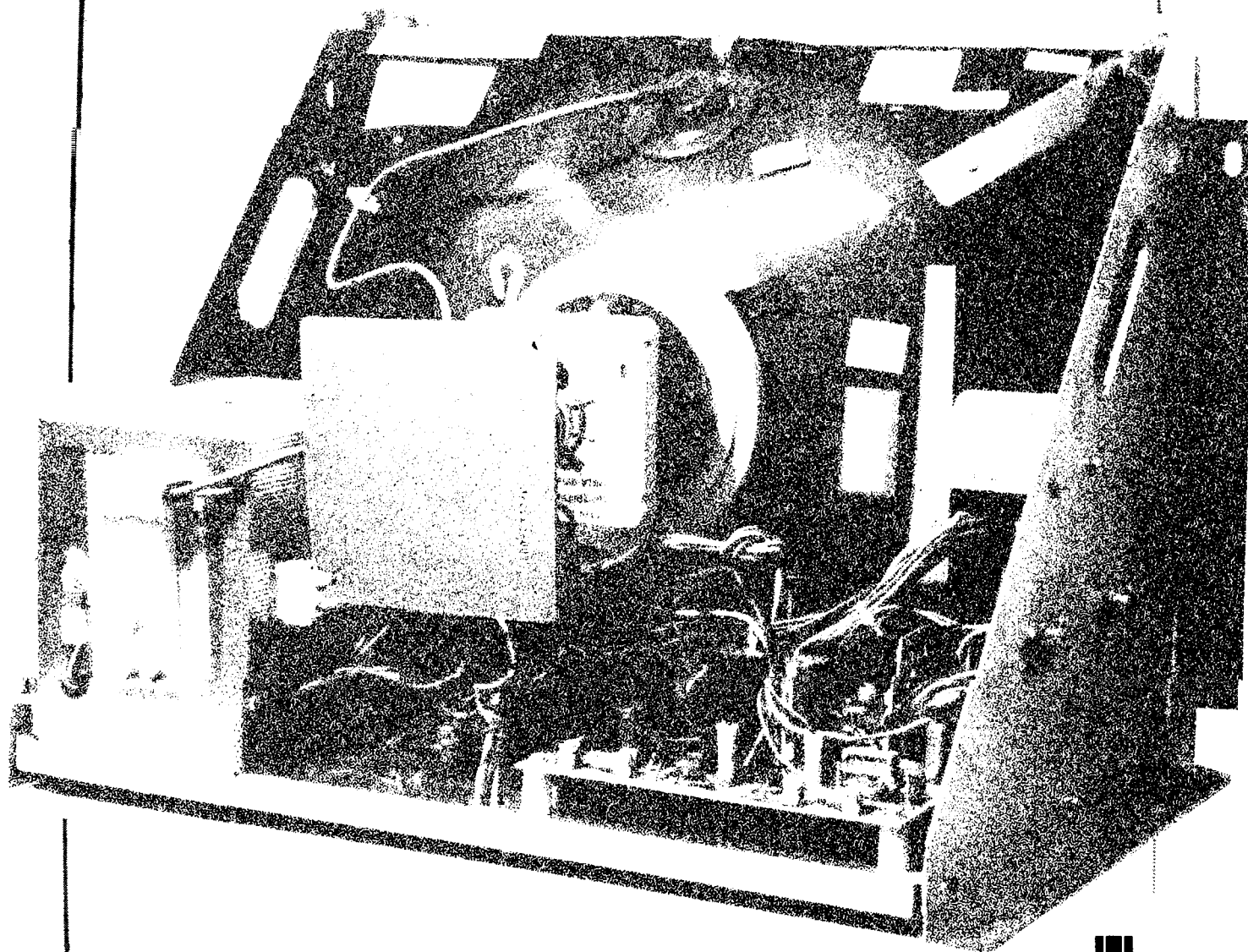


Wells-Gardner QuadrascanTM Color X-Y Display (Atari Part No. 92-053)



Service Manual

Complete with Schematic and Illustrated Parts Lists



TM 23K242

Wells-Gardner QuadrascanTM Color X-Y Display (Atari Part No. 92-053)

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Complete with Schematic and Illustrated Parts Lists

Display manufactured by Wells-Gardner Electronics Corp.
Chicago, IL 60639 U.S.A.

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1 Warnings and Cautions

This Quadrascan™ color X-Y display was designed to Atari specifications and built by Wells-Gardner Electronics Corp. The AC power, color, and X, Y, Z signals are fed to the display through a 15-pin harness connector located next to the right side panel.

This display differs very little from that used in Atari's black-and-white X-Y video games, such as Asteroids™, Battlezone™ or Red Baron. The only major difference is that it now has three Z amplifiers to control the three color guns. The cathode-ray tube is an off-the-shelf 100° in-line picture tube that is also used in raster-scan displays.

A. Before You Start...

You should **never attempt** to work on a display chassis if you are not familiar with servicing procedures and precautions necessary for high-voltage equipment. Any television or video display has three sources of possible danger:

- Strong electric shock due to high voltage or unisolated AC line voltages
- X-ray radiation, and
- implosion.

Therefore, please read this chapter carefully.

You should **never attempt** to modify any circuit in this display. You should do service work only after you are thoroughly familiar with all of the warnings and safety measures printed in this chapter.

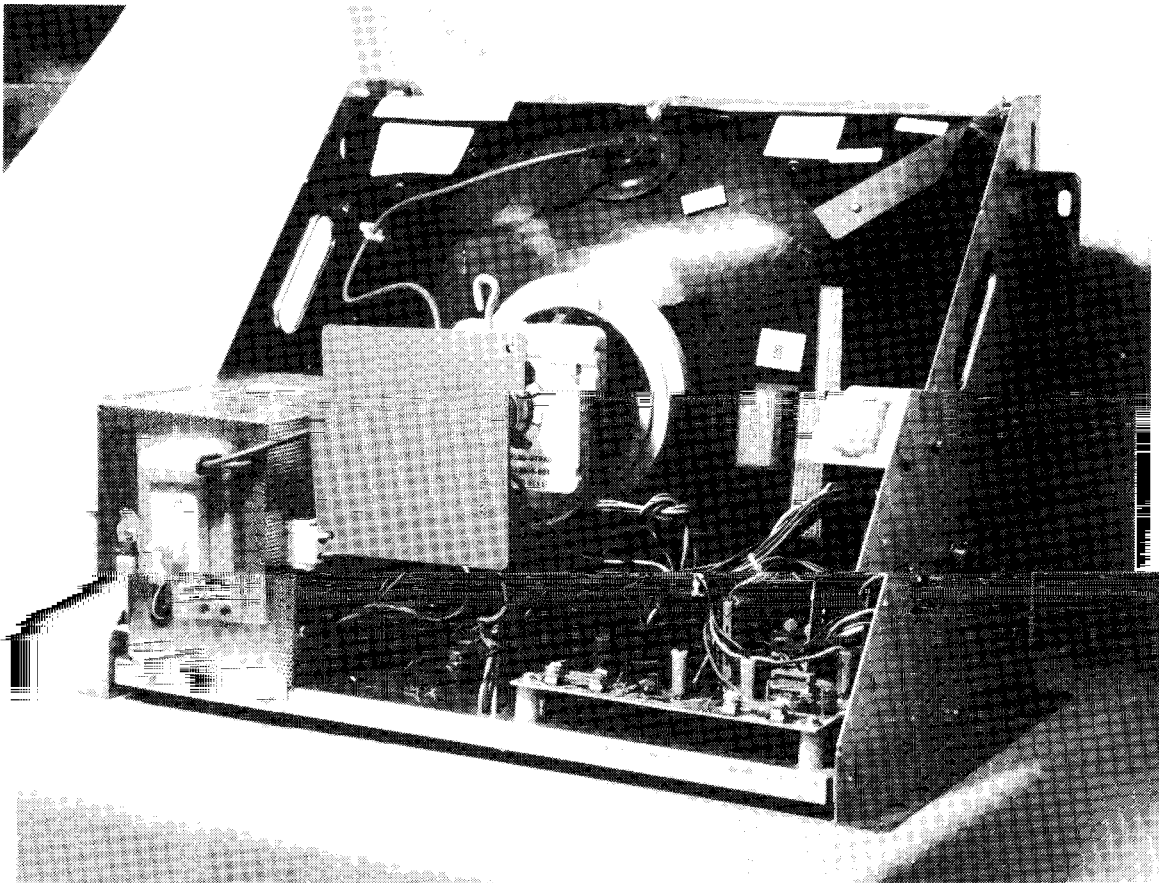


Figure 1 Overview of Display



WARNINGS



High Voltage

This display contains high voltages capable of delivering lethal quantities of energy. To avoid danger, do not attempt to service the chassis until you have observed all precautions necessary for working on high-voltage equipment.

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 you **never** modify the high-voltage circuitry.

Implosion Hazard

If you drop the display and the picture tube breaks, **it will implode!** Shattered glass and the yoke can fly 6 feet or more from the implosion. Use care when replacing any display.

B. Safety Measures

Develop good safety habits, so when you're rushed with repair work, you'll still automatically take the right precautions.

A good practice when working on any display is to first ground the chassis and **use only one hand** when testing circuitry. This will avoid the possibility of carelessly putting one hand on the chassis or ground, and the other on an electrical connection. **Doing so could cause a severe electrical shock.**

If you service this color X-Y display on a test bench, use only the power supply that came with the game. **Do not use standard line voltage or a power supply from a black-and-white game such as Asteroids™**, since the voltages produced by those sources will damage the Wells-Gardner color X-Y display.

To prevent fire or shock hazard, **never expose this display to rain or moisture.** Also check periodically for frayed insulation on wires.

If you need to service the display, observe the original lead dress (routing and length of harness wires). Use extra precaution in the high-voltage circuitry area of the display. Whenever a short circuit occurs, replace those components that indicate they have overheated.

C. Picture-Tube Handling


Use extreme care when handling the picture tube, since rough handling may cause it to implode, due to a vacuum inside. Do not nick or scratch the glass, or subject it to any undue pressure when removing or installing it.

Wear safety goggles and heavy gloves for protection when handling the picture tube. Keep others without safety goggles away. Never lift the tube by its neck.

Discharge the high voltage in the picture tube by shorting the anode connection to chassis ground—**not the cabinet or other mounting parts.** When discharging, go from ground to anode, and use a well-insulated piece of wire.

D. Replacing with Proper Components

It is important for you to maintain the specified values of all components in the high-voltage circuits, and anywhere else in the display that could cause a rise in high voltage, or in operating supply voltages.

The picture tube in this display employs integral implosion protection. For continued safety, replace it with a tube of the same type number. Refer to the parts lists in the back of this manual (Chapter 7), and use **only exact replacement parts**, especially for those parts identified with the  symbol.

E. Final Testing Before Reinstalling Display

Before installing the color display back in the game, you must check the following:

1. Inspect all harness wiring on the display, and be sure none of it is pinched between the chassis and other metal parts in the display.
2. Replace all protective devices such as insulating fishpaper, compartment covers, and shields.

2 Specifications

A. Inputs

1. Input Voltage

25-0-25 VAC RMS center-tapped at nominal line for amplifier

2. Input Voltage Range

+ 10% to - 15%

3. Input Power at 50 VAC

150 watts AC (amplifiers at maximum deflection)

4. Signal Inputs (at Maximum Deflection)

"X" horizontal: 16 volts P/P (± 8 volts).

"Y" vertical: 12 volts P/P (± 6 volts).

"Z" beam drive: 4.0 volts maximum brightness, 1.0 volt black level.

5. Input Impedance

"X" = 2.5K ohms, "Y" = 2.8K ohms, "Z" = 1K ohms

B. Writing Rate

"X" amplifier = .05 inch per microsecond, "Y" amplifier = .0375 inch per microsecond.

C. Z Bandwidth

5 MHz at - 3 dB point

D. High Voltage

19.5 kV at $I_b = 0$; adjustable to $\pm 2\frac{1}{2}\%$. High-voltage regulation restricted to 2% maximum ($I_b 0$ to 100 μA).

E. Controls

Factory-adjusted controls: High-Voltage adjustment, High-Voltage Tripping adjustment, and Z tracking. Operator-adjustable controls: Focus and Brightness.

F. Operating Temperature and Humidity

Ambient (in the game cabinet) humidity: 0 to 90% non-condensing.

Ambient temperature: 0 to 55° C (32 to 131° F)

3 Adjustable Controls

! WARNING !

Remember to observe the precautions regarding high voltages when making adjustments to this display!

c a "tweaking-tool") to adjust the BRIGHTNESS control until only five of the white lines in the center of the display are visible. (The longest line should be the dimmest.)

