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Cathodochromic Cathode Ray Tube

An Operations Manual

Philip M. Heyman
RCA Laboratories
Princeton, New Jersey 08540

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16. Abstract

A cathodochromic (CC) storage and display system capable of storing full TV resolution images has been built. The images are derived from standard TV signals: composite video, composite sync, composite blanking, horizontal drive, and vertical drive. Image storage takes place in the CC CRT; the fixed image is written for several TV frames for the contrast to be usable. Once stored on the CC CRT, the image can be read out in one of three modes: with the eye, a 35-mm camera, or a TV camera. Each mode uses light transmitted through the storage target from a lamp mounted directly behind the CRT. When desired, the image may be erased by activating a transparent conductive heater layer, an integral part of the target structure. Incoming information may also be stored in a storage tube similar to the CC CRT but with a phosphor layer behind the CC layer. By exciting the phosphor layer with a standard raster scan it is possible to read out an image stored in the CC layer in one of three modes: direct viewing, photography, or flying-spot readout using a photomultiplier. Erasure of images is the same as in the CC tube. Each tube may be individually selected by transferring the leads.

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I. INTRODUCTION

In the following text we describe the operation of a cathodochromic (CC) storage and display system that is capable of storing full-resolution TV images fed to the system in the form of standard TV signals (composite video, composite sync, composite blanking, horizontal drive, and vertical drive). Image storage takes place in the CC CRT and therefore requires that the fixed image be written on the tube for a number of TV frames for the contrast to be usable. Once the image is stored on the CC CRT it can be read out in any one of three modes, i.e., with the eye, with a 35-mm camera, or with a TV camera. Each viewing mode uses light transmitted through the storage target from a lamp mounted directly behind the CRT. When desired, the stored image may be erased simply by activating a transparent conductive heater layer that is an integral part of the target structure. The incoming information may also be stored in another storage tube similar to the first but containing a phosphor layer directly behind the layer of CC material. By exciting the phosphor layer with a standard raster scan it is possible to read out an image stored in the CC layer by one of three methods: direct viewing, photography, or flying-spot readout using a photomultiplier. Erasure of stored images occurs in the same way in this tube as in the single-layer tube. Although both tubes are mounted in the rack only one may be used at a time. The selection is accomplished by physically transferring the leads from one tube to the other.

II. GENERAL DESCRIPTION AND SPECIFICATIONS

The cathodochromic storage and display system is housed in a standard rack, standing approximately 6 feet high (Figure 1). This rack contains all the necessary electronics to store on and read out from the CC tubes, provided standard TV signals (composite video, composite sync, composite blanking, horizontal drive, and vertical drive) are supplied. In addition to the rack there is a small readout assembly consisting of a light-tight box; two mirrors, one movable; and a 35-mm camera mount. This assembly can be positioned in front of either the CC tube or the CC-phosphor tube, thereby directing the stored image to either the TV camera or the photomultiplier as the case may be. By pivoting the movable mirror it is always possible to photograph the stored image.

Storage is accomplished by writing an image into the CC material which is settled on the target of the CRT. The material used in these tubes is such that the coloration is due primarily to excitation of the thermal erase mode. Therefore, for contrast ratios in the 5:1 range there will be no significant decrease in image contrast for an extended period of time (at least 24 hours). The sensitivity of the CC materials is high enough that coloration of the darkest area of a full-resolution TV picture will surpass 3:1 in 10 seconds for the single-layer CC CRT and 2:1 in 10 seconds for the double-layer CC-phosphor CRT. Contrast ratios of 10:1 for the single-layer tube are possible without damage to the tube by extending the writing time. By passing a current equivalent to 10 W/in.^{2} through the transparent conductive heater built into the target, it is possible to erase a 3:1 stored image in 5 seconds or less. The erase rate is not a strong function of image contrast. Because these targets are designed for transmissive viewing they can be photographed easily and can produce high contrast images (>2.5:1) on film. Both the CC material and the electron gun have been selected to exhibit a limiting resolution in excess of 500 TV lines in the single-layer tubes.

The electronics contained within the rack are sufficient to operate both tubes (one at a time) in the write, read, or erase modes. All that must be supplied from the outside in addition to power is standard TV sync, blanking, video, and drive signals. The minimum usable video signal is 1 V from peak white to sync tips. This incoming video signal may be inverted if desired so that the stored image can be of either video polarity. The photomultiplier output can also be inverted if desired so that a positive readout image can be obtained from a stored image of either polarity. The TV camera output cannot be inverted. For most purposes it will be necessary to write an image on the CC CRT for times well in excess of one TV frame. However, there is the capability of writing on the CRT for only one TV frame if desired. The normal image stored on the CRT has approximately 500 horizontal lines but by switching to the "magnify" position it is possible to overscan the target so that 400 lines completely fill the target area. This gives an apparent image magnification of 5:4. The apparent contrast ratio will be somewhat lower in this magnify mode.

