HP 98770A Color Graphics Display

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Printing History

New editions of this manual will incorporate all material updated since the previous edition. Update packages may be issued between editions and contain replacement and additional pages to be merged into the manual by the user. Each updated page will be indicated by a revision date at the bottom of the page. A vertical bar in the margin indicates the changes on each page. Note that pages which are rearranged due to changes on a previous page are not considered revised.

The manual printing date and part number indicate its current edition. The printing date changes when a new edition is printed. (Minor corrections and updates which are incorporated at reprint do not cause the date to change.) The manual part number changes when extensive technical changes are incorporated.

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Chapter 1
General Information

Introduction

This manual provides service information for the 98770A Color Graphics Display and the 98775A Light Pen. The various chapters in this manual include:

- General Information
- Theory of Operation
- Troubleshooting
- Alignment Procedures
- Assembly Access
- Replaceable Parts
- Light Pen

This manual should be used in conjunction with the 9845B Service Manual (HP Part No. 09845-91030). This chapter contains general servicing information. Here are the topics discussed in this chapter:

- 98770A Configurations
- Specifications
- Repair Philosophy
- Safety
- 98770A Installation

98770A Configurations

The 98770A is available as either a part of the 9845C or the 98771A Upgrade Kit.

Available accessories are:

98771A	Upgrade Kit	(Upgrades 9845B to 9845C)
98775A	Light Pen	(Also available as 9845C #775) or 98771A #775)
98776A	RGB Interface	(Also available as 9845C #776) or 98771A #776)
98777A	Camera Attachment	

Available character sets are:

9845C	ASCII/European	(Also 98771A Standard)
9845C #840	Katakana	(Also 98771A #772)

9845B and 9845C Comparison

The 9845B and 9845C share the same mainframe assemblies except for the following:

- The 09845-66503 assembly of the 9845B is replaced by the 98770-66534 assembly for the 9845C.
- Two ROMs on the 09845-66527 assembly (A27) are changed for the 9845C. The 9845C, A27 assembly works in the 9845B. An unmodified A27 assembly from a 9845B does not work in the 9845C unless the two ROMs are changed.
- The 9845C uses the new Graphics ROM (98770-65501).
- Special function keycaps K8 through K15 are different.

All other mainframe assemblies are interchangeable. The big difference is the CRT display assembly. The 9845B has a 12-inch monochrome display and the 9845C has the 98770A, a 14-inch color display.

98770A Specifications

Environmental Range

Operating Temperature:	+5°C to +40°C ambient
Storage Temperature:	−40°C to +65°C
Ambient Humidity:	<80%

Size / Weight

Height:	32 cm
Width:	46 cm
Depth:	45 cm
Net Weight:	29.45 kg (65 lbs)

Power Requirements

AC Line Voltage:	110 volts ac (88 to 127 Vac)
	220 volts ac (198 to 250 Vac)
Line Frequency:	48 to 66 Hz (inclusive)
Power Consumption:	500 watts maximum

Display Features

Cathode Ray Tube:	14 inch diagonal, delta-gun, black matrix
Scan:	Non-interlaced raster scan
Refresh Rate:	60 Hz
Vertical Scan Rate:	60 Hz
Vertical Retrace Time:	1.03 milliseconds
Horizontal Scan Rate:	29.1 kHz
Horizontal Retrace Time:	10.2 microseconds
Dot Scan Rate:	29.7984 MHz

Alphanumeric Display

Alpha Raster Size (System Raster):	247 mm x 154 mm (720 dots x 455 dots)[1]
Screen Capacity:	2400 characters (30 lines of 80 characters)[2]
Character Font:	7 dot x 9 dot in a 9 x 15 matrix
Character Size:	2.40 mm wide x 3.09 mm high (7 x 9 character)
Character Colors:	Black, white, red, green, blue, cyan, magenta, yellow
Standard Character Set:	128 ASCII characters
Additional Character Sets:	European, Katakana
Cursor:	White blinking underline
Highlighting:	Inverse video, blinking and underline

Graphics Display

Graphics Raster Size:	192 mm x 154 mm (560 dots x 455 dots)
Matrix Size:	560 dots x 455 dots (254,800 addressable points)
Bits Per Point:	3 (one for each electron gun)
Graphics Colors:	Black, white, red, green, blue, cyan, magenta, yellow
Graphics Memory:	96k-bytes of read/write memory
Graphics Cursor:	Full-screen and small crosshair, blinking underline
Resolution:	Dots are spaced .343 mm center to center
Vector Drawing Speed:	Approximately 10,000 inches per second

1 The 98770A is capable of displaying a 247 mm x 154 mm raster (720 dots x 455 dots). This raster is displayed when using the A13 test switch, the self test fixture and the binary test cartridge. The 9845C does not use all of this area. During normal alpha operation, the alpha raster size is 247 mm x 144 mm (720 dots x 420 dots).

2 The 9845C only uses 28 of the 30 lines.

Repair Philosophy

The 98770A electronic assemblies are divided into those that can be exchanged and those that can be replaced or repaired in the field. Table 1-1 lists the 98770A electronic and electro-mechanical assemblies and whether they are to be exchanged on the Green Stripe Exchange Program or replaced in the field. Assembly replace items not repairable in the field should be ordered at list price but not returned.

Table 1-1. Repair Philosophy

Assembly Part Number	Assembly Description		Assembly Exchange	Assembly Replace
98770-66501	A1	Motherboard		X
98770-66502	A2	Convergence Waveform		X
98770-66503	A3	Convergence Output		X
98770-66544	A44	Deflection/High Voltage	X	
98770-66505	A5	Transistor/Heat Sink	X	
98770-66506	A6	Video Amplifiers	X	
98770-66510	A10	Interconnect		X
98770-66511	A11	Vector Generator	X	
98770-66532	A32	Graphics Memory	X	
98770-66513,33	A13,33	Display Logic (ASCII Character Set)	X	
98770-66553,54	A53,54	Display Logic (Katakana Character Set)	X	
98770-66534	A34	Alpha Control	X	
98770-66524	A24	Soft Keyboard		X
98770-67901		High Voltage		X
98770-67971		CRT/Yoke and shield	X	
98770-67980		Power Supply	X	

Product Support Package

The 98770-67100 Tools Product Support Package contains the special service tools needed to maintain the 98770A Graphics Display and the 98775A Light Pen. Here is a list of the tools in the kit.

Table 1-2. 98770A Kit Contents

HP Part No.	Description
7120-8549	Alignment Overlay
98770-66527	Test Fixture
98770-90030	98770A Service Manual
09845-91031	Test Cartridge (TBIN)
09845-92041	System Exer. Cartridge (B/C)
09845-92005	Owner's and System Exer. Manual

Tools Required

#2 Pozidriv Screwdriver
Alignment Tools (non-metallic)
(Recommended HP part no. 8710-0033 and 8710-0933)

Safety

WARNING

LETHAL VOLTAGES ARE PRESENT INSIDE THE 98770A. THERE ARE NO CUSTOMER SERVICEABLE PARTS INSIDE THE 98770A.

Procedure For All Personnel Trained In Electrical or Electronic Installation, Maintenance and/or Repair

- Do all possible operations with the power source deactivated.
- If the installation, maintenance or repair has to be done while energized, the following precautions should be taken:

a. Never work alone in high voltage areas. In case of accidental shock, a life may depend on rapid removal from the energized source and appropriate first-aid action.

b. Employees working in high voltage areas should know where to obtain respiratory resuscitation and/or cardiac pulmonary resuscitation (CPR), in case a fellow worker needs assistance.

c. In case of burns, treat only after the person is breathing and has a normal heartbeat.

These simple precautions can save a life.

General Safety Guidelines For High Voltage Testing

Here is a list of safety guidelines to be followed when working with voltages in excess of 50 Vdc or 50 Vac RMS.

1. Know each step of the test procedure. Check the test setup to be sure the instruments are connected properly and that all control settings are correct.
2. Never defeat interlocks.
3. Never have one hand on chassis or other ground while measuring high voltages with a probe held in the other hand. Use the one hand method; i.e., probe in one hand, the other hand behind the back or in a pocket.
4. Make sure the probe being used has voltage insulation higher than the voltage being measured. Check wires and probes for cracked insulation and defects. If any defects are noted do not use until repairs are made.
5. Make certain that the instrument being worked on is turned off and capacitors and high voltage circuits are discharged before any component or hardware is removed or touched. Remember that a circuit can be lethally charged if a component is open, missing, or a wire is disconnected or open even with the ac power switch off. Isolated heat sinks will also be statically charged.
6. Make certain that instruments used for testing are used within their rated specification. Never use instruments floated above their specified rating.
7. Never reach around energized high voltage circuits. Always turn equipment off and discharge the high voltage before reaching.
8. NEVER WORK ALONE. Be familiar with location of power switches in your area and what they control. Know how to free a fellow worker from high voltage without energizing yourself.
9. Keep work area neat, free of any interfacing conductive material, and free of any sharp objects. Remember a reaction to a shock can cause one to strike nearby objects which can result in a serious injury.
10. Always leave safety shields in place unless work must be done on circuits behind the shields. Replace the shields after work is completed.
11. Never leave work area with high voltage equipment energized and high voltage circuits exposed.
12. Have available and use approved warning signs and tags in areas where high voltage testing is in process.
13. Do not make measurements in a circuit where corona is present. Corona can be identified by a pale-blue color, or from a buzzing sound emanating from sharp metal points in the circuit, or from the odor of ozone.
14. Hands, shoes, floor, and workbench must be dry. Avoid making measurements under humid, damp or other environmental conditions that could affect the dielectric withstanding voltage of the test leads or instruments.
15. All test procedures and safety procedures should be strictly followed at all times.

Power Cords

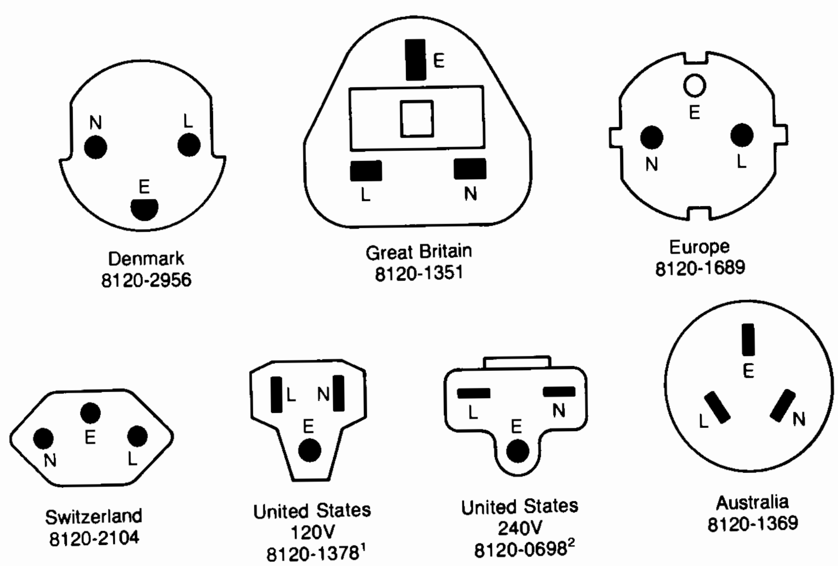
Power cords supplied by HP will have polarities matched to the power-input socket on the equipment, as shown below:

- L = Line or Active Conductor (also "live" or "hot")
- N = Neutral or Identified Conductor
- E = Earth or Safety Ground

WARNING

IF IT IS NECESSARY TO REPLACE THE POWER CORD, THE REPLACEMENT CORD MUST HAVE THE SAME POLARITY AS THE ORIGINAL. OTHERWISE A SAFETY HAZARD FROM ELECTRICAL SHOCK TO PERSONNEL, WHICH COULD RESULT IN INJURY OR DEATH, MIGHT EXIST. IN ADDITION, THE EQUIPMENT COULD BE SEVERELY DAMAGED IF EVEN A RELATIVELY MINOR INTERNAL FAILURE OCCURRED.

Power cords with different plugs are available for the equipment; the part number of each cord is shown below. Each plug has a ground connector. The cord packaged with the equipment depends upon where the equipment is to be delivered.



[1]UL and CSA approved for 100/120 Vac operation.
[2]UL and CSA approved for 220/240 Vac operation.

Power cords supplied by HP have polarities matched to the power-input socket on the computer:

L = Line or Active Conductor (also called "live" or "hot")
N = Neutral or Identified Conductor
E = Earth or Safety Ground

Ground Requirements

To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the computer chassis be grounded. The computer is equipped with a three conductor power cable which, when connected to an appropriate power receptacle, grounds the computer chassis.

Installation

The display assembly fits into place over the mainframe support legs.

CAUTION

THE 98770A RELIES ON THE MAINFRAME TOP COVER FOR WEIGHT SUPPORT. THE MAINFRAME TOP COVER MUST BE INSTALLED BEFORE INSTALLING THE 98770A.

WARNING

THE 98770A IS HEAVY (29.45 KILOGRAMS OR 65 POUNDS). TO AVOID DAMAGE TO EQUIPMENT OR POSSIBLE PERSONAL INJURY, IT IS RECOMMENDED THAT THE 98770A SHOULD ALWAYS BE LIFTED BY TWO PEOPLE (SEE FIGURE 1-2).

Place the 98770A over the mainframe support legs as shown in Figure 1-2.

Figure 1-2. 98770A Installation

CAUTION

THE 98770A HAS NO POWER SWITCH, IT IS SWITCHED ON VIA A RELAY WHICH IS ACTIVATED WHEN THE 9845C MAINFRAME IS SWITCHED ON. ALWAYS SWITCH THE 9845C POWER SWITCH TO THE OFF POSITION BEFORE CONNECTING THE 98770A POWER CORD.

Power Requirements

The display will operate on a nominal line voltage of either 110 volts ac (88 to 127 VAC) or 220 volts ac (98 to 250 VAC). The line frequency must be within the range of 48 to 66 Hz (inclusive). The display requires a maximum of 500 watts.

Line Fuse

WARNING

DISCONNECT THE AC POWER CORD BEFORE REMOVING OR INSTALLING A FUSE.

The display's fuse is located on the rear panel (see Figure 1-3).

The display requires a 10 amp fuse for 110 volt ac operation and a 6 amp fuse for 220 volt ac operation (see Table 1-3).

Table 1-3. Line Fuse

Nominal Voltage Range	Fuse Rating and Type	Fuse Part No.
110 V	10 Amp Normal Blow	2110-0422
220 V	6 Amp Normal Blow	2110-0056

To change the fuse, first disconnect the power cord from the display. Then remove the fuse cap by pressing inward while twisting it counterclockwise. Remove the fuse from the cap and insert the correct replacement fuse (either end) into the cap. Put the fuse and cap back into the fuse holder. Press on the cap and twist it clockwise until it locks in place.

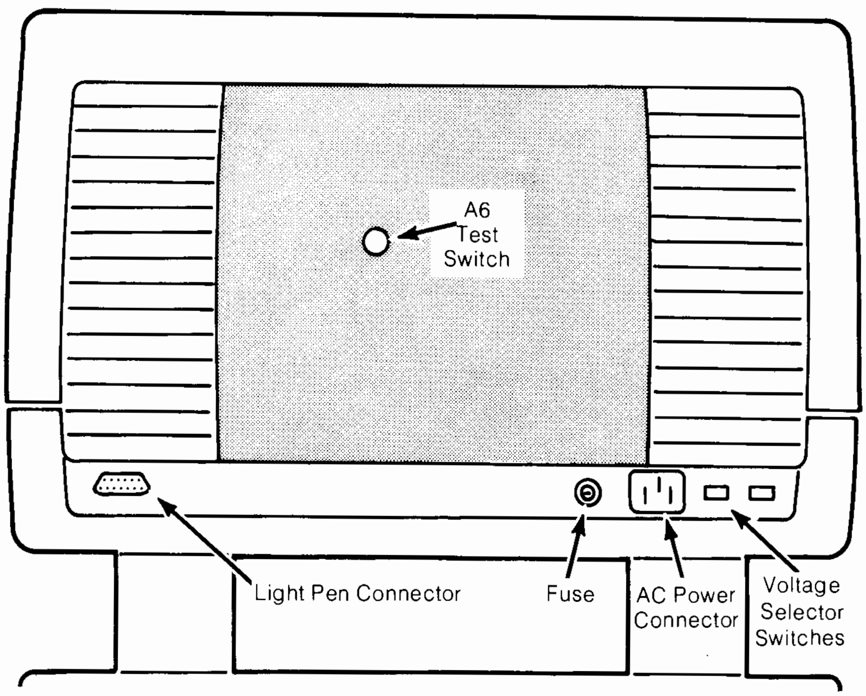


Figure 1-3. 98770A Rear Panel

Setting The Voltage Selector Switches

Ensure that the voltage selector switches on the rear panel are set to the correct nominal powerline voltage. Figure 1-4 shows the correct settings for each nominal line voltage. If it is necessary to alter the setting of the switches, insert the tip of a small screwdriver into the slot on the switch. Slide the switch so that the position of the slot corresponds to the desired voltage, as shown.

CAUTION

CHECK THE SELECTOR SWITCH SETTINGS BEFORE APPLYING POWER. DAMAGE TO THE DISPLAY WILL OCCUR IF THE SELECTOR SWITCHES ARE SET TO **110** VOLTS AC AND **220** VOLTS AC IS APPLIED TO THE POWER INPUT CONNECTOR.

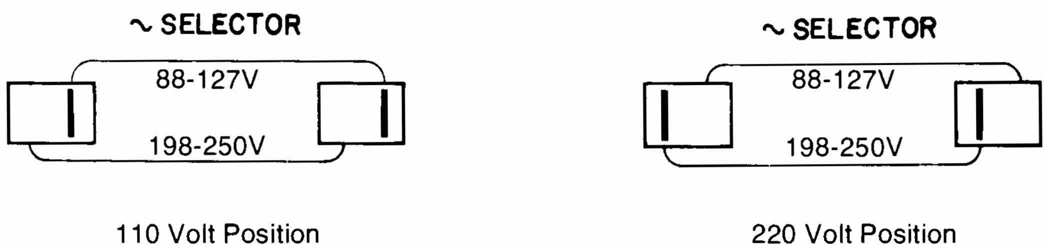


Figure 1-4. Voltage Selector Switch Settings

Initial Turn-On

Before applying power to the computer, check the following items.

- Disconnect power cords.
- Install the 98770A.
- Set line voltage selector switches on both the display and mainframe.
- Install proper fuse in both the display and the mainframe.
- Power switch set to off (right side of mainframe).
- Connect power cords to the display and the mainframe.

Switch the power switch on, after a 20 second (approximate) warmup time the message "9845C READY FOR USE" will appear on the CRT display, followed by the blinking cursor. Adjust the intensity control located beneath the lower left corner of the CRT bezel, for the desired display intensity. If the turn-on memory test fails, "PART OF MEMORY FAILED SELF-TEST" is displayed.

Chapter 2
Theory of Operation

Introduction

Refer to the block diagrams in text and the complete 98770A block diagram at the end of Chapter 2 when reading the circuit descriptions.

The 98770A uses two logic interfaces to the 9845C mainframe; one for graphics and the other for alphanumerics. The graphics circuits interface to the 9845C Internal I/O bus (IOD bus) while the alphanumeric circuits interface to the 9845C PPU memory bus (IDA bus). The graphics interface is through the right support leg via the A44 or A55 assembly. The alphanumeric interface is through the left support leg via the A34 assembly (98770-66534).

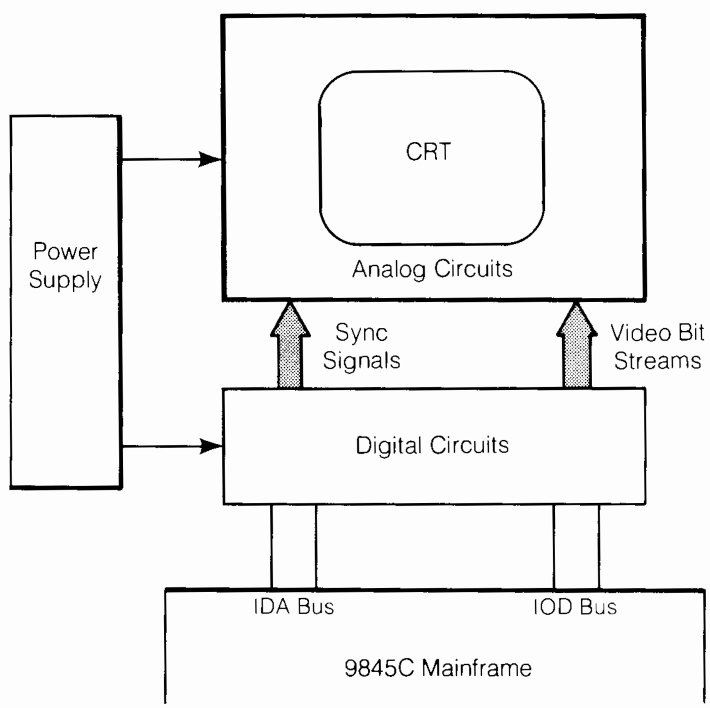


Figure 2-1. Basic Architecture

The 98770A can be broken down into three sections:

- Analog Circuits
- Digital Circuits
- Power Supply

The analog circuits include the CRT, horizontal and vertical deflection, convergence, video amplifiers and high voltage power supply. The digital circuits supply sync signals for the deflection circuits and serial video information to the analog circuits.

The digital circuits include the interface, timing logic, vector generator and graphics memory.

The power supply generates the required voltages for the analog and digital circuits and includes the CRT degauss circuit. Some of these voltages have regulators on the A5 transistor assembly.

Analog Circuits

Overview

The 98770A analog circuits comprise the deflection, convergence, high voltage and video drive.

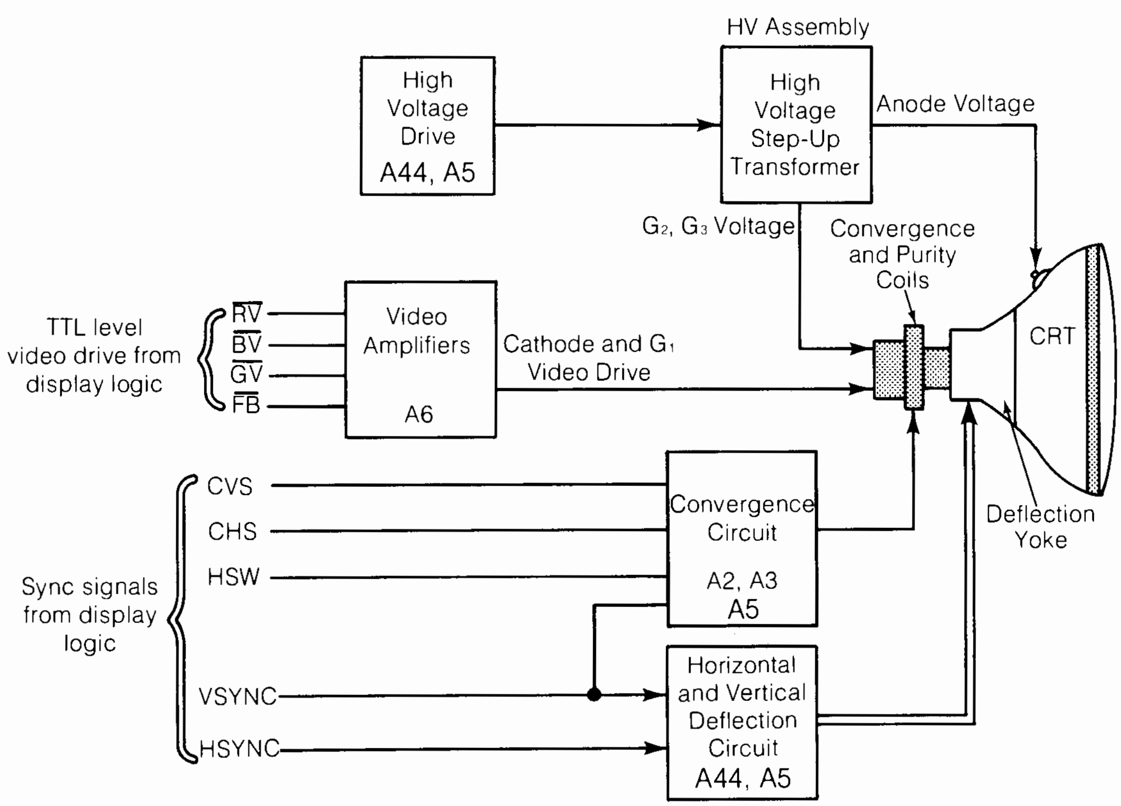


Figure 2-2. Basic Analog Circuits

Raster Scan (A44, A5)

The 98770A deflection system is of the raster scan type and scans the pattern shown in Figure 2-3. The displayed raster consists of 455 horizontal scan lines which are repetitively scanned 60 times per second.

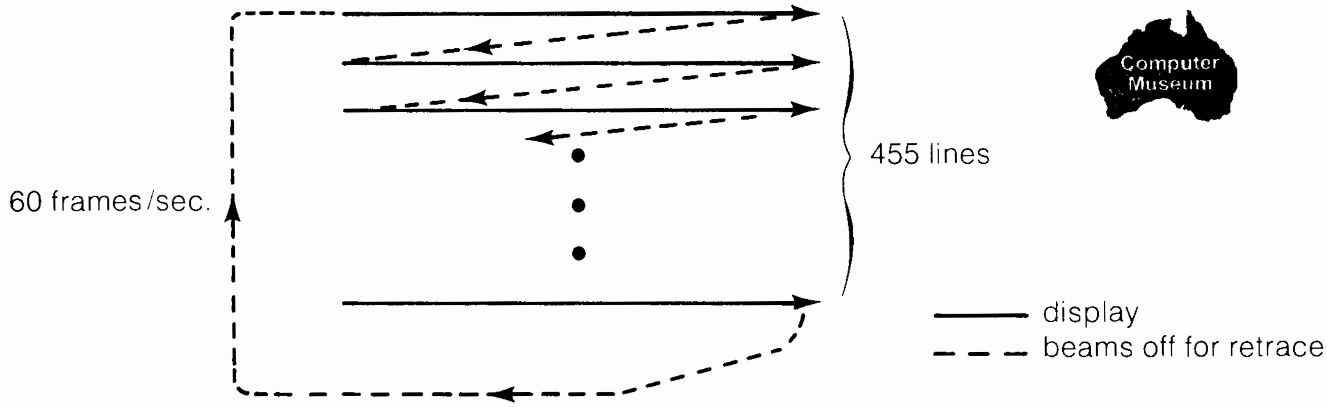


Figure 2-3. Raster Scan Pattern

While the same raster is scanned for both alphanumeric display and graphic display, different portions of the raster are used in each case as shown in Figure 2-4. The number of vertical dot positions is equal to the number of scan lines. The number of horizontal dot positions was chosen as 720 for an 80-character alphanumeric display and 560 for a graphic display.

NOTE

The 98770A is capable of displaying a 247 mm x 154 mm raster (720 dots x 455 dots). This raster is displayed when using the A13 test switch, the self test fixture and the binary test cartridge. The 9845C does not use all of this area. During normal system alpha operation, the displayed alpha raster size is 247 mm x 144 mm (720 dots x 420 dots) as shown in Figure 2-4.

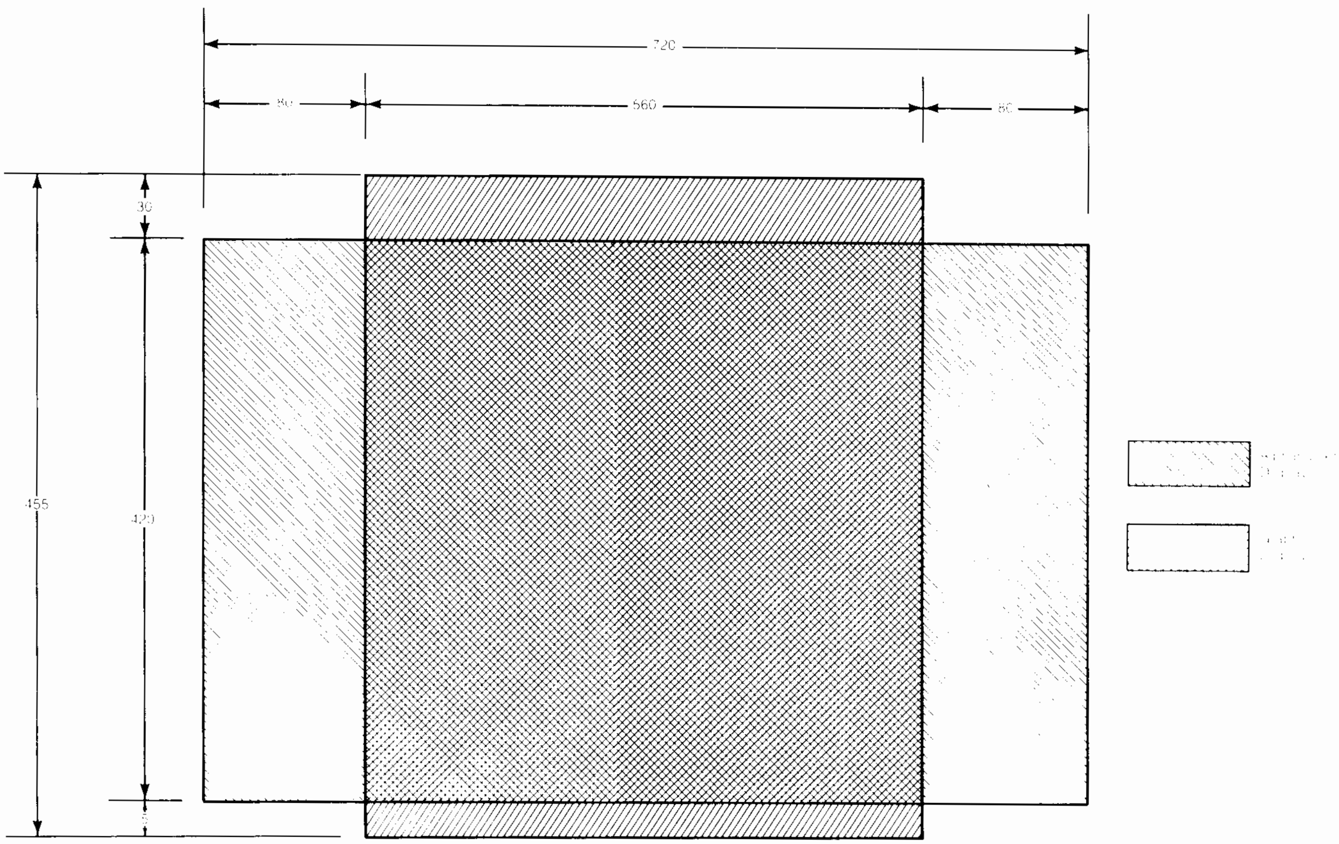


Figure 2-4. Alphanumeric and Graphic Raster Areas

Raster scan deflection is accomplished magnetically using a deflection yoke with horizontal and vertical windings. The required yoke current waveform for vertical deflection is approximately a sawtooth whose frequency is 60 Hz while that for horizontal deflection is approximately a sawtooth whose frequency is 29.1 kHz. Due to tube geometry, these sawtooth waveforms must be slightly 'S'-shaped to provide constant scan velocities across and down the face of the CRT. Pincushion distortion (Figure 2-5), also resulting from tube geometry, is eliminated by special modulations of both the horizontal and vertical deflection current waveforms.

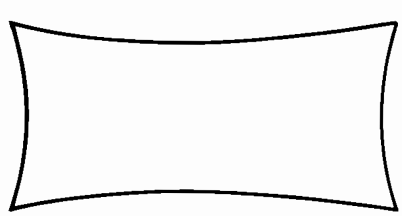


Figure 2-5. Pincushion-Distorted Raster

Three Electron-Gun System

The color CRT contains three separate electron-guns corresponding to the three primary colors: red, green, and blue. Two complications result from the three gun system. First, each gun must emit a beam that strikes only the corresponding color of phosphor on the faceplate. This concern is termed purity. Second, all three beams must scan so as to strike the same dot positions on the faceplate at the same time. This concern is termed convergence. Purity and convergence concerns necessitate special coil assemblies to introduce the appropriate magnetic correction factors.

Video Amplifier Assembly (A6)

The video amplifier assembly (A6) is located immediately behind the CRT rear connector to insure minimal lead lengths from the amplifier outputs to the CRT pins. Minimal lead lengths are important for good signal transfer (low capacitance and inductance) and to minimize electromagnetic radiation.

The CRT tube socket contains arc gaps which provide minimal protection in cases of high-voltage arc-over to gun elements. The video amplifiers contain additional arc-over protection circuitry for the amplifier outputs.

All power supply lines to the video amplifiers are decoupled from the amplifiers by both decoupling capacitors and series inductors. This insures an appropriate video current return path and restricts radio frequency currents potentially contributing to radio frequency interference.

The video amplifier assembly receives four signals from the display logic, red video (RV), green video (GV), blue video (BV) and full-bright (FB), all active low. TTL/ECL translators serve as the input stage for each of the three video amplifiers. Each amplifier has one translator for the appropriate color video signal and one translator for the full-bright signal. The differential outputs of these two translators are summed in common-base stages. Voltage gain is provided by an emitter-coupled cascode amplifier. The resulting drive from the three amplifiers is supplied to the three electron guns of the CRT by three linear emitter-coupled amplifiers driving the cathodes and control grids differentially. Both the grid and cathode swing approximately 15 volts, yielding a total swing of approximately 30 volts. Rise and fall times of the video signals are about 6 nanoseconds.

Deflection and High Voltage Circuits (A44, A5)

The deflection assembly (A44) contains the low power drive circuits for horizontal and vertical deflection, and the high voltage supply. The power output transistors for these circuits are mounted on a heat sink and plug into the A5 transistor assembly. The following is a discussion of the deflection and high voltage circuits.

Vertical Deflection

The vertical deflection circuit includes a rectangular voltage waveform generator and linear power amplifier driving the vertical windings of the deflection yoke. The rectangular voltage waveform, when integrated by the yoke inductance, yields the ramp current waveform required.

Due to the shape of the CRT, a slight curvature is required in the ramp waveform to produce a constant vertical scan velocity. This correction is achieved by adding a small parabolic component to the rectangular drive waveform.

The vertical deflection circuit is driven by a TTL signal, VSYNC. When VSYNC is low, the vertical yoke current increases during trace. When VSYNC is high, a vertical retrace occurs.

Top and bottom pincushion distortion is a vertical error which is corrected by the addition of an appropriate component to the vertical deflection current. This component increases the magnitude of the vertical deflection near horizontal center and decreases it at the sides. The correction component gets increasingly larger as the scan approaches the top and bottom of the screen. The appropriate corrective component and the corrected vertical deflection waveform are shown in Figure 2-6.

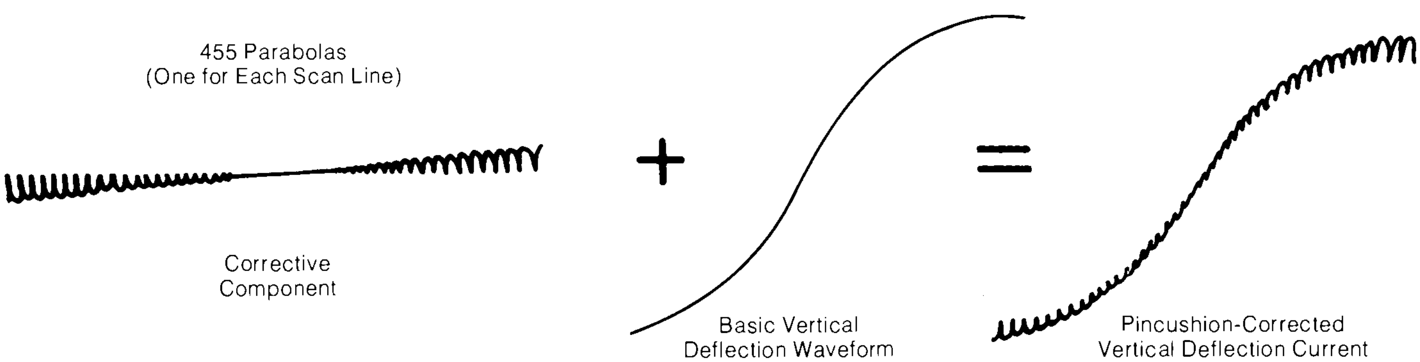


Figure 2-6. Waveform for Top and Bottom Pincushion Correction

The correction waveform is the product of a vertical-rate sawtooth and a horizontal-rate parabolic waveform. Since the vertical deflection coils are voltage driven (the resulting sweep current is proportional to the integral of the applied voltage), the appropriate drive waveform is obtained by differentiating this product.