1. Set the game to display the self-test diagnostic pattern that shows a series of colored bars of various intensities. (Refer to the game manual for details on selecting self-test diagnostic patterns.)
2. Use a non-metallic Allen wrench (commonly call-

Before making any of the following adjustments, turn on the display and allow it to warm up for at least 5 minutes.

Focus

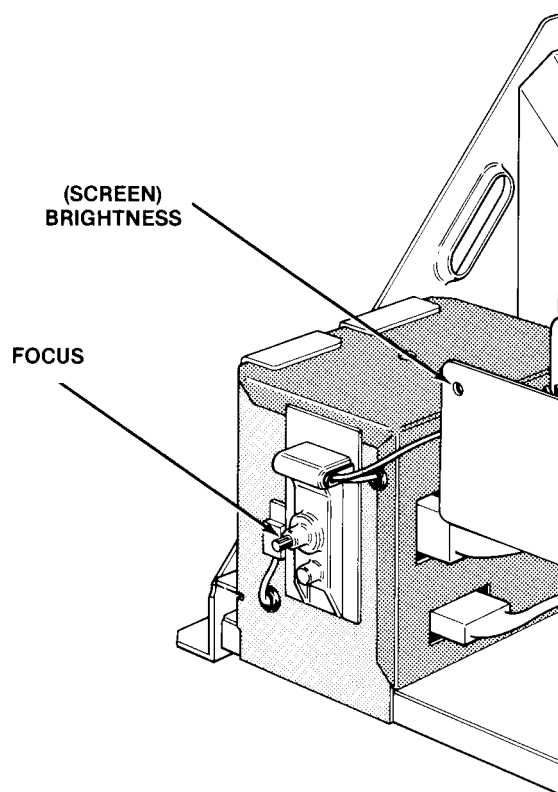
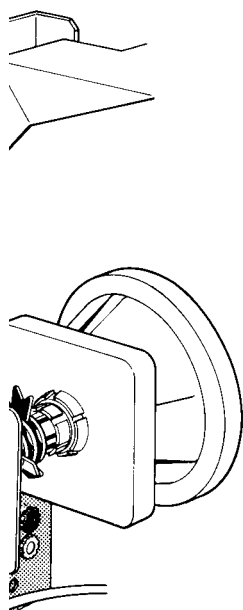
ie FOCUS control should be adjusted if the image is not sharply defined. Figure 2 shows location of the FOCUS control on the high-voltage cage. Turn this control until you get optimum image sharpness, then readjust to enlarge the line h.

A. Brightness

The BRIGHTNESS control (R535) should be adjusted if the picture image is either too bright or too dark. Figure 2 shows the location of the BRIGHTNESS control on the Neck printed-circuit board (PCB).

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Focus Controls

Figure 2 Brightness and

4 Replacement of Major Assemblies

NOTE

Tools Required to Replace all Assemblies Covered in This Chapter: $\frac{7}{16}$ -inch and $\frac{1}{4}$ -inch hex socket wrenches, and a Phillips-head screwdriver.

A. Picture-Tube Replacement

Be sure to first unplug the 15-pin power and color-signal connector. Remove display assembly from game as described in the game manual.

Use a well-insulated 20-kV jumper to discharge the high voltage from the tube. Remove the large high-voltage connector (anode wire) near the top of the picture tube. Unplug the Neck PCB at rear of picture tube.

Unplug the 5-pin connector on the Deflection PCB.

Using a $\frac{7}{16}$ -inch hex socket wrench, remove the steel cage.

You will have to readjust the picture tube after 5 of

5. To remove the PCB from the cage, turn the cage upside down. Remove the two sheet-metal screws inside that secure the PCB. Slide the PCB at an angle out of its slots in the cage.
6. When replacing the high-voltage transformer, be sure to check the picture for correct sharpness and brightness. If it's not correct, adjust FOCUS or BRIGHTNESS. After replacing the High-Voltage PCB, you will have to readjust the high voltage control. This adjustment procedure is covered in Chapter 5 of this manual.

C. High-Voltage PCB Replacement

First unplug the power and color-signal connector. Remove the display assembly from the game.

1. Use a well-insulated 20-kV jumper to discharge the high voltage from the tube. Remove the large high-voltage anode connector on top of picture tube. Then disengage the anode wire from its white holder on the purity shield.

2. Unplug the Neck PCB at rear of picture tube.
3. Unplug the white 3-pin harness connector on the side of the high-voltage cage. Also unplug the red 8-pin harness connector just below the 3-pin connector.
4. Using a $\frac{1}{4}$ -inch hex socket wrench, remove the 5 screws holding down the high-voltage protection cage. Do not remove the screws that hold together the side and bottom panels of the display chassis.
5. To remove the PCB from the cage, turn the cage upside down. Remove the two sheet-metal screws inside that secure the PCB. Slide the PCB at an angle out of its slots in the cage.
6. When replacing the high-voltage transformer, be sure to check the picture for correct sharpness and brightness. If it's not correct, adjust FOCUS or BRIGHTNESS. After replacing the High-Voltage PCB, you will have to readjust the high voltage control. This adjustment procedure is covered in Chapter 5 of this manual.

four screws that hold the picture tube in its frame. Carefully remove the tube by pulling toward the front.

4. **Important:** After replacing a picture tube, you have to re-converge the picture, readjust focus, and readjust the grey-level tracking. These adjustment procedures are covered in Chapter 5 of this manual.

B. Yoke Replacement

First unplug the 15-pin power and color-signal connector. Remove the display assembly from the game.

1. Use a well-insulated 20-kV jumper to discharge the high voltage from the tube. Unplug the Neck PCB at rear of picture tube.
2. With a $\frac{1}{4}$ -inch hex socket wrench and your fingers, loosen the screws that tighten the neck clamps around the picture-tube neck.
3. Slide the magnet assembly, then the yoke assembly off the end of the picture tube.
4. **Important:** After replacing a yoke, you will have to re-converge the picture, and readjust focus and brightness. These adjustment procedures are covered in Chapter 5 of this manual.

D. Power Transistor Replacement

When replacing any of the power transistors, observe the following precautions:

1. Hold the insulated transistor socket in its proper location. It is not "captive" or mounted onto the metal chassis; instead, the transistor's mounting screws secure the socket.
2. Apply silicone grease evenly to both sides of the mica insulator when replacing an output transistor.
3. Make sure the transistor mounting screws are tight before applying power to the display. This ensures proper cooling and electrical connection.

tions. Use a Phillips-head screwdriver and torque the mounting screws 7-10 inch-lbs.—**no more**. Excessive pressure will strip the threads, causing a poor electrical and mechanical connection.

E. Deflection PCB

This board is secured by mounting screws and a retaining bracket. Three plastic spacers are possible.

("stand-offs") and four plastic mounting posts under the board keep it away from the metal chassis.

Use a 1/4-inch hex socket wrench to remove the two rear screws. Then slide the board out toward the rear of the chassis. The harness has sufficient slack so you can service the board when it is removed from its mounted position. All plugs are keyed, so improper connection would be difficult, if not impossible.

Purity, Convergence, and Tracking Adjustments

5.

WARNING

Remember to observe the precautions regarding high voltages when working on the display!

1. Remove power from the display.

2. Loosen the screws securing the deflection yoke and magnet assemblies to the picture tube neck.

3. Remove any glue that may be holding the purity magnets in place.

4. Using a razor blade or thin knife, carefully loosen the glue holding the three rubber wedges beneath the yoke collar. Remove these wedges.

5. Position the magnetic material on the tube face either north or south.

6. Degauss the picture tube with a hand-held degaussing coil.

7. Apply power to the display.

Remember to make convergence adjustments to this circuit.

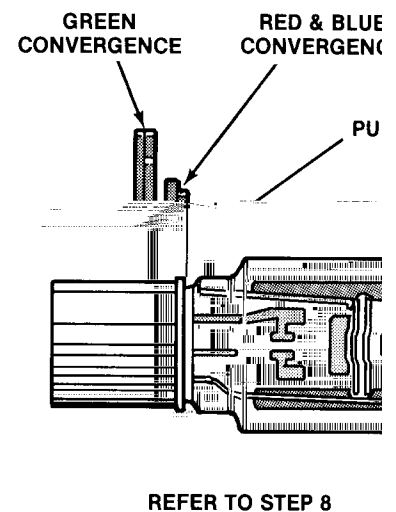
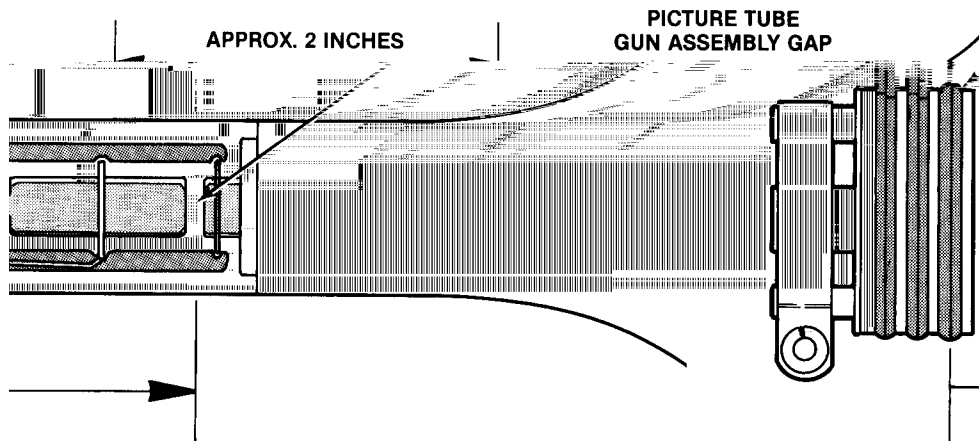
A. Purity Adjustments

NO

The convergence adjustments must be performed after completion of the purity adjustments.

DE

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Convergence Adjustments

Figure 3 Purity and Co

8. Position the magnet assembly so that the purity rings shown in Figure 3 are positioned as closely as possible over the gap in the gun assembly. This is about 2 inches forward from the start of the picture tube neck glass.
9. Secure the magnet assembly in position by tightening the neck-clamp mounting screw.
10. Set the game to display the self-test diagnostic pattern that shows a vertical and horizontal crosshatch with all three colors. This may appear as a white crosshatch pattern on the screen. (Refer to Self-Test Procedures within the game manual for details on selecting self-test diagnostic patterns.)
11. Preset the convergence magnets to superimpose the red, blue, and green lines at the center of the screen. (This is only a rough adjustment.)
12. Set the game to display only the green crosshatch diagnostic pattern.
13. Slide the deflection yoke toward the magnet assembly to produce a vertical green band within the center of the crosshatch pattern.
14. Adjust the purity rings of the magnet assembly shown in Figure 3 so that the green band is horizontally equal to the red and blue bands on either side.

NOTE

The purity rings must only affect the horizontal centering of the display. If they have a vertical or a diagonal centering effect, rotate the entire magnet assembly so that the purity rings affect **ONLY** the horizontal centering.

15. Slide the deflection yoke forward until the crosshatch pattern is all green. Continue the forward movement of the yoke until other colors just begin to show on the display. This is the forward purity-adjustment limit of the yoke.
16. Slide the yoke back toward the magnet assembly, through the position for a pure green display, to the point where the display again begins to show other colors. This is the rear purity-adjustment limit of the yoke.
17. Position the deflection yoke to the middle of the forward and rear purity-adjustment limits. Tighten the yoke-mounting screw.
18. Set the game to display the red crosshatch diagnostic pattern. Check for good overall purity.
19. Set the game to display the blue crosshatch diagnostic pattern. Check for good overall purity.
20. Perform the convergence adjustments.

B. Convergence Adjustments

NOTE

If the purity adjustments have been performed, you must also perform the entire convergence adjustments procedure.

1. Adjust for static convergence, which aligns the registration of all three colors over the entire display screen area, as follows:
 - a. Set the game to display the self-test diagnostic pattern that shows a magenta (both red and blue) crosshatch. (Refer to the Self-Test Procedures within the game manual for details on selecting self-test diagnostic patterns.)
 - b. Spread or close the ring tabs of the red and blue convergence magnets to superimpose the red and blue vertical lines in the center of the screen area. This will produce magenta vertical lines. These magnets are shown in Figure 3.

NOTE

Do not attempt to adjust the convergence of the outer areas of the display screen at this time.