The readout equipment includes a light source, the readout assembly, a TV camera, and a photomultiplier. For the single-layer tube the readout system includes the light source, the readout assembly, and the TV camera. The target

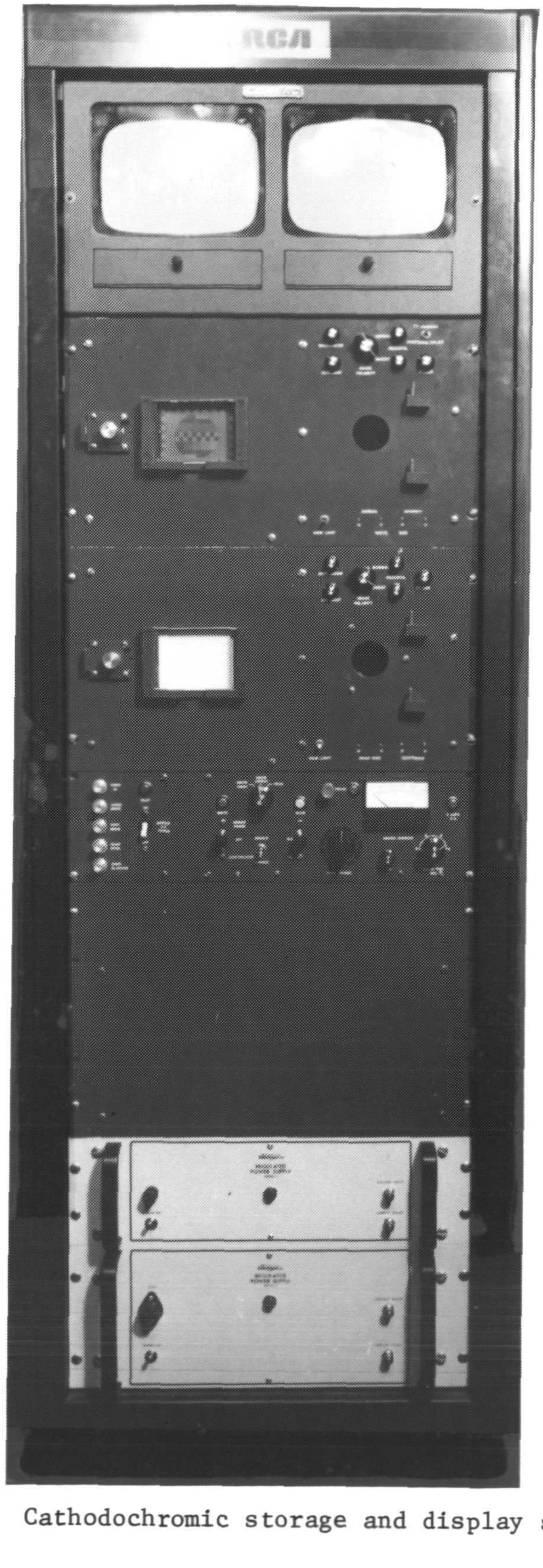


Figure 1. Cathodochromic storage and display system.

of the CRT is back lit and its image is brought into focus on the vidicon by the TV camera lens and the two mirrors of the readout assembly. The readout assembly also holds the Nikon 35-mm camera used to photograph the back-lit CRT target, if the movable mirror is pivoted out of the optical path of the camera. The image of the CRT target will just fill the 35-mm frame if a 50-mm f/1.4 lens is used in conjunction with #1 and #2 close-up lenses or if a 55-mm f/3.5 macro lens is used. The backlighting is of the correct level so that either ASA 400 or ASA 125 film can be used. For images stored on the two-layer tube the readout assembly is placed in front of the panel holding the two-layer tube so that the remaining part of this readout system (the photomultiplier) can be utilized. The photomultiplier and its associated electronics have a frequency response equivalent to greater than 500 TV lines and an output capable of driving a TV monitor.

III. DETAILED DESCRIPTION

A. Block Diagram (see Figure 2)

1. Level Shifter - converts the horizontal and vertical drive signals to negative-going signals to drive the Beta SG 1190 sawtooth generator.

2. Beta SG 1190 Sawtooth Generator - produces both horizontal and vertical ramps for deflection. The ramp frequency and duration are determined primarily by adjustments on the card, but the ramp is synchronized to the external drive signals.

3. Deflection Correction - primarily corrects for pincushion distortion in the CRT by predistorting the incoming ramps to compensate for the geometric distortion in the tube.

4. Display Mode Switch A - selects the magnitude of the corrected signal to be applied to the Beta DA 225 deflection amplifier. In the write normal mode the signal magnitude is just sufficient to fill the CRT target at the 25-kV anode potential. In the write magnify mode the deflection signal magnitude is about 25% greater so that 400 lines now fill the screen. In the read mode the anode voltage is only 10 kV so the deflection signal is only 63% of the write normal signal. (See Figures 2 and 6.)

5. Vertical and Horizontal Size Controls - are screwdriver adjust potentiometers located on the front panels. There are two controls for each of the three display modes. (See Figures 2, 4, and 5.)

6. Beta DA 225 Deflection Amplifier - is a high-quality voltage-to-current operational amplifier that forces ± 6 A through an external circuit (having less than 7-Ω impedance) for an input signal of ± 5 V.

7. Monitor 1 - continuously displays the incoming video signal. (See Figures 1 and 3.)

8. Display Mode Switch B - selects the image that is fed to the video processor and also controls the output of the video driver. (See Figure 2.)

9. Video Processor - serves two functions. In the write mode it converts the incoming video signal into the signal levels required by the video driver. In the read mode the processor takes the raw video from the photomultiplier and adds sync and blanking signals so that the resultant signal can drive a monitor. Inversion of both write and readout polarity takes place in the processor.

10. Video Driver - takes the 1-V level signal from the processor and amplifies it to a 60-V level to drive the cathode of the CRT in the write mode. In the read mode the video information is decoupled from the video driver output, and a dc voltage of about 30 V is fed to the CRT cathode.

