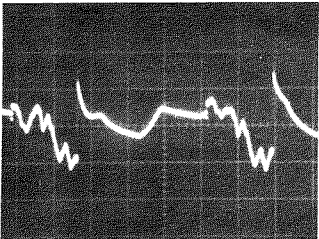
2. Vert. 15V P/P



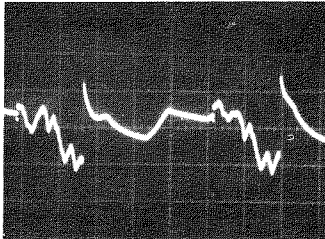
3. Vert 1-6V P/P



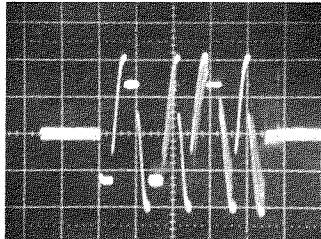
4. Vert 1-6V P/P



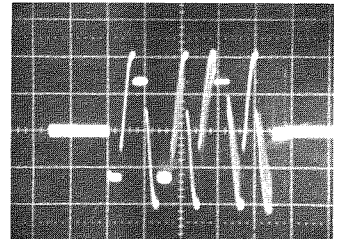
5. Vert. 1-1V P/P



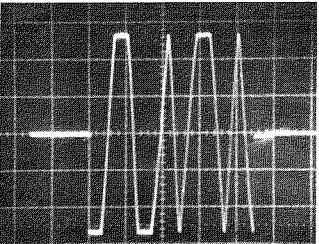
6. Vert. 1-1V P/P



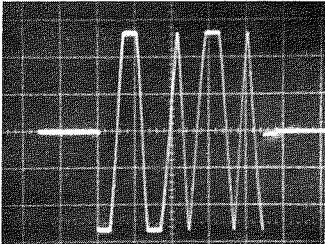
7. Vert. 22V P/P



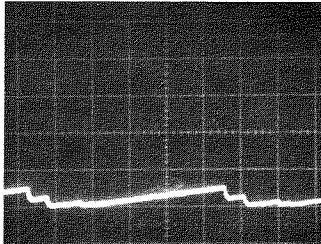
8. Vert. 22V P/P



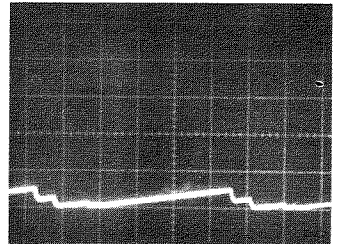
9. 5-2V P/P



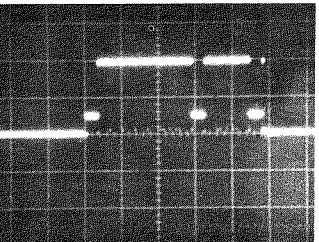
10. 5-2V P/P



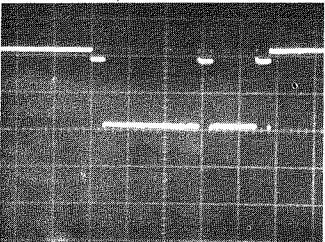
11. 1V P/P



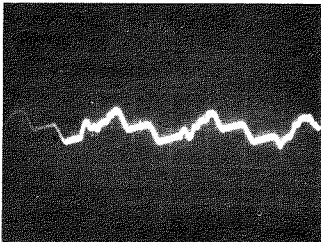
12. 7.1V P/P



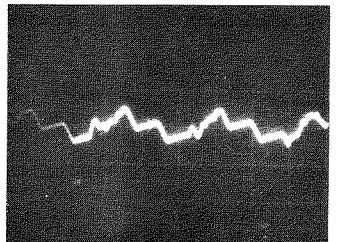
13. Vert. 4V P/P



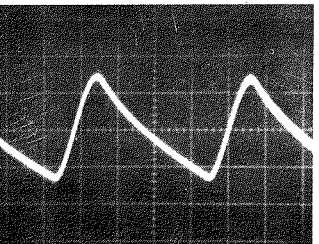