- c. Keeping the tab angle the same, rotate both tabs of these magnets to superimpose the red horizontal lines with the blue horizontal lines in the center of the screen area. This produces magenta horizontal lines.
 - d. Set the game to display the diagnostic crosshatch pattern composed of all three colors. (This should appear as a single white crosshatch pattern.)
 - e. Adjust the angle between the tabs of the green convergence magnets, shown in Figure 3, to superimpose the green vertical lines with the magenta vertical lines already converged in the center of the display screen.
 - f. Keeping the tab angle the same, rotate both tabs of the green convergence magnets to superimpose the green horizontal lines on the magenta horizontal lines already converged in the center of the screen.
2. Adjust for peripheral convergence, which sets the registration of all three colors at the outer areas of the display screen, as follows:

- a. If not already done as part of the purity adjustments, loosen the screw securing the deflection yoke assembly to the picture tube. Then

- g. Check the display for good convergence at all areas of the screen. If necessary, repeat the static convergence adjustments of step 1.

use a razor blade or thin knife to loosen the glue holding the three rubber wedges beneath the yoke collar. Remove the wedges.

5. Secure the rings of the magnet assembly and the rubber yoke wedges with white glue. Tighten the deflection yoke mounting screw.

Use the game to display the magenta (magenta and blue) cross-hatch diagnostic pattern.

- c. Tilt the deflection yoke in a vertical direction to superimpose the red horizontal lines with the blue horizontal lines at the 3 o'clock and 9 o'clock positions of the outer area of the screen.

Coloring Adjustments:

- d. While maintaining the vertical position of the yoke, tilt it in a horizontal direction to superimpose the red crosshatch with the blue crosshatch pattern at the 6 o'clock and 12 o'clock positions of the outer area of the screen.

1. Set the game to display the self-test diagnostic pattern that shows a series of colored bars of various intensities.
2. Turn all Bias and Drive controls to their fully clockwise position. Figure 4 shows the location of these controls.

- e. Install the three rubber wedges firmly beneath the yoke collar to hold the yoke in position. Recheck the convergence of the display; if necessary, repeat parts c and d of this step.

3. Adjust the BIAS (R516), BIAS (R517), and BIAS (R518) controls until the fifth line from the right in the center group of lines is pure white.

Set the game to display the crosshatch diagnostic pattern composed of all three colors. This should appear as a white crosshatch pattern.)

4. Adjust the DRIVE (R507), DRIVE (R508), and DRIVE (R509) controls until the far right line of the center group of lines is pure white.
5. If the fifth line from the right is no longer pure white, repeat step 3 of this procedure.

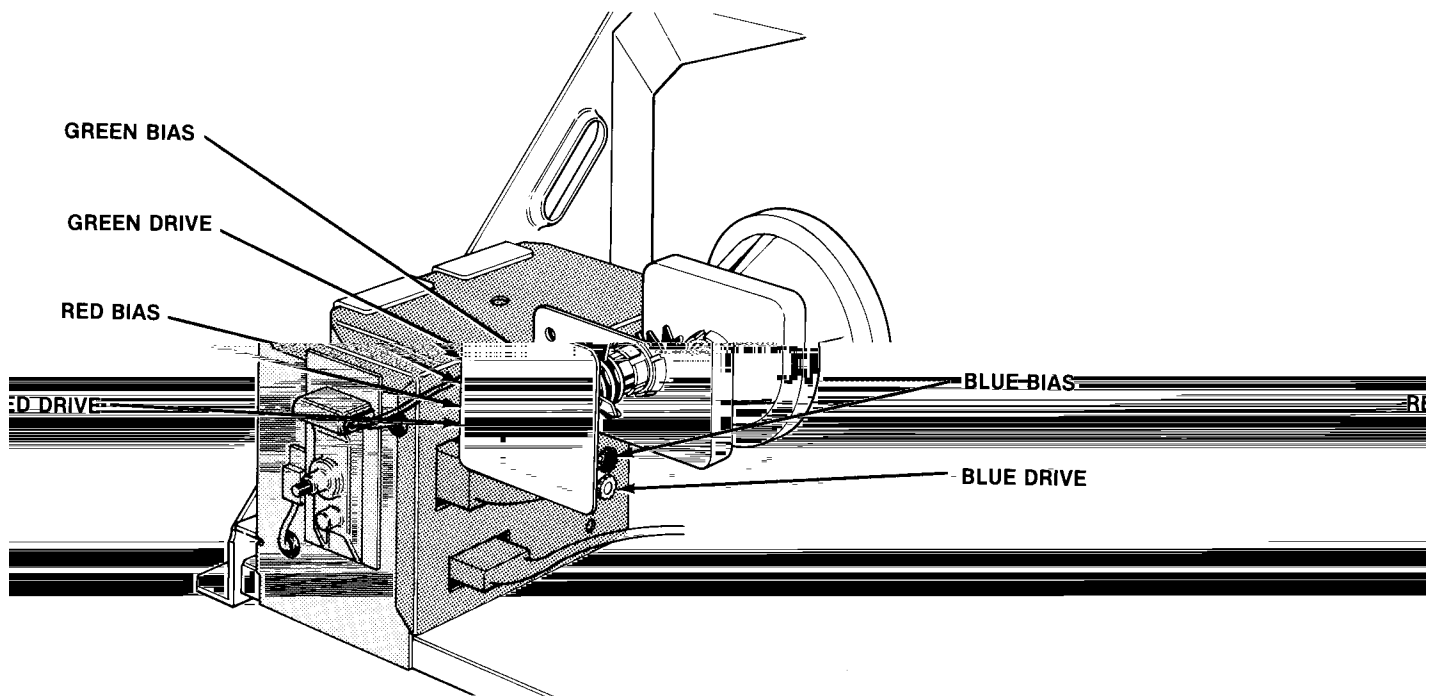


Figure 4 Adjustable Controls on Neck PCB

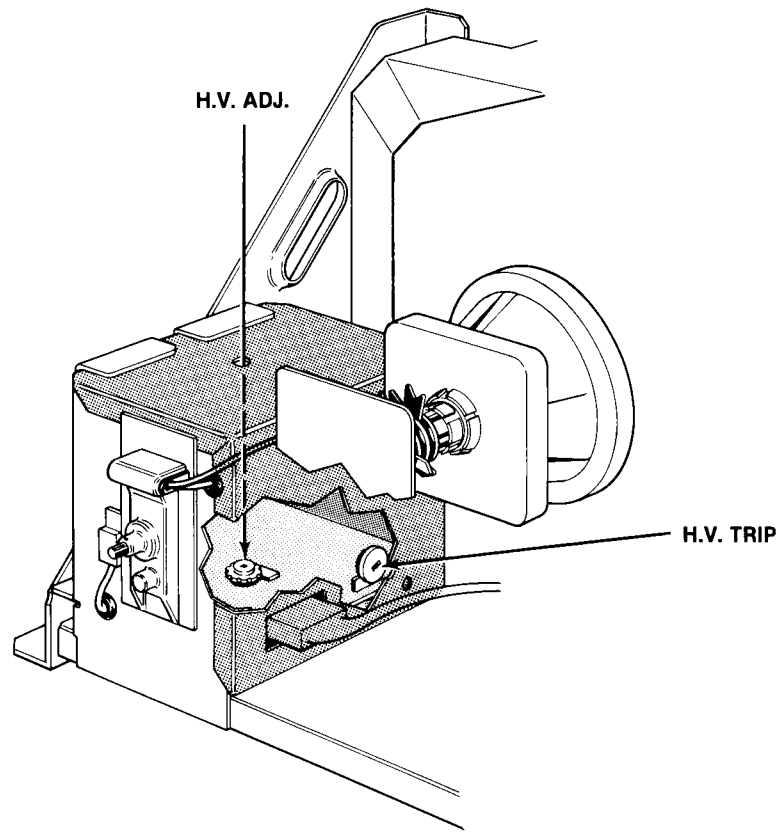


Figure 5 Adjustable Controls on High-Voltage PCB

D. High-Voltage Power Supply Adjustments



WARNING



To avoid possible electric shock, use extreme caution when making these high-voltage adjustments! Do not attempt to make these adjustments without the high-voltage probe!

1. Remove power from the display.
2. Attach the minus lead of the high-voltage probe to the DAG spring.
3. Connect the high-voltage probe to the anode connection at the picture tube by slipping it under the anode cap.
4. Rotate H.V. TRIP control R930 to its fully counterclockwise position. Figure 5 shows the location of this control.
5. Rotate H.V. ADJ. control R918 to its fully counterclockwise position. Figure 5 shows the location of this control also.
6. Apply power to the display and let the display warm up for a minimum of 5 minutes.
7. Rotate H.V. ADJ. control R918 for a reading of 22.5 kV on the voltmeter.
8. VERY SLOWLY rotate H.V. TRIP control R930 clockwise until the voltmeter reading just drops to 0.
9. Turn the display power off, and readjust the H.V. ADJ. control to its approximate center position. Then turn the display power on.
10. Readjust the H.V. ADJ. control for a voltmeter reading of 19.5 kV.
11. Remove power from the display and then remove the high-voltage probe from the anode connection.

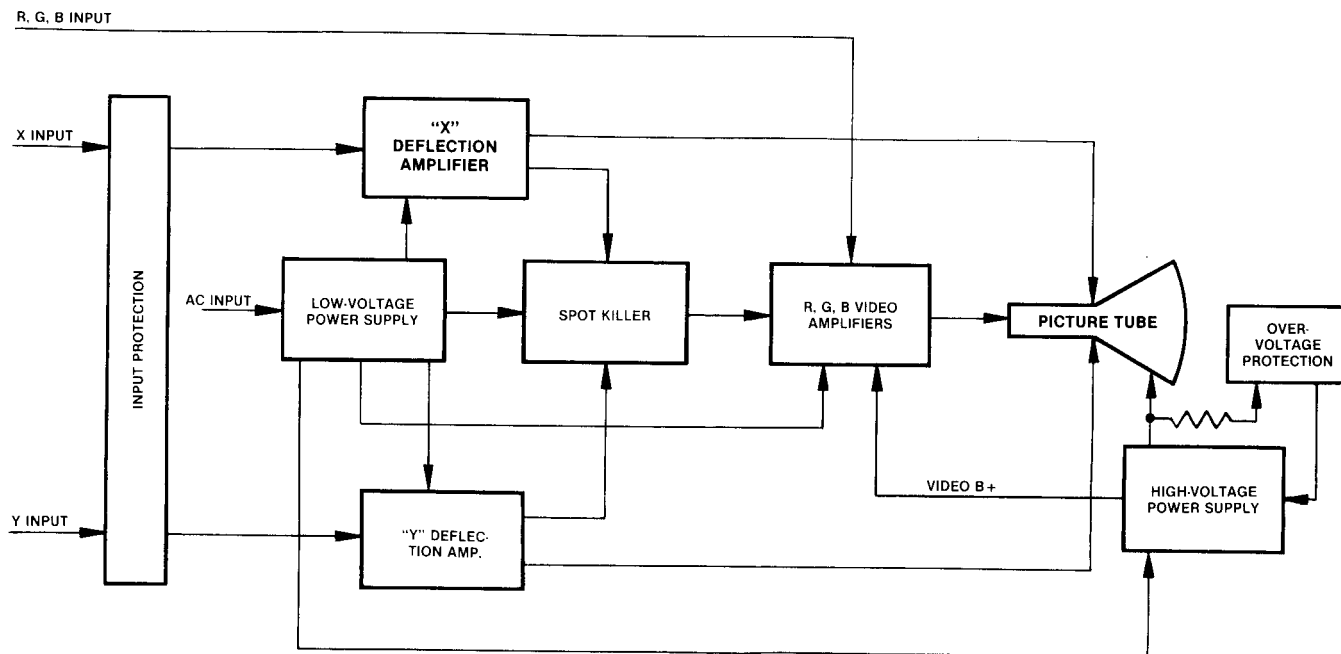


Figure 6 Display Block Diagram

6 Details of Operation

A block diagram of the display circuitry is shown in Figure 6. Detailed schematics of each circuit block are shown in Figures 7 through 13. The shading in Figures 7 through 13 masks areas of the circuitry that do not relate to the discussion of that block. Refer to Figures 6 through 13 during the following discussions.

A. Low-Voltage Power Supply

The input voltage of 48 VAC from the game power supply enters through fuses F100 and F101. Diodes D100 through D103 form a rectifier bridge that converts the AC input into an unfiltered DC. Capacitors C100 and C101 form the first stage of filtering. Resistors R102 and R103 and capacitors C102 and C103 form two low-pass filters which help filter out AC ripple. Transistors Q100 through Q103 form an active filter that provides the stable, filtered DC voltages.

temperature coefficient) thermistor is cool. Diodes D106 and D107 form a protective barrier from any residual current that might enter the degaussing coil during normal game play.

The output voltages from the low-voltage power supply should be as follows:

- J101 pin 2: ground
- J101 pin 3: +27.8 volts
- J101 pin 4: -27.7 volts

The picture-tube filament voltage is taken from the front end of the low-voltage power supply through D108 and R107.