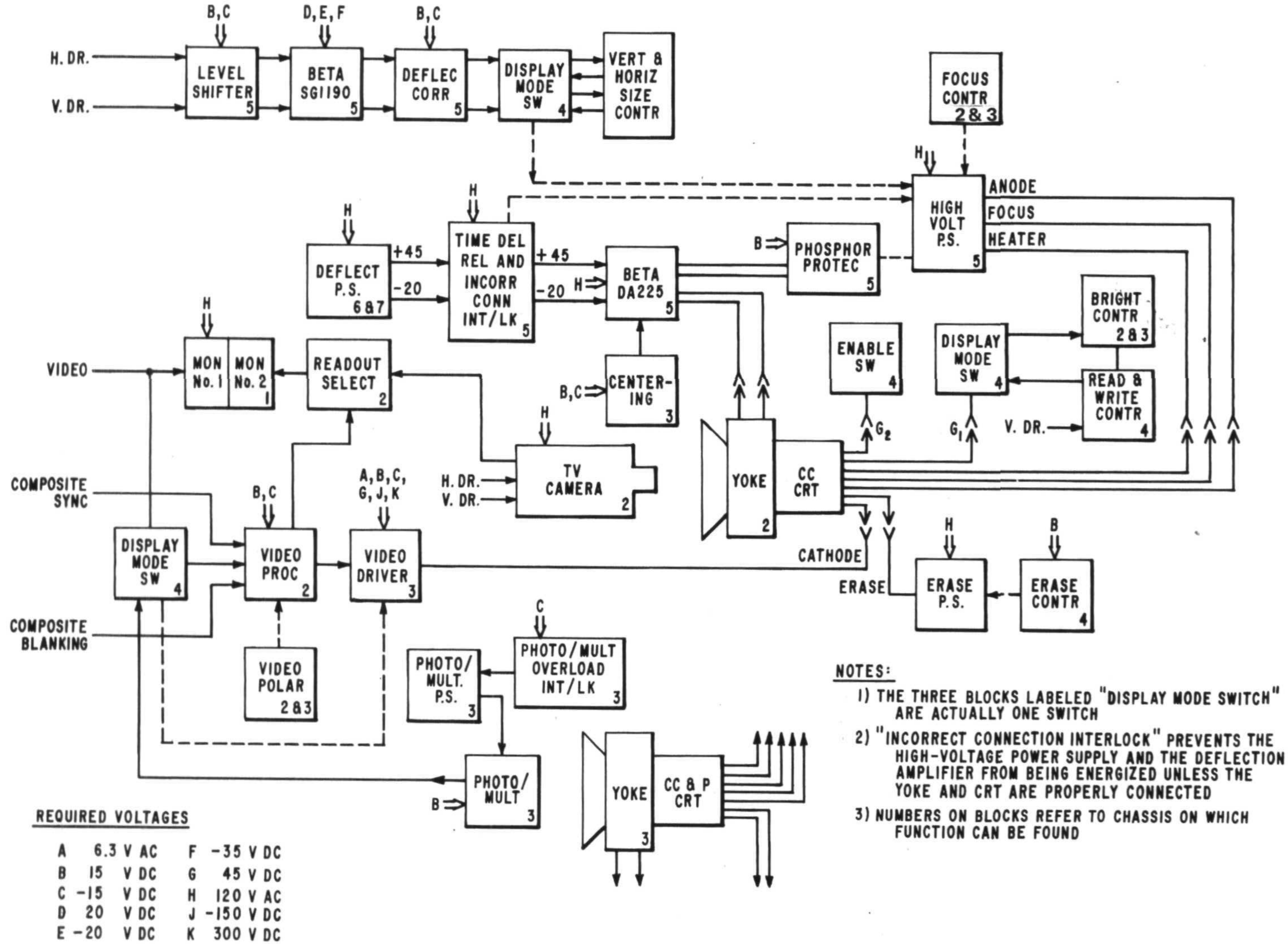


Figure 2. Block diagram of the CC storage and display system.