Raster height is controlled by adjustment of the rectangular drive waveform amplitude. Vertical centering is controlled by adjustment of a DC component through the vertical windings of the deflection yoke.

The vertical output amplifier is equipped with current limit circuits for both the negative and positive supplies. These circuits limit dissipation and protect the amplifier and power supply during initial start-up and in case of a loss of vertical sync.

Horizontal Deflection

The horizontal deflection circuit comprises a high voltage switch and a tuned circuit consisting of the horizontal yoke winding and two series-connected capacitors. When the voltage switch is on, one of the capacitors is effectively shorted and the circuit has a relatively low resonant frequency. This condition yields a slowly increasing horizontal yoke current and corresponds to the trace portion of the cycle. When the switch turns off, the series capacitors and yoke yield a much higher resonant frequency resulting in a rapid decrease in yoke current, i.e., the retrace portion of the cycle.

Due to the yoke/capacitor resonance, the increase in yoke current during trace is not perfectly linear; it is slightly 'S'-shaped providing the desired constant scan velocity across the face of the CRT.

Non-linearities in the horizontal scan might also result from the resistive voltage drop in the horizontal yoke winding and from slight yoke voltage discontinuities occurring at switching times. These non-linearities are avoided by sensing the purely inductive voltage across the winding and using a high gain amplifier to dynamically force this voltage to the proper value. The output of the amplifier thus consists of the negative of the resistive drop plus compensation for the switching discontinuities.

The horizontal deflection circuit is driven by a TTL signal, HSYNC. The end of horizontal retrace is phase-locked to the leading edge of HSYNC so that switching transistor storage-time variations will not affect horizontal centering.

Side pincushion distortion is a horizontal error which is corrected by an amplitude modulation of the horizontal deflection current waveform. This modulation increases the amplitude of the horizontal deflection near the vertical center of the screen and decreases the amplitude near the top and bottom of the screen. The modulated horizontal deflection current waveform is shown in Figure 2-7. The modulating signal is a vertical-rate parabolic waveform.

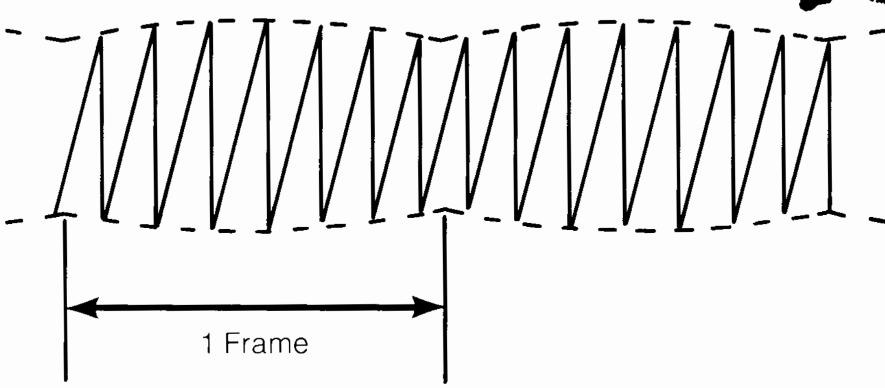


Figure 2-7. Side Pincushion Correction of Horizontal Yoke Current

Raster width is controlled by adjustment of the supply voltage to the horizontal deflection circuit. Horizontal centering is controlled by adjusting a dc component through the horizontal yoke windings.

The horizontal switching circuit is protected from loss of synchronization by reverting to a zero-current condition with no drive applied. The horizontal linearity amplifier is equipped with a current-limit circuit to limit output current and hence dissipation in case of synchronization loss.

High-Voltage Supply

The high-voltage supply includes a high-voltage switching circuit (much like that used for the horizontal deflection), a step-up transformer unit containing rectifiers and a resistive divider, and a linear feedback regulator. The regulator and drive circuitry are located on the A44 deflection assembly (with output transistors on the A5 transistor assembly). The step-up transformer is located adjacent to the CRT anode connection.

The high voltage circuit is driven by a TTL-level signal derived from the horizontal circuit's flyback pulse; hence, high voltage will not be generated unless horizontal deflection is present.

The primary of the step-up transformer is driven by the flyback pulse generated upon turn-off of the high-voltage switching circuit. The step-up transformer has two secondaries, one to provide approximately +700 V for the three electron-gun screen grids (G2), and one to provide approximately +20 kV anode voltage. The +4 kV focus voltage is derived from the anode voltage through a resistive divider.

The linear regulator provides anode voltage regulation at dc and very low frequencies. Regulation at higher frequencies is difficult due to large phase shifts and non-linearities in the transformer/rectifier assembly.

Convergence and Purity (A2, A3)

Convergence and purity are controlled by adjustment of the currents through six coils on the CRT neck (two for purity and four for convergence). Four printed circuit assemblies are required to generate the drive currents for these coils. The convergence waveform assembly (A2) contains the purity and blue lateral convergence circuit and generates some basic waveforms for the other three convergence assemblies (A3). One convergence output assembly (A3) is required to mix and amplify these basic waveforms for each of these other convergence coils. Convergence output transistors are mounted on the A5 heat sink and wired through the A5 transistor assembly.

Purity

Purity adjustment is accomplished by providing for pre-deflection beam centering. This is done with two coils (one for horizontal control and the other for vertical control) driven by independent dc current sources.

Convergence

Convergence is achieved by passing currents through four convergence coils as indicated in Figure 2-8.

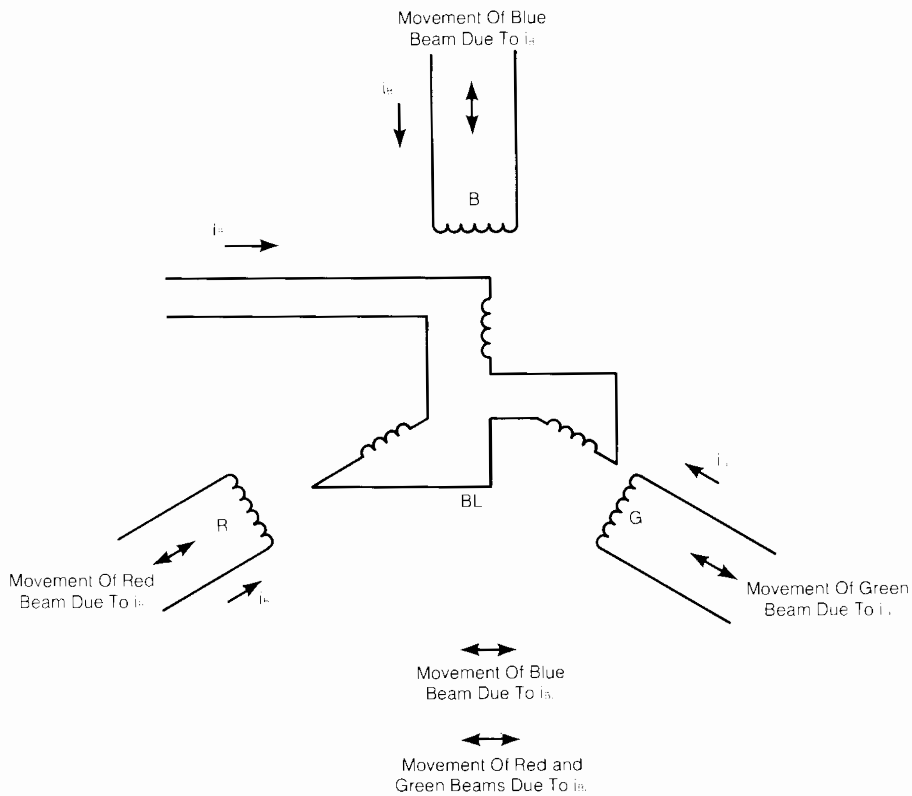


Figure 2-8. Convergence Coils and Resulting Beam Motion

The coils R, B, and G are located adjacent to the red, blue, and green guns respectively. Each of these coils primarily effects only the beam from the adjacent gun. The coil BL (blue lateral) moves the red, blue, and green beams horizontally. A given current through BL will deflect the blue beam in one direction and the red and green beams in the opposite direction. Given the operation of these four coils as shown above, the three beams can always be made to meet (converge) if appropriate currents are applied.

Due to gun misalignments, non-uniformities in the deflection fields, and the physically different location of the three guns, different values of currents are required to produce convergence at each different point on the CRT screen. Convergence is therefore achieved in a raster scan system by driving the convergence coils with current waveforms synchronized with the deflection waveforms.

The current required for the R, B and G coils consists of three basic components:

- DC
- A vertical rate (60 Hz) parabolic waveform
- A horizontal rate (29.1 kHz) parabolic waveform

Both parabolas are derived so as to yield zero current at their centers; hence, convergence at the center of the screen is controlled by adjustable permanent magnets and the DC components in the R, B, and G coils. Convergence at vertical and horizontal deflection extremes is controlled by adjusting the amplitudes of the sides of the parabolic waveforms as shown in Figure 2-9.

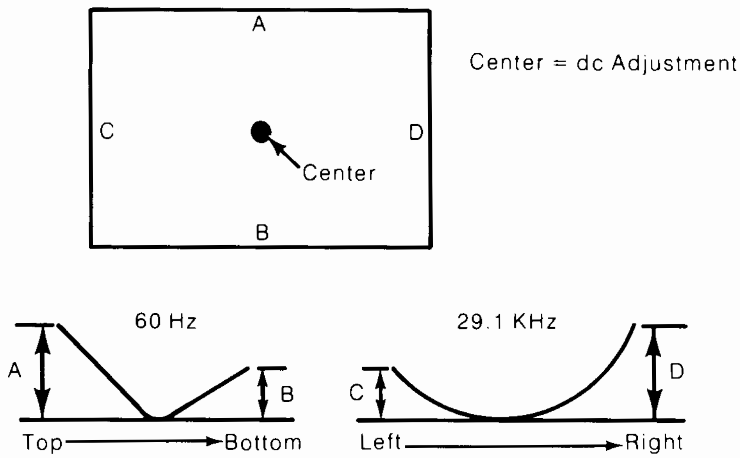


Figure 2-9. Convergence Waveform Adjustment for Deflection Extremes

Mid-axis convergence, e.g., convergence in the center area, is controlled by slightly varying the shape of the corresponding parabolic segment.

Corner convergence is controlled by changing the amplitude of the sides of the horizontal rate parabolic waveforms as a function of vertical position, i.e., at the vertical rate.

In summary, the drive current for each of the coils R, B, and G, is adjustable for thirteen areas of the screen as shown in Figure 2-10. This yields a total of 39 adjustments, thirteen each for the R, B, and G coils.

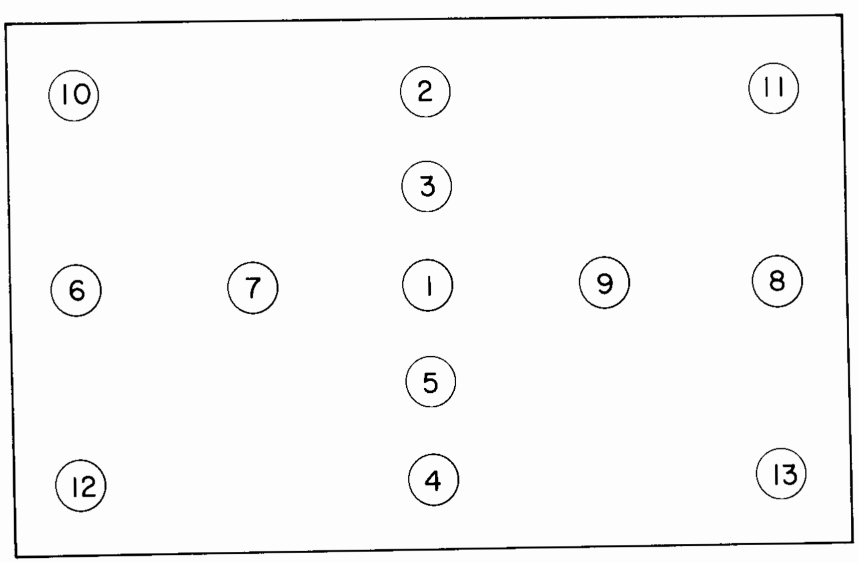


Figure 2-10. Convergence Adjustments for R, B, and G Coils

Let us now consider the drive required for the BL coil. The current required consists of two components.

- DC
- A horizontal rate parabolic waveform the halves of which are independently adjustable in polarity and amplitude

The nature of the parabolic drive component is shown in Figure 2-11.

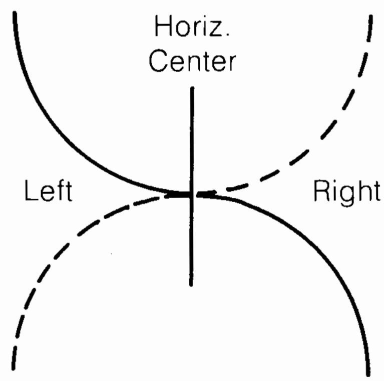


Figure 2-11. Parabolic Blue Lateral Component

Note that no vertical rate component of blue lateral current is required since the errors corrected by the BL coil are essentially independent of vertical position.

Digital Circuits

The digital circuits reside on four PC assemblies;

- Alpha control assembly (A34) – internal to the 9845C in the left support leg, contains the alpha control logic.
- Display logic assembly (A13, A33, A53 or A54) - contains timing and display logic, character generator and graphics cursor logic.
- Vector generator assembly (A11) – contains the vector generator, soft-key logic, IOD bus interface, graphics controller and memory addressing logic.
- Graphics memory assembly (A32) – contains graphics memory and memory control logic.

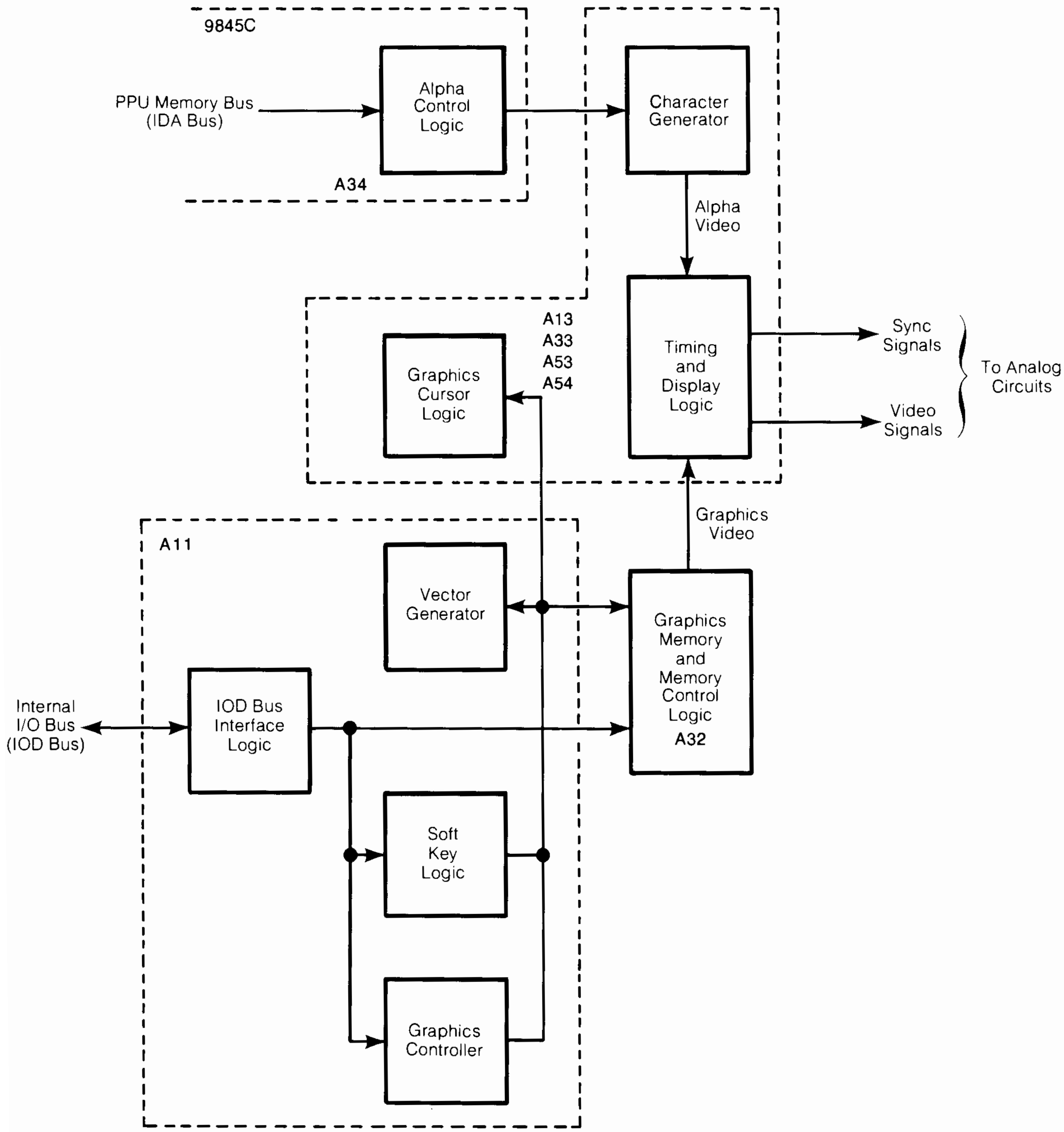


Figure 2-12. Basic Digital Block Diagram

Alpha-Control Assembly (A34)

The alpha-control logic buffers strings of ASCII character codes and highlighting information used to refresh the alphanumeric display. Memory cycle stealing is performed on the mainframe memory to fill 80-character line buffers which transfer the data to the character ROM in synchronism with the raster scan.

There are nine primary functional units within the alpha control logic:

- IDA bus bi-directional buffer
- Memory data register
- Memory address counters
- 80-character line buffer logic
- End-of-line detect
- New address detect
- 80-character counter
- Alpha/graphics select multiplexer
- Alpha controller and decoder

IDA Bus Buffer

This buffers the data and control lines of the IDA bus and satisfies the timing requirements to insure valid memory cycle operation.

Memory Data Register

When a memory cycle steal operation is performed, the data read from mainframe memory is stored in the data register. The possible data formats are as follows:

Data Format

Bit →	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	0	BLA	GRA	RDA	UL	B	IV	CUR	CS	I6	I5	I4	I3	I2	I1	I0
		FEATURE INFORMATION								ASCII CHARACTER CODE						

BLA	Blue Alphanumerics
GRA	Green Alphanumerics
RDA	Red Alphanumerics
UL	Underline
B	Blinking
IV	Inverse Video
CUR	Cursor
CS	Alternate Character Set

End-of-Line Format

Bit →	15	14		5	
	1	0	0	1	0

New Address Format

Bit →	15	14		5	
	1	0	X	0	X

No Operation Format

Bit →	15	14		5	
	1	1		X	

The end-of-line format specifies that the remainder of the 80-character buffer being filled should be loaded with ASCII spaces. The new address format specifies that the current data within the data register is to be ignored and that the next word of data is a memory address to be loaded into the memory address counters. The no operation format specifies that the current data in the data register should be ignored.

Memory Address Counters

These counters supply the address at which memory cycle stealing is to occur. They will automatically increment after each data transfer or may be loaded with an address contained in the data register under control of the new address detect logic.

The mainframe alphanumeric buffer begins at location 60000_8 in block 1 of memory. This address is automatically loaded at the start of raster sweep.

Character Buffer Logic

The character buffer logic has two 80-character buffers. When one of the buffers is being loaded from mainframe memory, the other is shifting out characters to be displayed. As soon as all 80-characters have been displayed, the roles of the buffers are interchanged for the next line of characters.

End-of-Line Detect

The end-of-line data format is detected by this logic and a status signal is issued to the alpha controller to signify that the remainder of the 80-character buffer currently being loaded should be filled with ASCII spaces.

New Address Detect

The new address data format is detected by this logic and a status signal to the alpha controller is activated to indicate that the next 16-bit word loaded into the data register is a memory address to be loaded into the memory address counters.

80-Character Counter

When an 80-character buffer is being loaded, this counter specifies when the buffer is full. When this condition occurs, memory cycle stealing stops until the buffers interchange roles.

Alpha/Graphics Select Logic

At the beginning of the alphanumeric buffer, memory location 60000_8, is an address to be loaded into the memory address counters. The two most significant bits of this address are not used by the memory address counters but are used to specify whether graphics and/or alpha are selected to be displayed. The data format for the memory address is as follows:

Memory Address Format

Bit →	15	14		0
	GS	AS	Not Used	

GS – 1 Graphics Display On
  0 Graphics Display Off

AS – 1 Alpha Display On
  0 Alpha Display Off

Alpha Controller

The alpha controller is a ROM-based synchronous state machine. It controls the memory cycle-steal timing and coordinates the loading of the 80-character line-buffers.

Display Logic Assembly (A13, A33, A53 or A54)

Timing and Display Logic

Central to the operation of the display is the system timing chain. It consists of a 10-bit x-counter and a 9-bit y-counter. The x-counter is clocked by the 29.8 MHz system clock with each count corresponding to an individual dot on the CRT screen. Each time the x-counter resets to zero, the y-counter is clocked, corresponding to each individual scan line on the screen. The y-counter resets 60 times per second giving a 60 Hz display refresh rate. A divide-by-9 dot counter, clocked at 29.8 MHz, is also present to indicate cell boundaries between alphanumeric characters. Various count sequences are decoded from the outputs of the x and y counters producing all of the necessary timing signals for the display.

The display logic selects and combines the alphanumerics and graphics video data, and appropriate blanking signals decoded from the timing chain. The red, green, blue, and full-bright video streams are then conditioned for transmission to the video amplifiers where they are terminated in 50Ω loads.

Character Generator

Alphanumeric video information is produced by means of two character ROMs. An eight-bit ASCII character code is received from the alpha control logic every nine counts of the system clock. This ASCII code addresses the character ROM, producing information at the ROM data outputs sufficient to display one, 9-dot horizontal line of the character cell. A divide-by-15 counter is clocked once every scan line and specifies which line of the character will be read from the ROM.

The ROM information is converted to a serial video signal and then combined with the highlighting information. Possible highlighting includes inverse video, underlining, blinking, and alpha cursor. The combined video is then distributed to the three color alpha video lines according to the color selected for each character.

Graphics Cursor Logic

The three graphics cursors are hardware generated cursors that may be moved within the graphics area without altering the data displayed. Any one of the three cursors may be selected by the user at any one time.

The cursor types are:

1. Small Underline Cursor - A line, 9 dots long that is used in conjunction with LABEL, and other statements to do alphanumerics in the graphics mode.
2. Full Screen Crosshair - Full screen vertical and horizontal lines whose intersection occurs at the specified cursor position (used in digitizing and other graphics operations).
3. Small Crosshair - A ROM defined pattern occupying not more than a 15-dot x 15-dot area with its center at the specified cursor position.

The position of the cursor on the screen is determined by X and Y addresses that are latched from the mainframe's I/O bus. These addresses are compared with the present count in the X and Y timing chain counters. The cursor is then generated at the instant both X and Y addresses agree with the counter outputs.

Vector Generator Assembly (A11)

IOD Bus Interface

The IOD bus (I/O data bus) is used for I/O cycles between the mainframe processor and external devices. An input cycle is used to read data from the device and an output cycle is used to write data to the device. All graphics data transfers between the 98770A and mainframe are via the IOD bus and may be transferred using one of three methods:

- Handshake (program controlled)
- Interrupt (jumps to program control)
- DMA (direct memory access)

The 98770A graphics interface is assigned peripheral address 13 and may be operated using any of these three methods while conforming to GPIO standards.

The IOD bus interface provides graphics macro-commands to the graphics controller and also enables the soft key logic and an optional graphics input device, e.g., light pen, to communicate with the mainframe. The graphics controller, soft key logic, and the graphics input device all provide status signals to the interface to indicate their readiness to send or receive data.

Note

There are 4 Revisions, ABCD

Rev ABC: 1. Have no switches.
2. Are scrapped by CSD when received on exchange program.
3. Field should use up inventory until gone.

Rev D 1. CSD now only ships D (or later).
2. A switch with 4 slides is located in the upper right corner of the assy, viewed from the component side, plastic tubs up.

3. All slides must be pushed to the right, or graphics problem will occur.
4. The switches are used for factory testing only.

Graphics Controller

The primary function of the graphics controller is to control data flow within the graphics logic of the 98770A. The graphics controller is a ROM-based synchronous state machine. As shown in Figure 2-13, macro-commands are received from the IOD bus interface and micro-commands are issued to the graphics logic, e.g., vector generator, cursor logic, etc. Status signals are returned from the graphics logic to the controller and are used in conjunction with the macro-commands as a basis for decision making and action of the graphics controller.

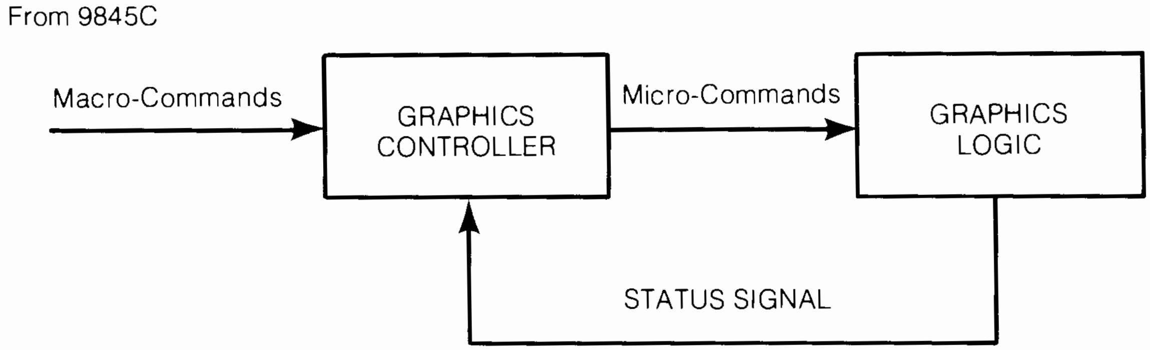


Figure 2-13. Graphics Controller Architecture

Data transferred out of the mainframe may be routed to the:

- Graphics memory and memory addressing logic
- Vector generator
- Cursor logic
- Video data generator

Data transferred from the 98770A to the mainframe may be sourced from:

- Graphics memory
- Soft key logic
- Optional graphics input device (e.g., a light pen)

The graphics controller routes data in response to the macro-commands it receives from the mainframe. The commands which are implemented are:

LXA – load the x address used in a graphics memory I/O operation
LYA – load the Y address used in a graphics memory I/O operation
SMC – store memory control data used in enabling memories and specifying input data
SLT – store line type select data
SCM – store memory color assignment data
LEP – load vector end-points to the vector generator
LYC – load the Y address at which the graphics cursor should be displayed
LXC – load the X address at which the graphics cursor should be displayed
MRC – perform a graphics memory read I/O cycle
MWC – perform a graphics memory write I/O cycle

The graphics commands are explained in more detail later in this chapter.

Whenever MRC or MWC commands are implemented, the X and Y address counters will automatically increment to the next address in the raster. Hence, successive memory I/O cycles may be performed without loading the X and Y address for every cycle.

Vector Generation

In order to represent straight lines on a dot matrix, an appropriate vector algorithm is used. This algorithm plots the dots of the matrix that most closely approximate the desired line. These plotted points, constituting a vector, must be individually stored in the graphics memory as they are computed.

The algorithm used for vector generation in the 98770A is often called the digital differential analyzer method, and is outlined below. In this discussion a vector is to be drawn from the point addressed by X_1, Y_1 to the point addressed by X_2, Y_2.

1. $X_2 - X_1 = \Delta X$ and $Y_2 - Y_1 = \Delta Y$ are computed to determine which direction has the greatest difference.
2. The slope of the vector is then calculated so that it is always less than 45°.

$$\text{Slope} = \frac{\text{Smallest } \Delta}{\text{Largest } \Delta}$$

3. The slope is then added to the contents of a fraction register (initialized to 0.5) and restored into the fraction register.
4. The address (X or Y) corresponding to the direction of greatest delta is automatically incremented by one. The address corresponding to the direction of smallest delta is incremented only when an integer overflow of the fraction register is detected.
5. Repeat steps 3 and 4 above until the endpoint X_2, Y_2 is reached.

System Architecture

The algorithm just described is executed by a hardware bit-slice processor system. Three, 4-bit slice, processors make up the central processing unit and six ROM's together with an LSI controller control the operation of the system.

The protocol for plotting is that of a standard plotter. Each time a vector is to be drawn, the pen must first MOVE to one endpoint of the vector and then DRAW to the other endpoint. The system is set up to receive two 12-bit words from the graphics controller for each endpoint of a vector. When an endpoint is received, bit 11 of the data word is checked. If it is a 1, then a MOVE is to be executed. If it is a 0, then a DRAW is to be executed.

Once the endpoint with a DRAW command is loaded into the bit-slice system, the algorithm previously described is executed. Each time a new point is ready to be plotted, the vector generator signals the memory cycle generator which then allows the point to be written into the graphics memory at the appropriate time. Once the point has been written into the memory, the memory cycle generator signals the vector generator to begin generating the next point in the vector. Due to the refreshing of the screen from the graphics memory, points may only be written during horizontal and vertical retraces. After the entire vector is plotted, the vector generator sets a status flag and waits for the next vector.

Line Types

When drawing vectors, several scaleable line types may be used.

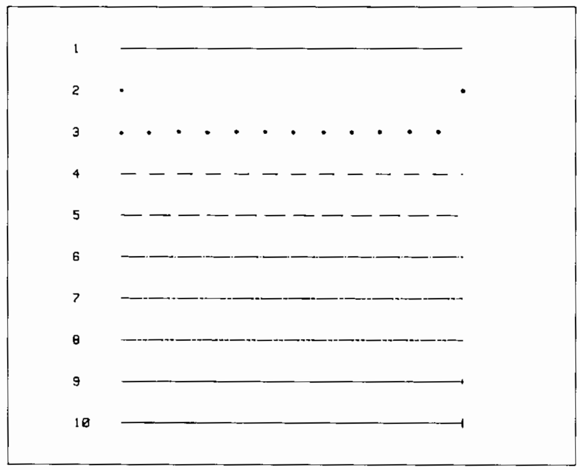


Figure 2-14. Scaleable Line Types

These line type patterns are stored in ROM and addressed by the mainframe via the latched IOD (LIOD) bus. The patterns are clocked out of the ROM in synchronism with the plotting of the vector. The line type pattern determines whether a 1 or 0 is stored in memory for each dot of the vector.

One of sixteen different scales may also be defined for each line type. Scaling is accomplished by repeating each bit within the line type pattern.

Area Fill

Area fill hardware provides the capability to rapidly fill defined areas with various patterns. This is done by dividing the screen into 4-dot by 4-dot cells. The dots within each cell are assigned a number from 0 to 15 according to the pattern in Figure 2-15.

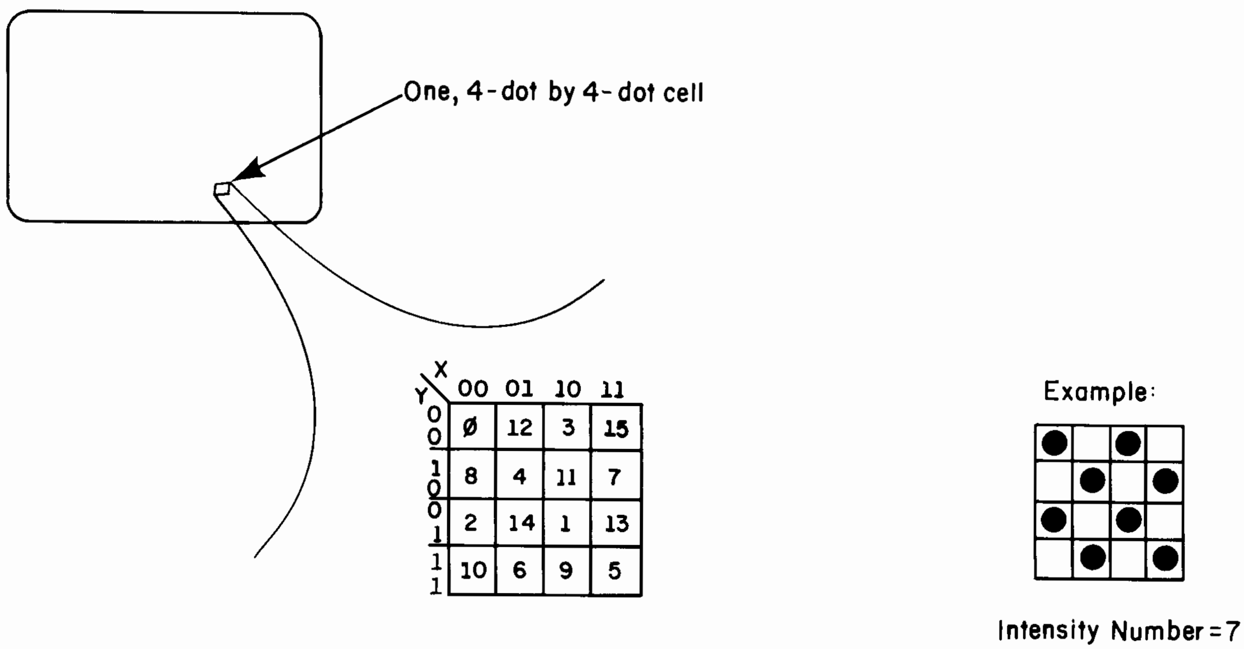


Figure 2-15. Area Fill Cell Assignment

An intensity number and color define the pattern for each area to be filled. Only the dots whose number is less than or equal to the intensity number will be turned on.

NOTE

The graphics memory addressing logic, which is part of the A11 assembly, is discussed in the following description of the A32 assembly.

Graphics Memory Assembly (A32)

Memory Array

The graphics memory array in the 98770A is arranged into three 16k x 16 (16k-words by 16-bits/word) planes of memory. Each plane stores a complete graphics raster image. Hence, there are three bits per pixel (picture element). Three separate images may be created independently of each other, one in each of the memory planes. When each of the memory planes is assigned a different color, two features of a color display become apparent:

- Image integrity is preserved between planes of memory (i.e., the red, green, and blue images are readily distinguishable).
- By combining images from two or more planes of memory (each assigned to different colors, e.g., red, green, blue) additional colors can be created (e.g., white = red and green and blue, yellow = red and green, magenta = red and blue, and cyan = green and blue).

Each plane of graphics memory within the 98770A consists of sixteen, 16k x 1 dynamic RAMs. Hence, there are forty-eight 16k RAMs which yields a total of 96k-bytes of graphics memory.

Memory Addressing Logic (Part of A11)

The memory addressing logic has five functional units:

- X and Y I/O address counters - These counters supply graphics memory addresses to be used whenever I/O data transfers occur (MRC or MWC macro-commands). They can be preset to a specified address by the LXA and LYA operations specified to the graphics controller. Whenever an I/O cycle with the graphics memory occurs, these counters automatically increment to the next location.
- X display address counter - This counter essentially duplicates production of the X scan address generated by the display logic; however, it is tailored to produce X memory word addresses.
- Address select logic - The primary function here is to select the source of memory addresses. While displaying the graphics raster, addresses are provided from the X-display address counter and the Y count sequence from the display logic. When not displaying the graphics raster, (i.e., during horizontal and vertical retraces) addresses may be selected from the X and Y I/O address counters or from the vector generator.
- Address conversion logic - Once an address has been selected it must be converted from an X/Y representation to an absolute memory address.
- Row/column select logic - Since 16k x 1 dynamic RAMS are used as the graphics memory, memory addresses must be given in terms of memory rows and columns. This logic performs the task of selecting the row address (7 lease significant bits of address) and the column address (7 most significant bits of address) at the correct time within a memory cycle.