B. Input Protection

The input protection circuit monitors the X and Y input signals from the game circuitry. If either of these signals exceeds a predetermined voltage range, this circuit applies a clamping signal to the inputs of the deflection amplifiers. The clamping

the degaussing coil operates when power is first applied to the display, when the P.T.C. (positive signal) is 180° out of phase with the received input signal.

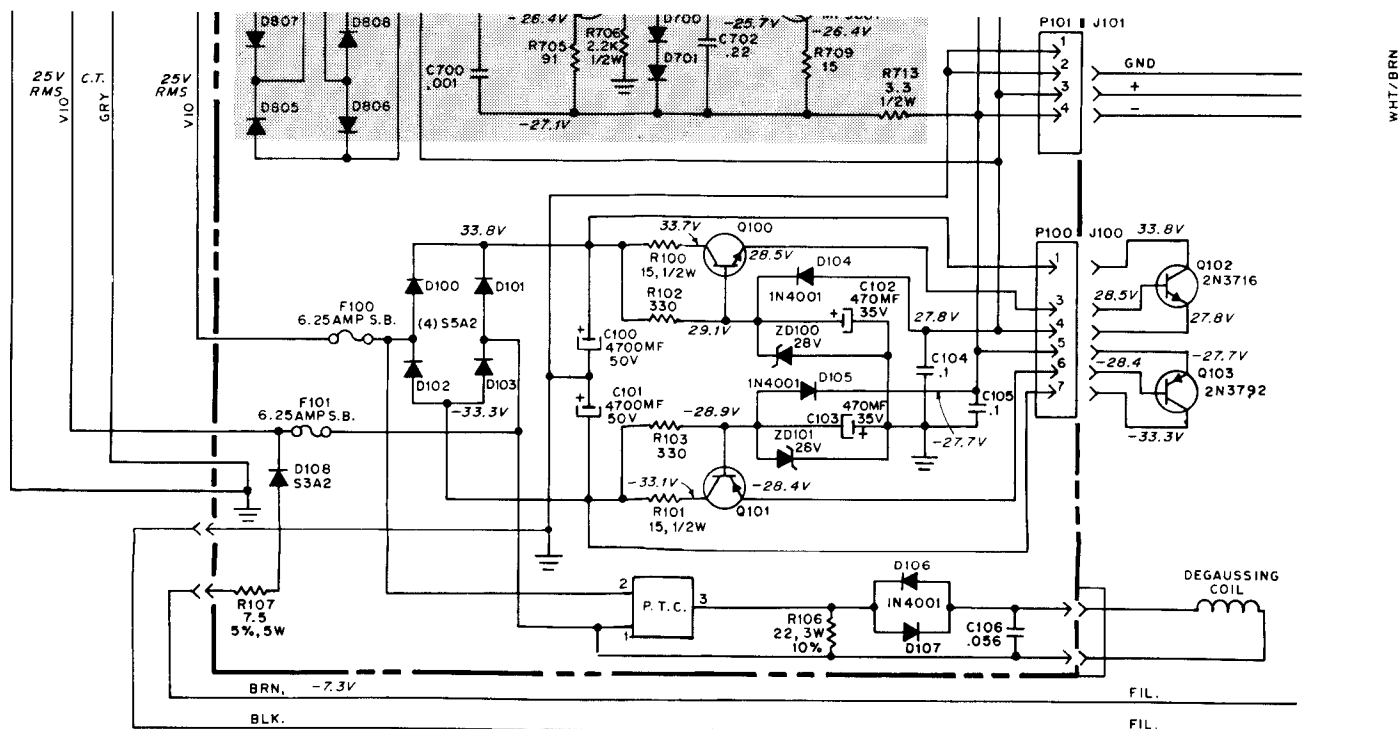


Figure 7 Schematic Diagram of Low-Voltage Power Supply

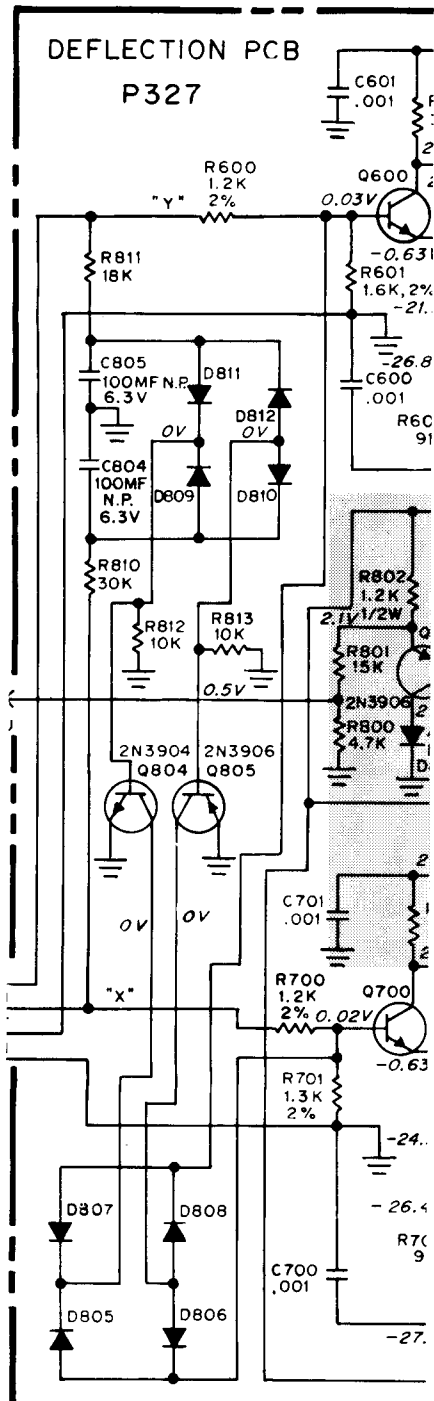


Figure 8 Schematic Diagram of Input Protection

The input protection circuit operates whenever the average DC level of the Y input signal is greater than + 2 volts or less than - 2 volts, or whenever the average DC level of the X input signal is greater than + 3 volts or less than - 3 volts.

To illustrate circuit operation, assume that the Y input signal increases above the clamping threshold of + 2 volts. At this time, D811 will conduct, causing Q804 to turn on. The negative-going voltage at the collector of Q804 is applied through D807 and D805 to turn off the Y and X deflection amplifiers, which turns on the spot killer circuit.

C. X and Y Amplifiers

Both the X and Y amplifiers are nearly identical. For this reason, only the Y amplifier is described.

The Y deflection signal from the game board is applied to the base circuit of transistor Q600. Transistors Q600 and Q601 form a differential amplifier. Transistor Q602 is a constant-current source providing current to the differential amplifier.

Transistor Q603 is the driver transistor that provides current to the emitter-follower transistors Q605 and Q606. Transistor Q604 is a constant-current source that provides current to the driver transistor Q603. Fuse F600 can open in case of circuit failure, protecting the deflection coil in the yoke from damage.

D. Z Amplifiers (Red, Green, and Blue)

Since the red, green, and blue amplifiers are identical, only the blue amplifier will be described.

Transistor Q502 is a common-emitter amplifier used to provide gain for the blue-intensity signal. Resistor R509 is the blue drive pot which determines the amount of gain in the blue amplifier. Resistor R518 is the blue bias pot which determines the cut off characteristics of the blue amplifier. The output of the Z amplifiers bias the cathodes of the three electron guns within the picture tube.

Transistor Q503 is biased by a voltage from the spot killer. When transistor Q503 is cut off, the collector of Q503 rises to the zener voltage of ZD500 (+ 4.3 volts). This allows the emitter of transistor Q502 to rise in voltage, which disables the blue signal from the picture tube.

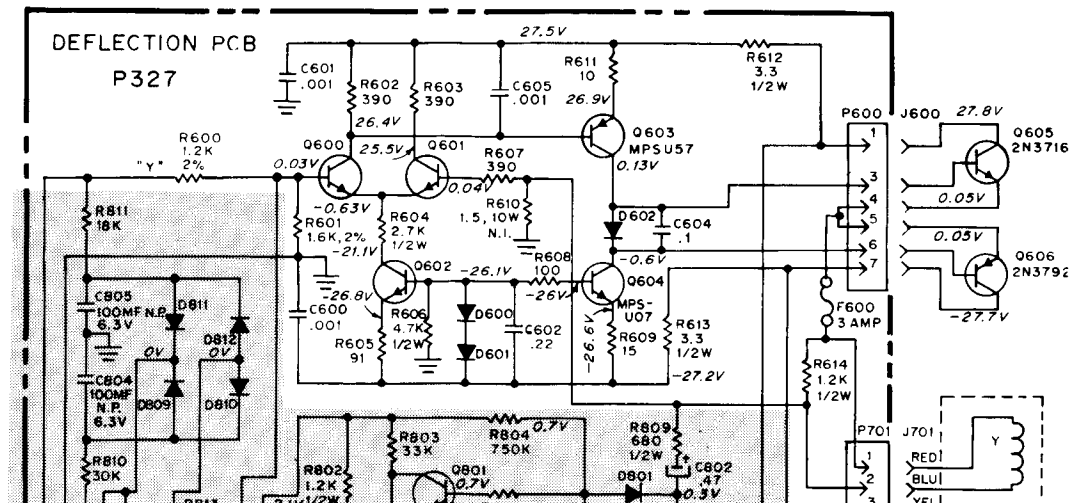
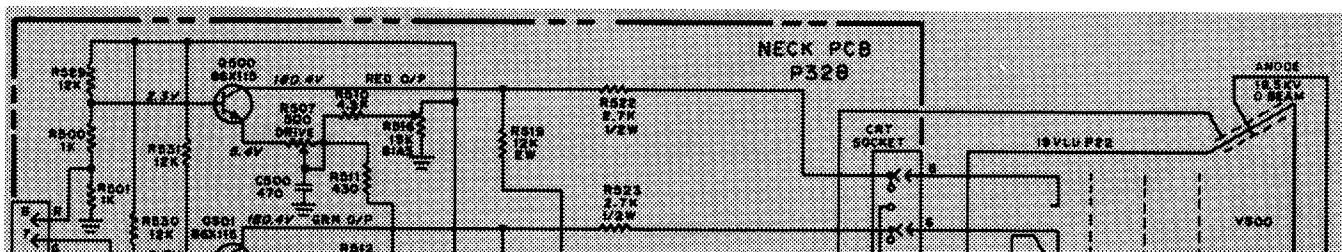


Figure 9 Schematic Diagram of Y Amplifier



E. Spot Killer Circuitry

The purpose of the spot killer is to turn off the video amplifiers when deflection is not occurring. Failure of the spot killer can allow the phosphor coating on the picture tube to burn.

The two signal input voltages to the spot killer are taken from resistors R610 and R710 in the X and Y deflection circuits. Diodes D801 through D804 and capacitors C800 through C803 form two separate

voltage doublers. The outputs of the voltage doublers are applied to the bases of transistors Q801 and Q802.

When either of the deflection amplifiers is not driving current through the deflection coils, then either transistor Q801 or Q802 becomes biased so that it conducts, which turns on transistor Q800 and the LED D800 in its collector circuit. When transistor Q800 is conducting, then transistor Q503 in the Neck PCB is cut off, forcing the red, green and blue amplifiers to turn off their electron beams.