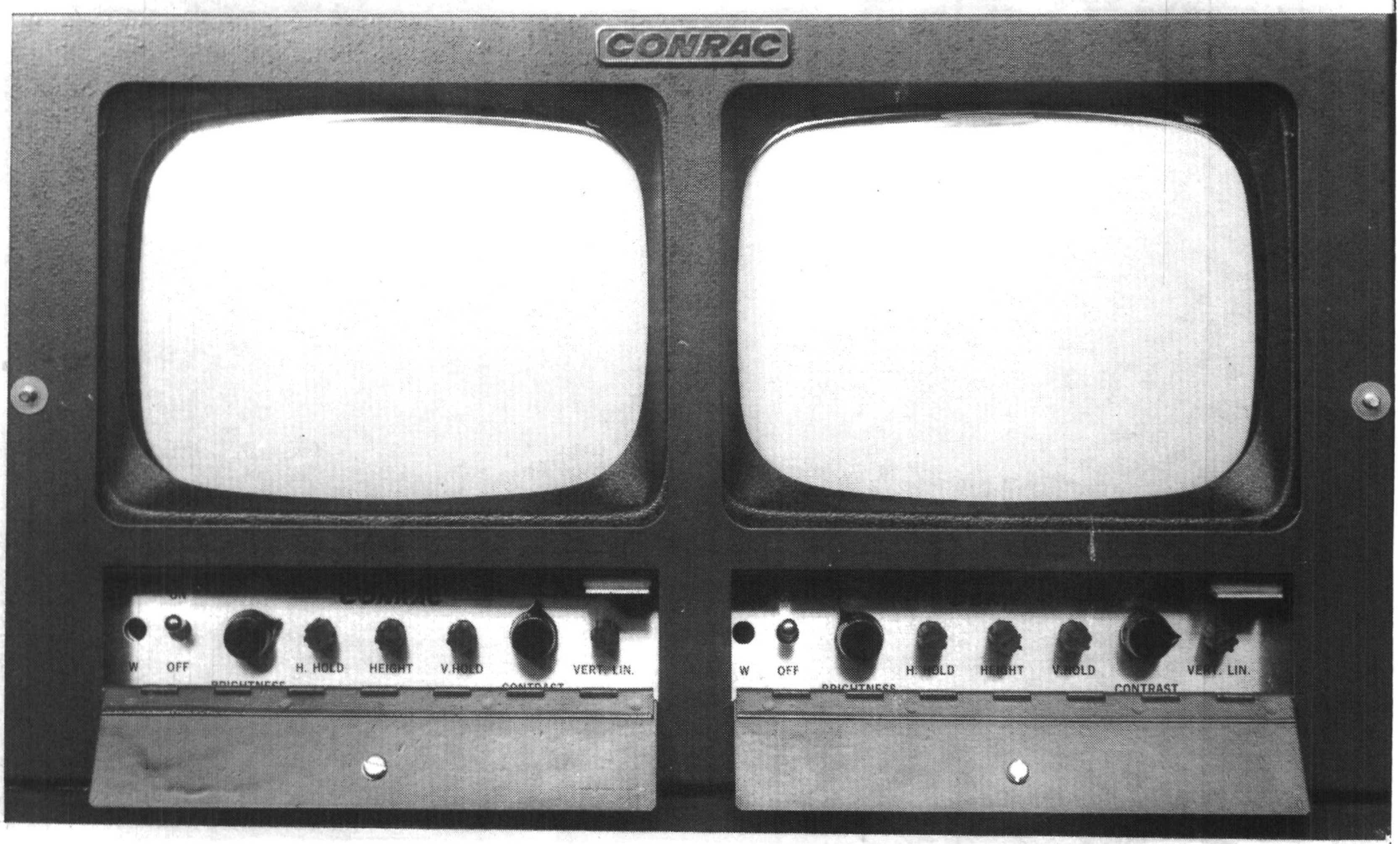


Figure 3. Monitor panel (#1).

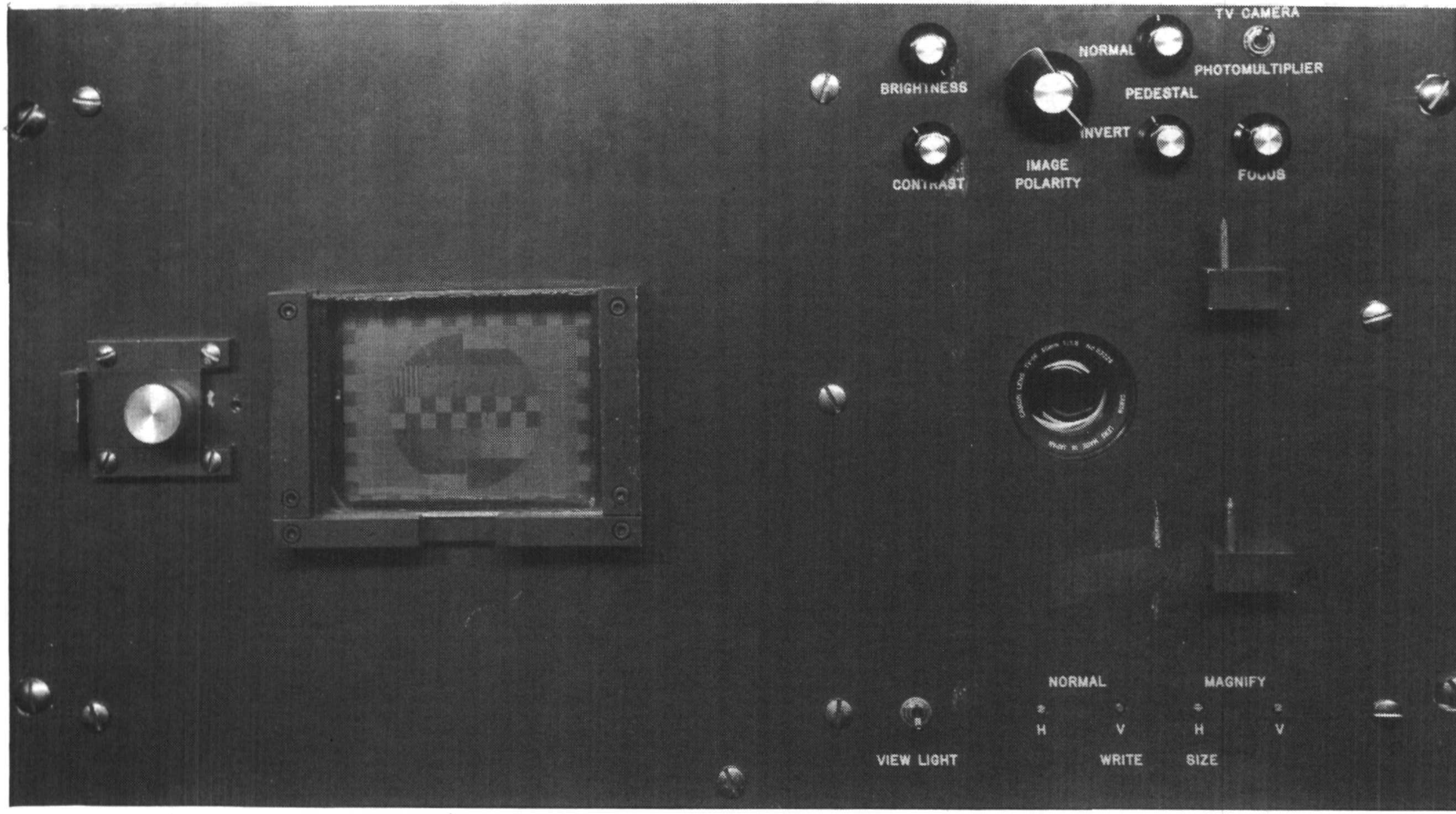


Figure 4. Panel #2 of the CC storage and display system.