14. Vert. 40V P/P



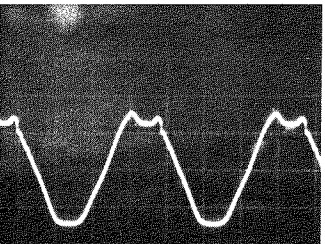
15. Vert 1V P/P



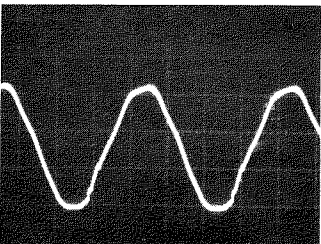
16. Vert. 1V P/P



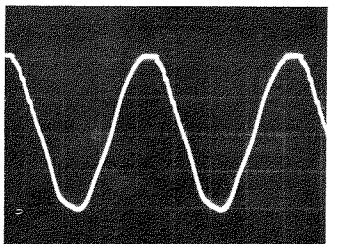
17. Vert. 3V P/P



18. Horiz. Rate 25 KHz  
Vert. 15V P/P



19. Horiz. Rate 25 KHz  
Vert. 32V P/P

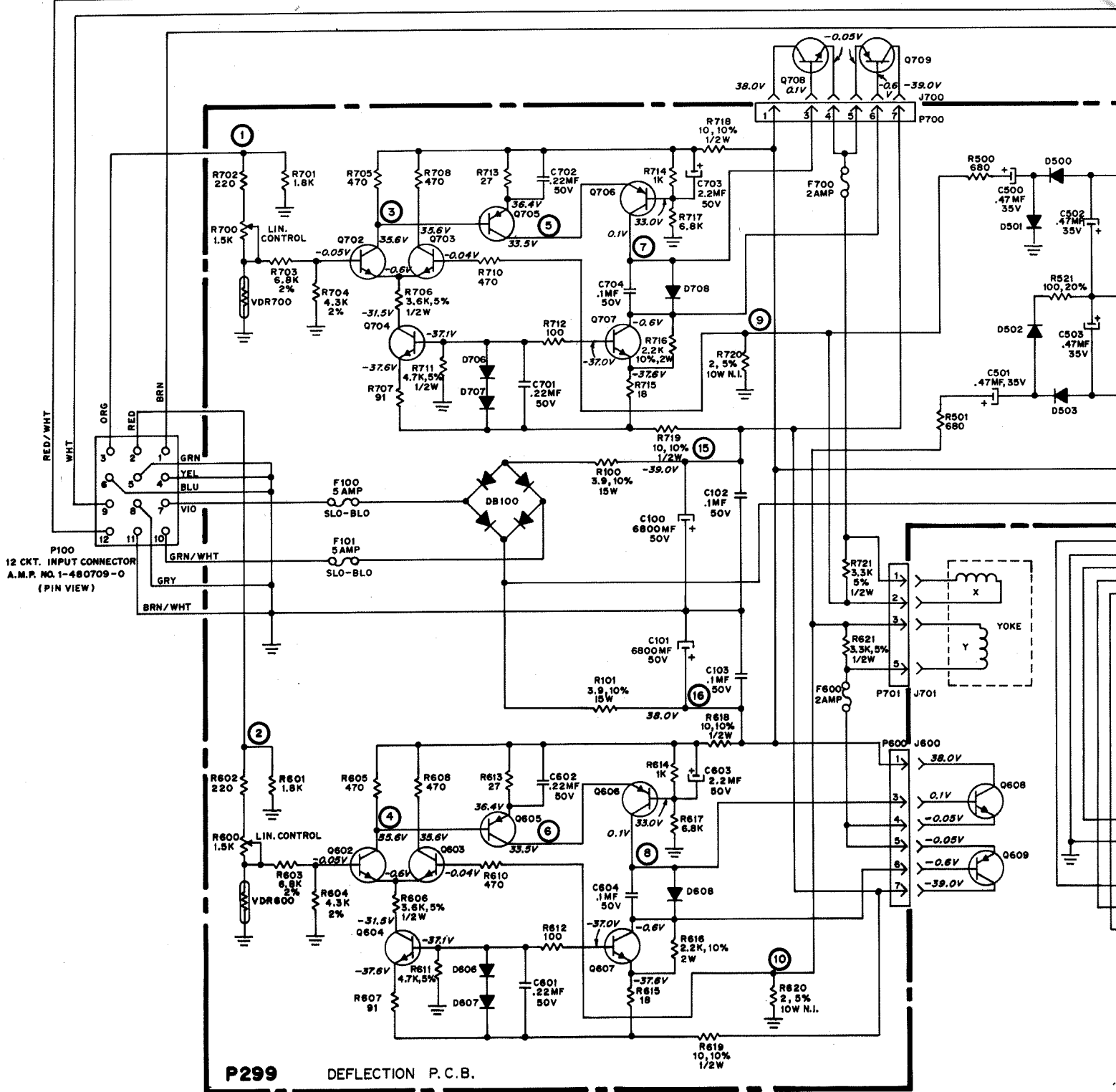


20. Horiz. Rate 25 KHz  
Vert. 200V P/P

## WAVEFORM MEASUREMENTS

TAKEN FROM POINT INDICATED TO CHASSIS WITH A WIDE BAND OSCILLOSCOPE SYNCHED NEAR SWEEP RATE OF 2MS/DIV. ON SCOPE EXCEPT WHERE HORIZONTAL RATE 25KHZ IS SHOWN. X AND Y INPUT SIGNALS OF CROSSHATCH PATTERN ARE 20V P/P AND 15V P/P RESPY. CONTROL POSITIONS ARE THE SAME AS THOSE USED IN D.C. VOLTAGE MEASUREMENTS.

FOR WAVEFORM REFERENCE NUMBERS, CHECK SCHEMATIC WITH CIRCLED NUMBERS.