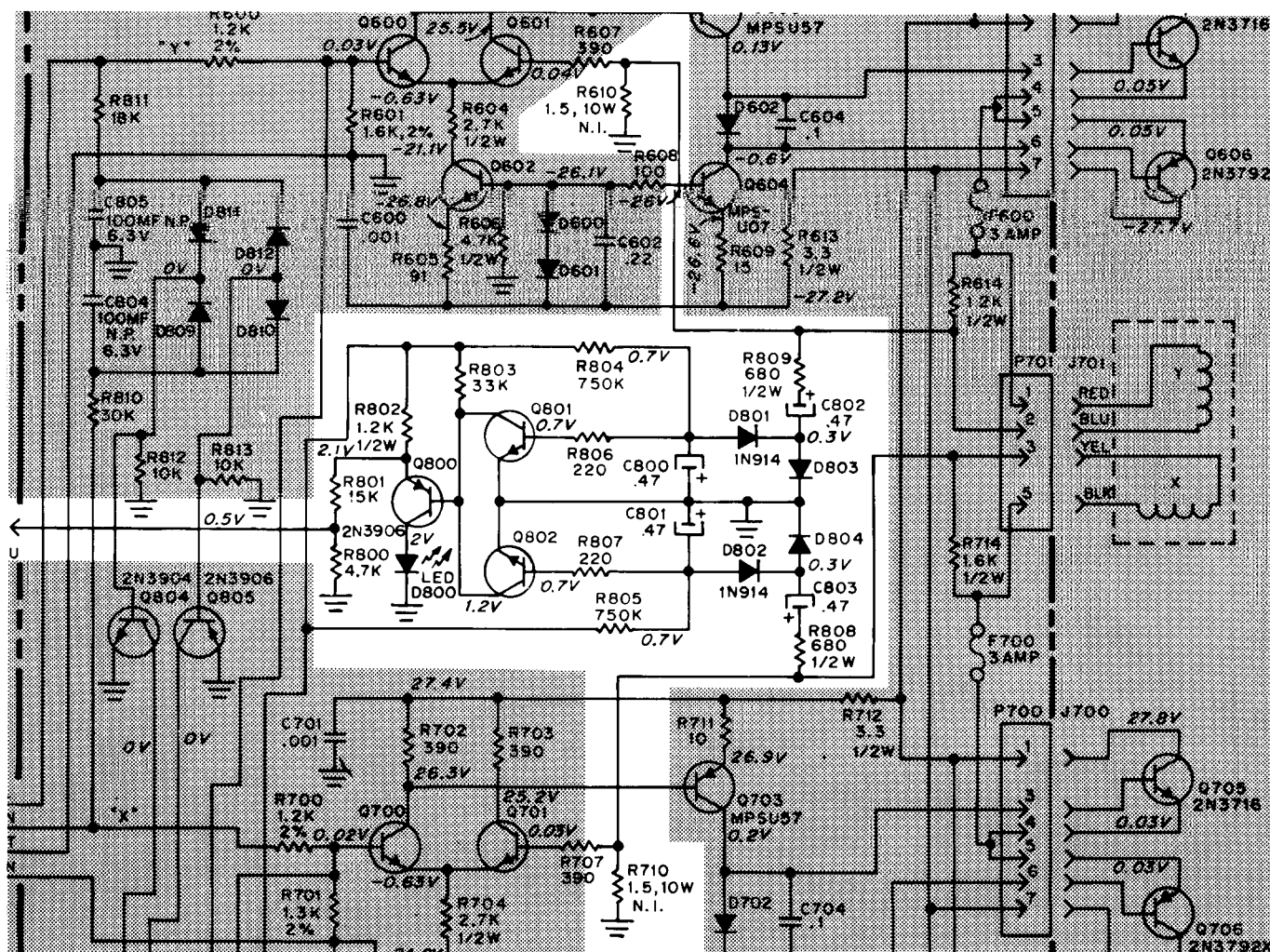


Figure 11 Schematic Diagram of Spot Killer Circuitry

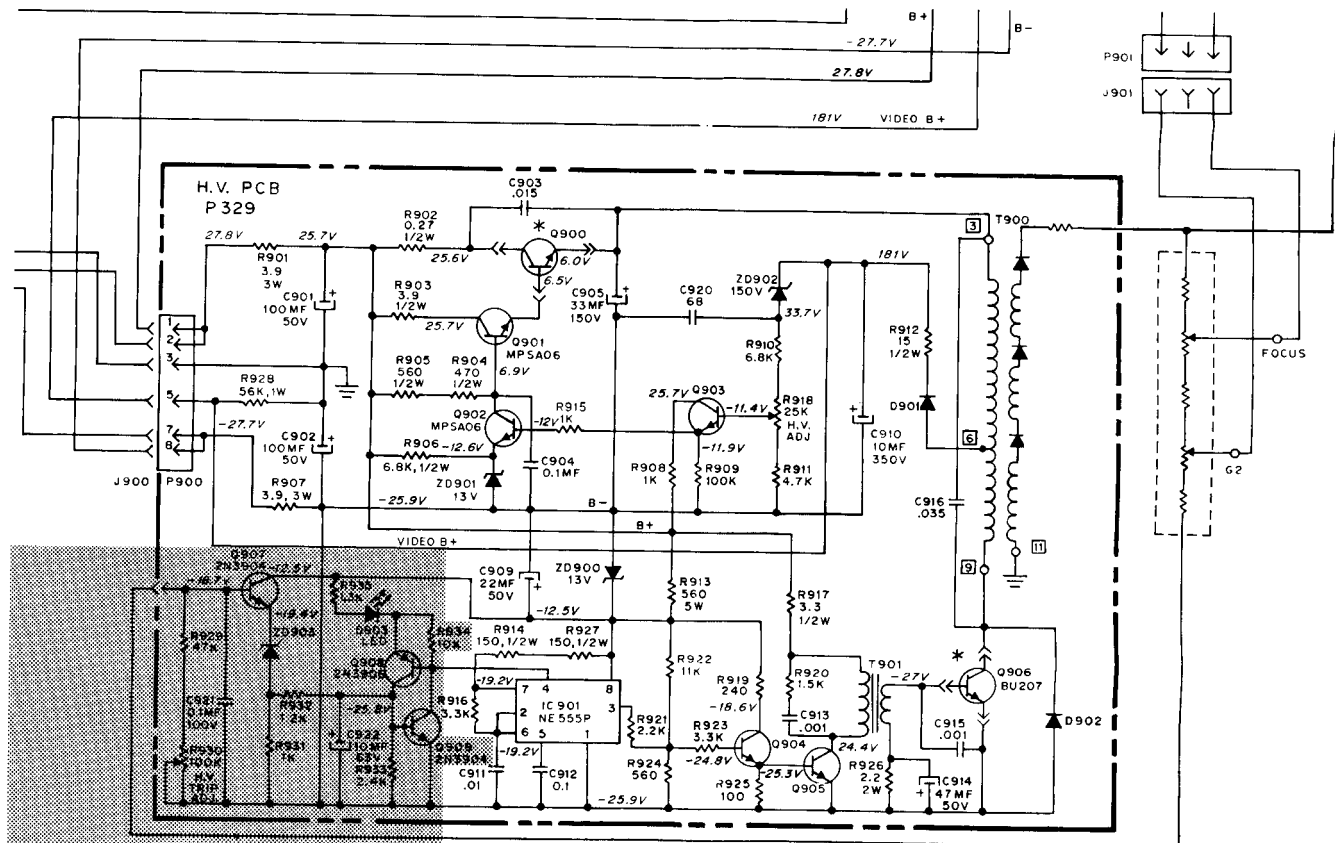


Figure 12 Schematic Diagram of High-Voltage Power Supply

F. High-Voltage Power Supply



WARNING

At no time is the high-voltage PCB to be serviced while power is applied! An extremely high voltage is present within this circuit. Output of the high-voltage power supply is over **19,000 volts**.

Integrated circuit IC901 is a timer circuit that produces a 20-kHz output which drives transistors Q904 and Q905. These transistors are current amplifiers that drive the primary of the step-down transformer T901 (current gets stepped up). Transistor Q906 amplifies the current further, and from there the 20-kHz signal is applied to the primary of the high-voltage step-up transformer T900. The output of the secondary windings is applied to the picture tube at the focus and brightness grids and the 19.5-kV anode.

Diode D901 allows capacitor C910 to charge to +180 volts during the discharge of the primary's magnetic field. Transistors Q900 through Q903 are error amplifiers that regulate the +180 volt video B+. Pot R918 provides an adjustment to the video B+ and hence the high voltage.

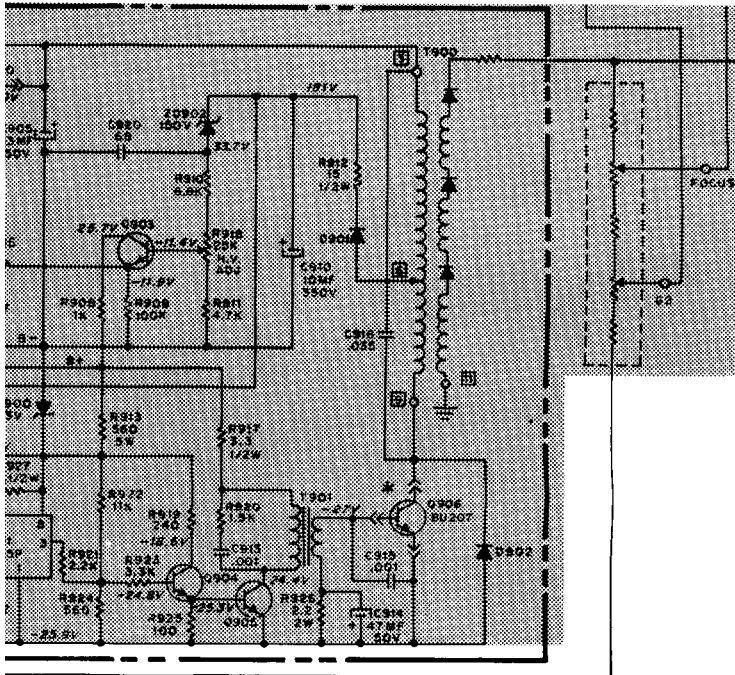
To adjust the high voltage, you will need a high-voltage probe, a voltmeter, and an insulated screwdriver-tipped adjustment tool. Turn off power to the display. Connect the high-voltage probe to the voltmeter, and insert the tip of the probe under the high-voltage anode rubber shield.

Insert the insulated screwdriver-tipped adjustment tool through the top of the high-voltage cage, making contact with potentiometer R918. Turn on power to the display, and adjust the high-voltage to 19.5 kV.

G. Over-Voltage Protection

The over-voltage protection circuit monitors the voltage of the focus assembly in the secondary circuit of T900. If the high-voltage at the anode of the picture tube increases beyond the threshold set by H.V. TRIP adjustment R930, this circuit shuts off the

timer of IC901. When the voltage at the base of Q907 increases, Q907 will turn off. Now the transistor pair of Q908 and Q909 will turn on, turning off IC901. Light-emitting diode D903 turns on to indicate an over-voltage condition.