The required memory mapping is subject to the following constraints:

- The graphics display consists of 455 rows (scan lines) with 560 columns (dots/row).
- The graphics memory uses 16k x 1 dynamic RAMS to achieve maximum bit density/package.
- The graphics memory is arranged in a 16k x 16 format (16 bit words) such that maximum data transfer may be accomplished during graphics memory I/O cycles.

So, in order to access 16-bit words from an X/Y mapping we divide the 560 columns into thirty-five, 16-bit words. The equation which will transfer X/Y word addresses into absolute memory addresses is,

$$\text{Memory Address} = 35Y + X$$

Hence, to access the proper word in the graphics memory the above equation is implemented in hardware and can translate X/Y addresses to absolute memory addresses in less than 90 nanoseconds.

Individual bits within a particular word are specified by the four least significant bits of the X address. The graphics memory map is shown in Figure 2-16.

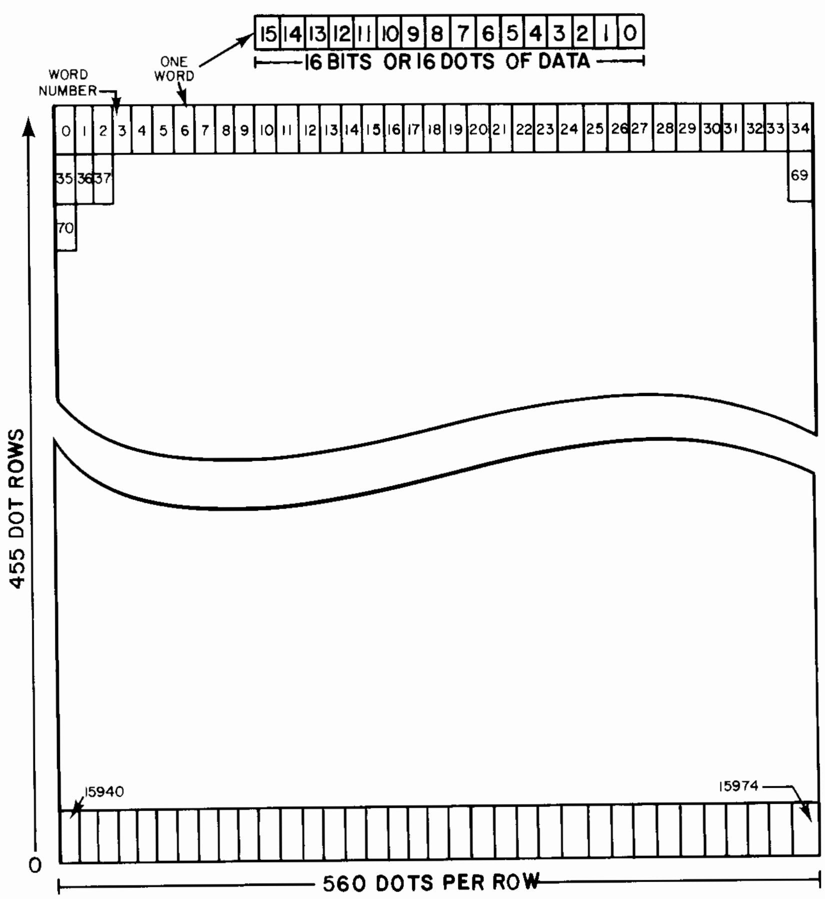


Figure 2-16. Graphics Memory Map

Memory Cycle Generator

Dynamic RAM's require carefully timed control signals to implement three basic functions:

- Memory read cycles
- Memory write cycles
- Memory refresh cycles

The first two functions are characteristic of all random access memories. Refresh cycles are necessary for the retention of data within a dynamic RAM as opposed to a static RAM which will retain its data without the use of refresh cycles. The advantage of the dynamic RAM is that its bit density per chip is much higher (uses a single transistor storage cell per bit) and power consumption is much lower.

In order to provide the three types of memory cycles listed above, there are three control signals which must be generated.

- RAS (Row Address Strobe) - The 16k x 1 dynamic RAMs are partioned into 128 rows by 128 columns. The RAS line strobes a seven bit row address into the RAM on its trailing edge.
- CAS (Column Address Strobe) - Similarly, the CAS line strobes a seven bit column address into the RAM.
- WRITE (Read/Write Select) - When this line is low during a memory cycle, a memory write cycle is performed at the address strobed by the RAS and CAS lines. If WRITE is high a memory read cycle is performed.

The memory cycle generator creates the above signals and synchronizes memory cycles with the refresh of the display raster. This hardware also coordinates external requests for memory cycles from the vector generator and I/O data transfers. The memory cycle generator is a synchronous, 16-state, counter-based state machine.

Write Enable Logic

The graphics memory array may have data written into it in one of two ways: a 16-bit word may be written during I/O memory cycles, or a single bit may be written during vector generator memory cycles.

The write enable logic determines whether 16 bits or 1 bit is to be written into the graphics memory and selects which memory plane or planes are to be active during a memory write cycle.

Memory Control Logic

The memory control logic performs two control functions on the graphics memory array:

- The data to be written into the memory may be selected from either a 16-bit word transferred during I/O with the mainframe, or a single bit value to be used in writing vectors into the memory.
- The memory planes which are active during write cycles are selected and control lines to implement this function are sent to the write enable logic.

These functions allow the user to write into one or more memory planes simultaneously with the same or different data to each plane. Alternatively, the user may also write into memory planes independently, treating each plane as a separate plotter.

I/O Data Logic

Data transferred to the 98770A from the mainframe via the IOD Bus is latched within this logic to create a 16-bit bus internal to the display. This bus is called the LIOD (Latched IOD) bus.

When memory read cycles are performed for the purpose of transferring the contents of the graphics memory array to the mainframe, output data select logic is used to select a 16-bit word from one to the three memory planes and latch that word. The latched data is enabled onto the IOD bus at the proper time during an IOD input cycle.

Video Data Generators (Memory Shift Registers)

The video data generator creates three serial strings of data (one for each of red, green, and blue) used to refresh graphics display. A parallel-to-serial conversion is implemented on each of three, 16-bit words read from the three planes of graphics memory.

This hardware also allows the user to specify which of the eight possible colors, i.e., white, red, green, blue, yellow, magenta, cyan and black, are represented by each of the three serial strings of video data. In essence, the use is allowed to define the color of the memory planes.

Soft-Keys (A24)

The soft-key keyboard consists of eight momentary contact switches mounted on the display bezel. An eight to three encoder is used to encode the key closures into a 3-bit code. After any key has been down continually for 15 ms., the identifying code for that key is latched and an interrupt request is sent to the graphics control logic.

Power Supply

Introduction

The 98770A power supply comprises the following basic functional blocks:

- ±15 volt internal supplies
- A regulated CRT filament supply
- An energy storage system
- Three independent switching regulators
- Protection and control circuitry
- CRT degauss circuitry

A block-level representation of the supply is shown in Figure 2-18. Each of the functional blocks listed above is discussed in more detail in the following sections.

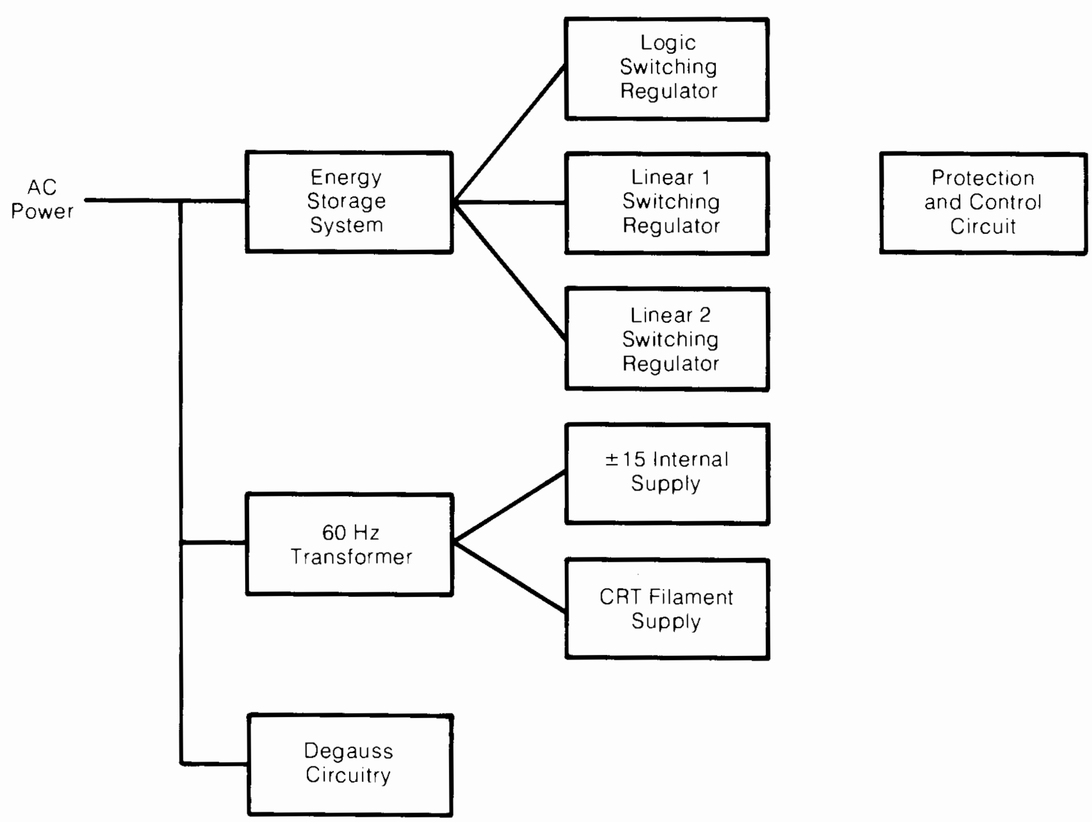


Figure 2-17. Power Supply Architecture

±15 Volt Internal Supply and CRT Filament Supply

Two secondary windings on a 60 Hz transformer provide raw voltages for the ±15 volt internal supply and the CRT filament supply. This internal 15 volt supply is always on, even when mainframe power is off. The ±15 voltages are derived with two full-wave rectifiers on a center-tapped secondary followed by capacitive filters and voltage regulators. The ±15 supply is used to power the control and monitor functions for the three switching regulators. Approximately 150 milliamps of current is required from these supplies even when the display is off.

The CRT filament voltage is supplied at all times. 5.0 Vdc is applied to the filament when the display is off and 6.3 Vdc is applied when the display is on. The filament voltage is derived from a secondary winding supplying a full-wave bridge rectifier followed by a capacitive filter and a zener-controlled linear regulator.

The Energy Storage System

The energy storage system exists to supply raw DC (≈300 volts) to the three switching regulators and consists basically of rectifier diodes charging two capacitors. Power is supplied to the energy system through a relay which is closed when +5 volts is present in the 9845 mainframe, i.d., when the mainframe is turned on. Thermistors are connected in series with the capacitors to limit the current surge at turn-on.

Switching Regulators

Three independent switching regulators are present in the 98770A power supply. One of these provides power for the logic boards while the other two develop the voltages required for the analog circuits.

Each of the three switching regulators is made up of:

- a pulse width modulator (PWM)
- a switch driver circuit
- a power switching bridge
- a 29.1 kHz power transformer
- rectifiers and filter components
- a voltage-error amplifier

The switching regulators are synchronized to, and operate at, the horizontal scan rate (29.1 kHz). HSYNC from the display logic assembly is used to establish the power supply switching frequency.

The PWM produces a train of pulses to drive the switch driver circuit which in turn drives the power switching bridge. The primary of the power transformer serves as the load for the bridge. Supply output voltages are derived from the transformer secondaries through full-wave rectifiers and LC filters. A selected output voltage from each switching supply is compared with a reference voltage in a frequency response shaper which controls the width of the pulses produced by the PWM, thus completing the control loop.

Protection and Control Circuits

Protection and control circuitry is present in the 98770A power supply to insure proper turn-on sequencing for the three switching regulators and to monitor and shut-down the supply in the event of abnormal supply outputs or load conditions.

The basic protective mechanisms consist of:

- Fuses
- Power transformer primary current limit for each of the switching regulators
- Overvoltage / overcurrent sensing

Fuses are present in the incoming power line and line frequency transformer secondaries to protect against power to ground shorts and for additional protection if other protective circuitry should fail. Four fuses are present, one for the energy storage system and three for the ±15 volt internal supplies and the filament supply.

Power-up sequencing allows the digital logic circuits (which provide synchronization signals to the analog circuits) to be powered first, followed by the vertical and convergence circuits, and finally the horizontal and high-voltage circuits. Each switching supply will activate only when the sequencing control circuitry has determined that the previously activated supplies are operating properly. The power-up sequence is:

1. Logic Supply
2. Linear 1 Supply
3. Linear 2 Supply

The overvoltage/overcurrent sensing circuit, fully active a few milliseconds after power is applied, monitors selected output currents and voltages. This circuit initiates a supply shut-down when any abnormal condition is detected. The conditions which force a supply shut-down are listed below:

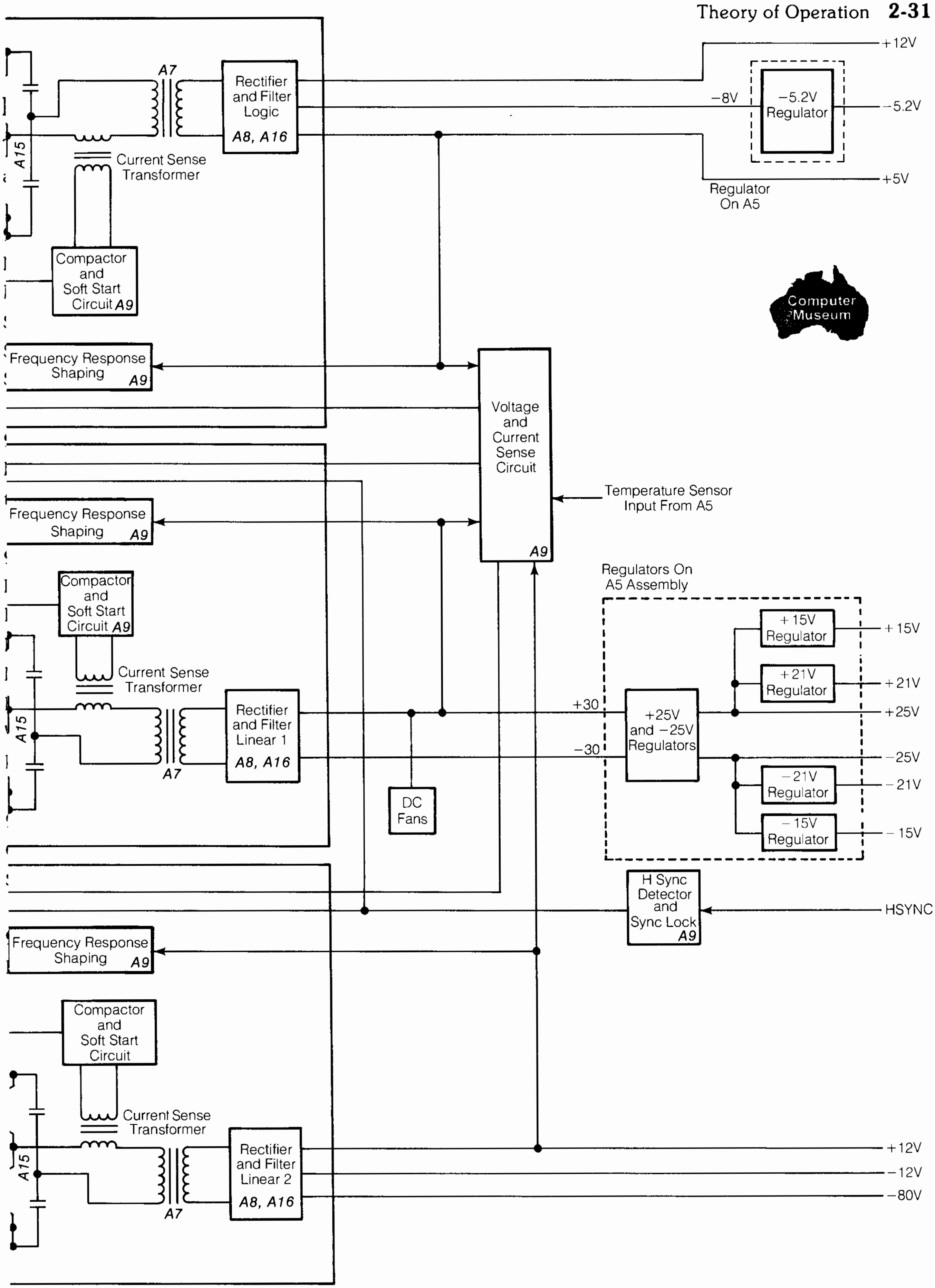
- +5 volt output greater than −5.2 volt output
- −5.2 volts less than −6.3 volts
- Now overcurrent condition in a switching transformer primary
- +15 volts greater than +16.7 volts
- −15 volts less than −16.7 volts
- +25 volts greater than +27.8 volts
- −25 volts less than −27.8 volts
- −80 volt current greater than 2 amps
- −80 volts less than −86.9 volts

The 98770A supply will also shut down if the temperature of the A5 deflection transistor heat sink exceeds 100°C. It will also shut down if the ±15 volt internal supply fails. Once shut-down by either current, voltage or temperature, the supply will remain in that state until the control circuitry is reset by cycling the mainframe power. Refer to Chapter 3 for power supply fault isolation using the supply's LED indicators and the power supply voltage specifications.

CRT Degauss Circuit

The degaussing circuit is necessary to remove residual magnetism in the CRT shadow-mask and shield which would disturb color purity and convergence. It consists of a coil, located inside the CRT shield, and the line-powered drive circuitry.

When a degauss cycle is requested, the coil is connected to the AC line by a solid state switching circuit. A positive temperature coefficient thermistor is connected in series with the coil such that when the line voltage is first applied a large surge current flows through the coil. The surge current quickly heats up the thermistor, increasing its resistance, and causing the coil current to decrease to a small value. After the current has reached a sufficiently small value (about 3 seconds) the solid state switch is turned off. The thermistor must be allowed to cool for approximately 5 minutes before the degauss cycle can be repeated. A degauss cycle is automatically performed when the mainframe is turned on and will also occur when the mainframe de-selects both alphanumerics and graphics. All video is blanked during the application of the magnetic field.


+12V
A7
Rectifier and Filter Logic
A8, A16
-8V
-5.2V Regulator
-5.2V
A15
Current Sense Transformer
+5V
Regulator On A5
Compactor and Soft Start Circuit A9
Frequency Response Shaping A9
Voltage and Current Sense Circuit
Temperature Sensor Input From A5
Frequency Response Shaping A9
A9
Regulators On A5 Assembly
Compactor and Soft Start Circuit A9
+15V Regulator
+15V
Current Sense Transformer
+21V Regulator
+21V
+30
+25V and -25V Regulators
+25V
A15
Rectifier and Filter Linear 1
A8, A16
-30
-25V
A7
-21V Regulator
-21V
DC Fans
-15V Regulator
-15V
H Sync Detector and Sync Lock A9
HSYNC
Frequency Response Shaping A9
Compactor and Soft Start Circuit
Current Sense Transformer
Rectifier and Filter Linear 2
A8, A16
A15
A7
+12V
-12V
-80V

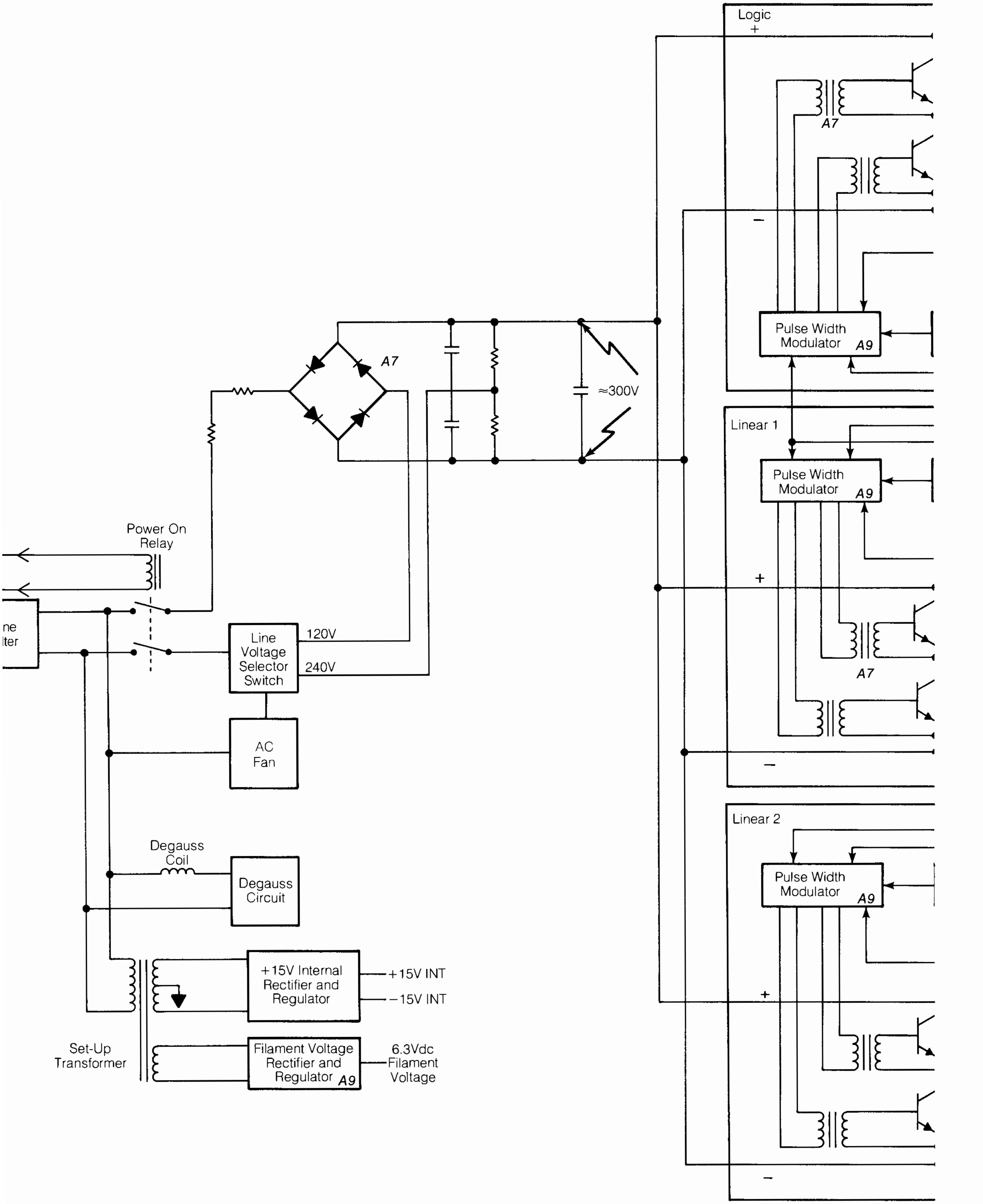


Figure 2-18. Power Supply Block Diagram

Power Supply Assemblies

The power supply assembly (98770-67980) is an exchange item; however, here is a list of the power supply PC assemblies and the circuits found on each assembly.

98770-66507 (A7) Primary Assembly

Degauss

Energy Storage Circuit (less 2 big capacitors)

Switching transformers

Switching regulator filter inductors

Surge limit thermistors

98770-66508 (A8) Filter Capacitor Assembly

Filter capacitors for the output voltages of the switching regulators. Voltages enter the 98770 motherboard via this assembly.

98770-66509 (A9) Control Assembly

Filament supply rectifiers and filter

Regulators for filament, ±15 INT and +12 supplies

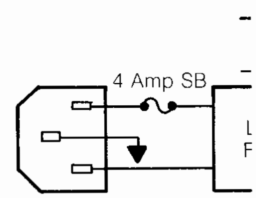
Pulse width modulators

Frequency response shaping

HSYNC synchronizer (phase-locked loop)

Voltage/current sense

LED indicator drivers



98770-66515 Switching Assembly

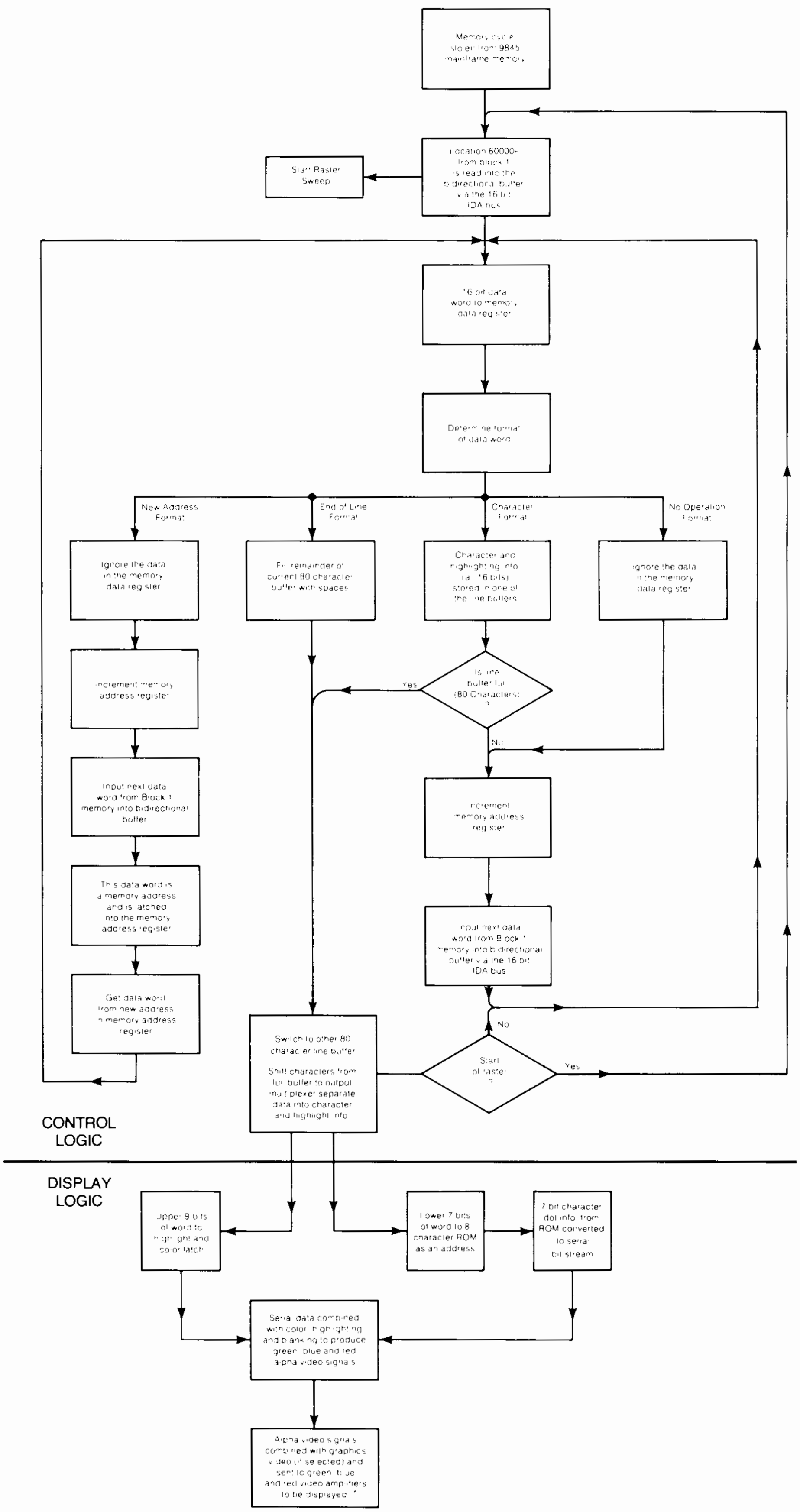
Current sense transformers

Switching transistors for the switching regulators

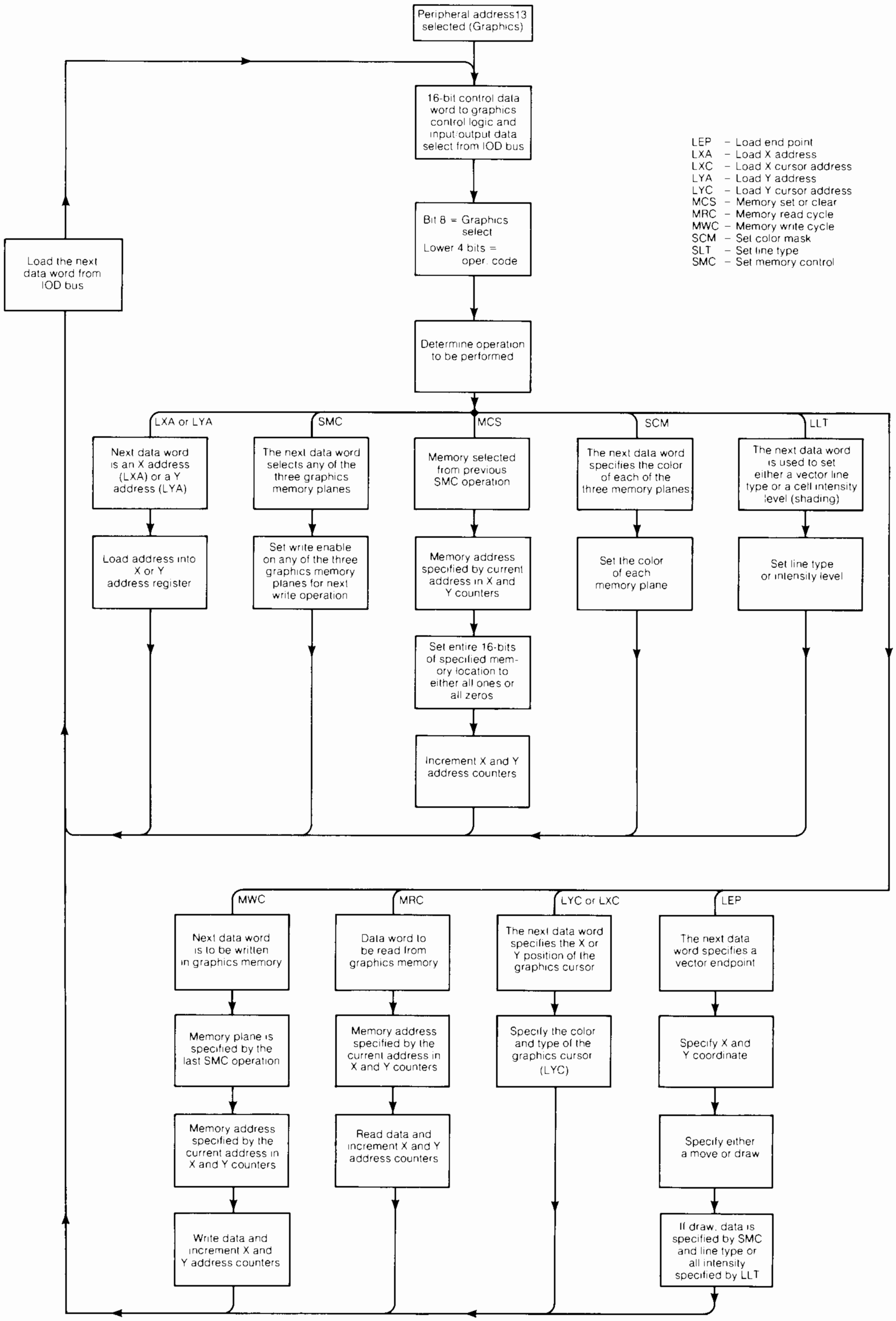
98770-66516 Rectifier Assembly

Rectifiers for the switching regulators

ALPHA OPERATION FLOWCHART



GRAPHICS OPERATION



Mnemonic	Description
ABL	Alpha Blanking
AS	Alpha Select
AVC	Address Valid Clear
BADR	B Address Lines
BAV	Blue Alpha Video
BGV	Blue Graphics Video
BLKG	Blinking
BR	Bus Request
BV	Blue Video
BVD	Blue Video Data
C80	80_{th} Character
CAS	Column Address Strobe
CEBG	Chained External Bus Grant
CL	
COLOR	Color Select Lines
CRT	CRT Status Line
CURS	Cursor
CSTM	Internal Start Memory Cycle
DO	Memory Data Out Lines
DOUT	Data Out
DMAR	Direct Memory Access Request
DSP	Display
EBG	External Bus Grant
EOL	End of Line
FB	Full Brightness
FLB	Full Line Buffer
FLG	Flag
GAV	Green Alpha Video
GGV	Green Graphics Video
GS	Graphics Select
GV	Green Video
GVD	Green Video Data
HIGH	Highlight Select Lines
HLT	Halt
HSYNC	Horizontal Synchronization
IC1	Register Select Line 1
IC2	Register Select Line 2
IDA	Instruction, Data, Address Bus Lines
INIT	Initialize
INT	Interrupt
IOSB	Input/Output Strobe
IRH	High Level Interrupt
IRQ	Interrupt Request
IS	Input Strobe
LDA	Load Address
LEP	Load End Point
LIOD	Latched IOD Bus Lines (Internal)
LTE	Line Type Enable