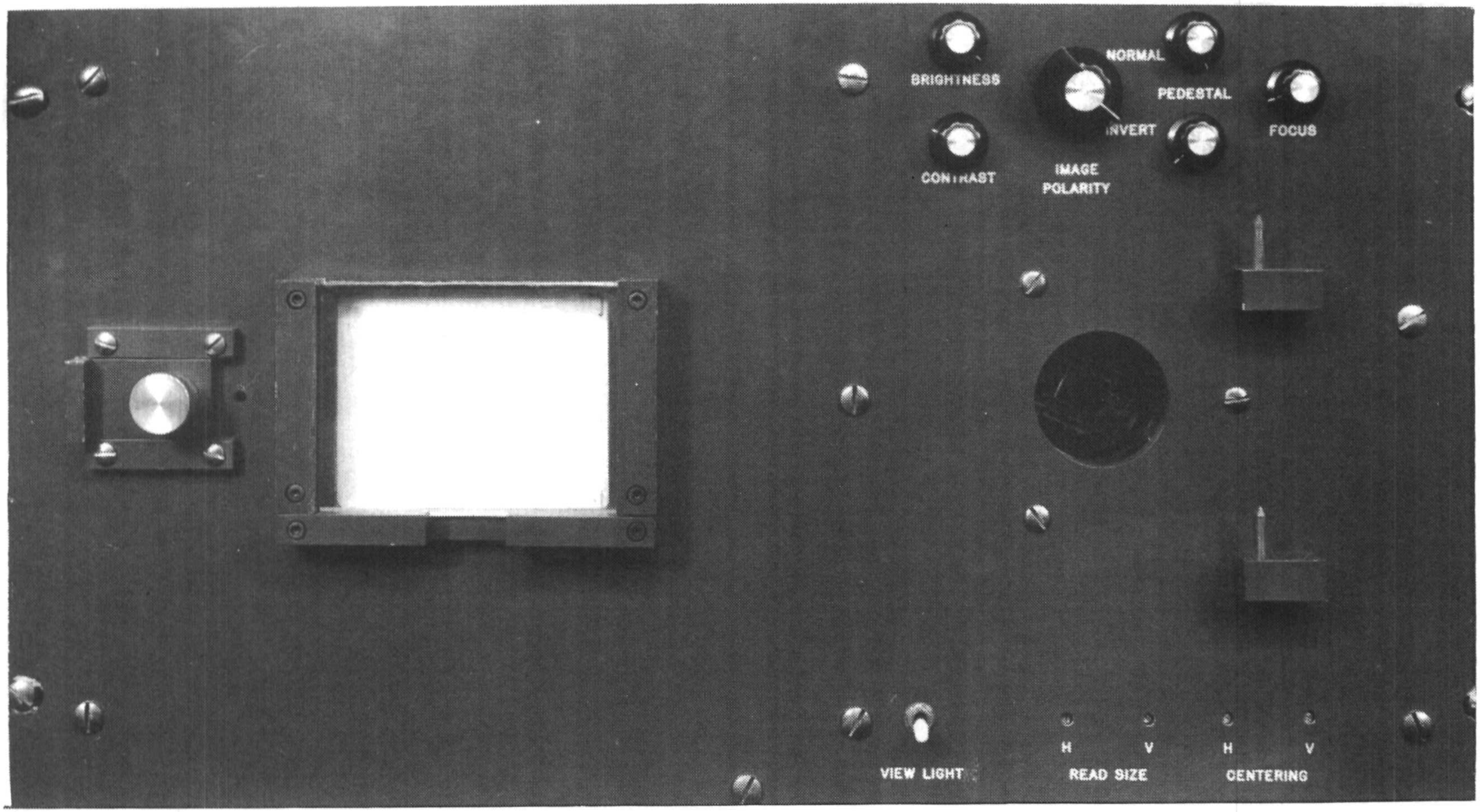


Figure 5. Panel #3 of the CC storage and display system.