ic Diagram of Over-Voltage Protection

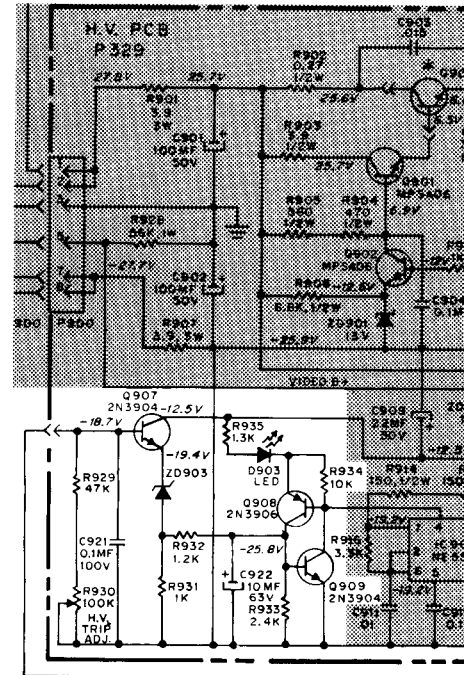
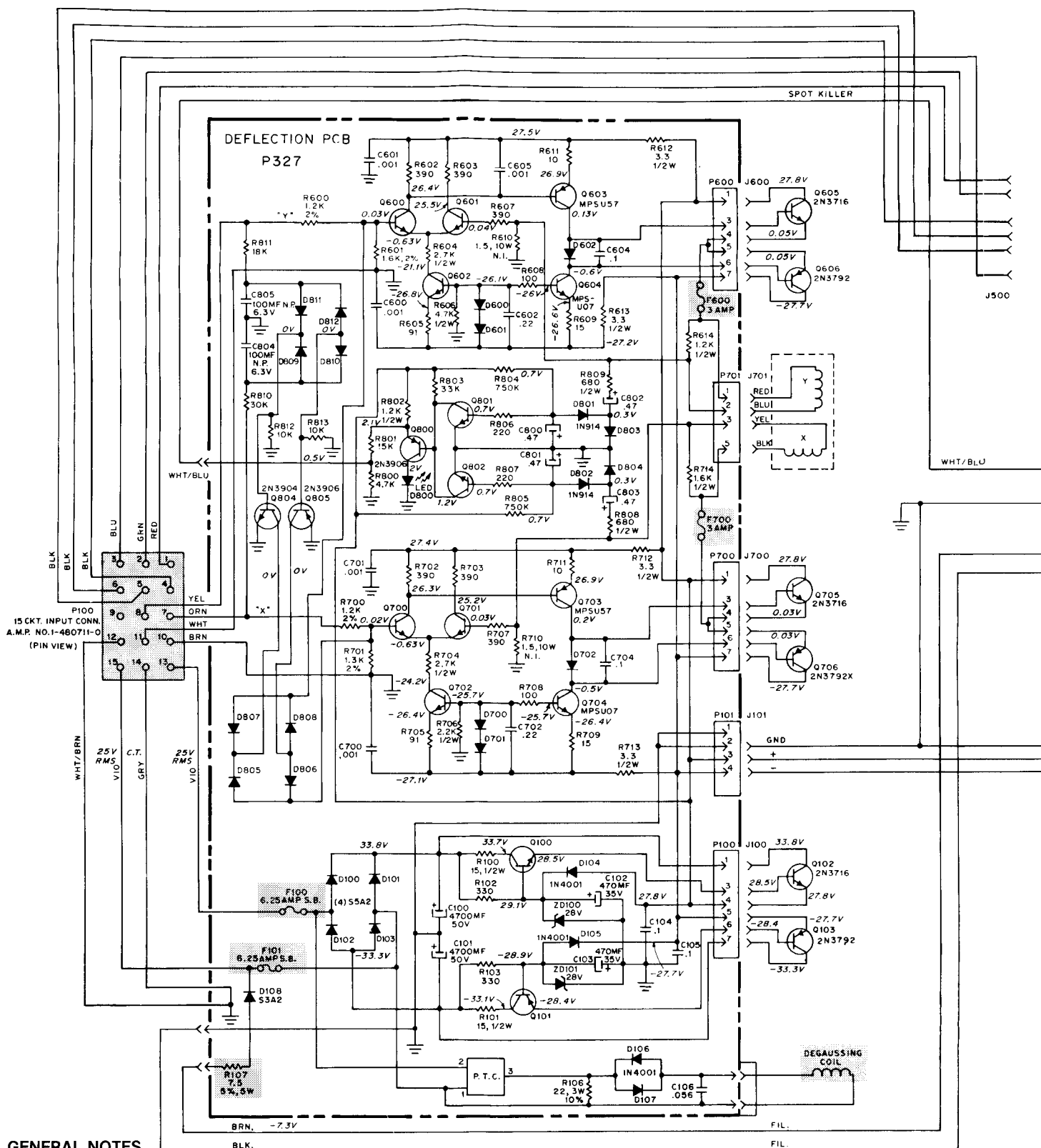
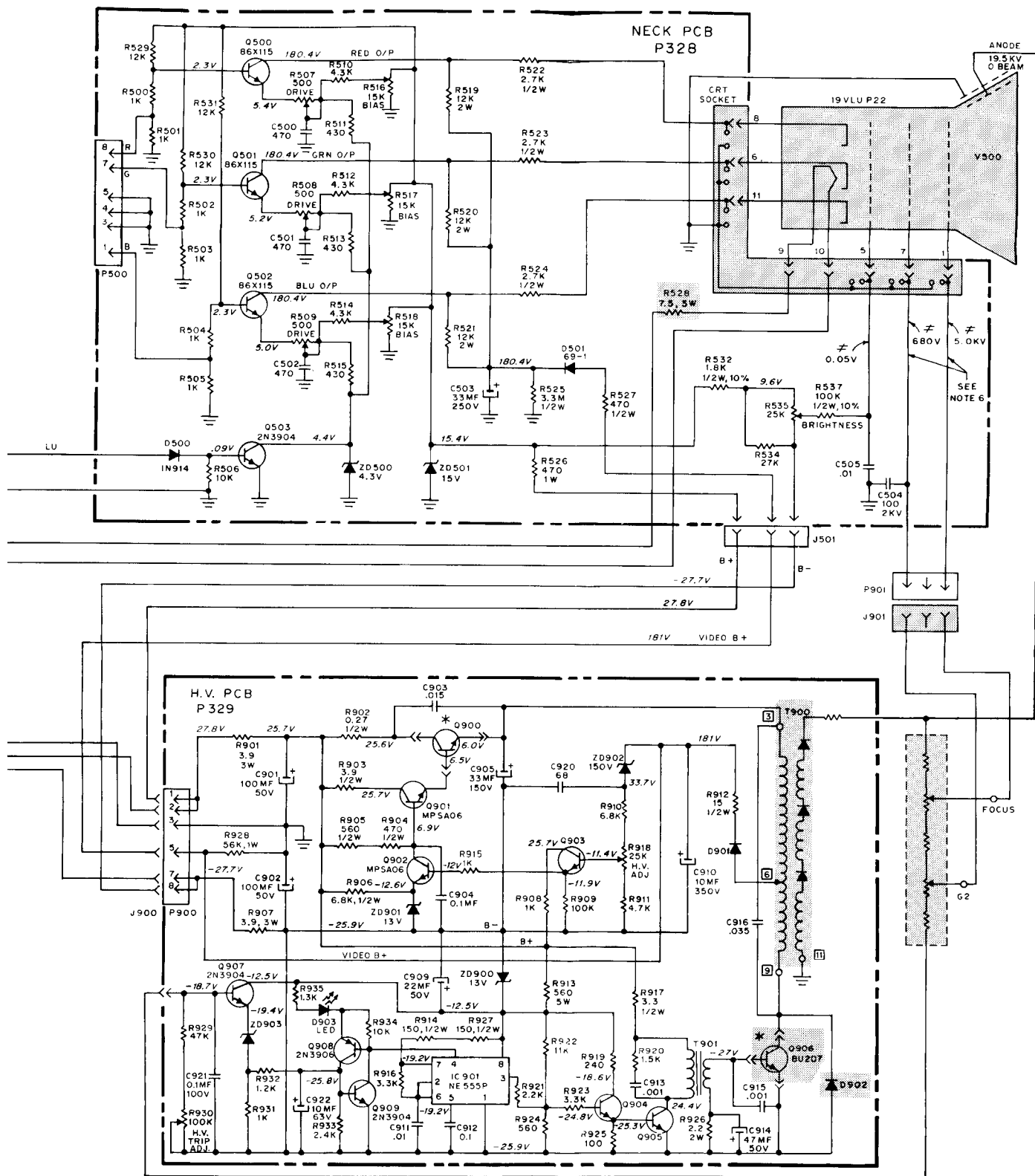


Figure 13 Schemat



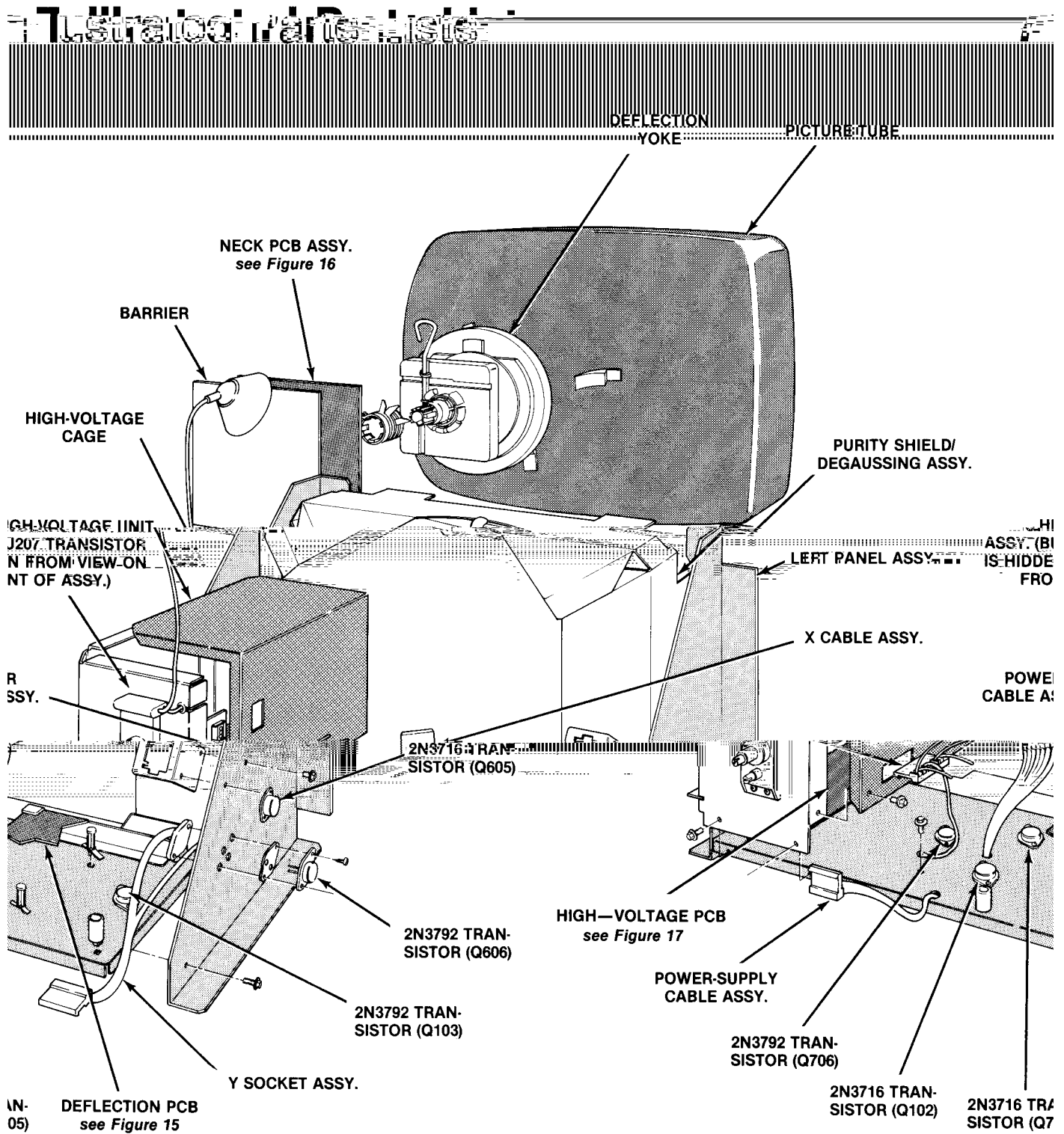
GENERAL NOTES

1. Resistance values in ohms, ¼ watt, $\pm 5\%$, unless otherwise noted. K = 1,000, M = 1,000,000
2. Capacitance value of 1 or less is in microFarads, above 1 in picoFarads, unless otherwise noted.
3. * Q900 and Q906 are not in High-Voltage PCB.
4. All D.C. voltages are $\pm 10\%$ 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.
5. Circled numbers indicate location of waveform reading.
6. ZD100-101 uses (66X0040-007) zener diode in series with (340X2331-934) 330-ohm resistor in early production models.
7. Use a 1,000:1 probe when measuring G2 (screen) or focus voltage.

**WARNING**

Components identified by shading have special characteristics important to safety and should be replaced only with identical types.

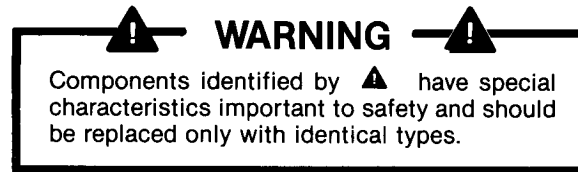
Figure 14. Schematic Diagram of Display



Display Assembly

Figure 15 Display Assembly

**Figure 15 Display Assembly, continued
Parts List**



Part No.	Description (Reference Designations and Locations in Bold)
99-130416	Type-2N3716 NPN Transistor (Q102, 705)
99-130417	Type-2N3792 PNP Transistor (Q103)
99-130467	Type-2N3792X Transistor (Q706)
99-130468	X Cable Assembly Assembly consists of: 99-130422—7-Circuit Receptacle Connector, and 99-130481—Key Plug
99-130469	Power Supply Cable Assembly Assembly consists of: 99-130422—7-Circuit Receptacle Connector
99-130470	Left Panel Assembly Assembly consists of: 99-130416—Type-2N3716 NPN Transistor, 99-130417—Type-2N3792 PNP Transistor, 99-130616—Mica Washer, and 99-130483—Y Socket
99-130484—Riveted Purity Shield	99-130471 ▲ Purity Shield/Degaussing Assembly Assembly consists of: 99-130485—Degaussing Coil Assembly, 99-130486—DAG Spring Assembly
AMP #350342-2 Connector, and	99-130472 ▲ Type-19VLUP22 Cathode-Ray Tube
	99-130476 Deflection Yoke
	99-130477 Deflection Yoke Wedge
	99-130478 Lateral Purity Assembly
	99-130480 Neck PCB Barrier
	99-130612 Deflection PCB Assembly—see Figure 16
	99-130613 Neck PCB Assembly—see Figure 17
7-Circuit Connector, Receptacle Connector, and	99-130614 Power Cable Assembly Assembly consists of: 99-130493—8-Circuit Connector, 99-130494—5-Circuit Connector, 99-130495—AMP #350850-1 Receptacle, 99-130481—Key Plug, and 99-130496—AMP #350342-3 Connector
	99-130615 Mica Washer
Riveted High-Voltage Unit (see Figure 18), 99-130618—Focus Control Insulation Cap, 99-130619—Bushing, 99-130620—Mica Insulator, 99-130621—Focus Control Insulation Cap, 99-130491—Focus Control Insulation Cap, 99-130622—Ground Lead Assembly, 99-130122—Type-BU207 Transistor, and 99-130623—Cover	99-130616 ▲ High-Voltage Unit Assembly Assembly consists of: 99-130489—High-Voltage Unit Assembly, 99-130611—High-Voltage PCB Assembly (see Figure 16), 99-130619—Bushing, 99-130620—Mica Insulator, 99-130621—Focus Control Insulation Cap, 99-130491—Focus Control Insulation Cap, 99-130622—Ground Lead Assembly, 99-130122—Type-BU207 Transistor, and 99-130623—Cover
	99-130617 Yoke Tab