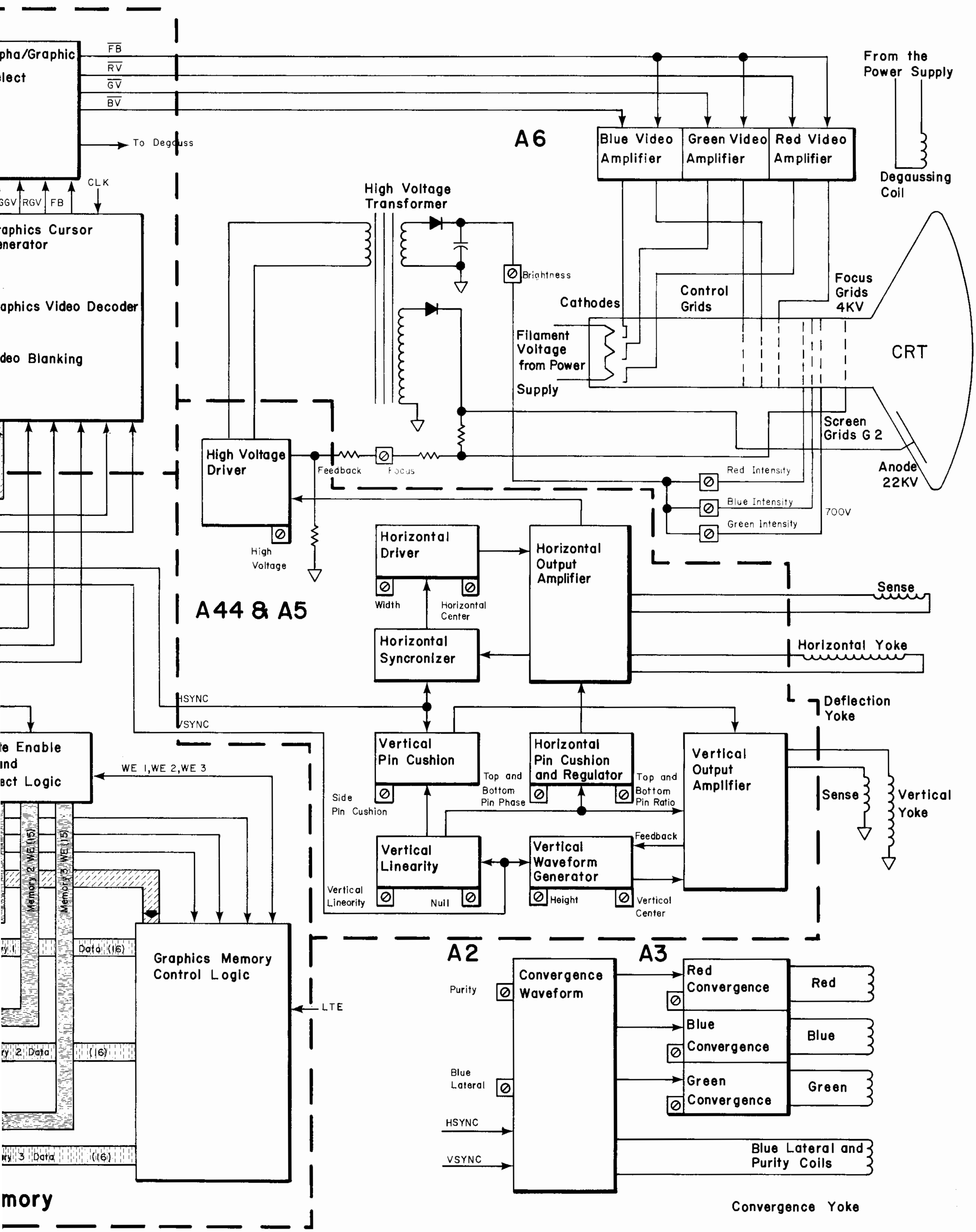
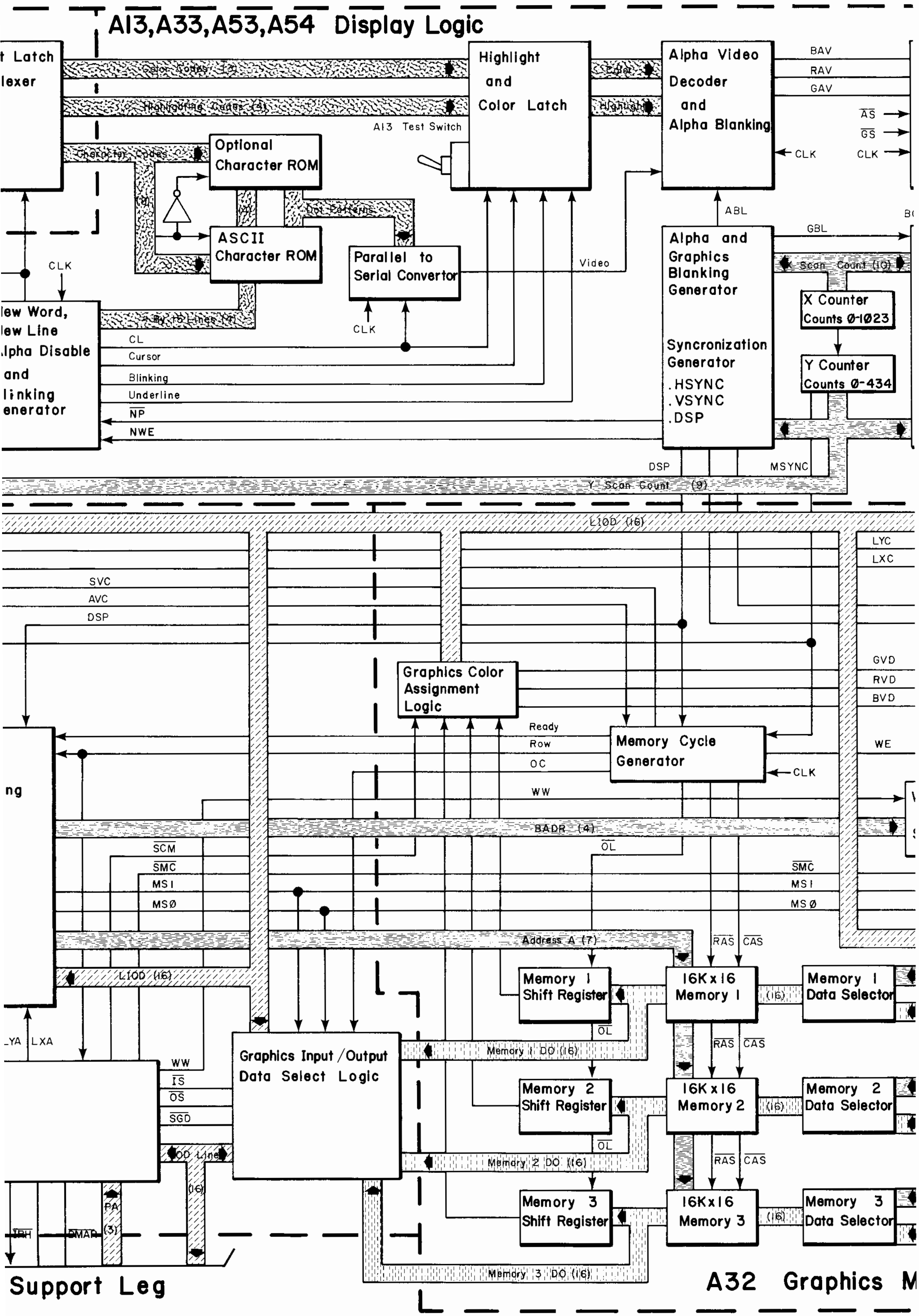
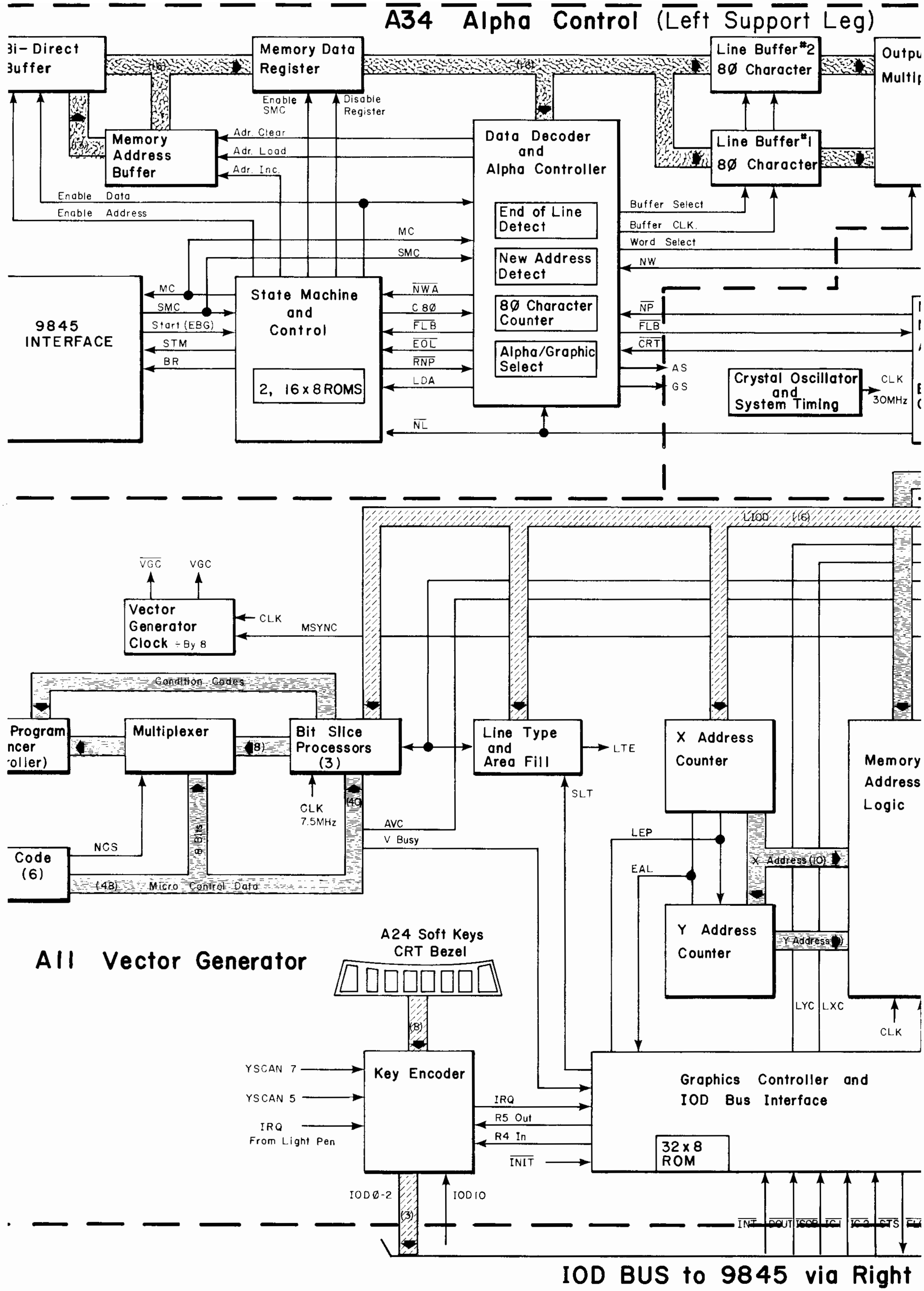
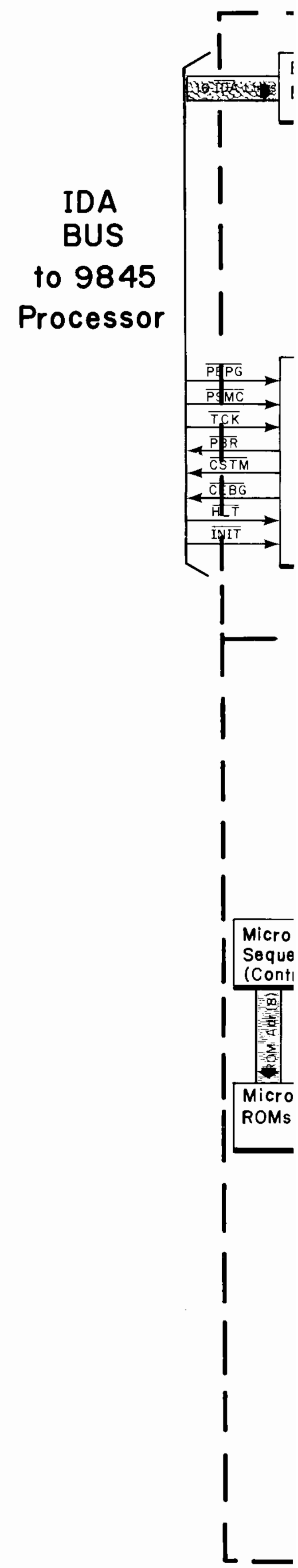

pha/Graphic
lect
FB
RV
GV
BV
To Degauss
CLK
GV RGV FB
aphics Cursor
nerator
aphics Video Decoder
deo Blanking
A6
Blue Video Amplifier
Green Video Amplifier
Red Video Amplifier
From the Power Supply
Degaussing Coil
High Voltage Transformer
Brightness
Cathodes
Control Grids
Focus Grids 4KV
Filament Voltage from Power Supply
CRT
Screen Grids G 2
Anode 22KV
High Voltage Driver
Feedback
Focus
High Voltage
Red Intensity
Blue Intensity
Green Intensity
700V
A44 & A5
Horizontal Driver
Width
Horizontal Center
Horizontal Output Amplifier
Sense
Horizontal Syncronizer
Horizontal Yoke
HSYNC
VSYNC
Deflection Yoke
e Enable
nd
ect Logic
WE 1, WE 2, WE 3
Vertical Pin Cushion
Side Pin Cushion
Top and Bottom Pin Phase
Horizontal Pin Cushion and Regulator
Top and Bottom Pin Ratio
Vertical Output Amplifier
Sense
Vertical Yoke
Vertical Linearity
Null
Vertical Waveform Generator
Feedback
Height
Vertical Center
Memory 2 WE (15)
Memory 3 WE (15)
Data (16)
2 Data (16)
3 Data (16)
Graphics Memory Control Logic
LTE
mory
A2
A3
Purity
Convergence Waveform
Blue Lateral
HSYNC
VSYNC
Red Convergence
Blue Convergence
Green Convergence
Red
Blue
Green
Blue Lateral and Purity Coils
Convergence Yoke

Figure 2-19. 98770A Block I




A34 Alpha Control (Left Support Leg)
Bi-Direct Buffer
Memory Data Register
Line Buffer #2 80 Character
Output Multip
Memory Address Buffer
Enable SMC
Disable Register
Adr. Clear
Adr. Load
Adr. Inc.
Data Decoder and Alpha Controller
Line Buffer #1 80 Character
Enable Data
Enable Address
Buffer Select
Buffer CLK.
Word Select
End of Line Detect
New Address Detect
80 Character Counter
Alpha/Graphic Select
MC
SMC
NW
9845 INTERFACE
State Machine and Control
2, 16x8 ROMS
Start (EBG)
STM
BR
NWA
C 80
FLB
EOL
RNP
LDA
NL
NP
CRT
AS
GS
Crystal Oscillator and System Timing
CLK
30MHz
LIOD (16)
VGC
Vector Generator Clock ÷ By 8
MSYNC
Condition Codes
Program ncer oller)
Multiplexer
Bit Slice Processors (3)
(8)
(40)
CLK 7.5MHz
Line Type and Area Fill
LTE
SLT
X Address Counter
Memory Address Logic
Code (6)
NCS
8 Bits
(48) Micro Control Data
AVC
V Busy
LEP
EAL
X Address (10)
Y Address Counter
Y Address
A11 Vector Generator
A24 Soft Keys CRT Bezel
(8)
LYC
LXC
Key Encoder
YSCAN 7
YSCAN 5
IRQ
IRQ From Light Pen
R5 Out
R4 In
INIT
Graphics Controller and IOD Bus Interface
32x8 ROM
IOD0-2
IOD10
(3)
INT
DOUT
ISOB
IC1
IC2
STS
IOD BUS to 9845 via Right

Mnemonic	Description
LXA	Load X Address
LXC	Load X Cursor Position
LYA	Load Y Address
LYC	Load Y Cursor Position
M1 Video	Video Data From Memory 1
M2 Video	Video Data From Memory 2
M3 Video	Video Data From Memory 3
MC	
MS0	Memory Select Line 0
MS1	Memory Select Line 1
MSYNC	Memory Synchronization
NCS	N Counter Select
NL	New Line
NP	New Page
NW	New Word
NWE	New Word Enable
OC	Output Clock
OL	Output Latch
OS	Output Strobe
PA	Peripheral Address Lines
PBR	Peripheral Bus Request
PEBG	Peripheral External Bus Grant
PSMC	Peripheral Synchronous Memory Complete
RAS	Row Address Strobe
RAV	Red Alpha Video
RGV	Red Graphics Video
RNP	Reset New Page
ROW	Row Select
RV	Red Video
RVD	Red Video Data
SCM	Store Color Mask
SGD	Select Graphics Display
SLT	Select Line Type
SMC	Store Memory Control
STM	Start Memory
STS	Status
TCK	Buffered Mainframe Clock
UL	Underline
VGC	Vector Generator Clock
V Busy	Vector Generator Busy
V Ready	Vector Point Ready
V SYNC	Vertical Synchronization
WE	Write Enable Lines
WW	Write Word
X ADR	X Memory Address Lines
Y ADR	Y Memory Address Lines
Y SCAN	Y Timing Chain Output Lines



Chapter 3
Troubleshooting

Introduction

This chapter provides information to help isolate a problem in the 98770A. The information includes:

- 98770A test program procedures
- Problem charts
- A5 regulators and transistors
- Test switches
- Power supply information

Items Required

The 9845B/C Test Binary Cartridge (revision B) contains the 98770A test programs. This chapter contains the procedures to run the 98770A tests. See Chapter 2 of the 9845B Service Manual for the 9845B/C mainframe test procedures.

Use a good volt-ohm meter to check power supply voltages.

Initial Checks

The purpose of this test is to determine whether the problem is in the 9845 mainframe or the 98770A display. If the problem is in the display determine whether the display is inoperative or operating properly.

If possible, ask the customer about the problem and get as many details as possible. This may clearly indicate where the problem lies.

Turn on the computer power switch. If after a sufficient warm-up time, the display does not appear on the 98770A, refer to Chapter 2 of the 9845B Service Manual and verify that te computer is working. If the computer is working, try adjusting the intensity control and press (CONTINUE) (STEP). If a cursor still does not appear, press the test button recessed in the 98770A rear panel. A large white raster should appear. If it does not, remove the 98770A from the computer and attach it to the 98770A test fixture. If the 98770A now turns, there is probably an interconnect problem between the computer and the 98770A. If the 98770A does not turn on, refer to the Inoperative Unit section in this manual.

If the 98770A did turn on but is not operating properly, use the procedures in Chapter 2 of the 9845B Service Manual to determine if the problem is in the computer or the 98770A. If the problem proves to be in the 98770A, then refer to the Operating Incorrectly section of this manual for further checks.

Inoperative Unit (No Display)

These Tests Performed With Top Cover On

These tests may be performed either using the 98770A test fixture or using the 9845 computer.

Turn the computer or test fixture off and disconnect the power cord(s). Check the voltage selector switches and the fuse on the rear panel to make sure that they are correct for the line voltage being used. Also inspect the power cord and verify that there is AC power at the receptacle.

Check that the fuse is not blown. On some displays the spark gap attached to the voltage selector switch occasionally blows the fuse when the computer is used on 110 VAC. This occurs when the computer is turned off. Therefore, installing a new fuse of the proper value should allow the computer to turn on.

If the fuse blows again, and the voltage selector switches are correct, and the AC line voltage is correct, then either the power supply, the rear panel assembly, or the 60 Hz transformer may be bad.

If the fuse is good but there is still no display, check the operation of the two rear panel fans by feeling the air flow around them. If both are running then the power supply is probably okay. If the fan above the line voltage selector switch is not running but the other one is, the power supply has probably detected a fault and shut down. If neither fan is running, either the display is not getting the turn on signal from the mainframe or test fixture, the 60 Hz transformer is bad or there is a problem on the rear pamel assembly. The problem could be a blown 60Hz transformer fuse. On some models this fuse is a 1 or 3 amp fuse located directly below the power supply. On others there are three transformer secondary fuses located on the bottom of the 98770-66507 board in the power supply. Check these with an ohmmeter.

These Tests Performed With the Top Cover Off

To remove the top cover, remove the four screws recessed in its top surface and lift the cover straight up. Notice that the screw in the back left corner, above the power supply is shorter than the rest. This screw must go here when re-assembling the display after repairs are made. If a longer screw is used here it can puncture an electrolytic capacitor in the power supply.

After the top cover is removed, connect the computer to AC power and observe the power supply LED indicators on the left side of the chassis. LED #4 in the right indicator group should be on (brite). LEDs in the left indicator group may be on depending on what state they came up in when power was applied. LED #4 indicates whether +15 volts is present in the power supply. If the rear panel fuse is good and the line selector switches are properly set, if LED #4 is not on (dark), then one of the following is probably wrong:

- The 60 Hz transformer is open.
- A fuse or fuses in the 60 Hz transformer line is open. See above for where these fuses are located.
- The +15 volt internal circuit in the power supply has failed.

Before changing anything, however, try unplugging the 98770A display and then plugging it back in. A poor connection can cause the problem.

If LED #4 in the right indicator group is on, then turn the computer or the test fixture on. One of the following should happen:

- The display will come on, one or more LEDs in the left indicator group will light (this turns on all LEDs in the right group).
- LED #1 OR #1 and #2 will remain on in the right indicator group.

LED #4 should remain on in all these cases.

If the display turned on, the problem was probably a poor connection with the power supply or one of the other boards. Turn the computer or test fixture on and off several times and verify that it always works. If it does, you may want to turn off the display, remove the power cord and reseat the circuit boards.

CAUTION

ALWAYS REMOVE THE POWER CORD BEFORE REMOVING CIRCUIT BOARDS AS SOME COMPONENTS MAY BE DESTROYED IF THE BOARDS ARE REMOVED AND RESEATED WITH THE POWER CONNECTED, EVEN THOUGH THE DISPLAY IS TURNED OFF.

If LED #1 or #1 and #2 in the right indicator group are on, the power supply is bad. Turn the display off and disconnect the power cord. Remove the power supply as per the instructions on the power supply top cover. Then reinstall the supply, connect power and try to turn it on again. If the problem returns, the power supply should be replaced. If LED #1 only is on, however, the problem could be on the A5 assembly. Verify this before reinstalling the supply by trying a new A5 assembly.

If one or more LEDs are on in the left indicator group the power supply has detected an overvoltage or overcurrent condition and shut down. This is not necessarily a power supply failure. The LEDs can help track down the problem. A listing of what each LED indicates is in the power supply section of this manual on page 3-19.

For further troubleshooting, consult the problem charts which follow.

Raster Problem Chart

Symptom \ Probable Cause	A2	A3	A4	A5	A6	HV Assy	CRT
No display			1	2		3	4
Improper focus control			3			1	2
No high voltage			1	2		3	
No raster deflection			1	2			
Odd raster shapes			1 not so bad	2 bad			
Raster related problems			1	2			
Improper intensity settings					1		
Color always on or always off					1		
Loss of one color					1		2
Improper purity	1						
Improper blue lateral	1			2			
Improper convergence	1	2					
Can't converge one color		1		2			

NOTE

A "1" is the most probable cause and a "4" is the least probable cause.

Graphics Problem Chart

Symptom \ Probable Cause	A11	A32
Incorrect lines being drawn	1	
Extra or missing lines	1	
Improper or no area fill	1	
Improper line type or no line type control	1	
Random or repetitive dots missing or always on display		1
Intermittent display dots		1
Groups of dots missing or always displayed		1
Can't read or write into graphics memory		1

Alpha Problem Chart

Symptom \ Probable Cause	A34	A13
No alpha display		1
No graphics display		1
Improper or incorrect characters	2	1
Characters missing (every other line) or incorrect	1	
Incorrect colors or highlighting	2	1
One or more cursors missing or incorrect		1
No alpha blanking		1
No graphics blanking		1

Display Tests

Display tests for the 98770A (or 9845C) are contained on the 9845B/C Test Binary Cartridge (Revision B), HP Part Number 09845-91031.

To use the tests, first install the cartridge in T15 and press: LOAD BIN "TBIN" execute. The 98770A display tests are available by pressing either K0 or K5.

After pressing K0 or K5, several keys on the keyboard are re-defined to initiate the various display tests. Here is a summary of the re-defined keys and the tests they initiate.

Table 3-1. Display Tests

Alpha Tests

Key	Test
B	Alpha display buffer test
F	Focus adjustment pattern
+	Convergence alignment pattern
C	Character set with highlighting features and color
O	Optional character set with highlighting and color
S	Color and highlighting in various combinations
A	Alpha on and off test

Graphics Tests

Key	Test
k8 – k15	Full graphics raster in different colors (one color per key)
M	Graphics memory test
K	Displays the three graphics cursors
k0 – k7	Changes the graphics cursor color (one color per key)
X	Grid based on present graphics cursor position
V	Vectors and linearity
G	Graphics on and off test
↑ ← → ↓	Moves graphics cursor in direction of arrow

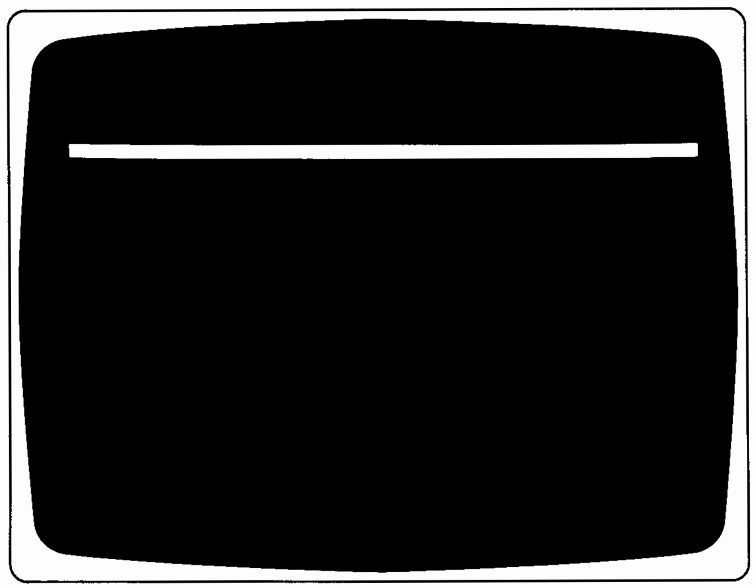
Other Tests

Key	Test
Soft Keys	Soft key test
P	Light pen test

Alpha Tests

(B) Alpha Display Buffer Test

Press (B); the CRT displays:



This test checks the 80-character line buffers on the A34 assembly, plus the ability to display information.

(F) Focus Alignment Pattern

Press (F); two columns of the word "FOCUS" appear. Check the characters to ensure they are clear and readable. If necessary, remove the display's top cover and adjust the focus control to achieve the best overall character focus (refer to Chapter 4 for adjustment procedures). It may not be possible to achieve perfect focus in all areas of the display.

(+) Convergence Alignment Pattern

Press (+); all thirteen +'s and the corresponding step number are displayed. Use this display for a quick convergence check and for any touch-ups.

(C) Character Set With Highlighting Features and Color

Press (C); the CRT displays:

NOTE

To see black, press one of the graphics color keys, (k8) through (k15).

This test checks the character RO, and the highlight and color latch on the A13, A33, A53 or A54 assembly.

(O) Optional Character Sets

Press (O); if an optional character ROM is installed (Option 771 or 772), the optional characters are displayed.

NOTE

If the optional character ROM is not installed, inverse video characters will be displayed.

(S) Color and Highlighting in Various Combinations

Press (S); the CRT displays:

NOTE

To see black, press one of the graphics color keys, (k8) through (k15).

(A) Alpha On and Off Test

Press (A); the alpha display should disappear. Press (A) again, the alpha display should appear again.

This test checks the alpha blanking circuit on the A13, A33, A53 or A54 assembly.

Graphics Tests

k8 – k15 Full Graphics Raster in Different Colors

Press any key from k8 through k15; a colored graphics raster will appear.

Here is a summary of the keys and the color each key produces.

Key	Color
k8	White
k9	Red
k10	Yellow
k11	Green
k12	Cyan
k13	Blue
k14	Magenta
k15	Black

This test checks the graphics memory and color assignment logic on the A32 assembly.

(M) Graphics Memory Test

Press (M); the three graphics memories on the A32 assembly are tested.

Memory errors are displayed in the following format:

Example	X Dot Location	Y Dot Location	Memory Number	Actual Data	Expected Data

```
GRAPHICS X:00000 ; Y:00000 ; MEM#:00000   HAS 000000 NOT 000000
```

This information can be used to isolate a bad RAM chip on the A32 assembly as follows:

1. Determine in which memory the error occurred by looking at the number in MEM# (either 1, 2 or 3). See Figure 3-1.
2. Decode the actual and expected octal data into its binary equivalent as shown below.

Example			Bit 15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Expected data	077777	=	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Actual Data	077577		0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1

Bit 7 does not compare

If a bit does not compare, the corresponding RAM shown in Figure 3-1 is probably defective.

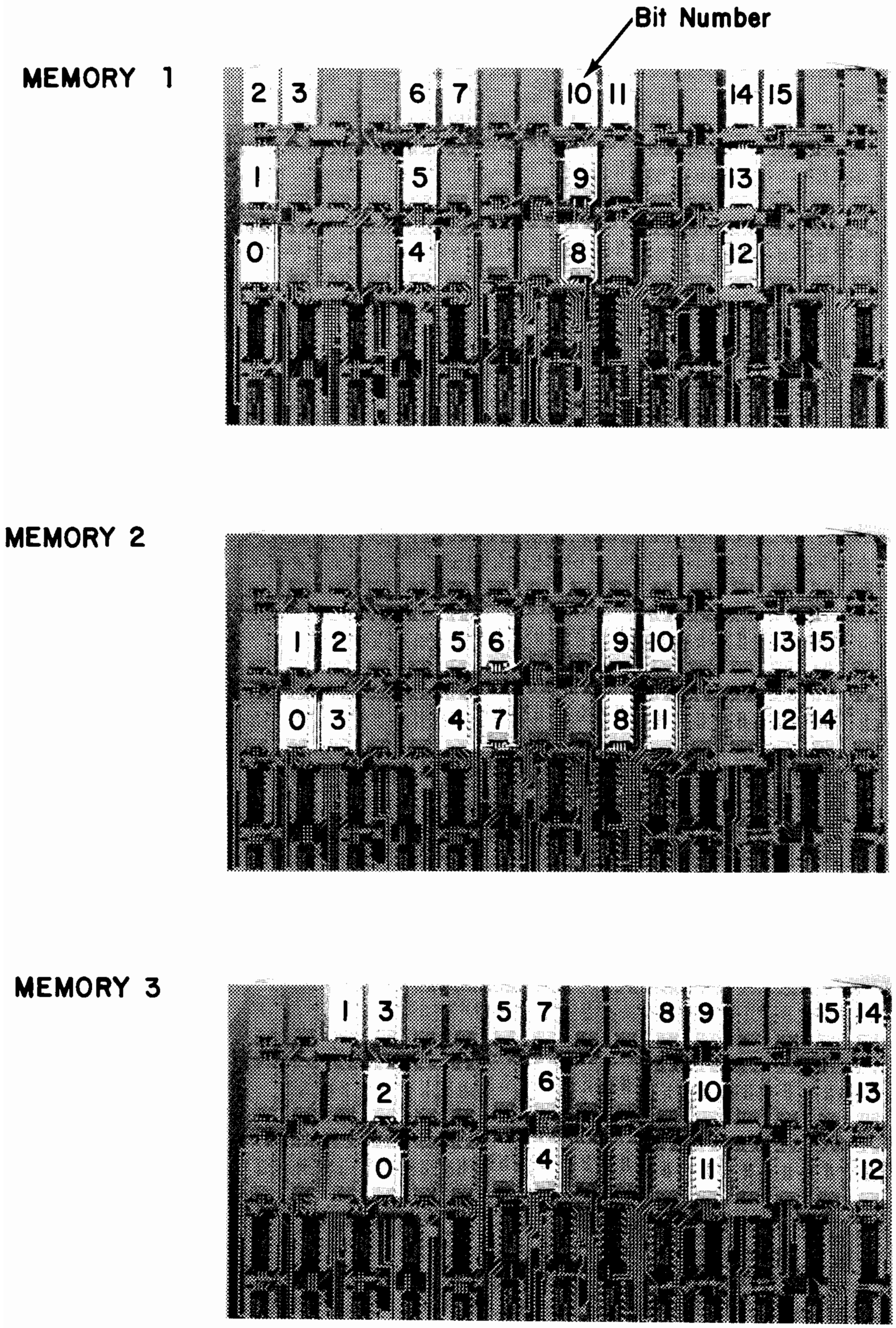


Figure 3-1. Graphics Memory Locations

(K) Graphics Cursors

Press (K); initially the small horizontal line cursor (—) appears. Press (K) again and the full screen cross-hair cursor appears. Press (K) once more to view the small cross-hair cursor.

This test checks the graphics cursor logic on the A13, A33, A53 or A54 assembly.

[k0] – [k7] Graphics Cursor Color

Press any key from [k0] through [k7] to change the color of the graphics cursor. Here is a summary of the keys and the color cursor each key produces:

Key	Color
[k0]	White
[k1]	Red
[k2]	Yellow
[k3]	Green
[k4]	Cyan
[k5]	Blue
[k6]	Magenta
[k7]	Black

(X) Grid

Press (X); a grid is produced, based on the present position of the graphics cursor.

(V) Vectors and Linearity

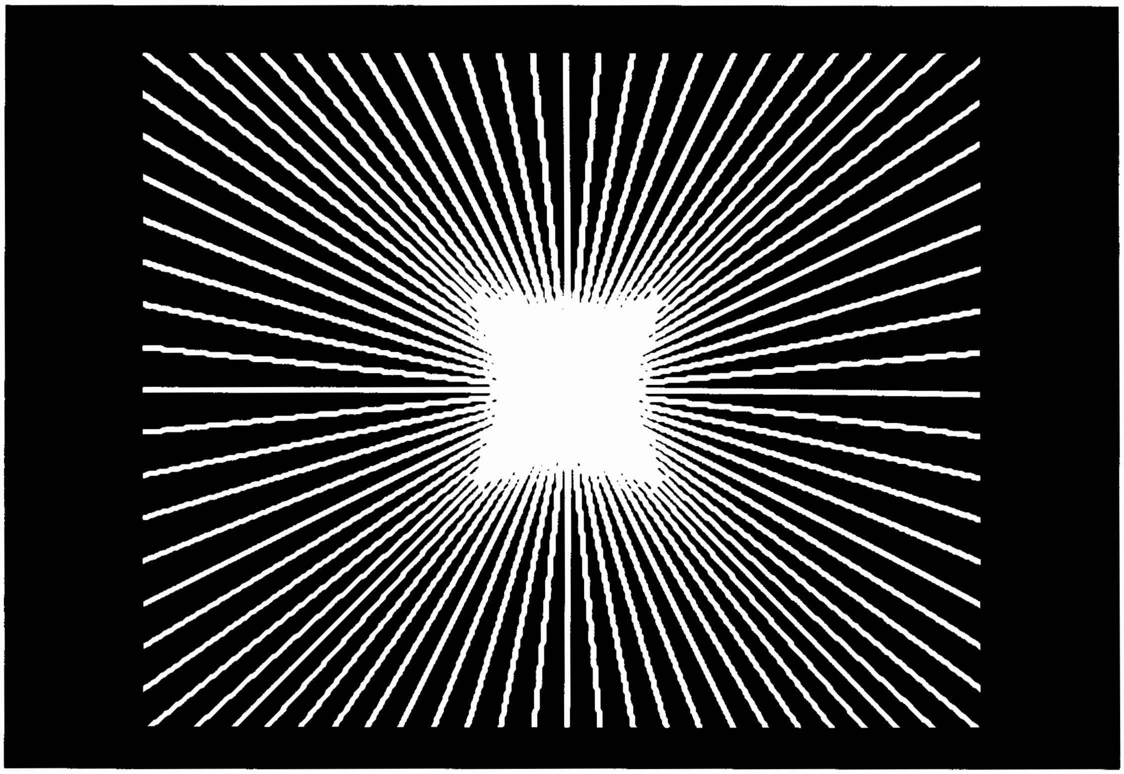
There are several sections to this test.

Press (V); the first display is five horizontal lines to be used for vertical linearity.

Using the alignment mask, ensure that the center line is aligned to the center line of the alignment mask. Then align the bottom and top lines with those on the mask. Refer to Chapter 4 for vertical linearity adjustment procedures.