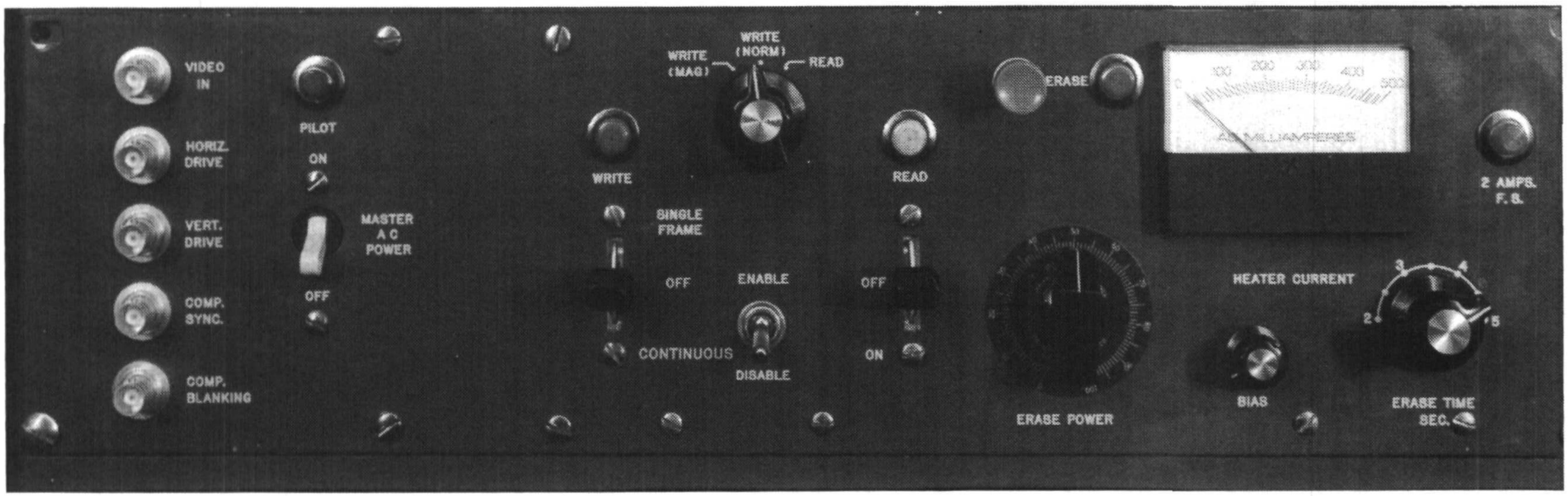


Figure 6. Panel #4 of the CC storage and display system.

11. Readout Selector - selects the signal to be displayed on Monitor 2. With the display mode switch in write and the readout selector in the photomultiplier position, Monitor 2 shows the signal applied to the gun of the storage CRT (white on monitor means the gun is on). If the display mode switch is in the read position, then the readout selector chooses the signal from either the TV camera or the photomultiplier to be displayed on Monitor 2. (See Figures 2 and 6.)

12. High-Voltage Power Supply - generates the anode, G_3, G_2, G_1 and filament voltages for the CRT. It also has several logic level circuits for CRT protection and anode voltage switching.

13. Display Mode Switch C - (DMS A, B, and C are all one switch) selects the appropriate anode and focus voltages as well as the correct brightness and read or write control. (See Figure 2.)

14. TV Camera - is located on the CC tube panel and is capable of scanning only the cathodochromic tube.

15. Photomultiplier - is located on the CC-phosphor tube panel and is capable of scanning only the CC-phosphor tube. (See Figures 5 and 7.)

16. Erase Power Supply - is an autotransformer and an isolation transformer which supply the erase energy to the heater. (See Figures 2 and 6.)

17. Erase Control - sets the duration of the erase period and the amount of bias heat applied to the CRT target. (See Figures 2 and 6.)

18. Time Delay and Incorrect Connection Interlock - is required to allow the deflection power supply to achieve full voltage before the load is applied. It also prevents damage to the CRT and deflection amplifier by not allowing the high-voltage power supply to come on and not applying supply voltage to the deflection amplifier unless the yoke and CRT connections are properly made.

B. Description of Block Diagram

1. Sync Level Shifter (Figure 8) - requires ± 15 V from the common ± 15 V supply. The horizontal drive signal enters on pin 4 and may have any dc level as long as the signal polarity and magnitude are correct (drive pulse negative-going and 4 V_{pp}). The drive pulse cuts off Q_1, which in turn cuts off Q_2, thus allowing Q_2's collector to fall to -5 V. When the pulse is not there the 47-kΩ resistor ensures Q_1, and therefore Q_2 is saturated and its collector is at 0 V.