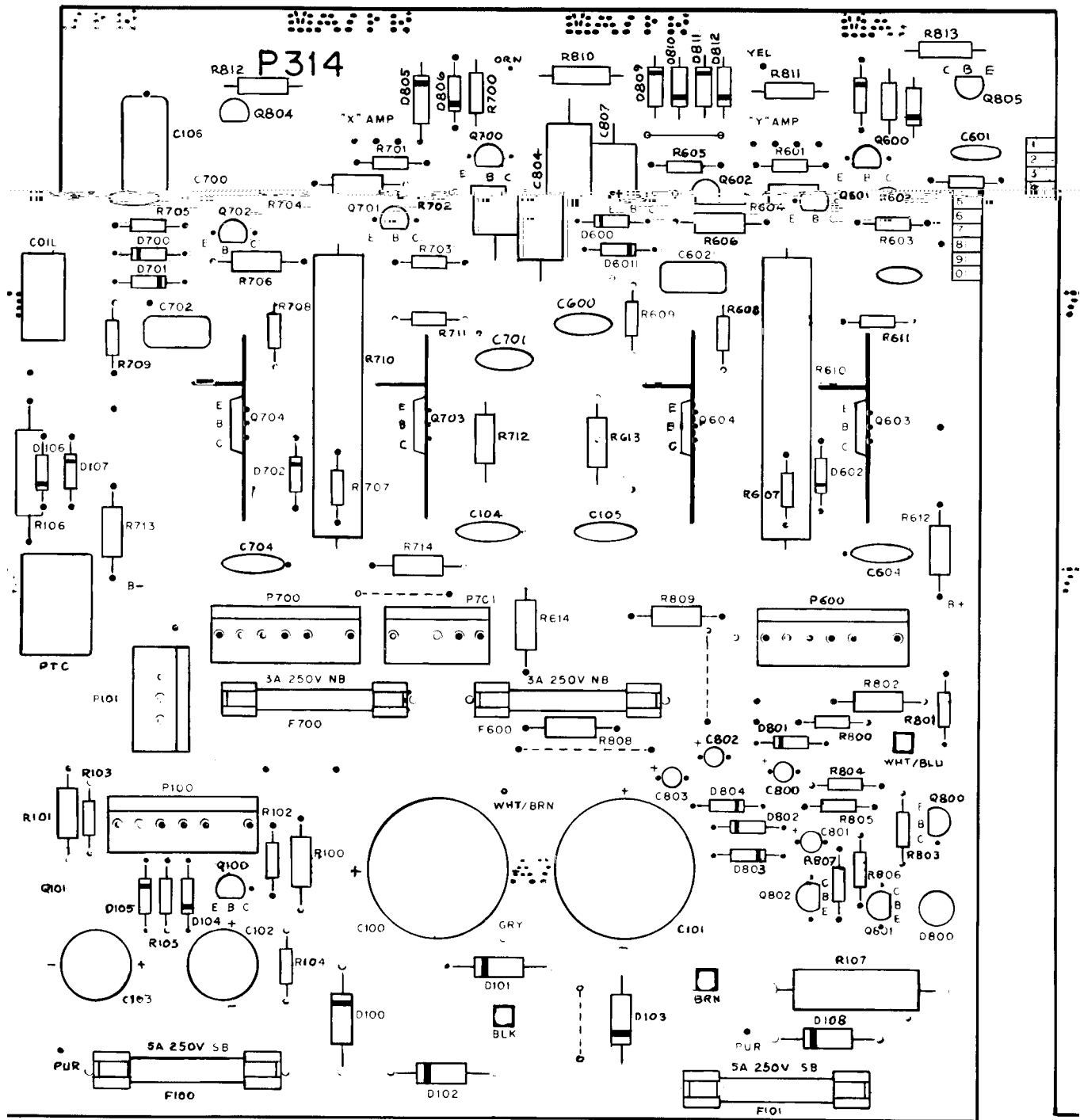
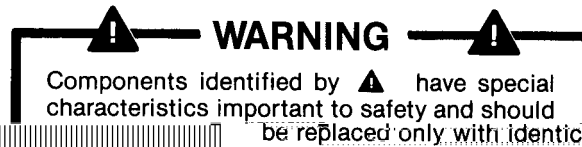


Figure 16 Deflection PCB Assembly
99-130474 C


Figure 16 Deflection PCB Assembly, continued
Parts List



Part No.	Description (Reference Designations and Locations in Bold)
99-130076	2.2 k Ω , $\pm 5\%$, 1/2 W Resistor (R706)
99-130128	Type-2N3906 PNP Transistor (Q800, 805)
99-130130	Type-MPSA06 NPN Transistor (Q100)
99-130351	100 Ω , $\pm 5\%$, 1/4 W Resistor (R608, 708)
99-130354	330 Ω , $\pm 5\%$, 1/4 W Resistor (R102, 103)
99-130366	3.3 Ω , $\pm 5\%$, 1/2 W Resistor (R612, 613, 712, 713)
99-130369	33 k Ω , $\pm 5\%$, 1/4 W Resistor (R803)
99-130385	220 Ω , $\pm 5\%$, 1/4 W Resistor (R806, 807)
99-130389	91 Ω , $\pm 5\%$, 1/4 W Resistor (R605, 705)
99-130390	4.7 k Ω , $\pm 5\%$, 1/4 W Resistor (R606)
99-130400	0.1 μ F, 50 V Disc Capacitor (C104, 105, 604, 704)
99-130401	0.47 μ F, 35 V Electrolytic Capacitor (C800803)
99-130405	0.22 μ F, 50 V Capacitor (C602, 702)
99-130407	Type-S3A2 Diode (D108)
99-130408	Type-1N914B Diode (D600, 601, 700, 701, 801806, 809-812)
99-130409	Light-Emitting Diode (D800)
99-130411	Type-1N4001 Diode (D104-107, 602, 702)
99-130412	Type-TPS98 NPN Transistor (Q600-602, 700-702, 801, 802)
99-130413	Type-2N3904 NPN Transistor (Q804)
ransistor, and 99-130414	PNP Transistor Assembly (Q603, 703) Assembly consists of: 99-130564—PNP 1 99-130563—Heat Sink
ransistor, and 99-130415	NPN Transistor Assembly (Q604, 704) Assembly consists of: 99-130562—NPN 99-130563—Heat Sink
99-130427	7-Circuit Header Connector (P100, 600, 700)
99-130429	5-Circuit Header Connector (P101, 701)
99-130527	▲ 7.5 Ω , $\pm 5\%$, 5 W Resistor (R107)
99-130547	1.5 Ω , $\pm 5\%$, 10 W Resistor (R610, 710)
99-130548	Type-S5A2 Diode (D100-103)
99-130550	PTC Thermistor
99-130551	Fuse Clips
99-130552	▲ 3 A Fuse (F600, 700)
99-130553	0.001 μ F, $\pm 20\%$, Type-Z5F Capacitor (C600, 601, 605, 700, 701)
99-130555	4700 μ F, 50 V Electrolytic Capacitor (C100, 101)
99-130556	470 μ F, 35 V Electrolytic Capacitor (C102, 103)
99-130560	Purple Lead Assembly
99-130561	▲ 15-Circuit Connector Assembly
99-130564	PNP Transistor (Q101)
99-130577	15 Ω , $\pm 5\%$, 1/2 W Resistor (R100, 101)

[Continued on next page]

**Figure 16 Deflection PCB Assembly, continued
Parts List**

Part No. (Location #)	Description (Reference Designation and Location in Deflection PCB Assembly)	Description (Reference Designation)
313)	99-130581	10 k Ω , \pm 5%, 1/4 W Resistor (R812, 1
	99-130586	4.7 k Ω , \pm 5%, 1/4 W Resistor (R800)
700)	99-130587	1.2 k Ω , \pm 2%, 1/4 W Resistor (R600,
	99-130588	1.6 k Ω , \pm 2%, 1/4 W Resistor (R601)
	99-130589	1.3 k Ω , \pm 2%, 1/4 W Resistor (R701)
303, 607, 702, 703, 707)	99-130590	390 Ω , \pm 5%, 1/4 W Resistor (R602, 1
1)	99-130591	10 Ω , \pm 5%, 1/4 W Resistor (R611, 71
99)	99-130592	15 Ω , \pm 5%, 1/4 W Resistor (R609, 71
	99-130593	15 k Ω , \pm 5%, 1/4 W Resistor (R801)
805)	99-130594	750 k Ω , \pm 5%, 1/4 W Resistor (R804,
704)	99-130595	2.7 k Ω , \pm 5%, 1/2 W Resistor (R604,
802)	99-130596	1.2 k Ω , \pm 5%, 1/2 W Resistor (R614,
	99-130597	1.6 k Ω , \pm 5%, 1/2 W Resistor (R714)
309)	99-130598	680 Ω , \pm 5%, 1/2 W Resistor (R808, 1
1, 101)	99-130599	28 V, \pm 5%, 1 W Zener Diode (ZD101
	99-130627	22 Ω , \pm 10%, 3 W Resistor (R106)
1)	99-130628	 6.25 A Slow-Blowing Fuse (F100, 101
15)	99-130629	100 μ F, 6.3 V, NP Capacitor (C804, 80
106)	99-130630	0.056 μ F, 400 V, \pm 10%, Capacitor (C
	99-130632	18 k Ω , \pm 5%, 1/4 W Resistor (R811)
	99-130633	30 k Ω , \pm 5%, 1/4 W Resistor (R810)
1)	99-130634	Germanium-Special Diode (D807, 808