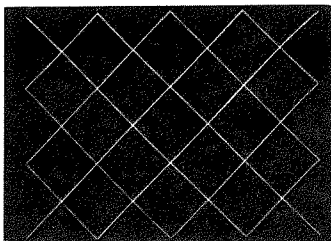


**P299** DEFLECTION P.C.B.

**GENERAL NOTES:**

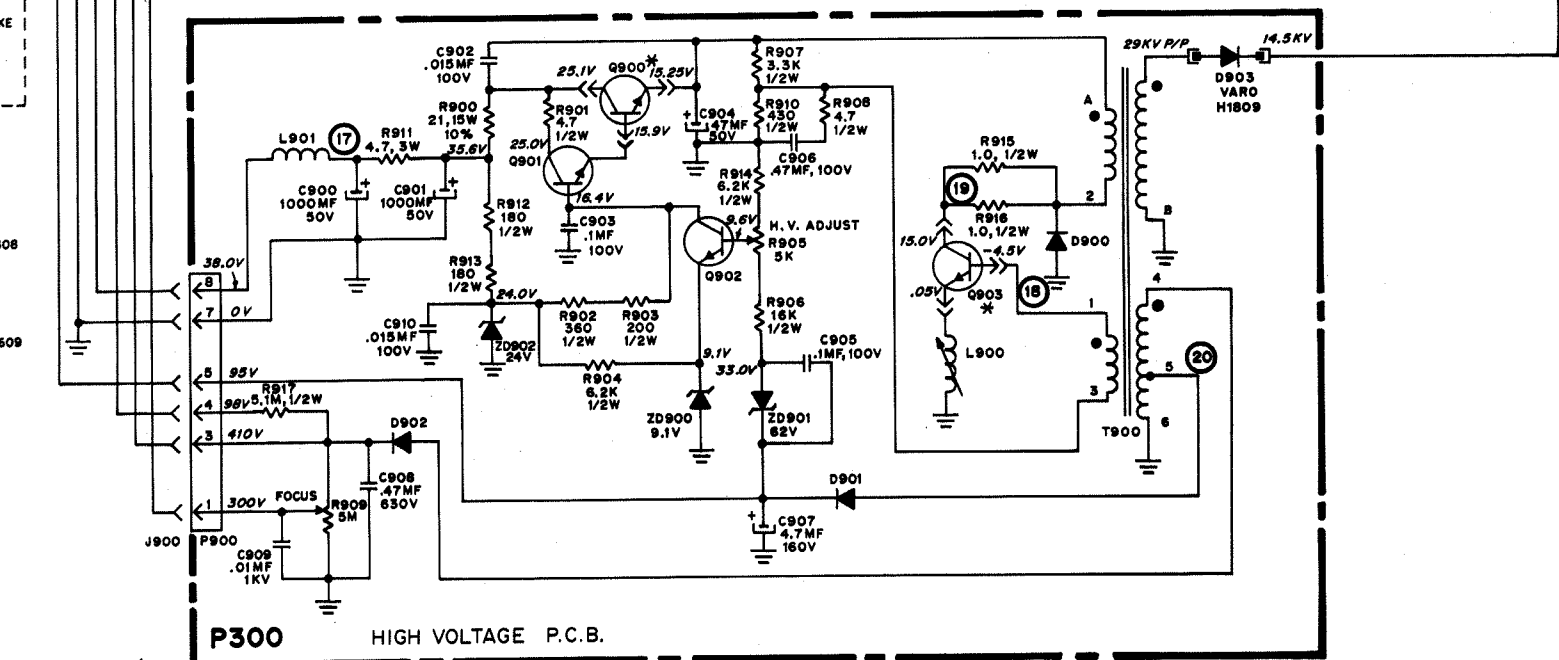
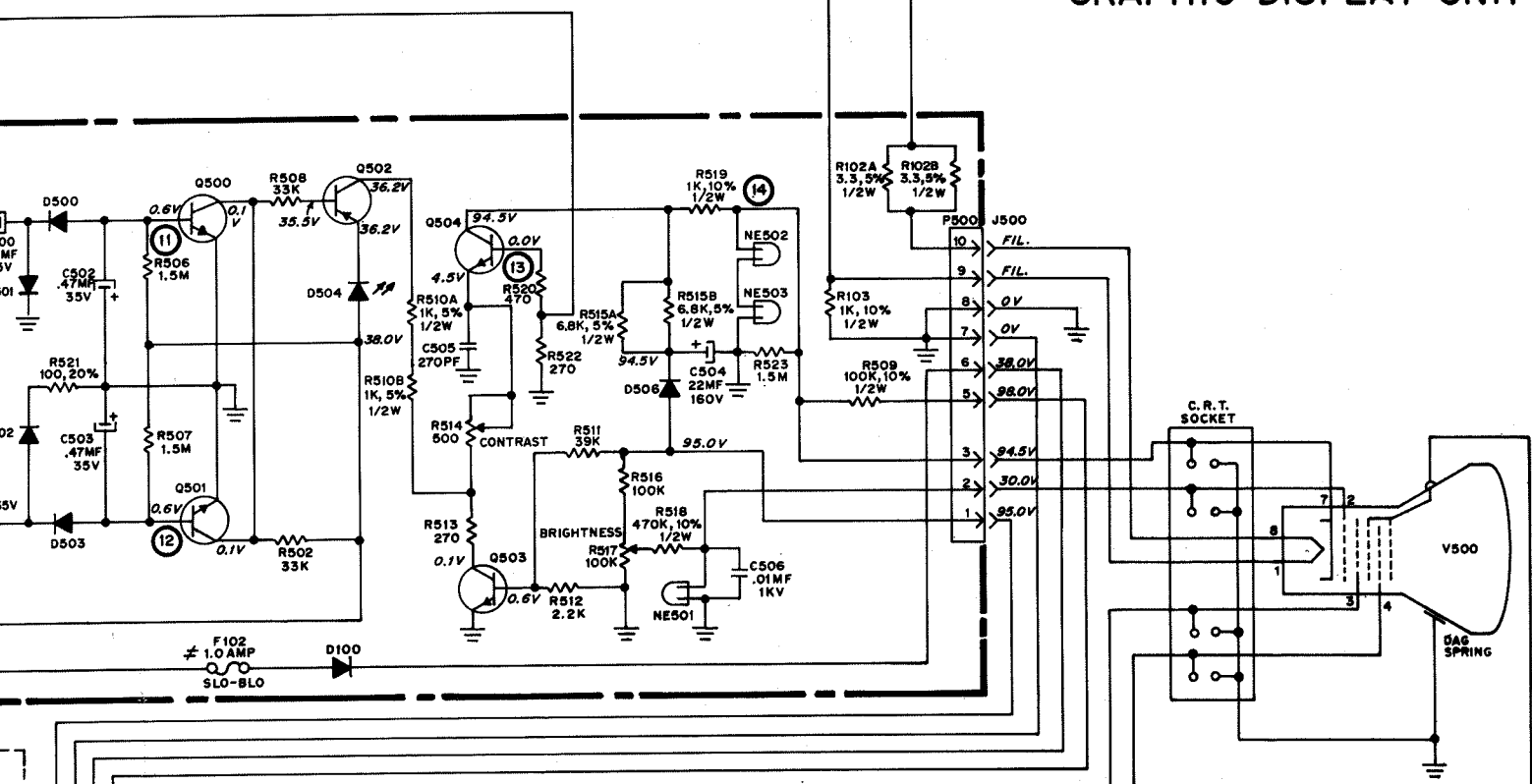
1. RESISTANCE VALUES IN OHMS, 1/4 WATT, 5% UNLESS OTHERWISE NOTED. K=1,000 M=1,000,000
2. CAPACITANCE VALUE OF 1 OR LESS ARE IN MICROFARADS ABOVE 1 IN PICOFARADS UNLESS OTHERWISE NOTED.
3. ≠ F102 IS 1.5AMP IN EARLY MODELS