2. Beta Signal Generator SG 1190 - see manufacturer's specifications.

3. Deflection Correction Unit (made by Intronics, C102) - see manufacturer's specifications. (See Figure 9.)

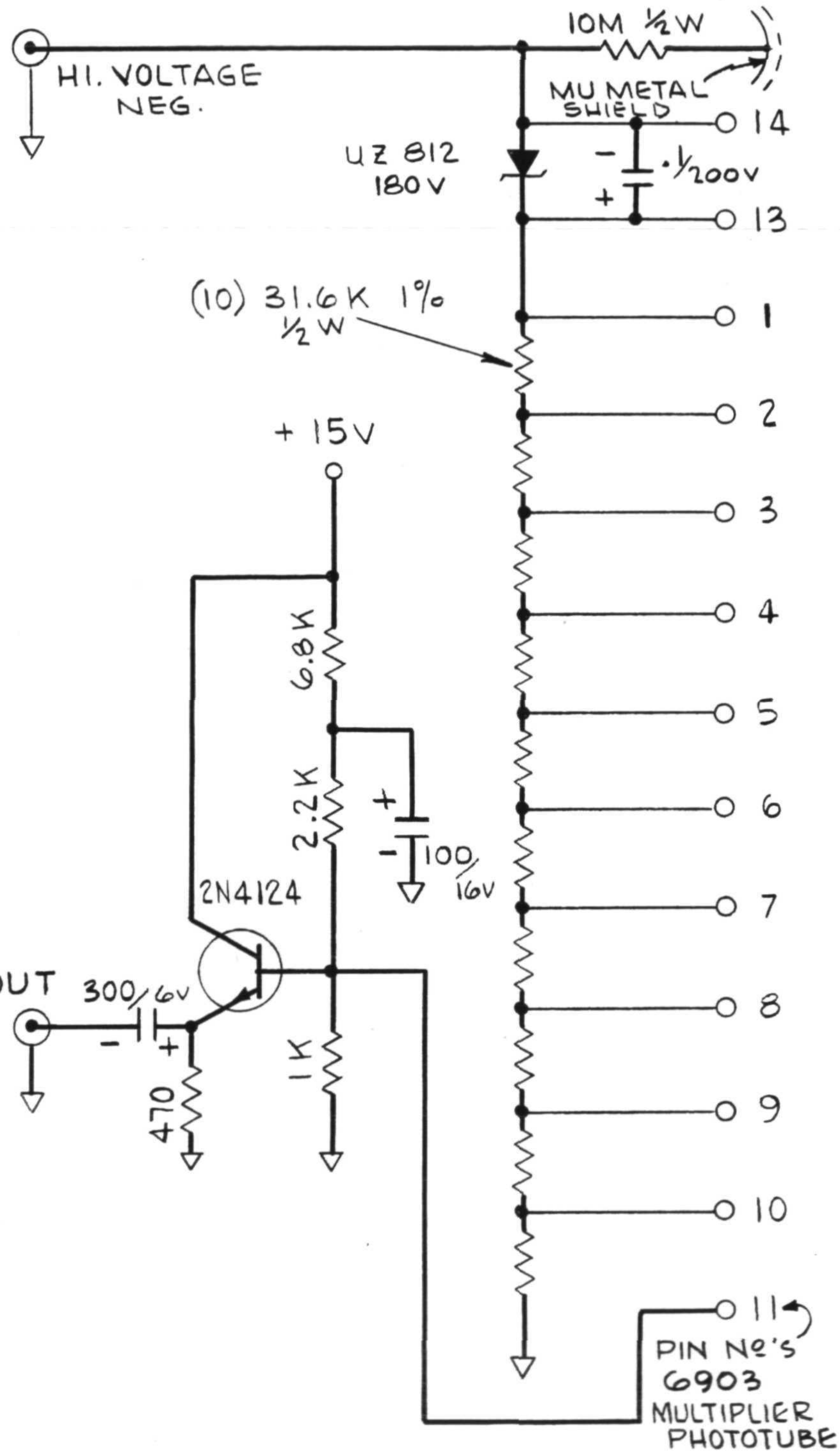


Figure 7. Schematic of photomultiplier.

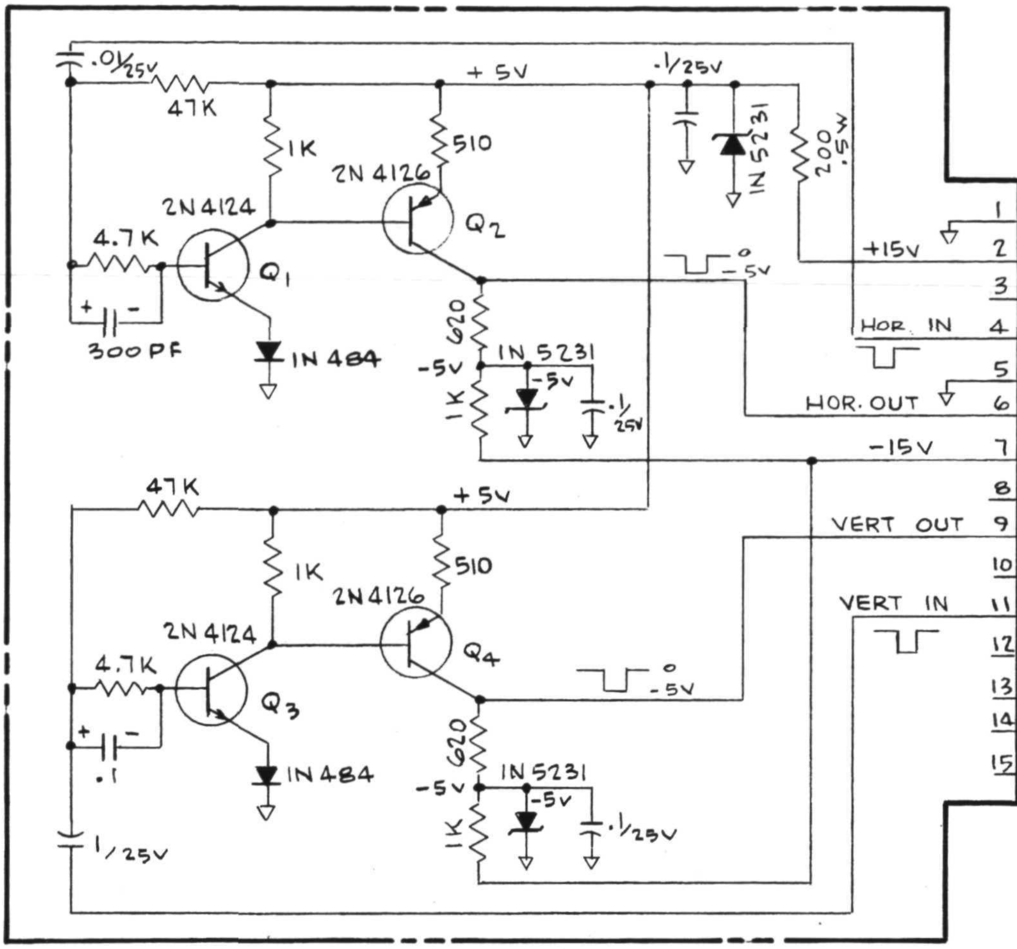


Figure 8. Schematic of sync level shifter.