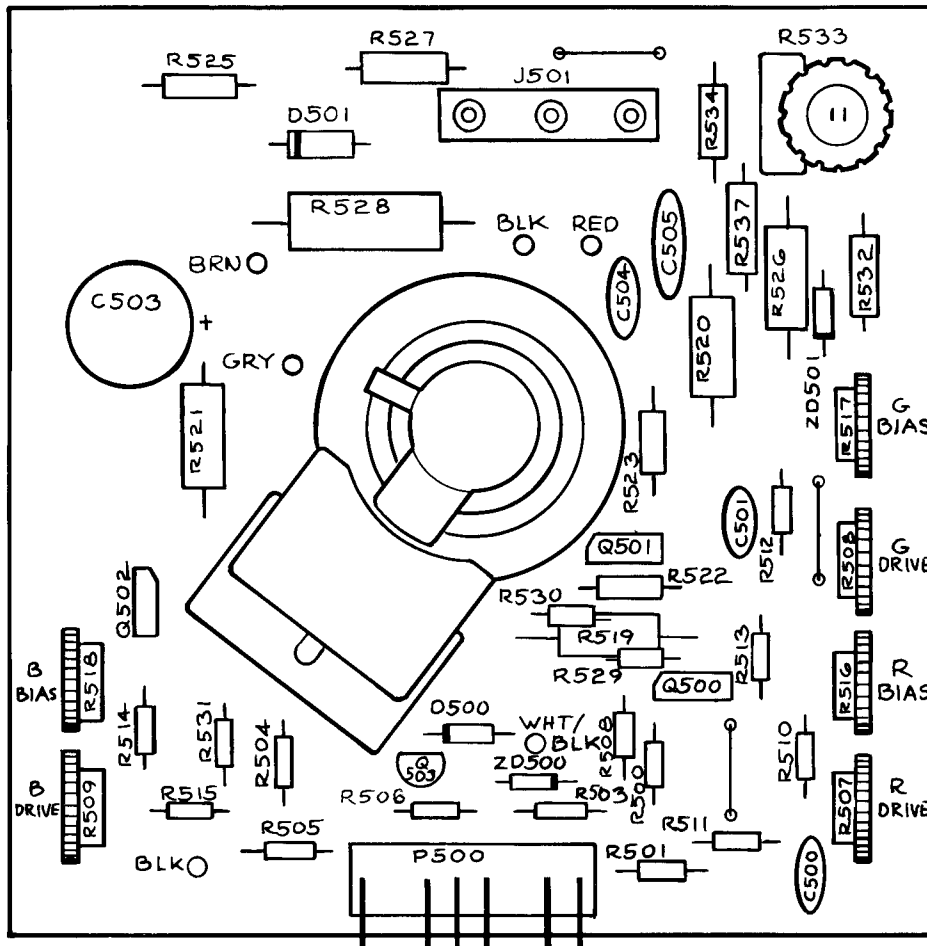
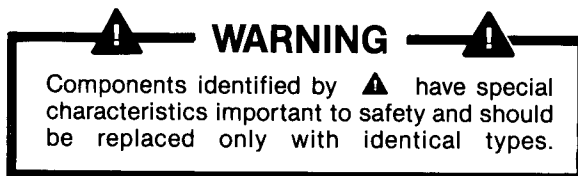
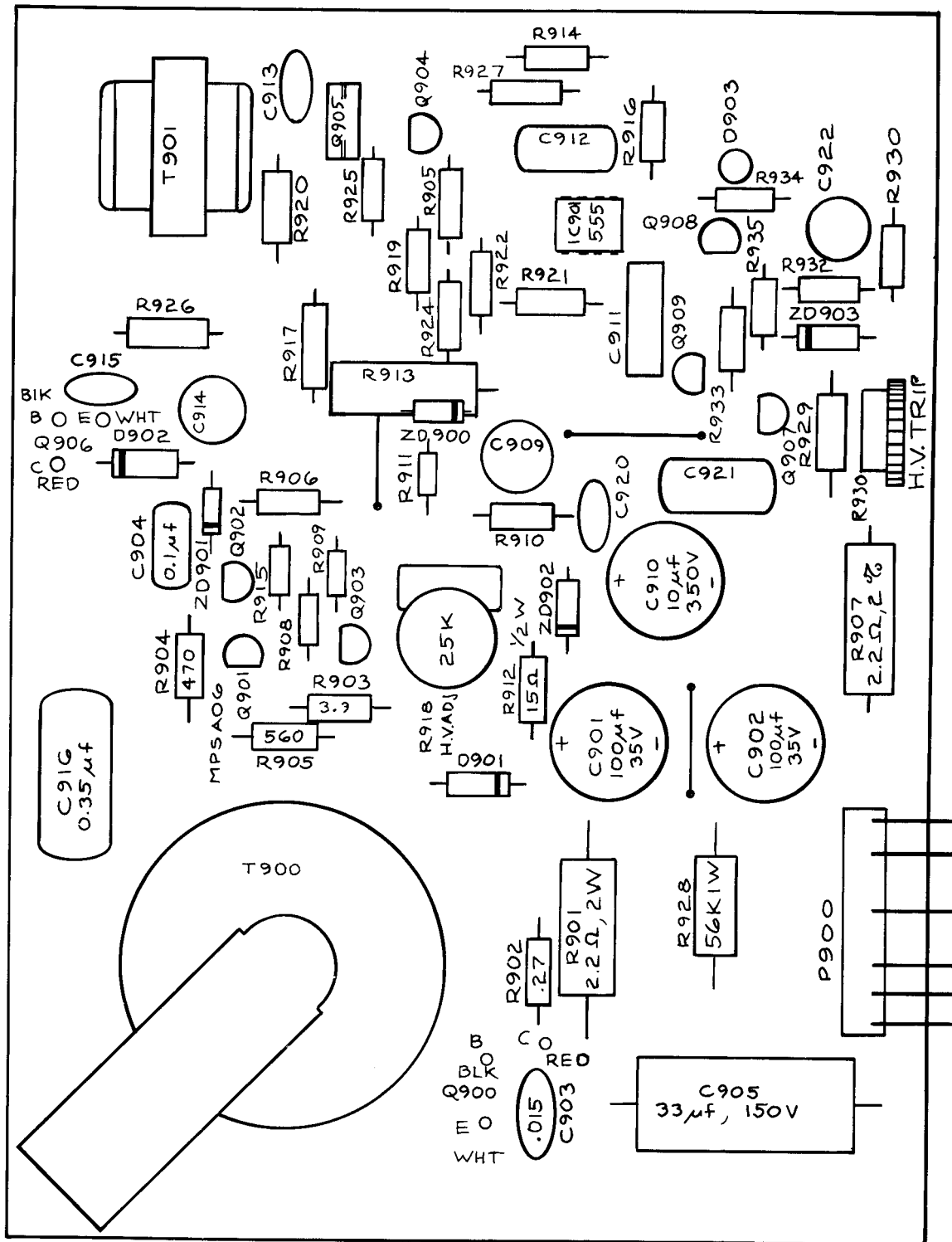


Figure 17 Neck PCB Assembly
99-130479 C

Figure 17 Neck PCB Assembly, continued Parts List

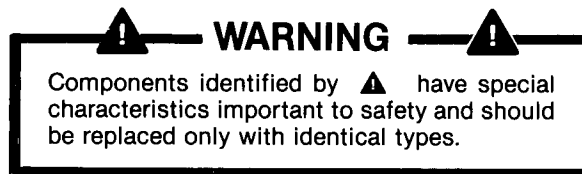


<i>Part No.</i>	<i>Description (Reference Designations and Locations in Bold)</i>
99-130034	470 pF, $\pm 10\%$, Type-Z5F Ceramic-Disc Capacitor (C500-502)
99-130093	1.8 k Ω , $\pm 10\%$, $\frac{1}{2}$ W Resistor (R532)
99-130111	470 Ω , $\pm 5\%$, $\frac{1}{2}$ W Resistor (R527)
99-130129	Type-D40P3 NPN Transistor (Q500-502)
99-130371	100 k Ω , $\pm 10\%$, $\frac{1}{2}$ W Resistor (R537)
99-130392	1 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R500-505)
99-130404	0.01 μ F, 1 kV, Type-Z5U Capacitor (C505)
99-130408	Type-1N914B Diode (D500)
99-130410	250 V Diode (D501)
99-130413	Type-2N3904 NPN Transistor (Q503)
99-130507	25 k Ω Green Potentiometer (R535)
99-130519	8-Circuit Right-Angle Header Connector
99-130525	12 k Ω , $\pm 5\%$, 2 W Resistor (R519-521)
99-130527	▲ 7.5 Ω , $\pm 5\%$, 5 W Resistor (R528)
99-130528	100 pF, $\pm 10\%$, 2 kV Ceramic-Disc Capacitor (C504)
99-130529	33 μ F, 250 V Electrolytic Capacitor (C503)
99-130531	15 k Ω Potentiometer (R516-518)
99-130532	▲ CRT Socket
99-130534	Black Wire Assembly Assembly consists of: 99-130639—PC Wire Terminal, 99-130495—AMP #350850-1 Receptacle Connector, and 99-130540—1-Circuit Housing Connector
99-130535	Brown Wire Assembly Assembly consists of: 99-130639—PC Wire Terminal, 99-130495—AMP #350850-1 Receptacle Connector, and 99-130540-1—1-Circuit Housing Connector
99-130536	White/Blue Wire Assembly Assembly consists of: 99-130639—PC Wire Terminal, 99-130495—AMP #350850-1 Receptacle Connector, and 99-130540-1—1-Circuit Housing Connector
99-130537	Ground Wire Assembly Assembly consists of: 99-130639—PC Wire Terminal
99-130538	▲ Focus and Red Wire Assembly Assembly consists of: 99-130541—Focus Wire Assembly, 99-130542—Red Wire Assembly, and 99-130543—3-Circuit Plug Connector
99-130539	SG Lead Assembly
99-130578	12 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R529-531)
99-130581	10 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R506)
99-130583	2.7 k Ω , $\pm 10\%$, $\frac{1}{2}$ W Resistor (R522-524)
99-130584	3.3 M Ω , $\pm 10\%$, $\frac{1}{2}$ W Resistor (R525)
99-130585	4.3 V, $\pm 5\%$, $\frac{1}{2}$ W Zener Diode (ZD500)
99-130637	470 Ω , $\pm 5\%$, 5 W Resistor (R526)
99-130638	500 Ω Potentiometer (R507-509)
99-130643	27 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R534)
99-130644	430 Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R511, 513, 515)
99-130645	15 V, $\pm 5\%$, 1 W Zener Diode (ZD501)
99-130646	4.3 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R510, 512, 514)



**Figure 18 High-Voltage PCB Assembly
99-130490**

Figure 18 High-Voltage PCB Assembly, continued Parts List



<i>Part No.</i>	<i>Description (Reference Designations and Locations in Bold)</i>
99-130028	0.1 μ F, 100 V, $\pm 20\%$ Mylar Capacitor (C904, 921)
99-130049	Horizontal-Drive Transformer (T901)
99-130087	1.5 k Ω , $\pm 5\%$, $\frac{1}{2}$ W Resistor (R920)
99-130089	2.2 Ω , $\pm 5\%$, 2 W Resistor (R926)
99-130094	150 Ω , $\pm 5\%$, $\frac{1}{2}$ W Resistor (R914, 927)
99-130111	470 Ω , $\pm 5\%$, $\frac{1}{2}$ W Resistor (R904)
99-130115	3.9 Ω , $\pm 5\%$, $\frac{1}{2}$ W Resistor (R903)
99-130128	Type-2N3906 PNP Transistor (Q908)
99-130130	Type-MPSA06 NPN Transistor (Q901, 902, 904)
99-130132	Type-2N6557 NPN Horizontal Driver Transistor (Q905)
99-130351	100 Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R925)
99-130360	6.8 V, $\pm 5\%$, $\frac{1}{2}$ W Zener Diode (ZD903)
99-130366	3.3 Ω , $\pm 5\%$, $\frac{1}{2}$ W Resistor (R917)
99-130373	2.2 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R921)
99-130376	6.8 k Ω , $\pm 5\%$, $\frac{1}{2}$ W Resistor (R906)
99-130377	100 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R909)
99-130392	1 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R908, 915, 931)
99-130395	6.8 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R910)
99-130409	Light-Emitting Diode (D903)
99-130413	Type-2N3904 NPN Transistor (Q907, 909)
99-130444	0.015 μ F, 100 V Ceramic Capacitor (C903)
99-130448	▲ Type-F9C77-13 Diode (D901, 922)
99-130507	25 k Ω Potentiometer (R918)
99-130508	56 k Ω , $\pm 5\%$, 1 W Resistor (R928)
99-130509	Transistor (Q903)
99-130510	Clock Integrated Circuit (IC901)
99-130512	22 μ F, 50 V Electrolytic Capacitor (C909)
99-130514	0.01 μ F Polypropylene Capacitor (C911)
99-130515	0.1 μ F, $\pm 5\%$, 100 V Mylar Capacitor (C912)
99-130516	▲ High-Voltage Transformer (T900)
99-130517	3-Circuit Transistor-Lead Assembly Assembly consists of: 99-130521—Terminal, and 99-130522—Power Transistor Socket
99-130518	TO-3 Transistor Lead Assembly Assembly consists of: 99-130497—Transistor Socket
99-130519	8-Circuit Right-Angle Header Connector (P900)
99-130520	68 pF Capacitor (C920)
99-130553	0.001 μ F, $\pm 20\%$, Type-Z5F Capacitor (C913, 915)
99-130567	10 μ F, 300 V Electrolytic Capacitor (C910)

[Continued on next page]

Figure 18 High-Voltage PCB Assembly, continued Parts List

<i>Part No.</i>	<i>Description (Reference Designations and Locations in Bold)</i>
99-130568	560 Ω , $\pm 10\%$, 5 W Resistor (R913)
99-130569	0.035 μF , 400 V, Polypropylene Capacitor (C916)
99-130570	560 Ω , $\pm 5\%$, $\frac{1}{2}$ W Resistor (R905)
99-130571	11 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R922)
99-130572	3.3 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R916, 923)
99-130573	240 Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R919)
99-130574	560 Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R924)
99-130575	13 V, $\pm 5\%$, 1 W Zener Diode (ZD900, 901)
99-130576	150 V, $\pm 5\%$, 1 W Zener Diode (ZD902)
99-130577	15 Ω , $\pm 5\%$, $\frac{1}{2}$ W Resistor (R912)
99-130579	0.27 Ω , $\pm 10\%$, $\frac{1}{2}$ W Resistor (R902)
99-130581	10 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R934)
99-130586	4.7 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R911)
99-130649	47 μF , 50 V Electrolytic Capacitor (C914)
99-130650	100 μF , 50 V Electrolytic Capacitor (C901, 902)
99-130651	100 k Ω Grey Potentiometer (R930)
99-130652	33 μF , 63 V Electrolytic Capacitor (C905)
99-130653	3.9 Ω , $\pm 10\%$, 3 W Resistor (R901, 907)
99-130654	10 μF , 63 V Electrolytic Capacitor (C922)
99-130657	47 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R929)
99-130658	1.2 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R932)
99-130659	2.4 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R933)
99-130660	1.3 k Ω , $\pm 5\%$, $\frac{1}{4}$ W Resistor (R935)