4. \* Q900 AND Q903 ARE NOT ON H.V. P.C.B.
5. ALL D.C. VOLTAGES ±10% MEASURED FROM POINT INDICATED TO GROUND USING A HIGH IMPEDANCE METER. VOLTAGES ARE MEASURED WITH NO SIGNAL INPUT AND CONTROLS ARE IN A NORMAL OPERATING POSITION.
6. CIRCLED NUMBERS INDICATE LOCATION OF WAVEFORM READING.



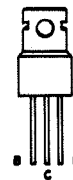
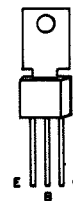
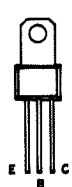
Diagonal Crosshatch on CRT

# GRAPHIC DISPLAY UNIT



ON H.V. P.C.B.  
 MEASURED FROM  
 USING A HIGH  
 RESISTANCE  
 MEASUREMENT  
 CONTROLS ARE  
 POSITION.  
 LOCATION OF

COLLECTOR CONNECTED  
 TO CASE



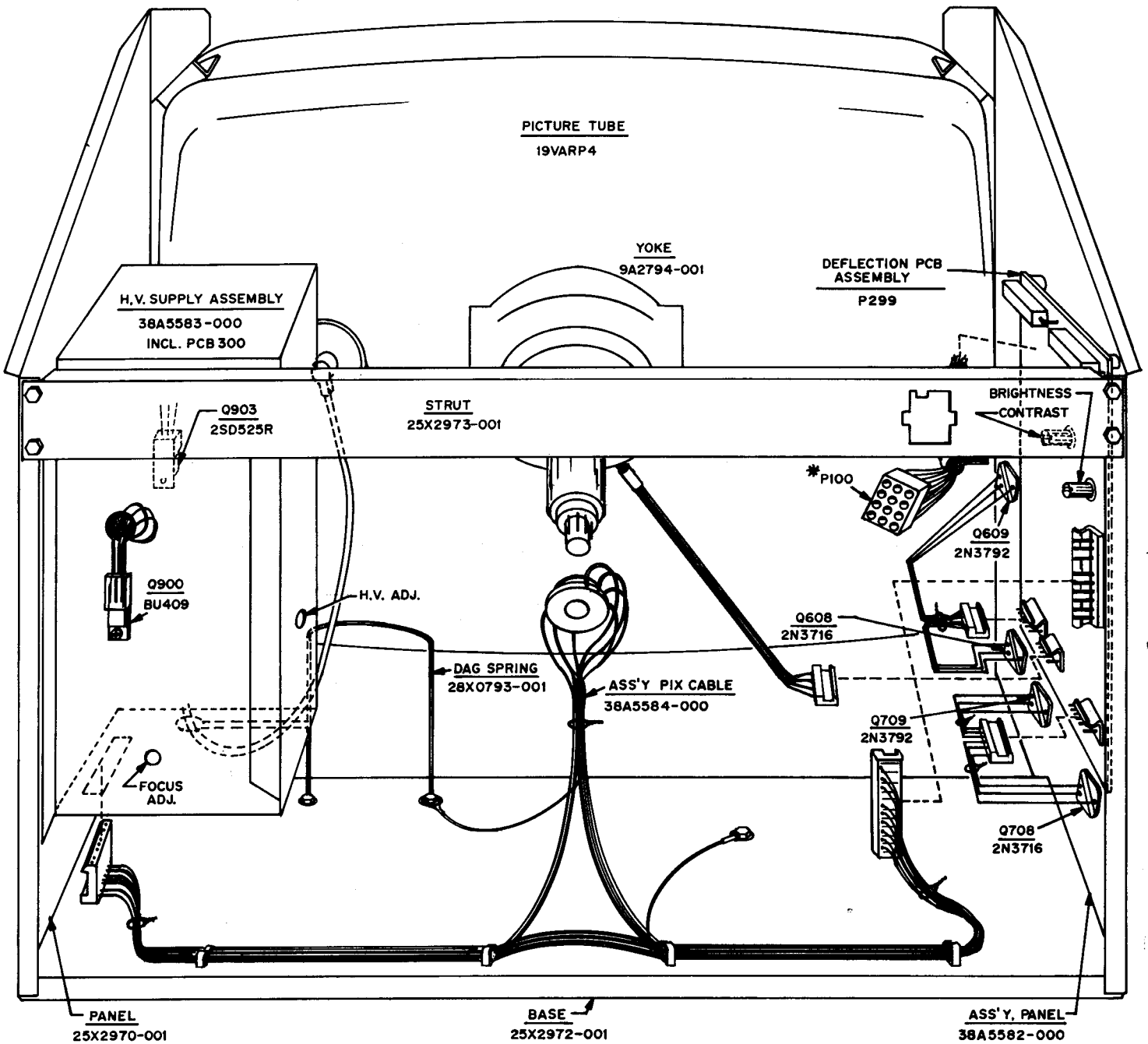
Q808  
 Q809  
 Q708  
 Q709

Q500  
 Q501  
 Q502  
 Q503  
 Q504  
 Q505  
 Q506  
 Q507  
 Q508

Q606  
 Q607  
 Q706  
 Q707

Q504

Q900  
 Q903



\* INPUT CONNECTOR P100  
 12 CKT A.M.P. TYPE  
 A.M.P. NO. 1-480709-0

PIN NO.	COLOR	FUNCTION
1.	BRN.	"Z" INPUT
2.	RED	"Y" INPUT
3.	ORANGE	"X" INPUT
4.	YEL.	"Z" GND.
5.	GRN.	"Y" GND.
6.	BLUE	"X" GND.
7.	VIOLET	AC 30V RMS.
8.	GRAY	CENTER TAP (30V-0-30V) AC RMS
9.	WHITE	FILAMENT 6.6VAC RMS
10.	GRN/WHT.	AC 30V RMS.
11.	BRN/WHT.	GND. (MAIN POWER SUPPLY)
12.	RED/WHT.	FILAMENT 6.6 VAC RMS

P100 CONNECTOR NUMBERING