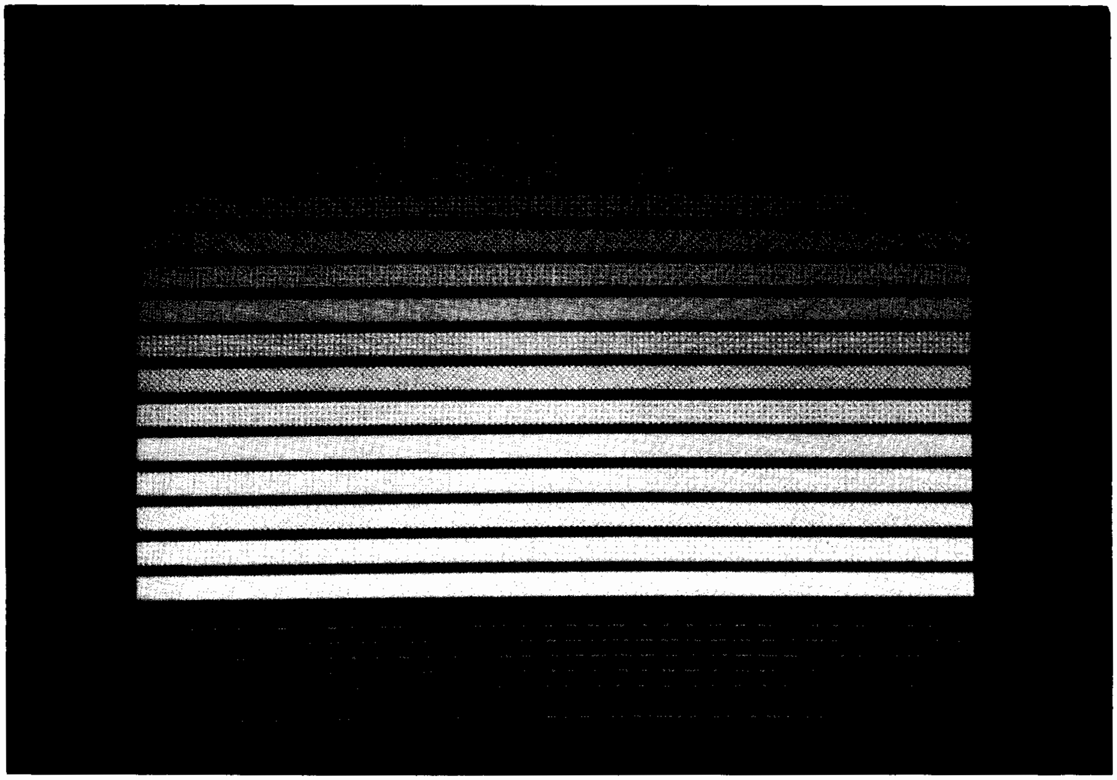
Press (CONT); the next pattern is vertical lines for horizontal linearity.

Press (CONT); the following display appears:

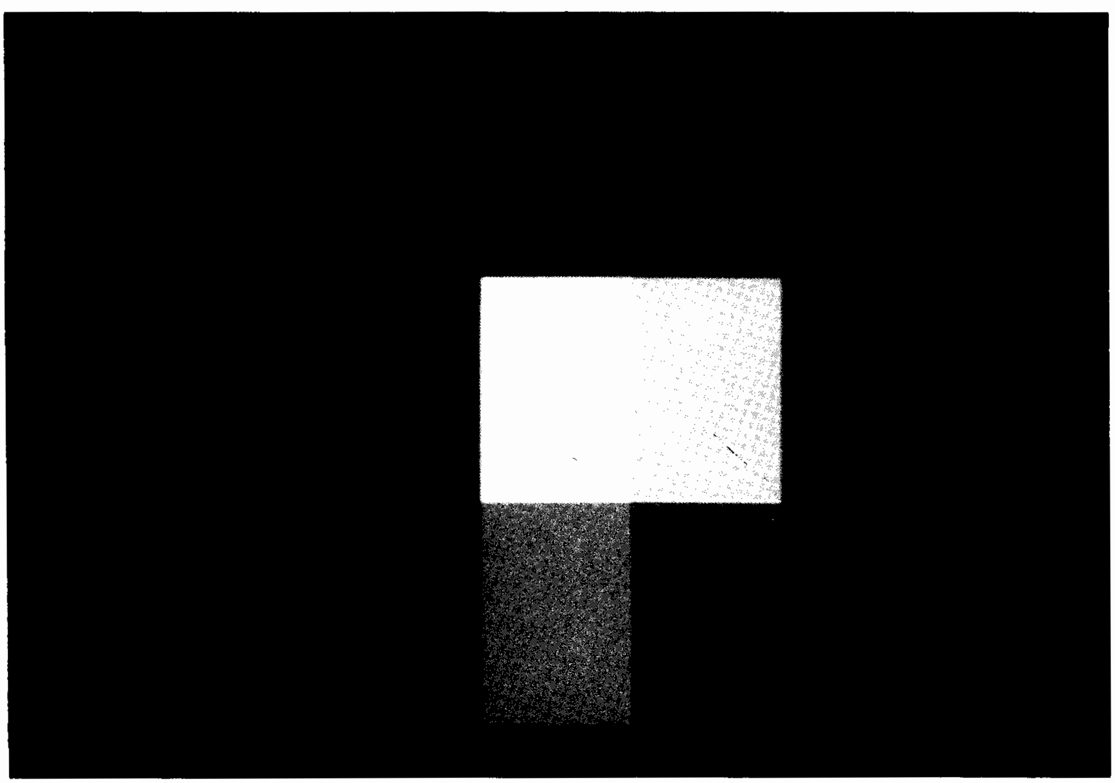


This display tests the ability of the vector generator to compute and draw vectors. The vector generator is on the A11 assembly.

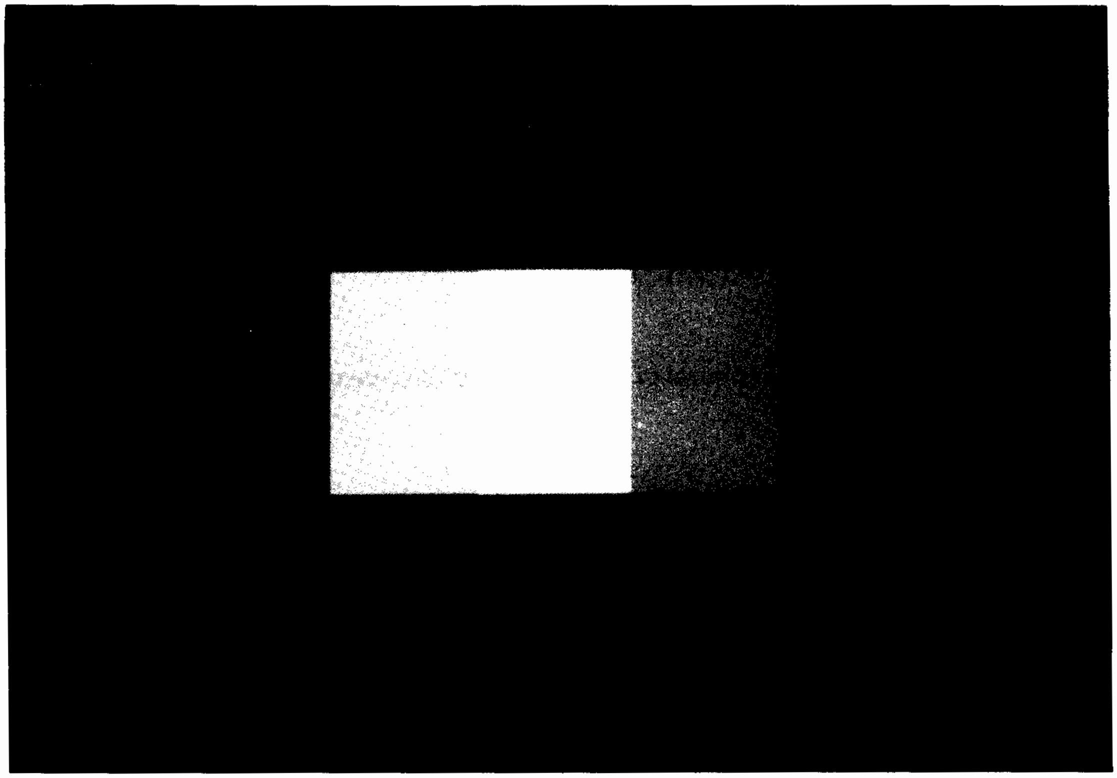
Press (CONT); the display shows the 16 area fill patterns and the 8 line types.



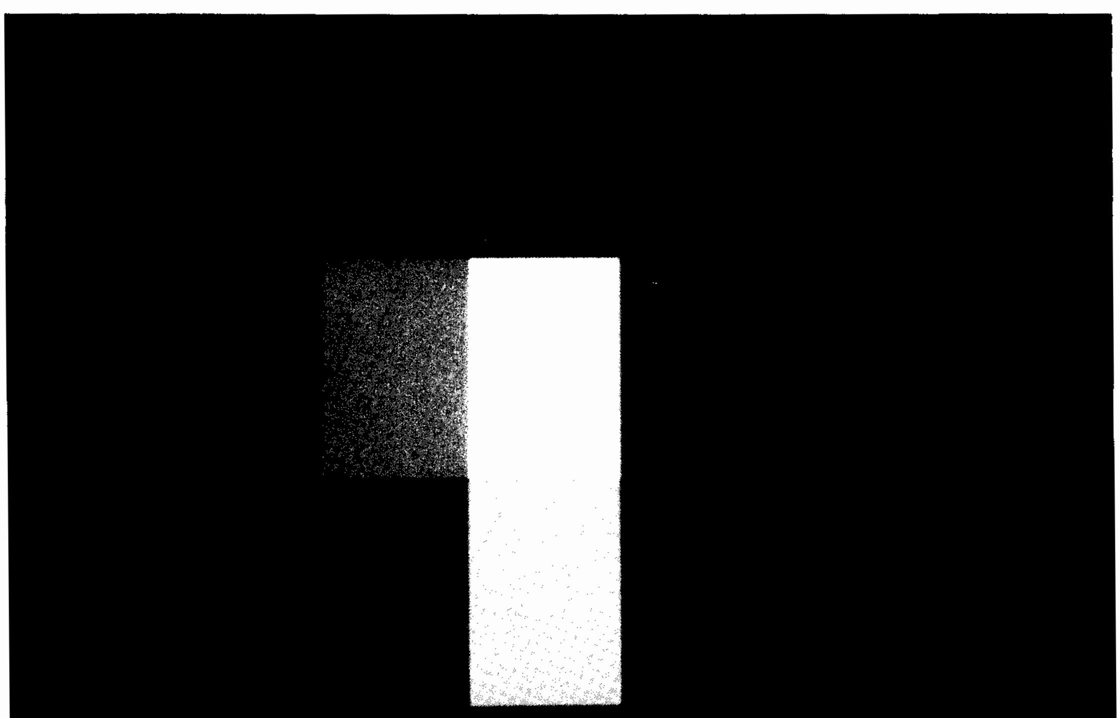
Press (CONT); the display shows three overlapping blocks. The three memories are assigned different colors for this section and the next two sections. The colors are rotated in the three memories.



Press (CONT)



Press (CONT)



Press (CONT) to return to the main program.

(G) Graphics On and Off Test

Press (G); the graphics display should disappear. Press (G) again, the graphics display should appear again. This test checks the graphics blanking circuit on the A13, A33, A53 or A54 assembly.

(↑)(←)(→)(↓) Move Graphics Cursor

The arrow keys allow graphics cursor movement within the graphics raster.

Other Tests

Soft Key Test

Press each of the keys on the lower front bezel of the display. An X appears above the key that was pressed.

(P) Light Pen Test

Press (P); a self test is performed on the light pen's position circuits.

Press (CONT); position the pen over the cursor and press the "pick" button. "ok" should appear on the display. This tests the ability of the light pen to pick a point.

Press (CONT); point the light pen at the cursor. Check the offset and field values.
The offset value should be 8 ±3.
The field value should be greater than 18.

Press (CONT); point the light pen at the cursor. A threshold shift test is performed. OK appears when the test passes.

Power Supply Checks

The power supply test points are shown in Figure 3-2. Table 3-2 lists the voltage tolerances for each supply.

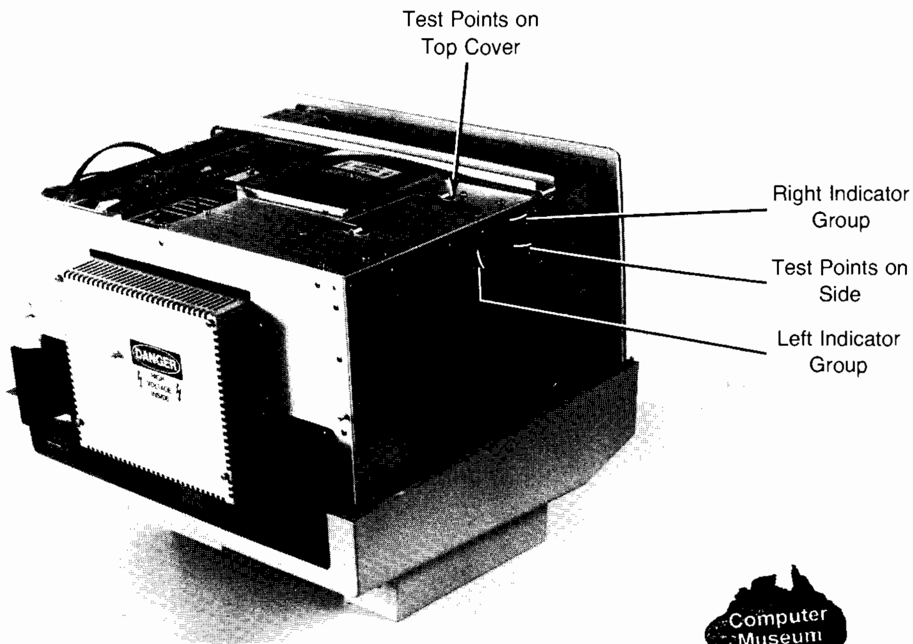


Figure 3-2. Power Supply Test Points

Table 3-2. Power Supply Voltage Tolerances and Distribution

DC Voltage	Voltage Tolerance	Average Current Maximum	Comes From	Where Used
±15 INT	±5%	1.5A (+15) 100ma (−15)	Regulator on start-up transformer	Internal power supply voltages used during power supply start-up to initially power the switching supplies. Also supplied to the A5 transistor assembly for the same purpose.
+5	±5%	13A	Logic switching supply	Logic Voltage for A2, A6, A11, A32, A13, A33, A53, A54 and the light pen logic assembly.
+12	±5%	1.5A	Logic switching supply	A32
±12	±10%	2.2A	Linear 2 switching supply	A44,A5
±15			Originates as ±27V from Linear 1. Generated via ±25V and ±15V regulators on A5 assembly.	A2,A3 and A44. −15V also used on A6.
±25	+25 greater than −26.5V −25 less than −26.5V	5A	Originates as ±27V from Linear 1. Generated via ±25V regulators on A5 assembly.	A2 and A44. +25V also used on A6.
−5.2		5A	Originates as −8V from Logic. Generated via −5.2V regulator on A5 assembly.	A2, A6, A32, A13, A33, A53, A54 and the light pen logic assembly.
−80	±2%	750ma	Linear 2 switching supply	A44, A5 and A6
+6.3 (Filament)	±5%	1A	Regulator on start-up transformer	CRT filament voltage

Noise and ripple on all supplies is less than 100mv.

Causes of failures may be determined by the LED indicators on the power supply. When on, each LED indicates which voltage is related to the failure. Figure 3-3 shows the LEDs and describes the failure that each indicates. Figure 3-2 shows which assemblies are affected by or may have caused the failure.

Left Indicator Group

○ ○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6 7 8

Light	Description
1	Lit when the −80V supply is experiencing an overcurrent condition.
2	Lit when the −80V supply is in an overvoltage condition.
3	Lit when either the +15V, −15V, +25V or the −25V supplies have an overvoltage condition.
4	Lit when the +12V supply has an overvoltage condition.
5	Lit when the A5 heat sink is greater than 100°C.
6	Lit when a switching transformer primary has an overcurrent condition.
7	Lit when the −5.2V supply has an overvoltage condition.
8	Lit when the +5V supply has an overvoltage condition.

Right Indicator Group

○ ○ ○ ○
1 2 3 4

Light	Description
1	Lit when the Linear 2 switching regulator is inhibited.
2	Lit when the Linear 1 switching regulator is not operating.
3	Lit when the Logic switching regulator is inhibited.
4	Normally on to indicate presence of ±15V INT. When off, power supply is inhibited.

Figure 3-3. Power Supply Failure Indicators

Test Switches

A13, A33, A53 or A54 Test Switch

The A13, A43, A53 test switch provides two special displays used in alignment purposes. For normal operation, the switch is in the center position. The forward switch position displays a RED alpha raster. The rear switch position displays a WHITE alpha raster. The switch enables the color and highlighting latch to convert incoming characters from the mainframe to inverse video spaces. The color mask bits are changed to display either the white or red raster. If the raster does not appear, the problem could still be in the 9845 mainframe. Characters must be transferred from the mainframe for the raster to be generated.

Figure 3-4. A13, A33, A53 or A54 Test Switch

A6 Test Switch

The A6 test switch is accessible from the rear panel. Pushing this switch results in a full-screen, white display. The presence of this display confirms the basic operation of the following circuits:

- High voltage
- Horizontal and vertical deflection circuits
- Power supply
- Horizontal and vertical sync signals

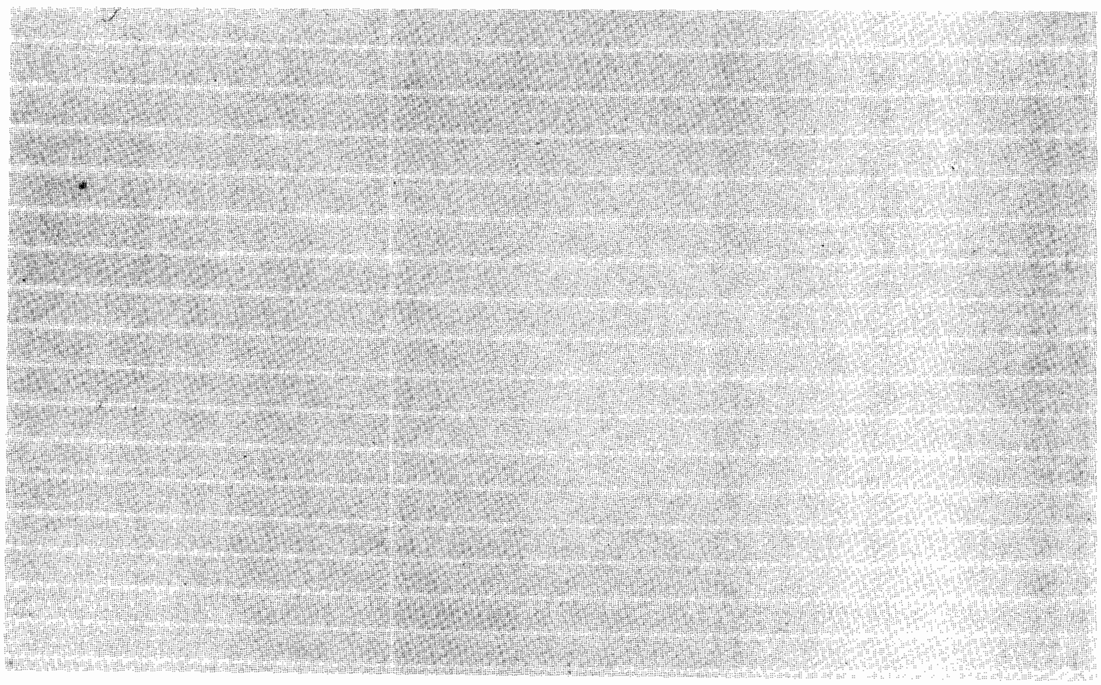
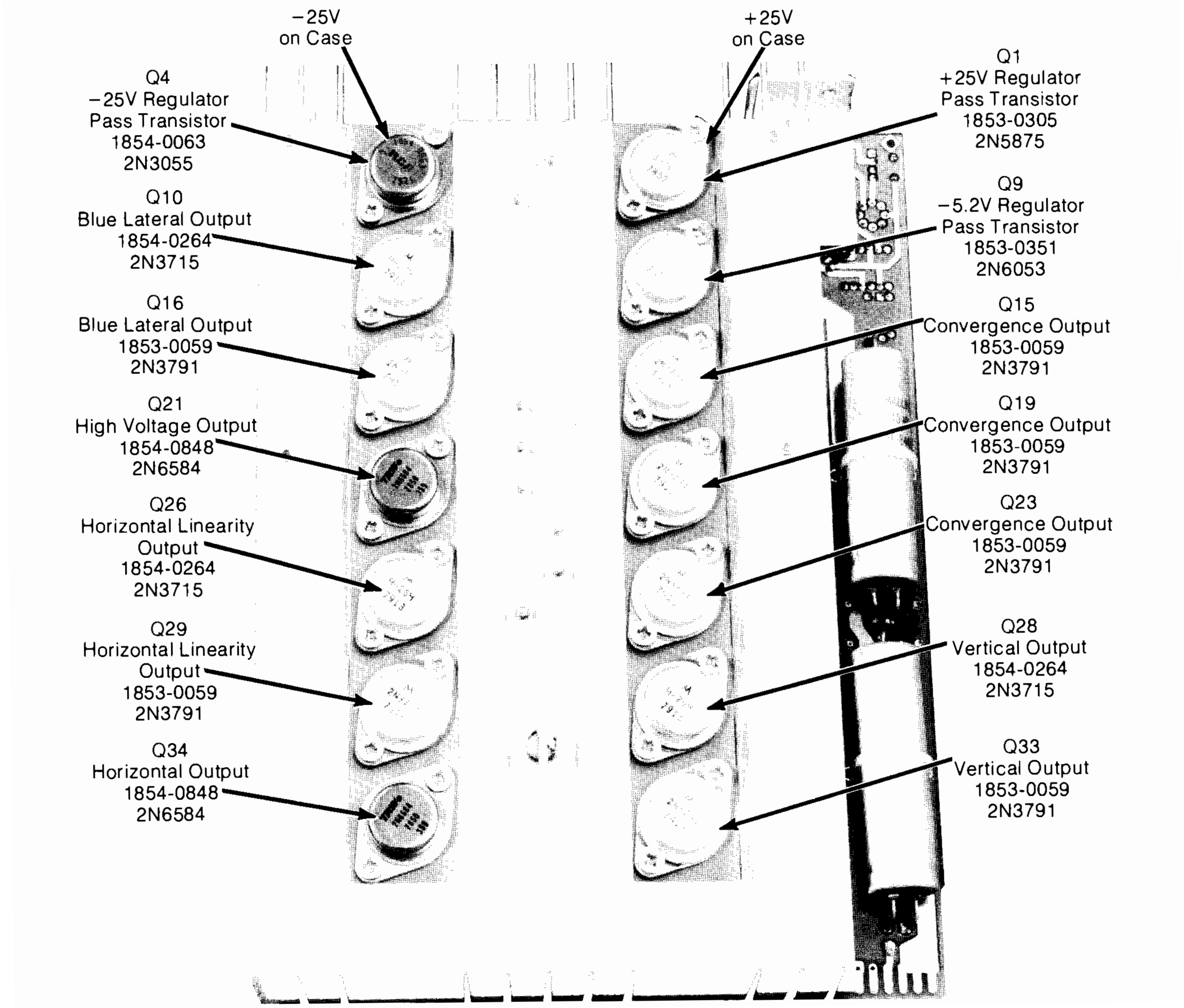
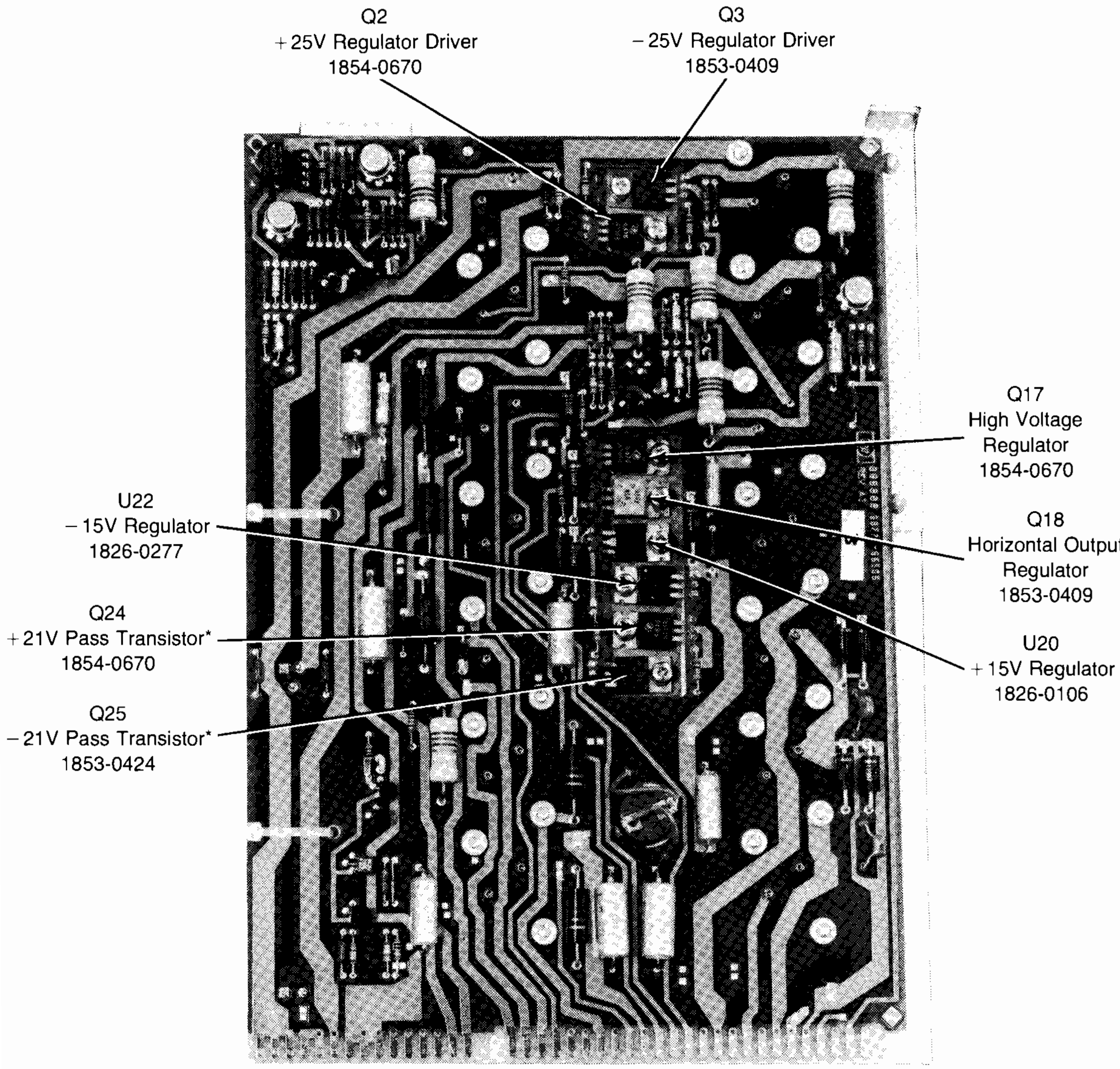


Figure 3-5. A6 Test Switch Display

A5 Regulators and Transistors

The A5 assembly (98770-66505) contains a variety of miscellaneous regulators and transistors. By knowing what circuit these devices are associated with, a faulty device on the A5 assembly can be isolated and replaced. Figure 3-6 defines the major devices on both sides of the A5 assembly. The HP Part Number for each device described is also given.





*±21V Used on A44

Figure 3-6. A5 Regulators and Transistors

98770A Test Fixture

The 98770A Test Fixture is used to test the basic display operation when a 9845 mainframe is not available.

With the test fixture, it is possible to align a 98770A without the 9845 mainframe.

Here is a description of the test fixture switch functions:

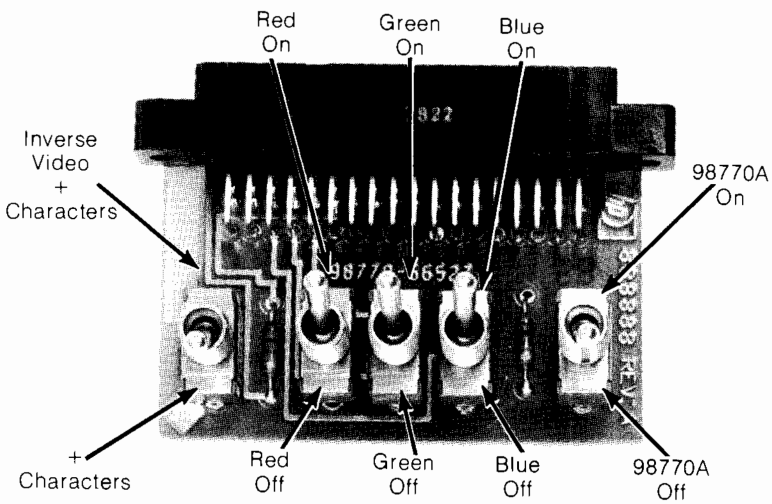


Figure 3-7. Test Fixture Switches

For normal operation, all three colors should be ON and the ON/OFF switch should be in the ON position.

The patterns provided by the left-most switch can be used to aid in alignment.

Installation

Install the test fixture in the left leg of the display with the switches facing the inside as shown in Figure 3-8.

Once the fixture is installed, connect ac power and switch the 98770A on via the test fixture switch.

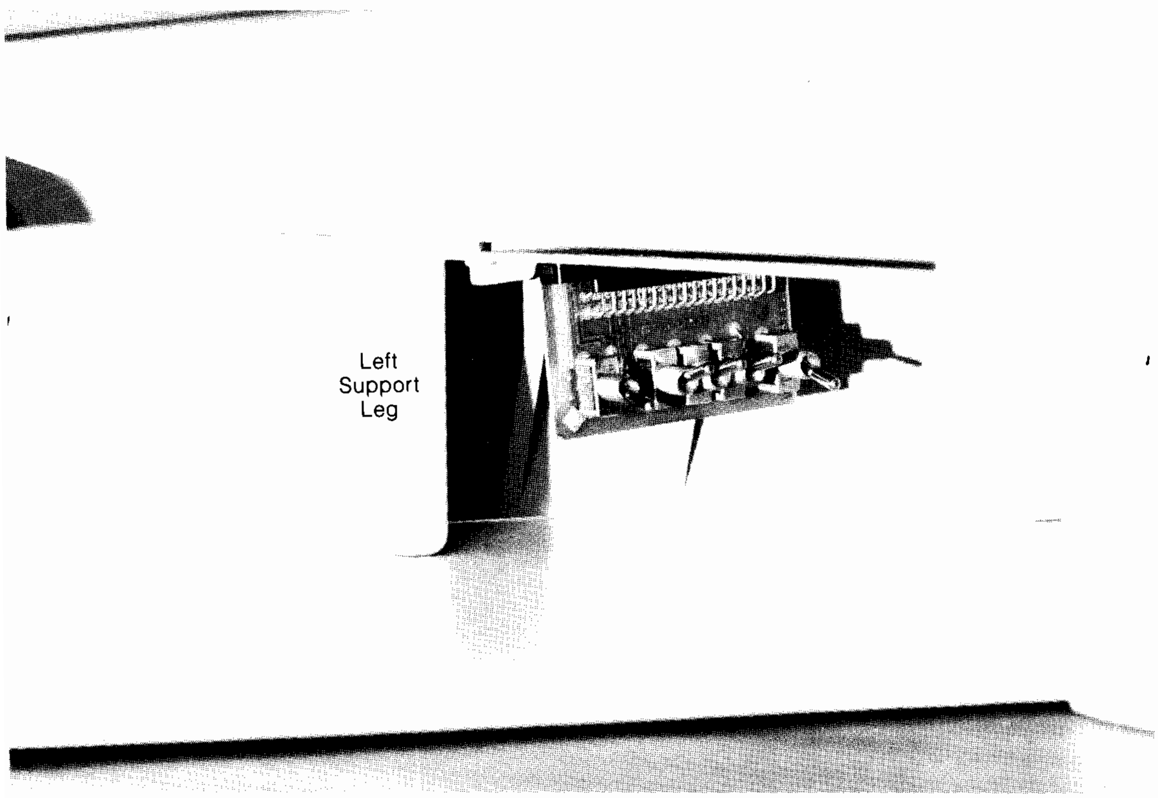


Figure 3-8. Test Fixture Installation

Chapter 4
Alignment Procedures

This chapter includes the procedures to align a 98770A. Besides individual adjustment procedures, this chapter also contains:

- A list of tools required for alignment
- General order in which to perform adjustments if a total alignment is to be done
- What adjustments to do when a particular assembly is replaced

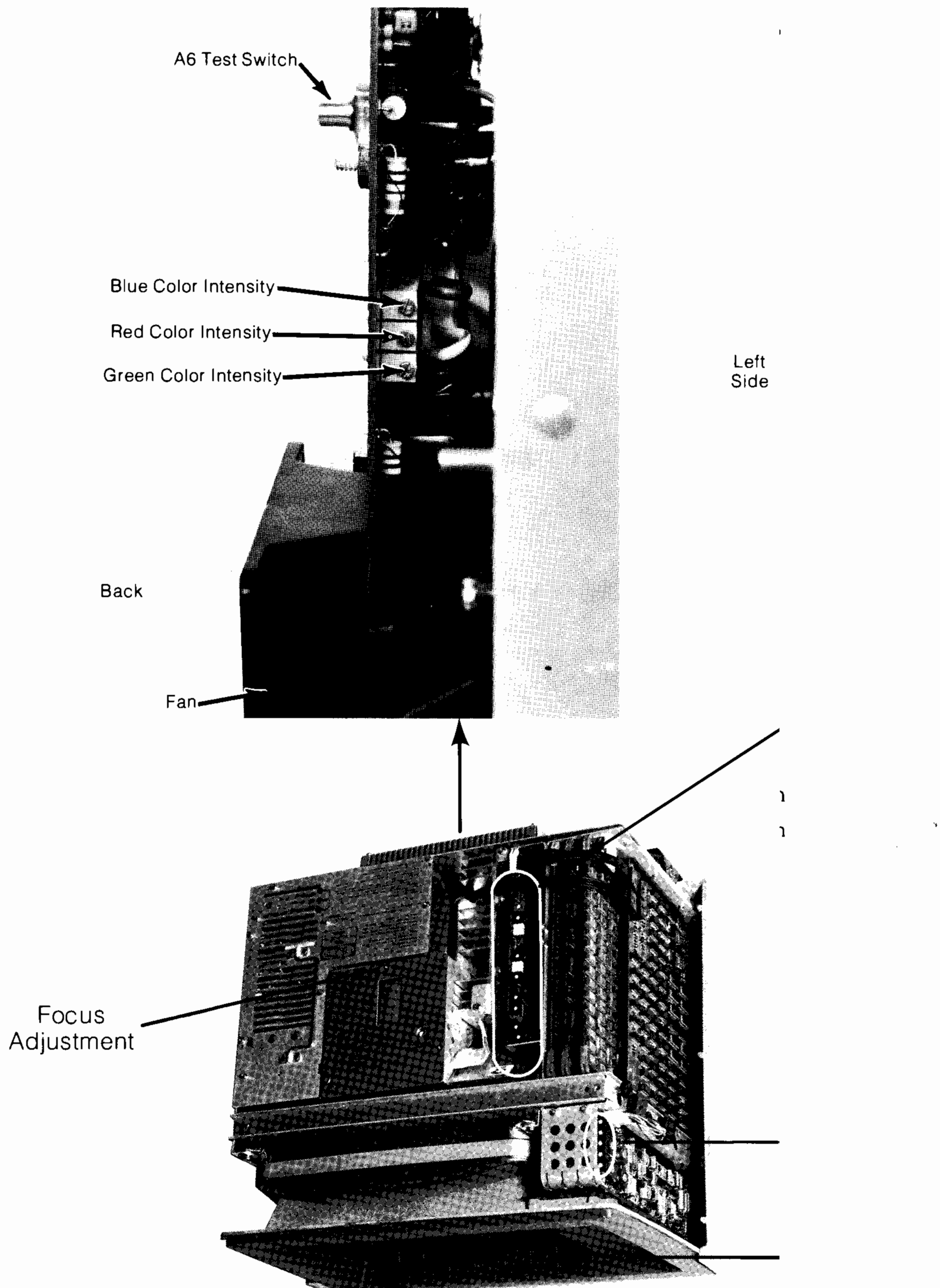
All adjustments (except the color intensity adjustments) can be accessed by removing the top cover.

Tools Required

The following tools are required to align the 98770A:

- #2 Pozidriv Screwdriver (to remove the cover)
- Alignment Mask – (HP Part No. 7120-8549)
- Alignment Tools (non-metallic)
  Recommend HP Part Nos. 8710-0033 and 8710-0933

A6 Adjustments



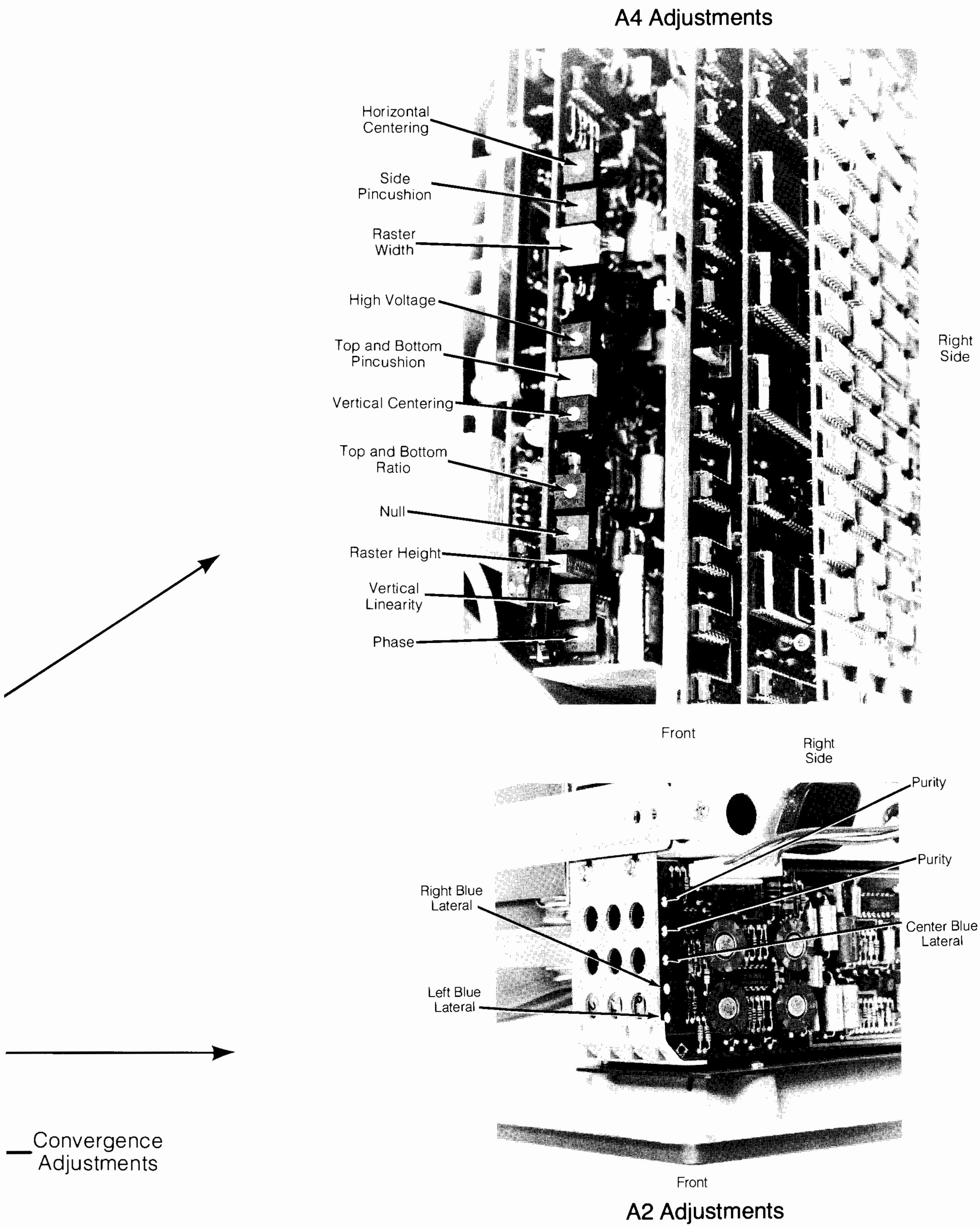


Figure 4-1. Adjustment Locations

Adjustment Summary

Here is a summary of the 98770A adjustments listed in the order in which they would be performed to completely align a 98770A. Complete alignment is required when the CRT/Yoke assembly is replaced.

Adjustment	Page
Preliminary	4-3
High Voltage	4-3
Focus	4-4
Purity	4-5
Color Intensity	4-6
Convergence (Prelim)	4-7
Raster Position	4-8
Raster Size	4-9
Raster Shape	4-9
Vertical Linearity	4-12
Convergence (Final)	4-7

NOTE

Before performing any adjustment, ensure that all the power supply voltages are functioning properly. Refer to Chapter 3 for power supply test points.

When to Adjust

Usually adjustments have to be done only when the assembly, on which the adjustments are located, has been replaced. There are some exceptions which are included below. Some of the adjustments are interactive with other adjustments which may have already been performed.

Here is a list of the assemblies and the adjustments to be performed when the assembly is replaced.

Assembly Replaced	Start at (and perform all subsequent steps in the preceding list)
CRT/Yoke	Preliminary Adjustments
High Voltage Unit	High Voltage
98770-66502	Purity
98770-66503	Convergence (Final)
98770-66506	Color Intensity
98770-66544	High Voltage

Preliminary Adjustment

Use this adjustment procedure when adjusting a badly misaligned unit, or one in which the CRT/Yoke assembly has been replaced.

Procedure

1. Set the switch on the A13, A33, A53, or A54 assembly to its forward (red raster) position.
2. Turn the High Voltage control (A44) fully CCW for maximum high voltage.
3. Adjust the Brightness control CW for a visible raster. If none appears, adjust the Red Intensity control (A6) until a raster appears.
4. Depress the A6 test switch and adjust the Focus control for the sharpest retrace lines.
5. Adjust the A2 Purity controls for an even red color throughout the raster.
6. Adjust the A44 Height, Width, Vertical Centering, and Horizontal Centering so all raster edges are at least 1 cm. inside the screen edges. Touch-up the A2 Purity controls if necessary for optimum purity.
7. Perform a preliminary Color Intensity adjustment per the procedure on page 4-6.

Note

If the A6 video drive assembly has been changed, perform a preliminary color intensity adjustment before proceeding.

Procedure

1. Set the switch on the A13, A33, A53 or A54 assembly to its read (white raster) position.
2. Set the brightness control to maximum.
3. Turn the High Voltage adjustment (A44) fully CCW for maximum high voltage.
4. Turn the High Voltage adjustment CW until the raster increases in width by approximately .5 cm on each side.

Focus

Use this adjustment (High Voltage Unit) to set the CRT focus grid voltage to a value which gives the best overall character focus.

WARNING

USE A NON-CONDUCTIVE ALIGNMENT TOOL WHEN ADJUSTING THE FOCUS CONTROL.

Procedure

1. Set the switch on the A13, A33, A53 or A54 digital assembly to its center position.
2. Use the 9845B/C binary test cartridge (Rev. B or newer) to display the focus pattern. (Refer to Chapter 3.)
3. Turn the focus control to achieve the best overall display focus of the displayed characters.

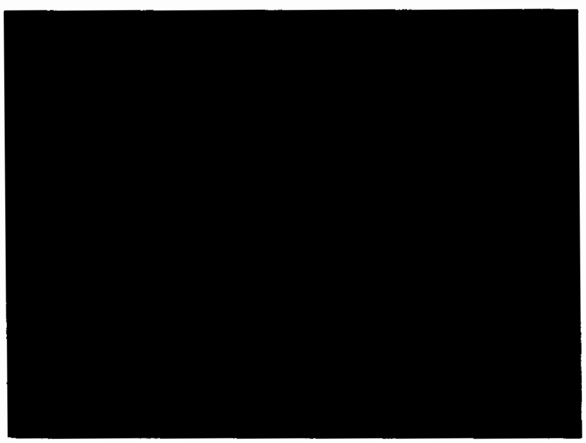
Purity

This adjustment varies the current in the purity coils so that the beam from the red electron gun strikes only the red phosphor.

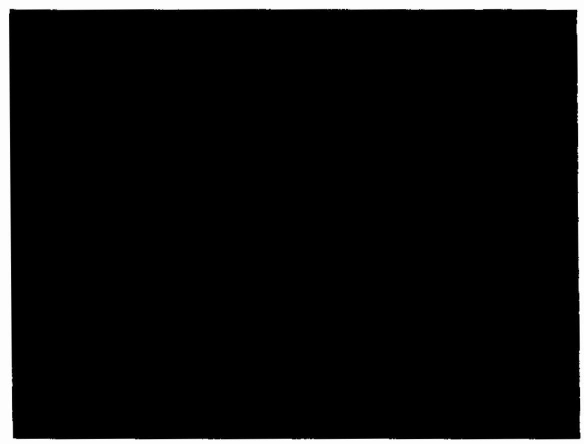
This adjustment is interactive with the Raster Position adjustment, and affects convergence.

Procedure

1. Execute "DEGAUSS" from the keyboard. (Exit Test Binary first.)
2. Set the switch on the A13, A33, A53 or A54 digital assembly to its forward position to produce a red raster.
3. Adjust the Brightness control for maximum red intensity.
4. Turn the Vertical and Horizontal Purity controls (A2) to obtain a pure red raster.



Wrong



Correct

Note

If good purity cannot be achieved, decrease the brightness, wait a few minutes, and repeat the purity adjustment procedure. High intensities can overheat and warp the CET shadow mask which will affect purity. This warpage is not permanent and will disappear when the intensity is reduced to a normal level.

---

adjustment should be done prior to convergence.

Set the switch on the A13, A33, A53 or A54 digital assembly to the rear position to display a white raster. Turn the brightness control to the minimum brightness position (full CCW).

Procedure
Perform this procedure in normal room lighting.

WARNING

BEWARE OF THE FANS WHEN MAKING ADJUSTMENTS WITH THE REAR PLASTIC COVER REMOVED.

1. Adjust the 3 Color Intensity controls (A6) until none of the three rasters are visible. (Use an insulated tool ONLY. If necessary, remove the metal shield.)

WARNING

THIS EXPOSES LETHAL VOLTAGES PRESENT ON THE 06 ASSEMBLY.

2. Adjust the Green Color Intensity control clockwise to produce a dim, but entirely visible green raster. Turn this control 1/3 turn more CW from this setting.
3. Adjust the Red and Blue Color Intensity controls to cause the raster to appear gray and very slightly increased in brightness from step #2.
4. Turn the brightness control slowly toward maximum brightness, looking for any dominant color or tint appearing as the raster changes from gray to white.
5. Adjust the appropriate Color Intensity control to minimize any objectional color tinting over the brightness range from gray to white. Disregard tinting in small areas which may be related to misconvergence or less-than-perfect purity.

Convergence

This adjustment converges the red, green and blue electron beams so that as the beams scan across the display area all beams scan in unison as one dot.

Set the switch on the A13, A33, A53 or A54 digital assembly to its center position (Normal position).

Procedure

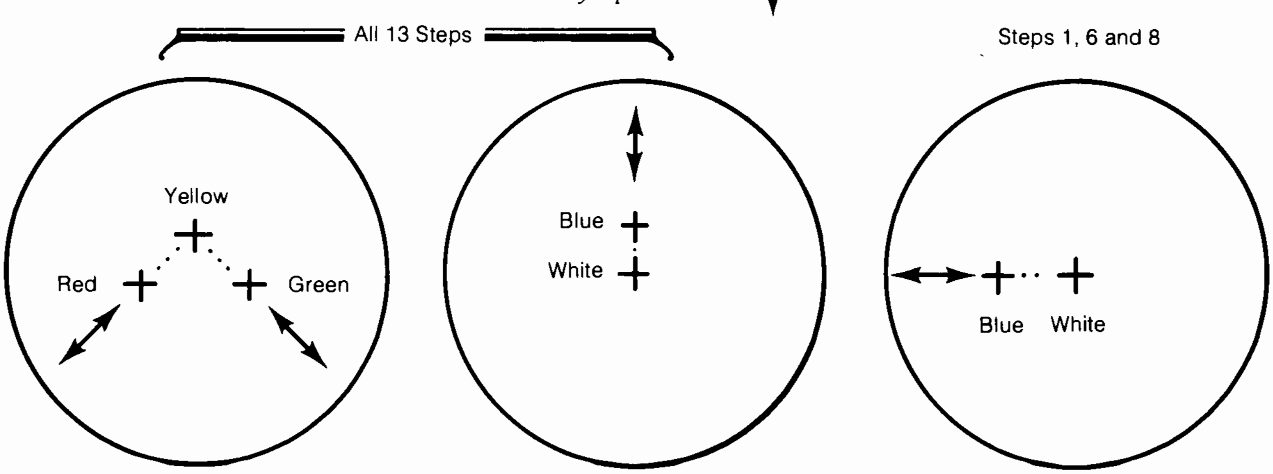
1. From the keyboard, type in CONVERGE and press execute.
2. A "+" character will appear on the screen along with a number on the right-hand side.
   - The "+" character is used to converge the three beams in the area that the "+" appears.
   - The number on the right-hand side indicates the step number (13 total) and it appears directly opposite the convergence controls used for that step.
3. On all 13 convergence steps,
   a. converge the red and green "+" to make yellow.
   b. converge the blue "+" to make white.
   c. press CONTINUE to proceed with the next step.
4. On steps 1, 6 and 8, you may have to adjust the blue A2 blue lateral adjustments.

   If the blue is to either side of the converged +, use the appropriate blue lateral adjustment to center the blue + horizontally on the converged red and green +.

   On step 1 adjust the center blue lateral
   On step 6 adjust the left blue lateral
   On step 8 adjust the right blue lateral

   Example

   Red moves along an upper right to lower left line
   Green moves along an upper left to lower right line
   Blue moves vertically up and down



A
Converge Red and Green
to Make Yellow

B
Converge Blue
to Make White

Use Blue Lateral to
Move Blue Left or
Right as Necessary

Raster Position

Two adjustments, horizontal and vertical centering are used to position the raster in the center of the CRT screen.

The raster position adjustments are interactive with and affected by:

- Raster Size adjustments
- Raster Shape adjustments
- Purity adjustment

These adjustments should be performed after the initial raster position adjustment; then, recheck the raster position and readjust as necessary.

Set the switch on the A13, A33, A53 or A54 digital assembly to the rear to display a full white alpha raster. Install the CRT alignment mask.

Procedure

1. Center the raster horizontally with the horizontal center control.
2. Center the raster vertically with the vertical center control.
3. Touch up convergence as necessary (See CONVERGENCE, page 4-7).
4. Check and perform, if necessary, the raster size, raster shape and purity adjustments.

Raster Size

Two adjustments, raster width and raster height are used to dimension the raster to the proper size.

You may have to readjust the raster position slightly after sizing.

Set the switch on the A13, A33, A53 or A54 digital assembly to the rear to display a full white alpha raster. Install the CRT alignment mask.

Procedure

1. Adjust the raster width and height so that the displayed raster is the same size as the alpha raster outline on the alignment mask.
2. Adjust the raster shape and readjust the raster position as necessary.

Raster Shape

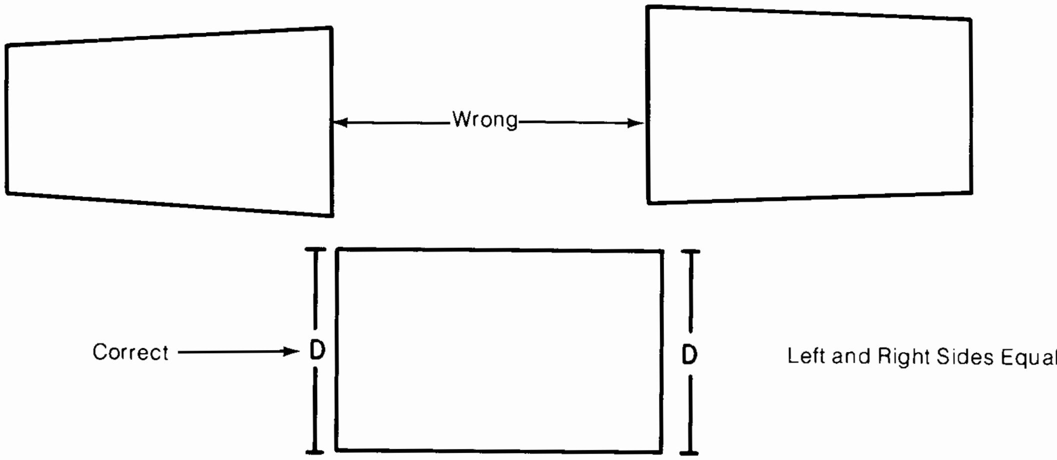
Once the raster is positioned and sized, the raster shape adjustments are used to straighten and proportion the raster sides to obtain a rectangular raster.

The raster shape adjustments interact with each other and may affect the raster size.

Set the switch on the A13, A33, A53 or A54 digital assembly to the rear to display a full white alpha raster. Install the CRT alignment mask.

Procedure

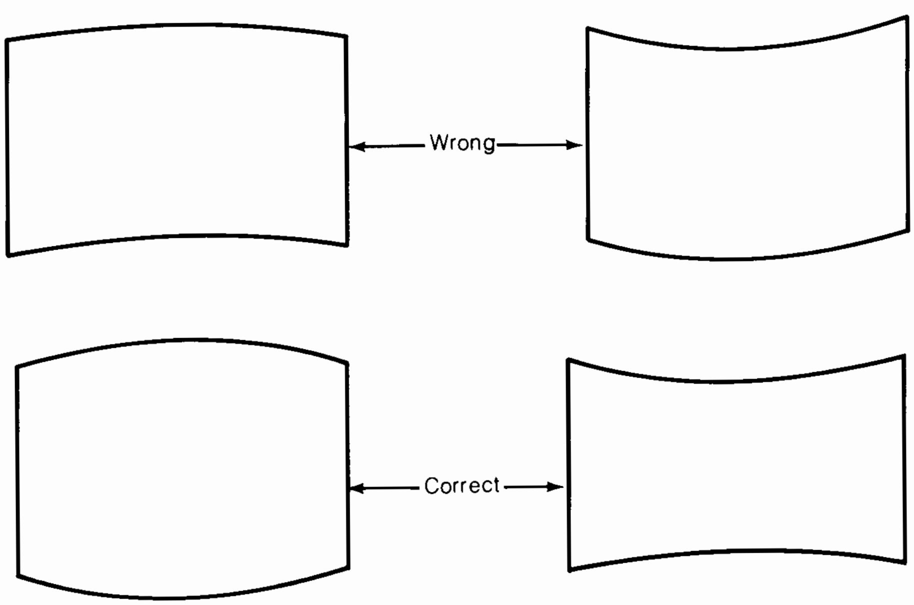
1. Adjust the phase control to make the edges of the raster equal in height.



2. Adjust the top and bottom ratio control to produce an equal but opposite shape on the top and bottom edges of the raster.

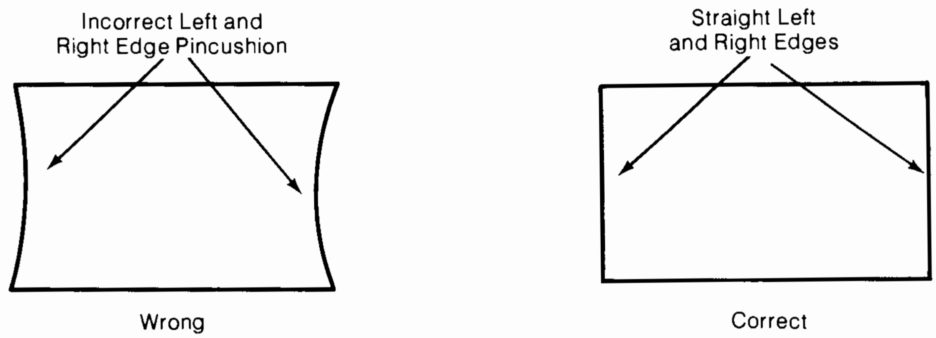
Note

If the raster appears tilted after this adjustment (with the bezel seated evenly), remove the bezel assembly, loosen the four screws securing the CRT assembly, and tilt the CRT assembly as necessary to correct the raster tilt. Recheck tilt after firmly tightening the CRT mounting screws and reseating the bezel and repeat if necessary.

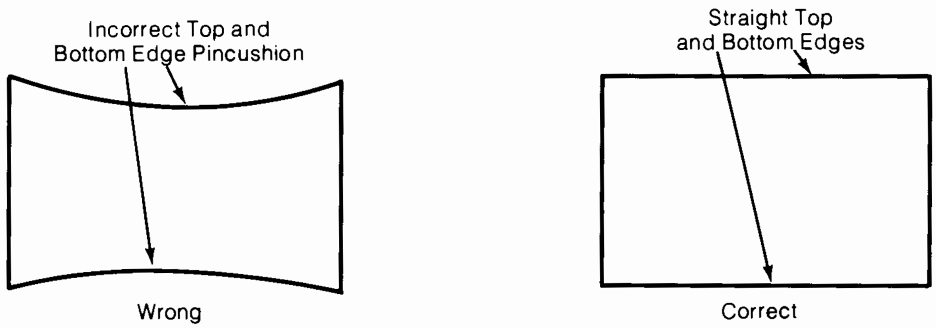


Equal but Opposite Shapes of Top and Bottom Edges

3. Adjust the side pincushion control to straighten the left and right edges of the raster.



4. Adjust the top and bottom pincushion control to straighten the top and bottom edges of the raster.



5. Recheck adjustments made in steps 1 through 4; then recheck the raster size adjustments to see if they have been affected.

Vertical Linearity

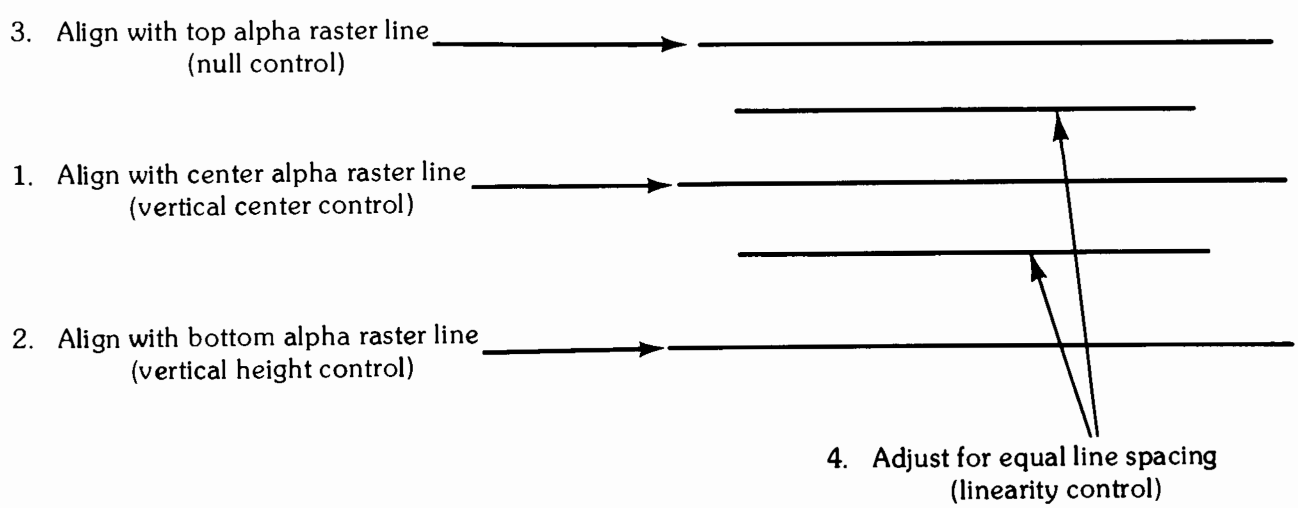
These adjustments remove any areas of compression or expansion in the raster making the raster linear from top to bottom. Poor linearity can be seen when characters in some areas of the display are either stretched larger or compressed smaller than normal height.

This adjustment affects the vertical raster size. Recheck the raster's vertical size after adjusting.

Use the 9845B/C binary test cartridge (Rev. B) to display the linearity pattern.

Procedure

1. Install the CRT alignment mask.
2. Align the center line of the display with the center line on the alignment mask. Readjust the vertical center control as necessary.
3. Align the bottom line of the display with the bottom line on the alignment mask. Readjust the raster vertical height control as necessary.
4. Adjust the null control to align the top line of the display with the top line on the alignment mask.
5. Adjust the linearity control to obtain equal spacing between the horizontal line in the areas between the Top, Center and Bottom lines.
6. Press "F" to display the FOCUS pattern. Readjust NULL and VERTICAL LINEARITY as necessary for even character height throughout the pattern. Readjust HEIGHT if necessary.



Final Convergence

As the previous adjustments may have affected convergence slightly, a final convergence adjustment should be made at this time.

Procedure

1. Perform the convergence procedure found on page 4-7.

Chapter 5
Assembly Access

Introduction

This chapter identifies the major 98770A assemblies and gives procedures to disassemble the 98770A.

The following tools are required to disassemble the display:

- #1 Pozi-driv screwdriver
- #2 Pozi-driv screwdriver
- Flat-blade screwdriver
- Needle-nose pliers
- 7 mm wrench or "spin-tight"

WARNING

THE 98770A IS HEAVY (29.45 KILOGRAMS OR 65 POUNDS). TO AVOID DAMAGE TO EQUIPMENT OR POSSIBLE PERSONAL INJURY, IT IS RECOMMENDED THAT THE 98770A SHOULD ALWAYS BE LIFTED BY TWO PEOPLE (SEE FIGURE 1-2).

WARNING

REMOVE ANY AC POWER FROM THE DISPLAY BEFORE REMOVING ANY ASSEMBLY.

CAUTION

THE 98770A RESTS ON THE MAINFRAME TOP COVER. IT IS NOT LOCKED INTO PLACE. DO NOT PLACE THE 9845C ON ITS REAR PANEL WITHOUT FIRST REMOVING THE 98770A.

Assemblies Under the Top Cover

Most of the 98770A assemblies can be accessed by removing the top cover.

To remove the top cover, remove the four screws on the top cover shown in Figure 5-1 and lift the top cover from the display.

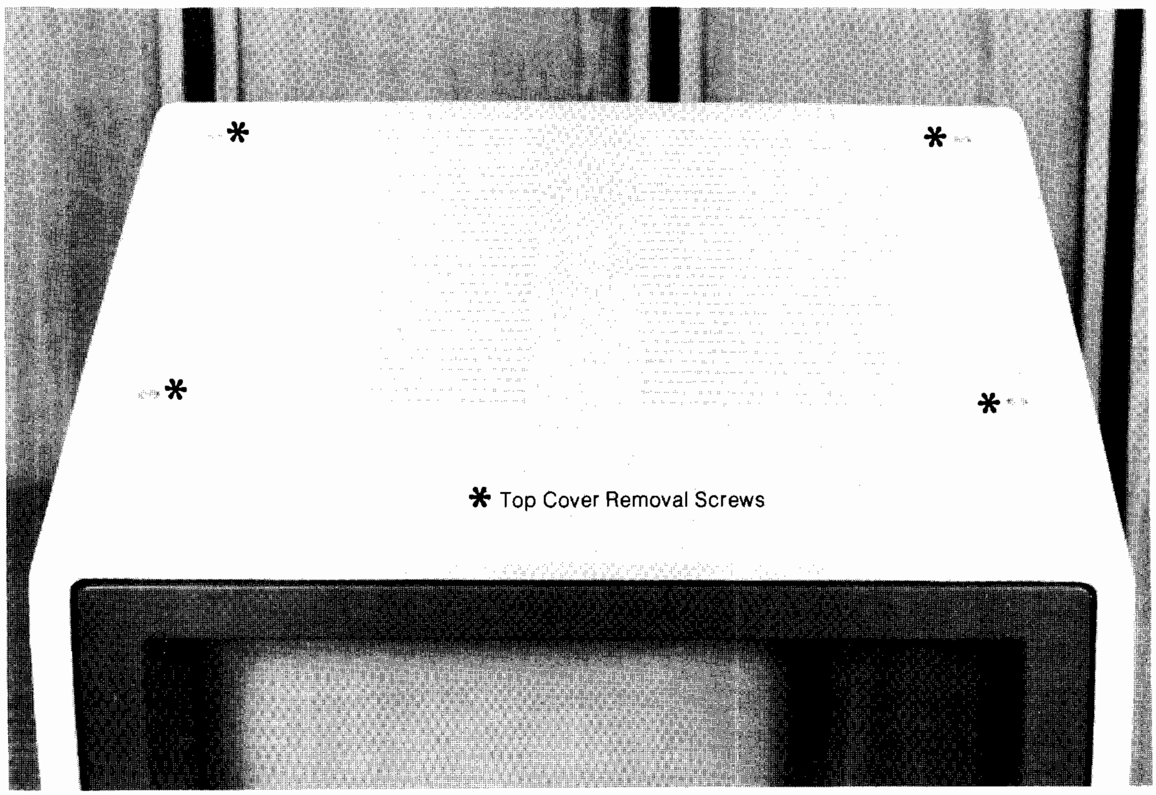


Figure 5-1. Top Cover Removal Screws

Figure 5-2 identifies the major assemblies under the top cover.

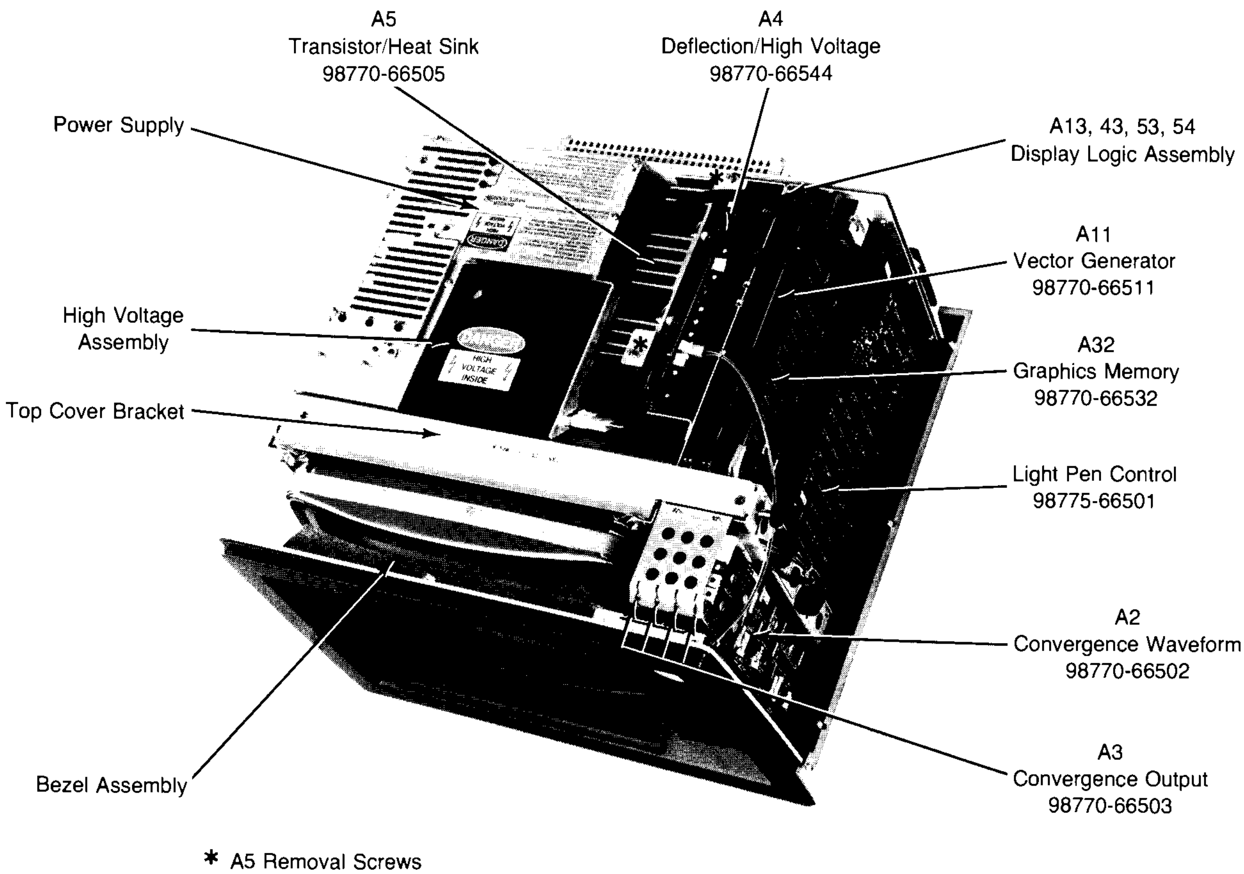


Figure 5-2. Assemblies Under the Top Cover

CAUTION

FOR SUPPLY REMOVAL FOLLOW INFORMATION ON TOP COVER.

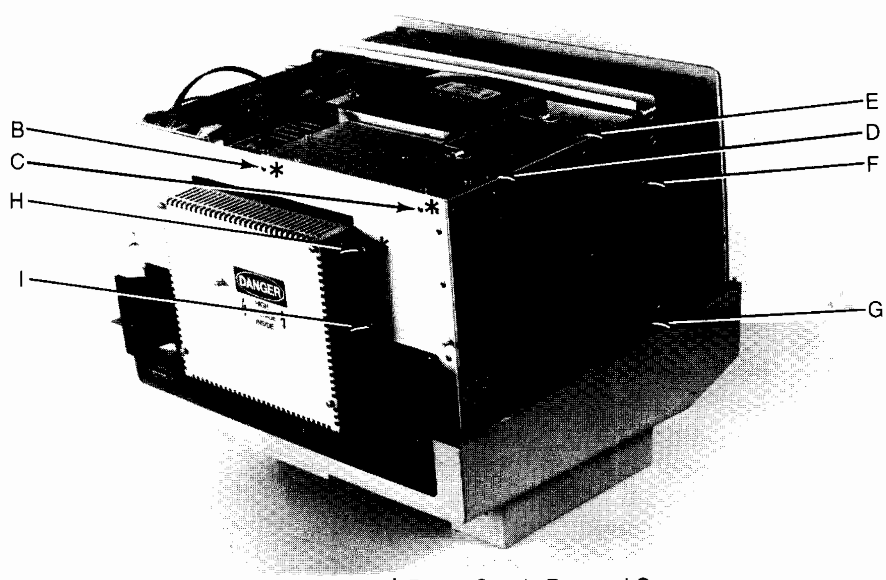
Power Supply Removal

CAUTION

ALWAYS DISCONNECT LINE CORD BEFORE REMOVING THE POWER SUPPLY AND DO NOT RECONNECT WITHOUT A POWER SUPPLY IN PLACE.

Remove the screws shown in Figure 5-3 that hold the power supply to the display chassis. Grasp the power supply handle and pull up to remove the supply.

When re-installing the supply, ensure that the guides on the power supply and the chassis are aligned. Press down gently on the top of the supply to seat the connectors.



* Power Supply Removal Screws

Figure 5-3. Power Supply Removal Screws

High Voltage Assembly Removal

- Remove the high voltage cover .

CAUTION

DO NOT TOUCH ANODE SOCKED IN TUBE. TUBE CAN CHARGE UP TO HIGH POTENTIALS WHILE DISCONNECTED AND CAUSE SEVERE ELECTRICAL SHOCK.

- Remove focus and ground leads (see Figure 5-4).
- Remove the anode connector by pressing down and then moving the connector to one side to release one side of the connector (see Figure 5-5). Tip the connector to the side to release the connector.

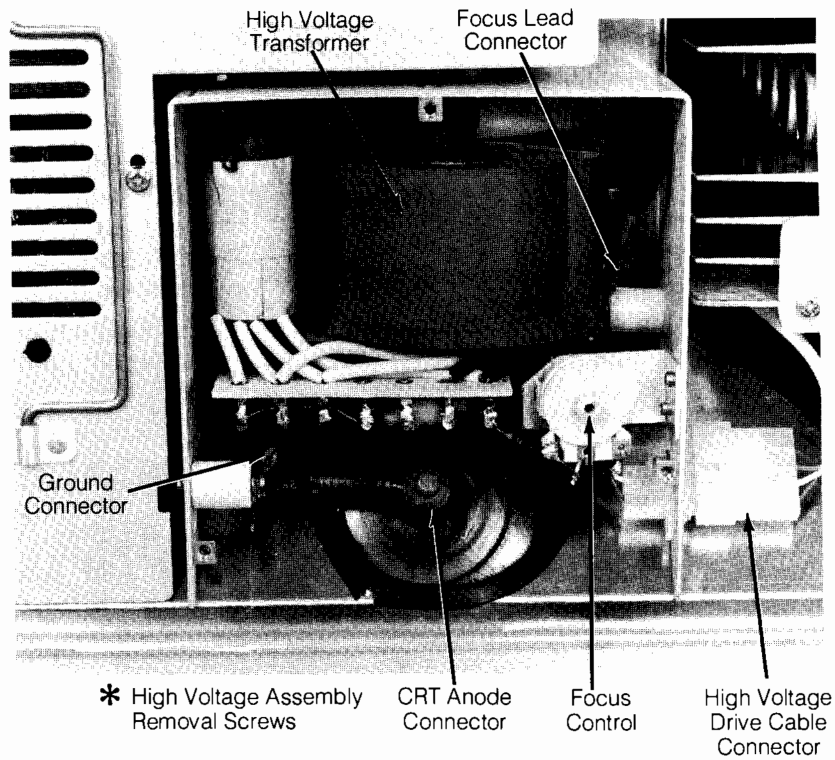
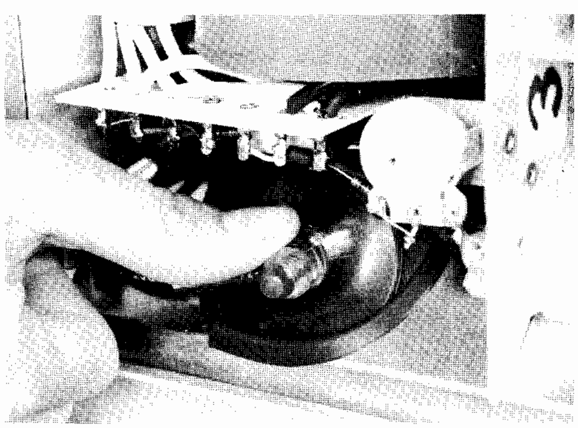


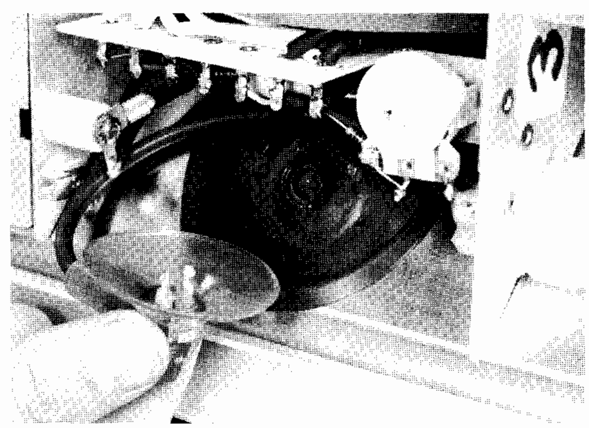
Figure 5-4. High Voltage Assembly Components

Press the Anode Cable Connector In and to the Side.



A

Tip the Connector to the Side to Release it From the CRT.



B

Figure 5-5. Anode Connector Removal

- Disconnect the high voltage drive cable connector (see Figure 5-4).
- Remove the three screws holding the high voltage assembly to the CRT shield and remove the high voltage assembly.

CAUTION

DISCONNECT LINE CORD BEFORE REMOVING THE A5/HEAT SINK ASSEMBLY.

A5/Heat Sink Assembly

- Remove the two screws that hold the A5 assembly to the chassis.
- Slowly lift the A5/Heat Sink assembly to remove it.

A2, A3 Assemblies

- Remove the cover from the A2 and A3 assemblies.
- Pull up on the assemblies to remove them.

NOTE

Each A3 assembly is aligned in a specific location. Be sure to re-install the assemblies in their original locations.

Other Printed Circuit Assemblies

Remove the A44, A11, A32, A13 (A33, A53 or A54) and the light pen PC assembly by first removing the hold down strap, then remove the PC assemblies by pressing outwards on the colored PC assembly extractors.

The video cable on the A13, (A33, A53 or A54) assembly and the light pen PC assembly must be disconnected when removing those assemblies.

Slowly lift the PC assembly to remove it from the chassis.

Assemblies On the Rear Panel

The only major assembly on the rear panel is the A6 assembly. To access this assembly, use this procedure:

- Remove the two nuts (7 mm) that hold the plastic rear cover to the chassis and remove the cover.
- Remove the four screws from the metal housing on the rear panel.
- Remove the metal housing and disconnect the connectors shown in Figure 5-6 to remove the A6 assembly.

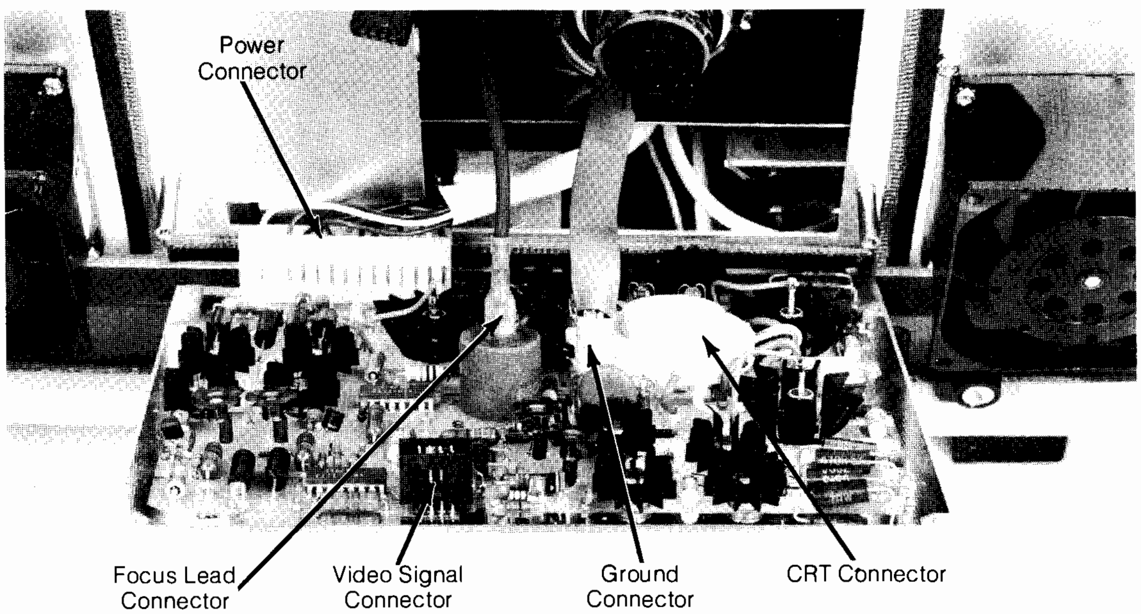


Figure 5-6. A6 Connections

Front Bezel

To remove the front bezel, first remove the top cover, then;

- Lift the right side of the bezel up until movement becomes difficult (see Figure 5-7).
- Pull out (to the right) on the forward right corner of the base cover.
- Continue to move right side of the bezel up and forward until it is free of the slot in the base cover.

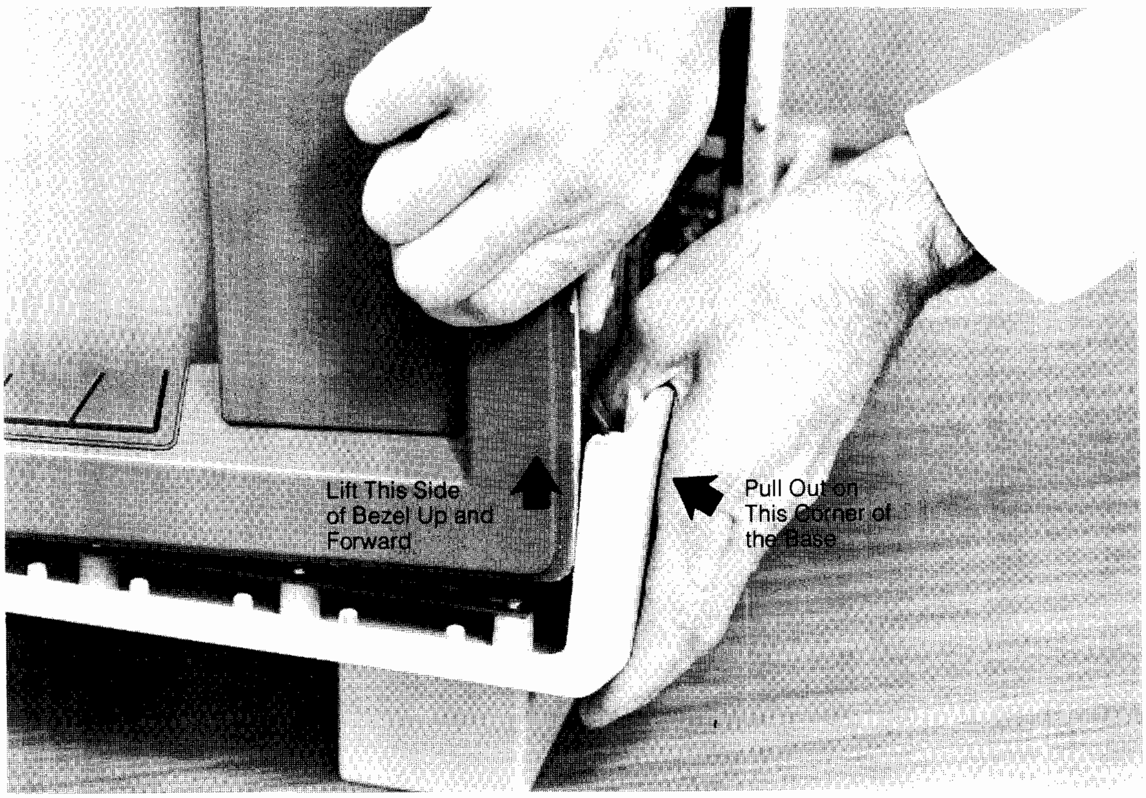


Figure 5-7. Bezel Removal

- Disconnect the cable to the soft keys (A24 assembly) and remove the bezel.

CRT Assembly Removal

The CRT assembly consists of the CRT, its yokes and the metal shield around it. This whole unit or assembly is exchanged as one assembly. Do not separate the shield from the CRT.

Use this procedure to remove the CRT assembly.

- Remove the top cover and the rear cover.
- Remove the A6 assembly from the rear panel.
- Remove the A5 assembly.
- Remove the power supply assembly.
- Remove the high voltage assembly.
- Remove the front bezel.
- Remove the metal strip (used to hold the top cover on) from the top of the CRT (see top cover bracket in Figure 5-8).
- Remove the two screws on either side of the 98770A that hold the CRT assembly to the chassis (refer to Figure 5-8).

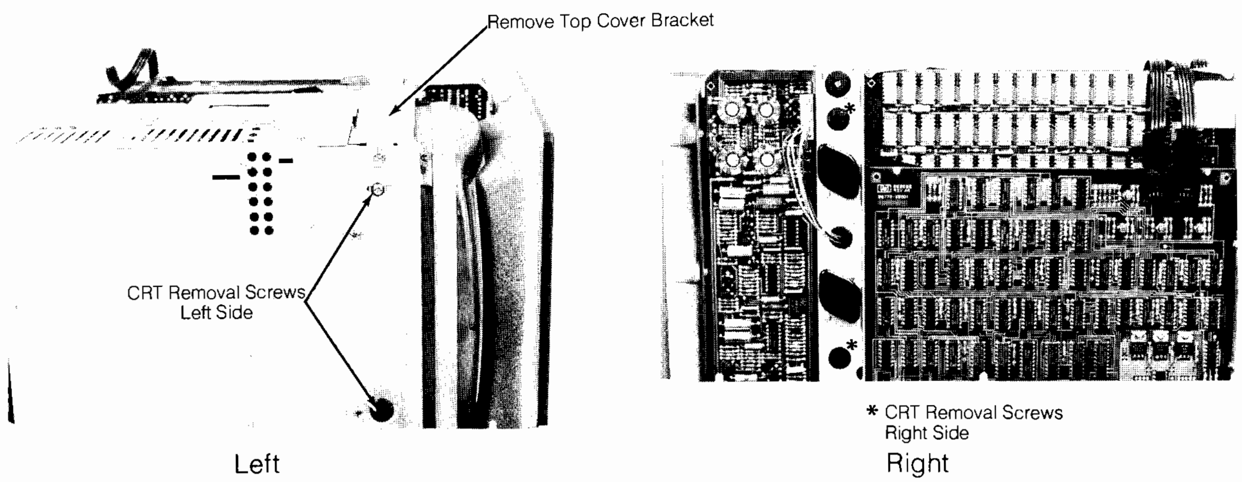


Figure 5-8. CRT Assembly Removal Screws

- Tilt the top of the CRT assembly forward and disconnect the yoke cables, grounding strap and degauss connector shown in Figure 5-9.

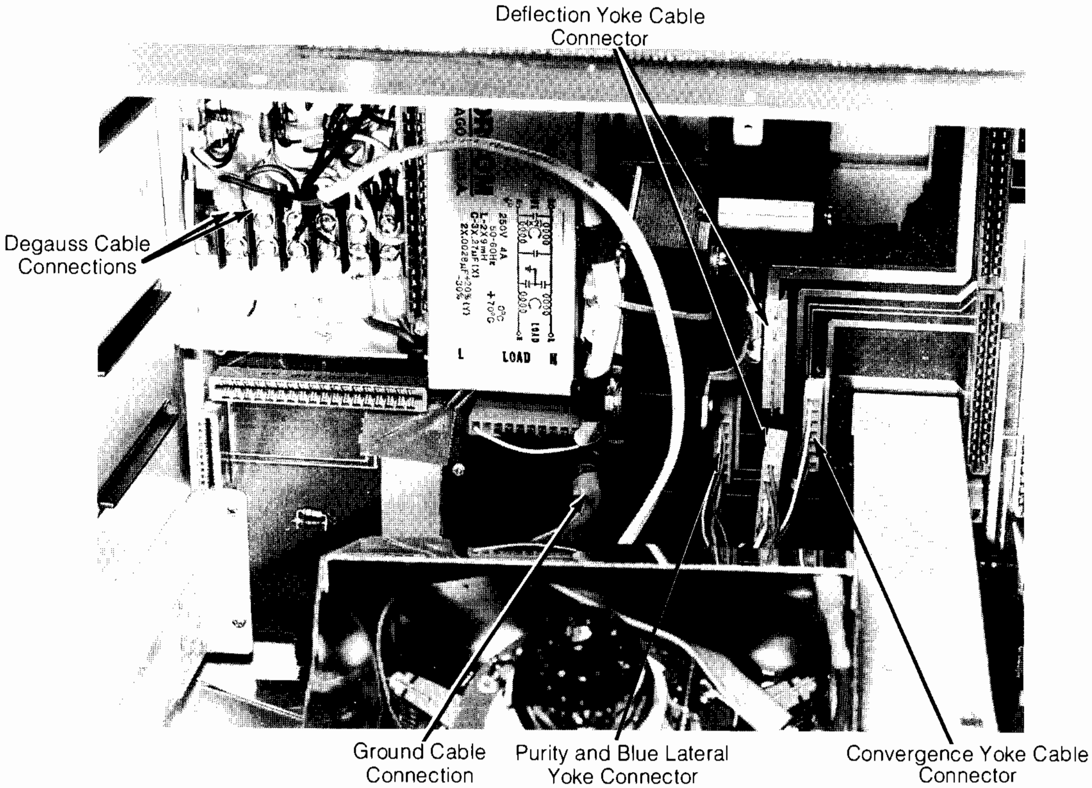


Figure 5-9. CRT/Yoke Cables

- Lift the CRT assembly from the display chassis.

CRT Safety

The CRT assembly should be handled with care to avoid breakage and possible implosion of the CRT.

Implosion

The CRT can implode if it is dropped, hit by a tool or other object, or subjected to stress exceeding the glass strength. The most critical area on the CRT is the funnel area. A break in this area will almost always result in an implosion.

Here is a list of precautions that should be followed when handling the CRT assembly.

1. The CRT acts as a big capacitor when the computer is turned off. Always allow 10 minutes for the CRT to discharge before you touch or remove the anode connector.
2. Always wear safety glasses.
3. Use a protective shop jacket or coat.
4. Use a rubber mat or carpet on the floor in the working area to reduce the possibility of breakage if the CRT is dropped.
5. When the CRT assembly is removed from the display chassis, place it down on its shield as shown in Figure 5-10.

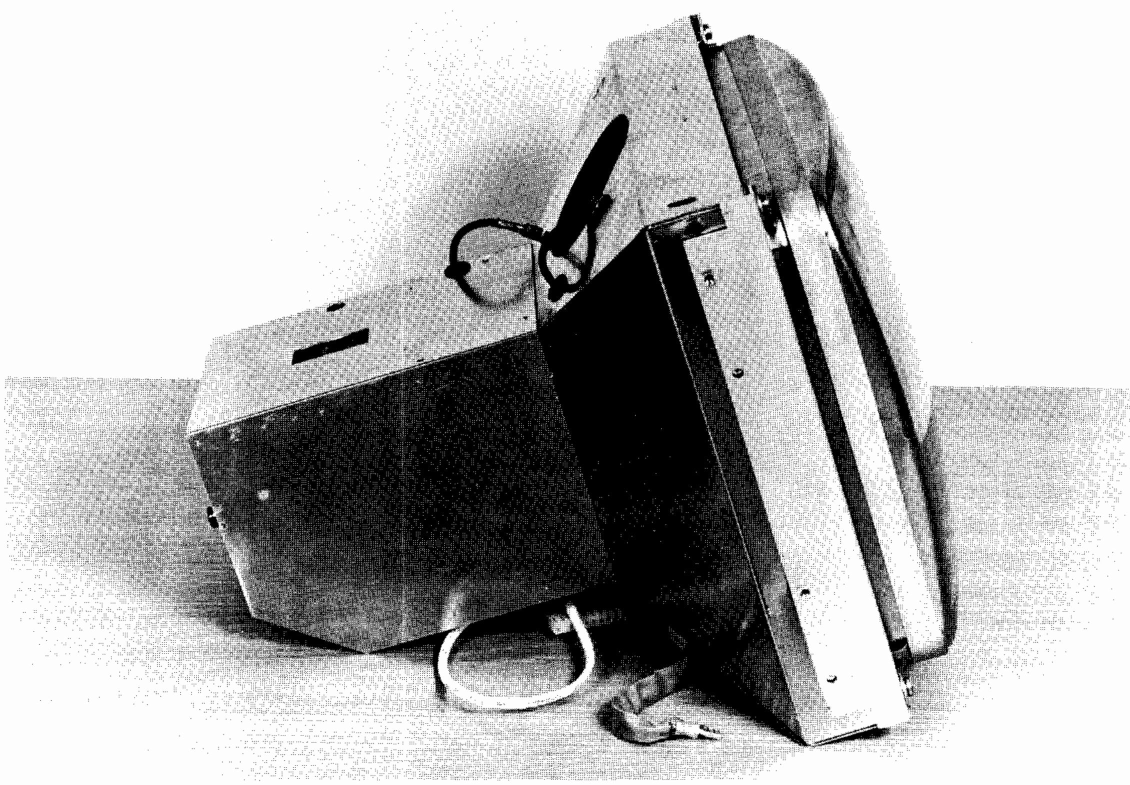


Figure 5-10. CRT Assembly Storage Position

6. When storing the CRT assembly put it someplace where it can't fall or be bumped.
7. The CRT can become recharged any time the anode connector is removed. Always ground the anode to the shield before touching the anode.

Chassis Assemblies

Several assemblies are located on the display's bottom chassis. These assemblies can be accessed after the power supply, CRT assembly and the various PC assemblies have been removed. Figure 5-11 identifies the assemblies located on the bottom chassis.

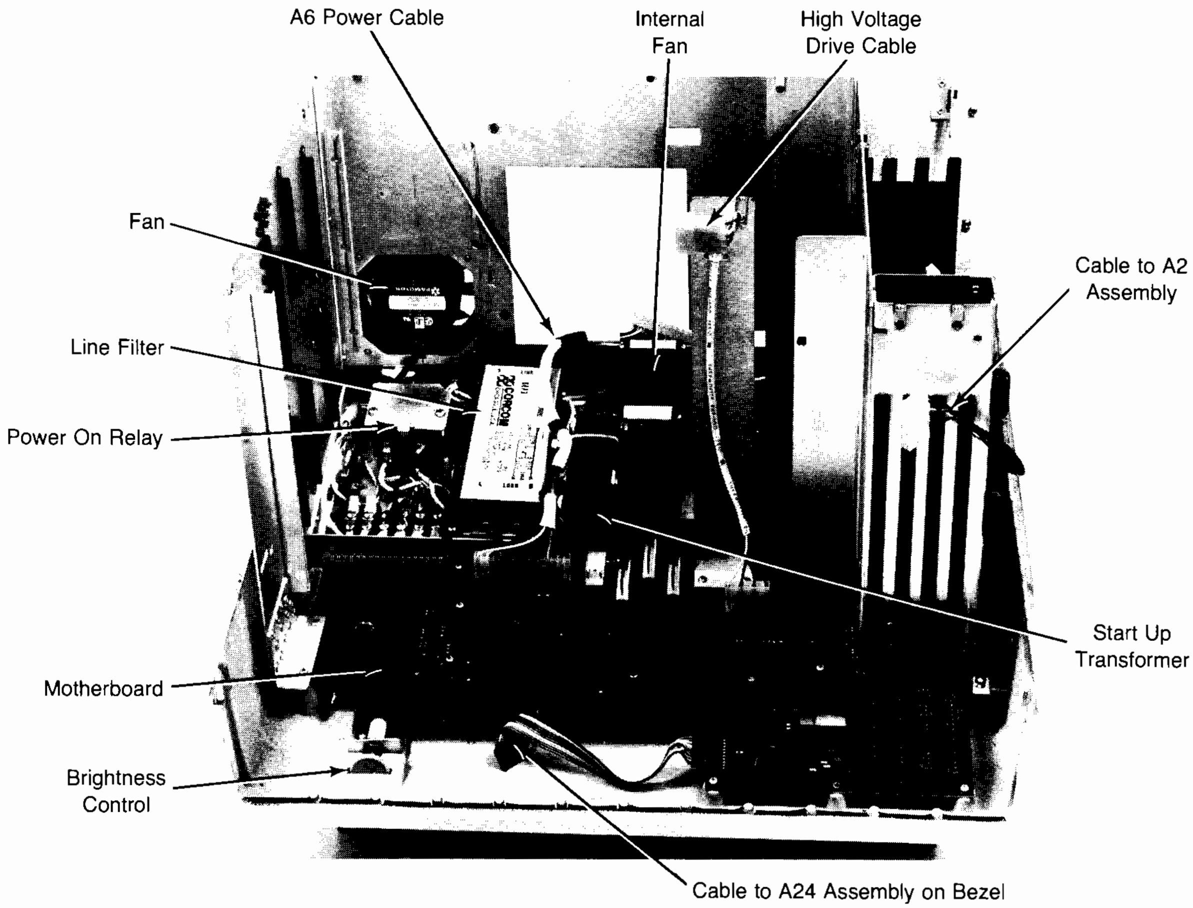


Figure 5-11. Chassis Assemblies

Chapter 6
Replaceable Parts

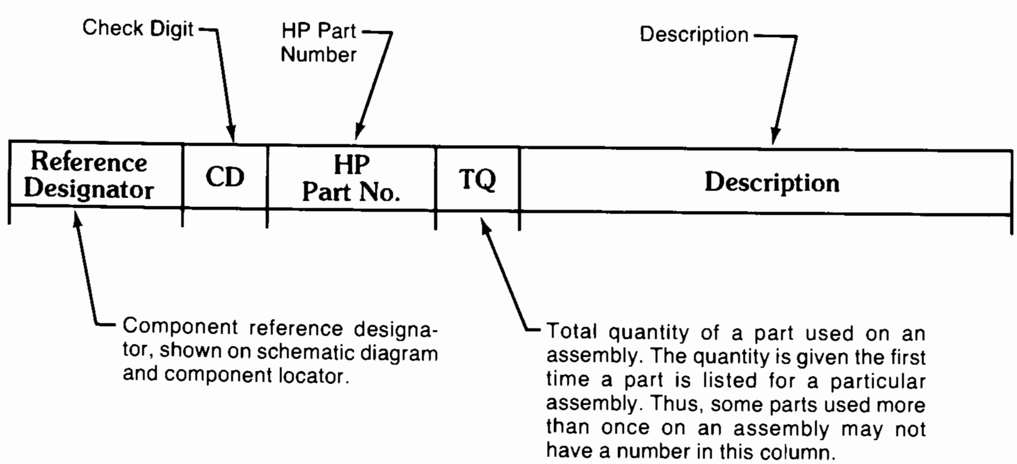
Introduction

This chapter contains part number information for the 98770A and 98775A computers. This information is listed in the following manner.

1. Assemblies
2. Electronic parts by assembly
3. Keyboard and case parts
4. Support package contents
5. Miscellaneous items

The part number information is presented in this manner:

Table 1 lists the replaceable parts. Here is a description of each table column.



Parts may be ordered from Corporate Parts Center. The address is:

Corporate Parts Center
333 Logue Avenue
Mountain View, California 94042

The telephone number is: (415) 968-9200

Table 6-1. Replaceable Parts

Assembly Level	Reference Designator	CD	hp Part No.	TQ	Description
1		1	1600-0907	1	Convergence Bracket
1		4	5041-2388	1	Rear Cover
1		1	7120-7260	1	Information Label
1		5	7122-0058	1	Serial Plate
1		1	8120-2988	1	Ribbon Coax Assembly
1		9	98770-00601	1	Rear Shield Cover for A6
1		8	98770-01202	1	Top Cover Bracket
1		2	98770-01206	1	PC Assembly Hold Down Plate
1		2	98770-04101	1	Right Hand CRT Mounting Bracket With Captive Screws
1		5	98770-64405	1	Top Cover
1	A2	7	98770-66502	1	Convergence Waveform Assembly
2		0	1205-0011	4	Transistor Heat Sink
2		1	2100-3207	2	R-V: 5K, 10%, ½W
2		7	2100-3352	3	R-V: 1K, 10%
1	A3	8	98770-66503	3	Convergence Output Assembly
2		7	1205-0274	1	Heat Sink
2		6	2100-3210	2	R-V: 10K
2		2	2100-3274	13	R-V: 10K, 10%
1	A44	9	98770-66544	1	Deflection/High Voltage Assembly
2		2	1205-0021	1	+12 Heat Sink
2		6	1205-0033	5	Transistor Heat Sink
2		6	2100-3103	1	R-V: 10K, 10%
2		1	2100-3273	1	R-V: 2K, 10%
2		2	2100-3274	4	R-V: 10K, 10%
2		7	2100-3352	2	R-V: 1K, 10%
2		8	2100-3353	3	R-V: 20K, 10%
1	A5	0	98770-66505	1	Transistor/Heat Sink Assembly (See Figure 3-6 for Transistor Part Numbers)
2		4	3103-0077	1	Thermostat
2		2	98770-61101	1	Heat Sink (Large Aluminum)
1	A6	1	98770-66506	1	Video Amplifier Assembly
2		0	1200-0871	1	Tube Socket (CRT)
2		6	1205-0033	12	Transistor Heat Sink
2		0	1205-0037	6	Transistor Heat Sink
2		8	2100-3163	3	R-V: 1M, 20%
2		6	3101-1972	1	A6 Test Switch
1	A11	8	98770-66511	1	Vector Generator Assembly
1	A32	3	98770-66532	1	Graphics Memory Assembly
2		8	1818-0391	48	IC: 16K RAM
1		2	98770-67901	1	High Voltage Assembly
2		9	1600-0947	1	High Voltage Cover
2		2	2100-3852	1	60M Focus Pot
2		8	9100-0485	1	High Voltage Transformer
2		7	98770-61205	1	High Voltage Shield
1		3	98770-67902	1	Base Assembly
2		8	0340-0486	2	Transistor Insulator/Cover
2		9	1853-0059	1	XSTR: 2N3791
2		0	1854-0264	1	XSTR: NPN 2N3715
2		6	7120-8677	1	Error Card
2		7	7120-8678	1	Syntax Card
2		8	7120-8679	1	Graphics Card
2		1	7120-8680	1	Option 03 Error Card
2		2	7120-8681	1	General Information Card
2		1	98770-01205	2	Brackets for Inside Fan
2		4	98770-01208	1	Bracket to Hold A5 Heat Sink
2	A10	3	98770-26510	2	Interconnect Assemblies in Left and Right Feet

Table 6-1. Replaceable Parts (Cont'd.)

Assembly Level	Reference Designator	CD	hp Part No.	TQ	Description
2		1	98770-60201	1	Rear Panel Assembly
3		3	2110-0543	1	Fuse Holder
3		5	2110-0545	1	Fuse Holder Cap
3		7	98770-61601	1	Light Pen Cable Assembly
3		4	0490-1235	1	Power Switch Relay
3		4	2110-0007	1	Fuse, 1A, 250V
3		1	3101-2298	2	Voltage Selector Switch
3		4	9135-0123	1	Line Filter 10EP3
3		7	1251-0334	1	PC Connector, 36-Pin (2 x 18)
3		3	9100-0498	1	60 Hz Transformer (Start-up)
3		0	98770-68501	2	Fan Assembly
2		3	98770-61201	1	Main Bracket Assembly
3		8	98770-61602	1	Upper Transistor Socket and Cable
3		9	98770-61603	1	Lower Transistor Socket and Cable
2		0	98770-61604	1	A24 Cable (from Motherboard to A24)
2		1	98770-61605	1	Intensity Control Assembly
3		9	2100-3833	1	R-V: 250K
3		5	5040-8149	1	Thumb Wheel
2		2	98770-61606	1	High Voltage Power Cable (from Motherboard to HV Assy.)
2		3	98770-61607	1	A6 Power Cable (from Motherboard to A6)
2		1	98770-64401	1	98770A Base
2		2	98770-64402	1	Left Foot Assembly
2		3	98770-64403	1	Right Foot Assembly
2	A1	6	98770-66501	1	Motherboard (see Figure 6-3 for Connector Locations and Part Numbers)
2		0	98770-68501	1	Inside Fan Assembly
1		6	98770-67971	1	CRT/Yoke Assembly
1		7	98770-67980	1	Power Supply
1		0	98770-69301	1	Bezel Assembly
2		2	5041-2386	1	Door
2		9	9164-0119	2	Magnet
2		3	5041-2387	1	Convergence Tool
2	A24	3	98770-66524	1	Keyboard Assembly
1	A34	5	98770-66534	1	Alpha Control Assembly
1	A13, A33	0	98770-66513,33	1	Display Logic Assembly (ASCII Character Set)
1	A54,A54	8	98770-66553,54	1	Display Logic Assembly (Katakana Character Set)
					Light Pen Assemblies
1		1	98775-66501	1	Light Pen Control PC Assembly
2		7	8120-3073	1	Ribbon Coax Assembly
1		1	98775-67971	1	Light Pen Assembly
2		2	5041-3037	1	Nose Cone Assembly
2		3	98775-66503	1	Switch PC Assembly
1		0	98775-67970	1	Light Pen Holder
1		3	98775-67973	1	Light Pen Repair Kit (Includes Nose Cone, Switch PC Assembly and Switch Actuator)
					Unique 9845C Mainframe Parts
1		6	98770-66501	1	Graphics ROM
1		8	1818-1208	1	Block 5 ROM (Low Byte) for A27
1		9	1818-1209	1	Block 5 ROM (High Byte) for A27
1		8	0371-2073	1	K8 Keycap
1		9	0371-2074	1	K9 Keycap
1		0	0371-2075	1	K10 Keycap
1		1	0371-2076	1	K11 Keycap
1		2	0371-2077	1	K12 Keycap
1		3	0371-2078	1	K13 Keycap
1		4	0371-2079	1	K14 Keycap
1		5	0371-2080	1	K15 Keycap

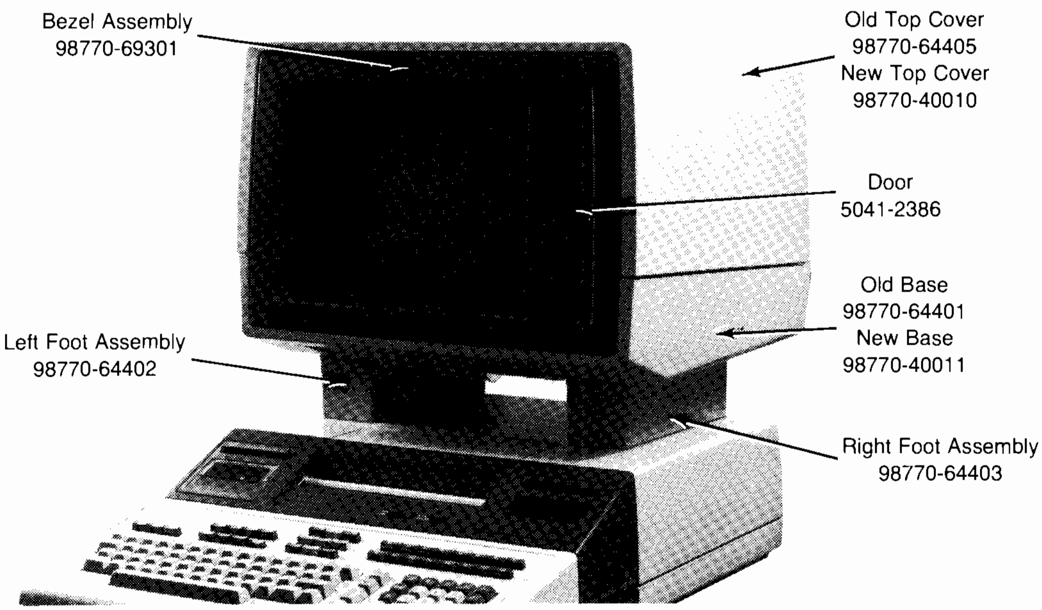


Figure 6-1. Case Parts

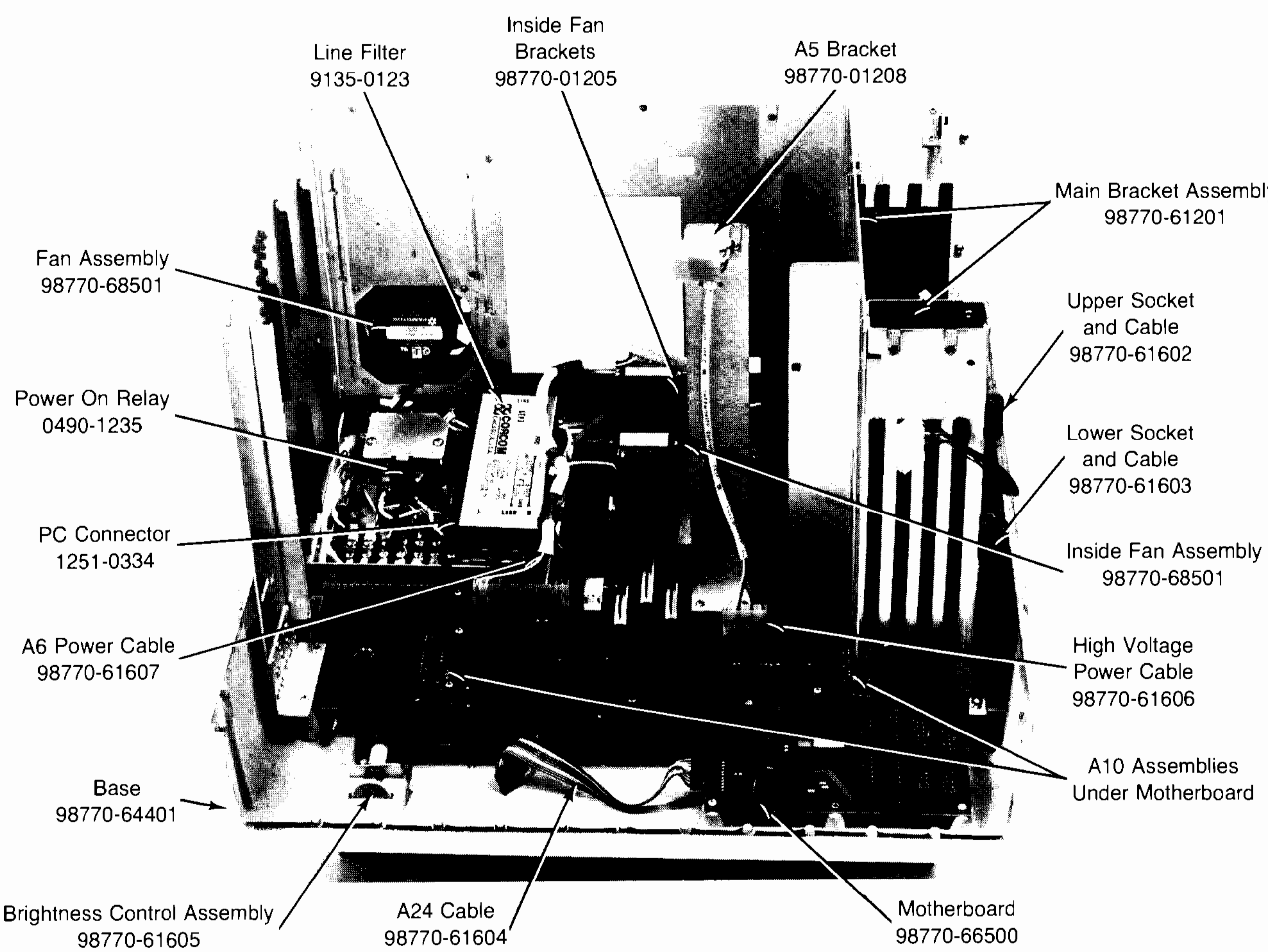


Figure 6-2. Base Assemblies

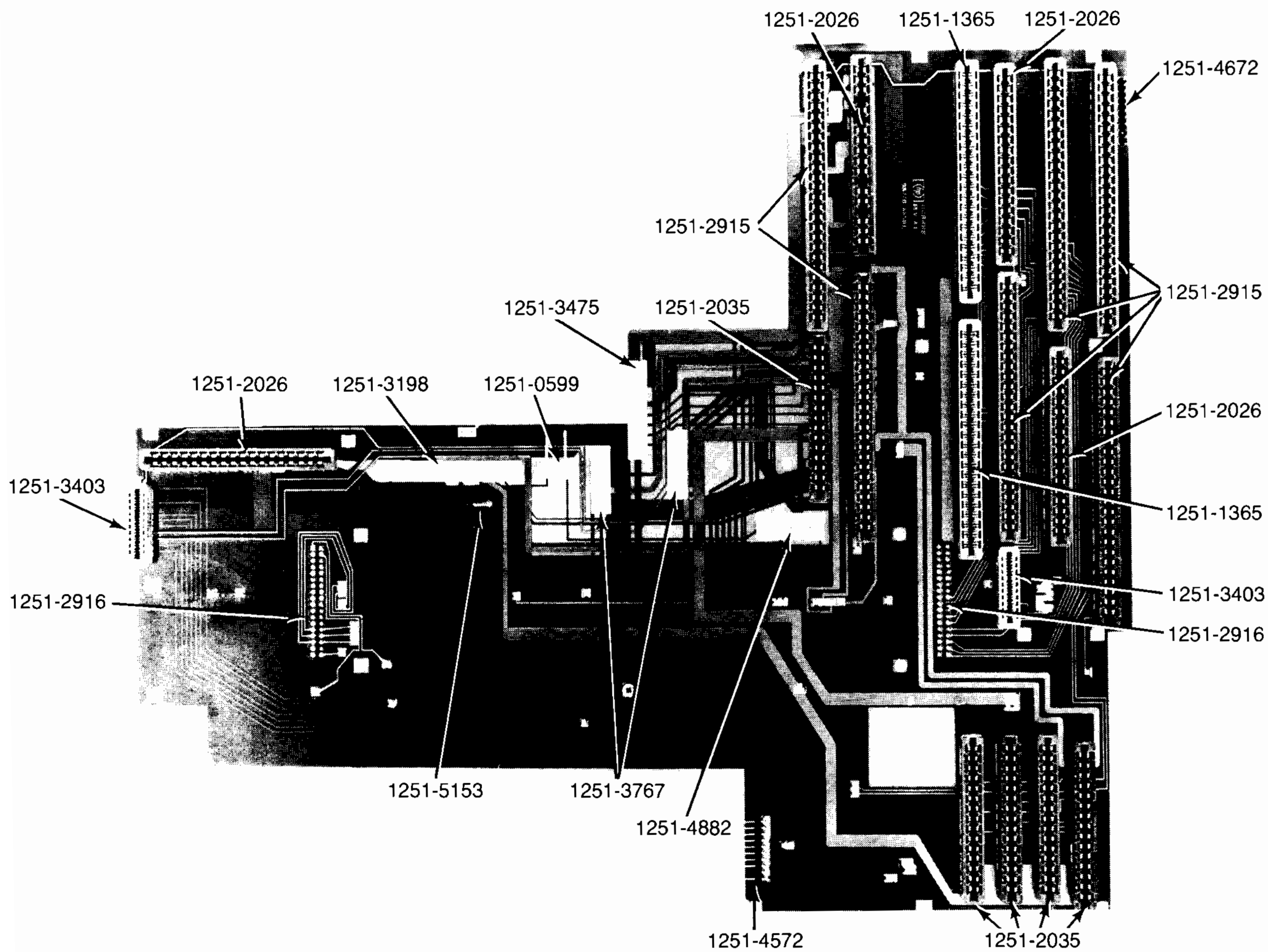


Figure 6-3. Motherboard Connectors

Chapter 7
Light Pen

Introduction

This chapter describes the 98775A, or Option 775, Light Pen. This chapter includes:

- Description
- Specifications
- Installation
- Theory of Operation

Assembly access and replaceable parts information is included in Chapters 5 and 6, respectively.

Description

The 98775A Light Pen can be used in either alphanumeric or graphics modes to return raster scan addresses (points on the screen) to the 9845 mainframe for processing. In graphics mode, a light pen cursor can be moved for the placement of figures or for line drawing.

The major assemblies of the 98775A are the light pen itself, a light pen logic assembly located in the 98770A display and a read-only memory which is part of the 98770-65501 Graphics ROM located in the 9845C LPU ROM drawer.

Specifications

Optics:	Modified double plano convex condensor
Tracking Intensity Range:	20 Footlamberts minimum 70 Footlamberts maximum
Distance from Face of Screen:	0 mm minimum 15 mm maximum
Field of View:	20 picture elements (dots) minimum
Select Code:	The light pen uses select code 13

98775A Installation

Use this procedure to install the 98775A.

- Switch the 9845C off.
- Remove the 98770A display's top cover.
- Install the light pen PC assembly (98775-66501) into the empty PC slot at the right side of the display chassis (see Figure 7-1).
- Disconnect the video cable from the A6 assembly (Figure 7-1) and connect it to the rear connector on the 98775-66501 assembly (Figure 7-2). The other end of this cable remains connected to the A13 (A33, A53 or A54) assembly.
- Connect the new video cable provided in the kit from the A6 assembly (where the original video cable was installed) to the front connector on the 98775-66501 assembly).

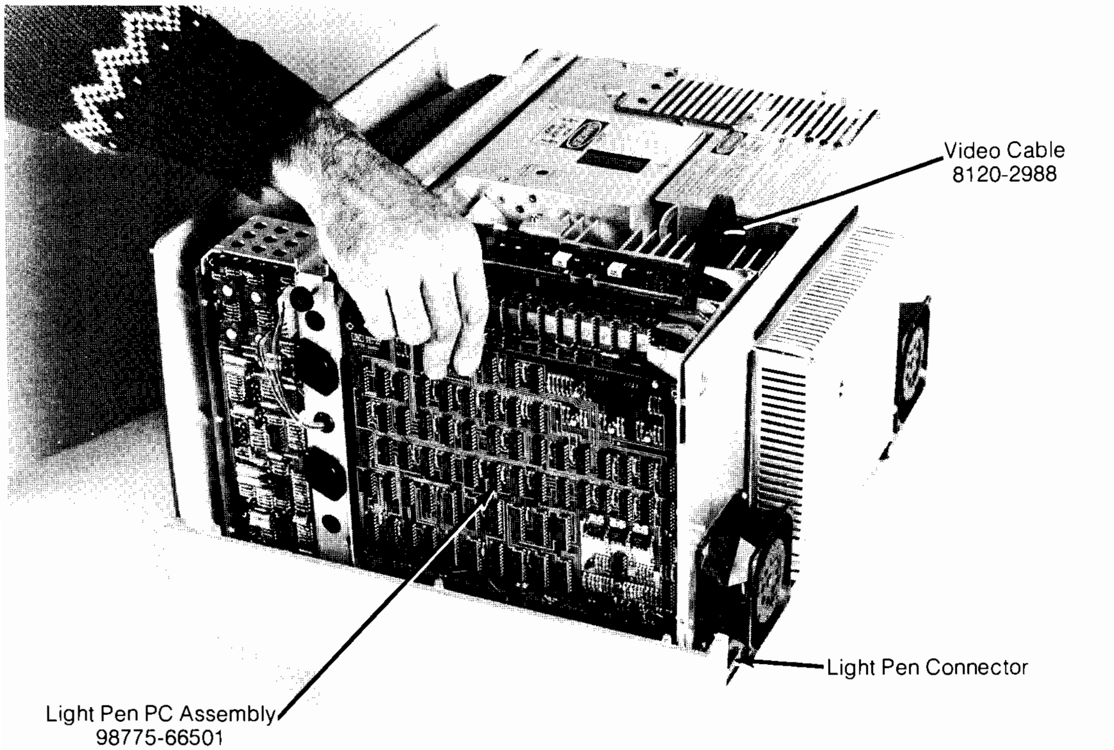


Figure 7-1. Light Pen PC Assembly Installation

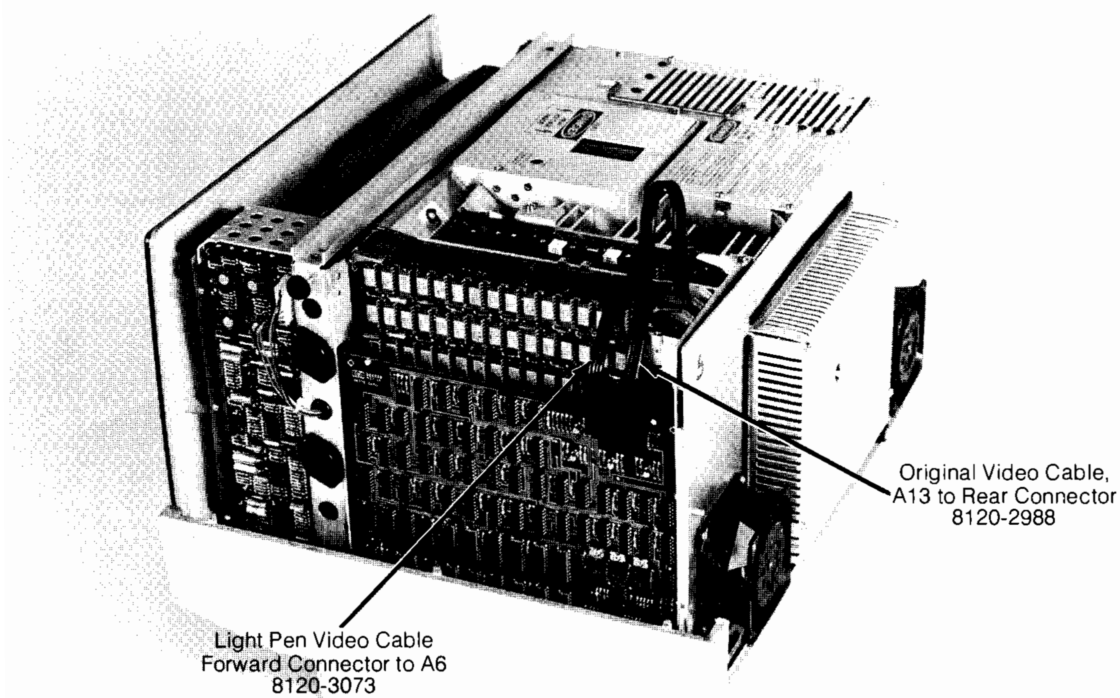


Figure 7-2. Video Cable Connections

- Release the locks on the rear of the support legs, and lift the front of the display. Install the light pen holder on the front of the right support leg (see Figure 7-3). The metal catch on the pen holder is held by the support leg. Lower the front of the display when the pen holder is in place and reseat the leg locks.
- Place the light pen in the pen holder and connect the light pen cable to its connector on the lower left corner of the rear panel.

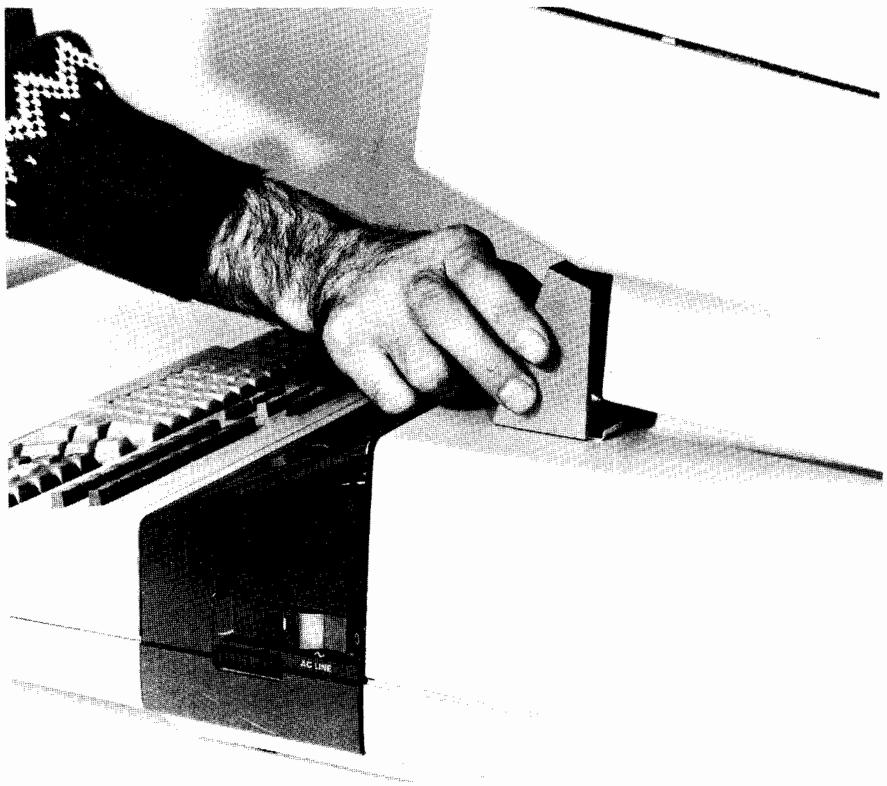


Figure 7-3. Light Pen Holder Installation

- Replace the display top cover.
- Switch the 9845C on and verify the light pen operation by performing the light pen tests on the 9845B/C binary test cartridge. Test procedures are found in Chapter 3.

Basic Operation

Refer to the 98775A block diagram, Figure 7-6. The light pen consists of an optical system to collect light from the CRT, an optical detector, an amplifier and a user actuated button. When the electron beam sweeps across the phosphor in the field of view of the light pen, the emitted light energy is collected by the optical system and is focused onto a PIN diode detector in the light pen assembly. The PIN diode converts the optical energy into an electrical signal which is then amplified. A high speed comparator on the light pen control assembly senses when the amplified signal exceeds a predetermined threshold and generates a digital signal (a hit). The comparator uses a dual threshold scheme for detection. The lower threshold is used to sense the presence of single illuminated picture elements (pixels) while the higher threshold is used when measuring the X position of the pen in relation to the horizontal line of the cross hair cursor. The time of arrival of the hit indicates the X and Y position of an image which is in the pen's field of view.

The light pen control PC assembly consists of three major sections. These sections are a cursor generator, a hit correlator, and a bus controller. The cursor generator creates a specialized cursor cross hair which interlaces the background video at a 30 hertz rate. This interlacing allows for rejection of signals detected by the light pen due to non-cursor pixels illuminated on the screen. The hit correlator accepts the hit signal received from the light pen and latches the X and Y coordinates on the screen associated with that hit. The bus controller requests an interrupt from the mainframe through the 98770A and enables hit coordinates to be sent to the processor as well as cursor coordinates to be sent to the cursor generator.

The 98775A has two fundamental modes of operation, Picking and Tracking. These are described below.

Picking

In the PICK mode, the 98775A hardware looks for the X and Y coordinates of the first illuminated pixel in the field of view of the pen in the current frame. This information is sent to the mainframe which converts it to user units.

Tracking

In the tracking mode, a firmware controlled cross hair follows the X-Y movements of the pen across the face of the CRT. The light pen control assembly supplies the 9845C firmware with sufficient data to estimate the pen's position with respect to the cross hair cursor. This data consists of three X,Y pairs which essentially lie on the circumference of the pen's field view. The firmware center estimating algorithm assumes the field of view of the pen to be a perfect circle. It uses these three points to calculate the circle's geometric center and thus the center of the pen's field of view which is it's position.

Only three of the six numbers representing the three coordinate pairs YHI, XLEFT and YLO are actually transmitted by the 98775A firmware. The other three are implied from the cursor position.

Background images are prevented from interfering with the tracking operation by interlacing a 49 dot square window around the cursor. The hardware disregards hits which occur on interlaced scan lines which have not been blanked within the window.

Theory of Operation

All digital logic for controlling the light pen is located on the 98775-66501 light pen control assembly. This digital circuitry has three major functions:

- Correlating detections by the light pen to X and Y coordinates of the display
- Transferring detection information to the mainframe via I/O operations
- Displaying a specialized cursor for tracking on the display.

The normal sequence of events that would occur during tracking is as follows. The 9845C sends the position at which the cursor is to be displayed. While the cursor is being displayed the control assembly waits for detect signals from the light pen. As these are received, the control board latches the X and Y information pertaining to the signals (hits). The control assembly then interrupts the mainframe to read the data. After a prediction is made for the position of the light pen, on the next frame, a new cursor position is sent to be displayed at that position. Another feature on this assembly is a self test. When the self test command is written to the control assembly the cursor data from the cursor generator is fed directly into the input of the light pen controller. This effectively takes the light pen out of the control loop and exercises the control assembly to its full extent.

Refer to the Light Pen Block Diagram, Figure 7-6, when reading this description.

Cursor Generator

The cursor generator produces a specialized cursor for use by the light pen. The cursor is a full-bright, white cross hair with alternate lines of the background blanked on alternate frames.

X-Cursor Address Register

This register contains X-position information of the cursor on the screen. The number saved is the compliment of the X-address in pixel coordinates.

Y-Cursor Address Register

This register contains Y-position information of the cursor on the screen. The number saved is the Y-address in pixel coordinates referenced to the top edge of the graphics raster.

Vertical Line and Window Generator

This generates the vertical line of the cursor. In addition, there is a window which extends 24 dots on both sides of this line. This defines the X boundaries of the interlace window as well as the X boundaries of the 49-dot x 49-dot cursor.

Horizontal Line and Window Generator

This generates the horizontal line of the cursor. In addition, there is a window which extends 24 dots above and below this line. This defines the Y boundaries of the interlace window as well as the Y boundaries of the 49-dot x 49-dot cursor.

Interlace Mixer

This mixes the two window signals which define the interlace area and generates a blanking signal to blank alternate lines in the window on alternate frames with use of the even/odd frame signal. Even numbered scan lines are blanked on even frames and odd numbered scan lines are blanked on odd frames as shown below.

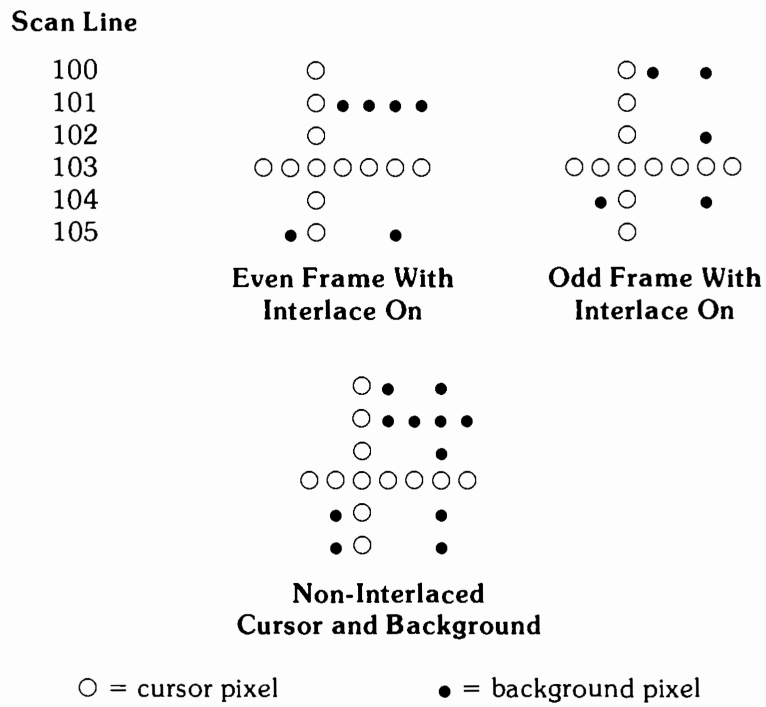


Figure 7-4. Example of Interlacing on the Light Pen Cursor

Video Mixer

This block intercepts the video stream on its way to the video amps. It blanks out the appropriate scan lines within the window and adds the cursor. The modified video is then sent to the video amplifiers.

Sync Control

This block generates a vertical blanking signal, synchronization with the X-scan counters in the display, an even/odd frame signal and the switch enable signal. These are used as indicators of the beam position throughout the control assembly.

Light Pen Hit Correlator

The light pen hit correlator consists of 4 latches for YHI, XLEFT, YLO, and switch status, a controller to enable these latches, and an X-address counter.

Hi Hit Y Address

This register contains the Y address of the first hit in the field of view, or, if a hit occurred in the window, the first hit in the window.

Left Hit X Address

This register contains the X address of the first hit in the field of view, or, if a hit occurred on the horizontal bar of the cursor, the address of that hit.

Low Hit Y Address

This register contains the Y address of the last hit in the field of view, or, if a hit occurred in the window, the last hit in the window.

Here are examples of the cursor with the pen's field of view in various positions and the hits generated at each position.

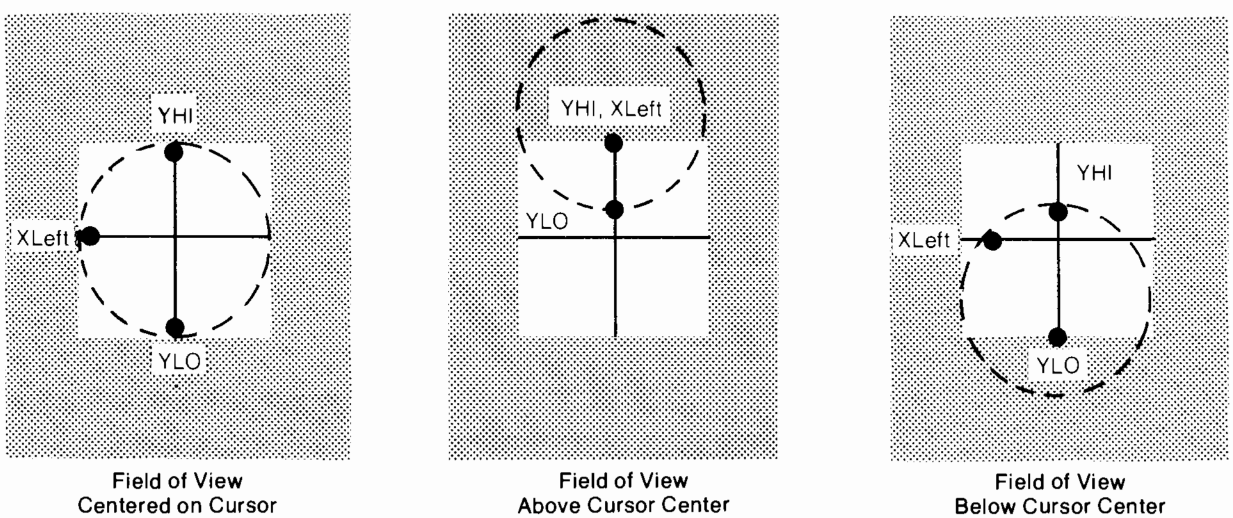


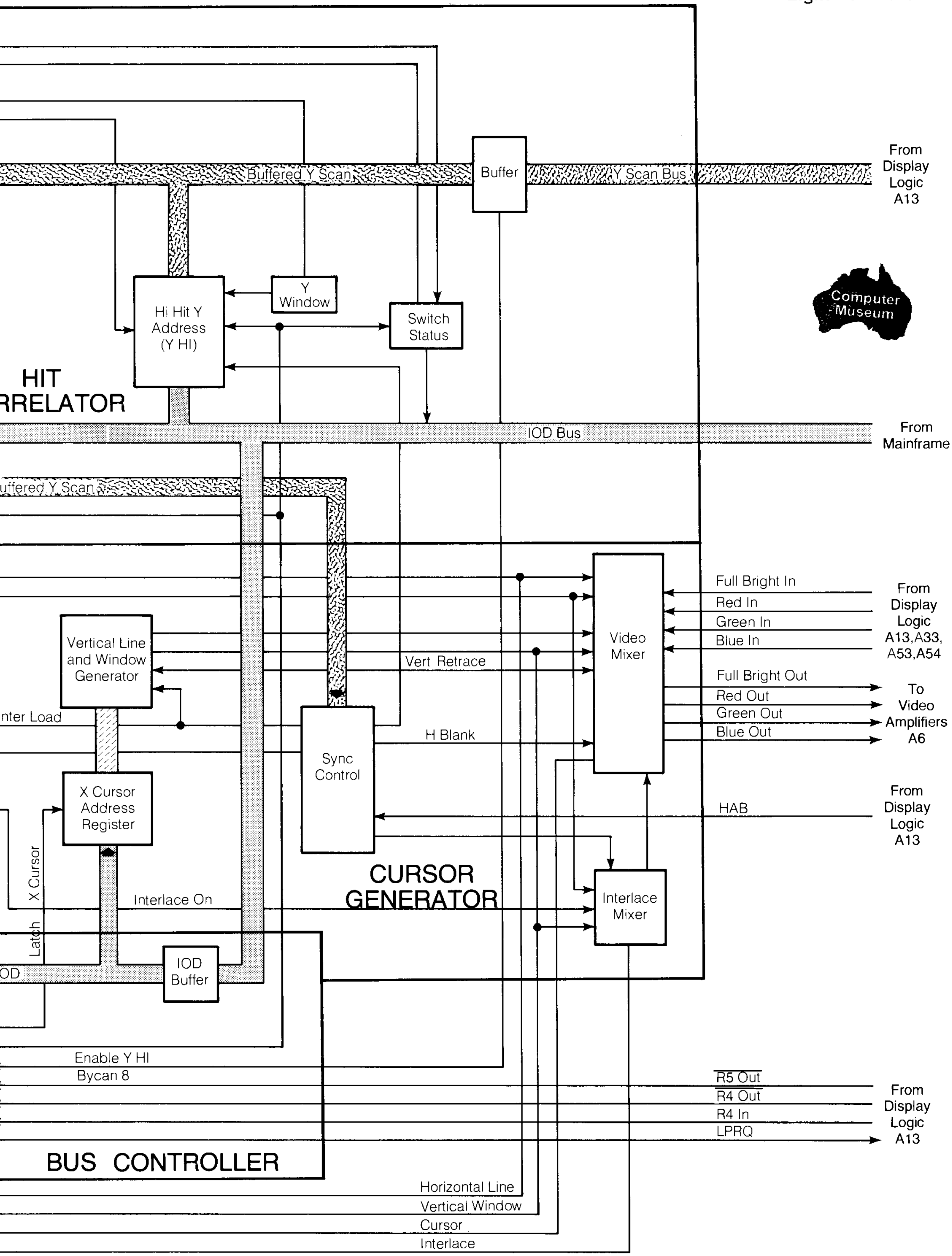
Figure 7-5. Light Pen "Hits"

X-Counter

The X counter is a ripple counter which is halted each time a hit occurs. If the X address is to be latched, this is the number which is latched. The latch occurs during horizontal retrace to allow this counter to complete the ripple for a particular count.

Switch Status

This register samples the state of the button on the pen during vertical retrace. The sampling is done at this time so that any rapid voltage changes which might fire the pen amplifier will not be registered as a light pen hit.



ght Pen Block Diagram

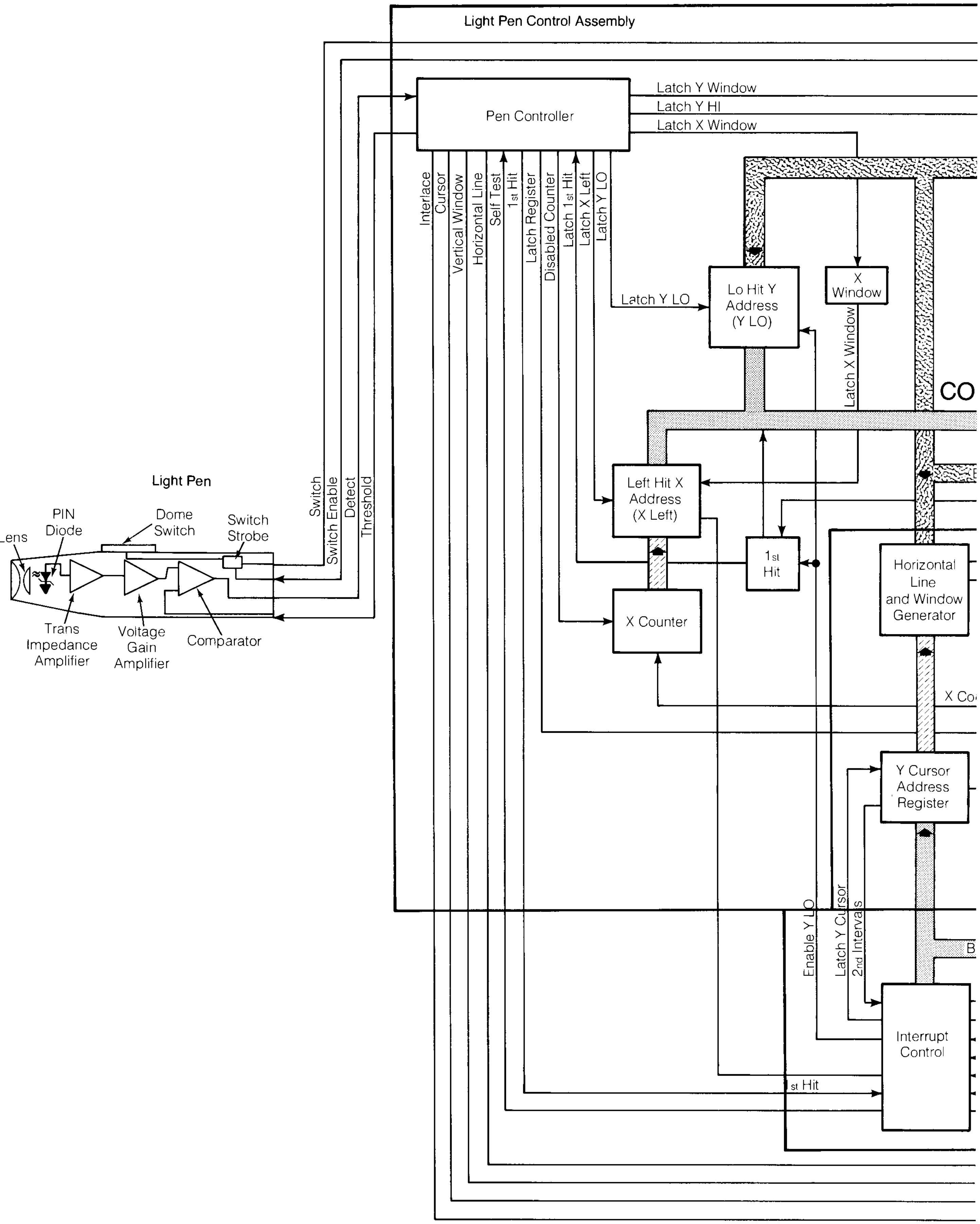

Light Pen Control Assembly
Pen Controller
Latch Y Window
Latch Y HI
Latch X Window
Interlace
Cursor
Vertical Window
Horizontal Line
Self Test
1st Hit
Latch Register
Disabled Counter
Latch 1st Hit
Latch X Left
Latch Y LO
Latch Y LO
Lo Hit Y Address (Y LO)
X Window
Latch X Window
CO
Left Hit X Address (X Left)
1st Hit
X Counter
Horizontal Line and Window Generator
X Co
Y Cursor Address Register
Enable Y LO
Latch Y Cursor
2nd Intervals
B
Interrupt Control
1st Hit
Light Pen
Lens
PIN Diode
Dome Switch
Switch Strobe
Switch
Switch Enable
Detect
Threshold
Trans Impedance Amplifier
Voltage Gain Amplifier
Comparator

Figure 7-6. Li

Pen Controller

This controls the latching of all of the registers. This is the decision block for which registers will or will not be latched for a particular hit. It also contains information pertaining to previous hits in the frame including:

FIRST HIT:	Was there a hit in this frame yet?
YWINDOW:	Has a hit occurred in the Y window this frame?
XWINDOW:	Has a hit occurred in the X window this frame?

This information is latched and transmitted to the 9845C mainframe with the address registers.

Interrupt Controller

The interrupt controller requests interrupts, decodes, writes to R5 and controls which register is enabled when R4 is read. When interrupts are enabled, an interrupt may occur in the middle of the screen if a hit has occurred, or at vertical retrace. This means that there may be one or two interrupts in one frame depending on bit 5 of the Y cursor address (0 = 2 interrupts per frame, 1 = 1 interrupt per frame). Two interrupts per frame means that there will always be an interrupt at vertical retrace and there may be one at the middle of the screen if a hit occurred prior to that point. This capability is to allow an interrupt at a time when software will be able to change the screen without discontinuities.

Optics

The light pen optical system consists of a modified double plano convex condensor which concentrates light onto a surface of a high speed PIN diode. The optical system is focused at infinity and has a very wide acceptance angle. This configuration gives the field of view a raised cosine attenuation characteristic at varying distances and angles to the screen. It is the shape of the field of view, pen amplifier frequency response, sweep rate and CRT phosphor response which make the tracking of the cursor possible.

The tracking algorithm is able to estimate the location of the pen by calculating the center of the pen's field of view. The center estimating algorithm uses the fundamental assumption that the pen's field of view is circular, and that the three coordinate hit pairs it receives lie on that circle.

Firmware Support

The main firmware support for the 98775A hardware is provided by means of an interrupt service routine. The interrupt service provides the basic light pen functions of picking and tracking. Picking is defined as obtaining the X,Y coordinate pair of an object displayed on the CRT. Tracking is the ability to obtain X,Y information from areas of the screen where no light currently exists. This is accomplished by keeping a tracking cross in front of the light pen as the pen moves, in order that the pen will always see light and thus its location on the screen can be determined. The cross is kept in front of the pen by using X and Y positional information received from the pen to estimate the center of the field of view of the pen. Using this estimate of the pen's present position along with the pen's past movement, the location of the pen during the next frame is predicted. The tracking cross is then moved to this predicted location so the pen will see light on the next frame.