4. Beta Deflection Amplifier DA 225 - see manufacturer's specifications.

5. Deflection Power Supply (by Deltron, L46-17 and L20-15) - see manufacturer's specifications.

6. Power Supply (-35 V and +20 V) and Time Delay/Interlock Board - (Figure 10) - The -35 V and +20 V power supplies are standard shunt regulator supplies using zener diode references. The -35 V supply has its own ac to dc conversion whereas the +20 V supply simply splits the 20 V level out of the 45 V deflection power supply. The time delay (5 sec) portion of this board is found in the circuitry associated with Q_5. The collector of Q_5 stays at 45 V until C_1 charges up sufficiently to allow Q_5 to come on. As Q_5 comes on the relay driver Q_6 is also turned on. The incorrect connection interlock is implemented by routing the relay coil current through sets of contacts on both the CC tube chassis and the CC-phosphor tube chassis. If all circuits are not properly completed, the relay cannot close at the end of the 5-sec delay. This

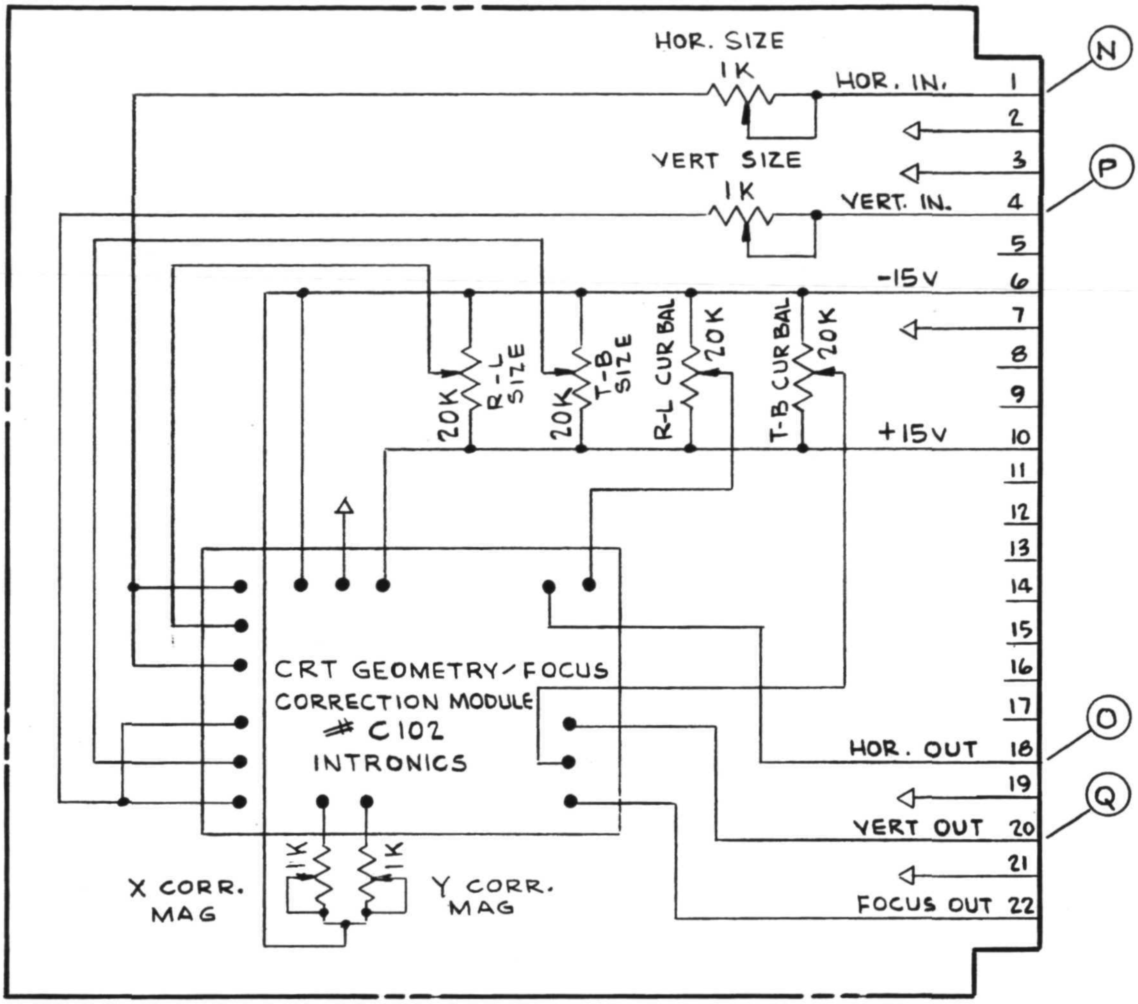


Figure 9. Schematic of CRT geometry/focus correction module.

prevents the deflection amplifier from being connected to its power supply, and it also prevents the high-voltage power supply from being activated.

7. Target Protection Board - (Figure 11) - senses deflection failure. A horizontal sweep rate sawtooth from the sampling output on the deflection amplifier is fed into pin 6 of the protection board. The signal is amplified in Q_1 and Q_2 and then fed to Q_3 which acts as a switch to discharge C_1 when the incoming ramp reaches a given voltage. Q_4 and IC_A act as a threshold detector. If C_1 is not discharged at the appropriate time, pin 3 of IC_A will go low. A similar discussion applies to the vertical section. If pins 9 and/or 10 of IC_C are low, then pin 8 will be high and the G_1 output on the high-voltage power supply will go to -110 V to cut off the CRT gun.

8. High-Voltage Power Supply - see manufacturer's specifications.

9. Dual Conrac Monitor - see manufacturer's specifications.

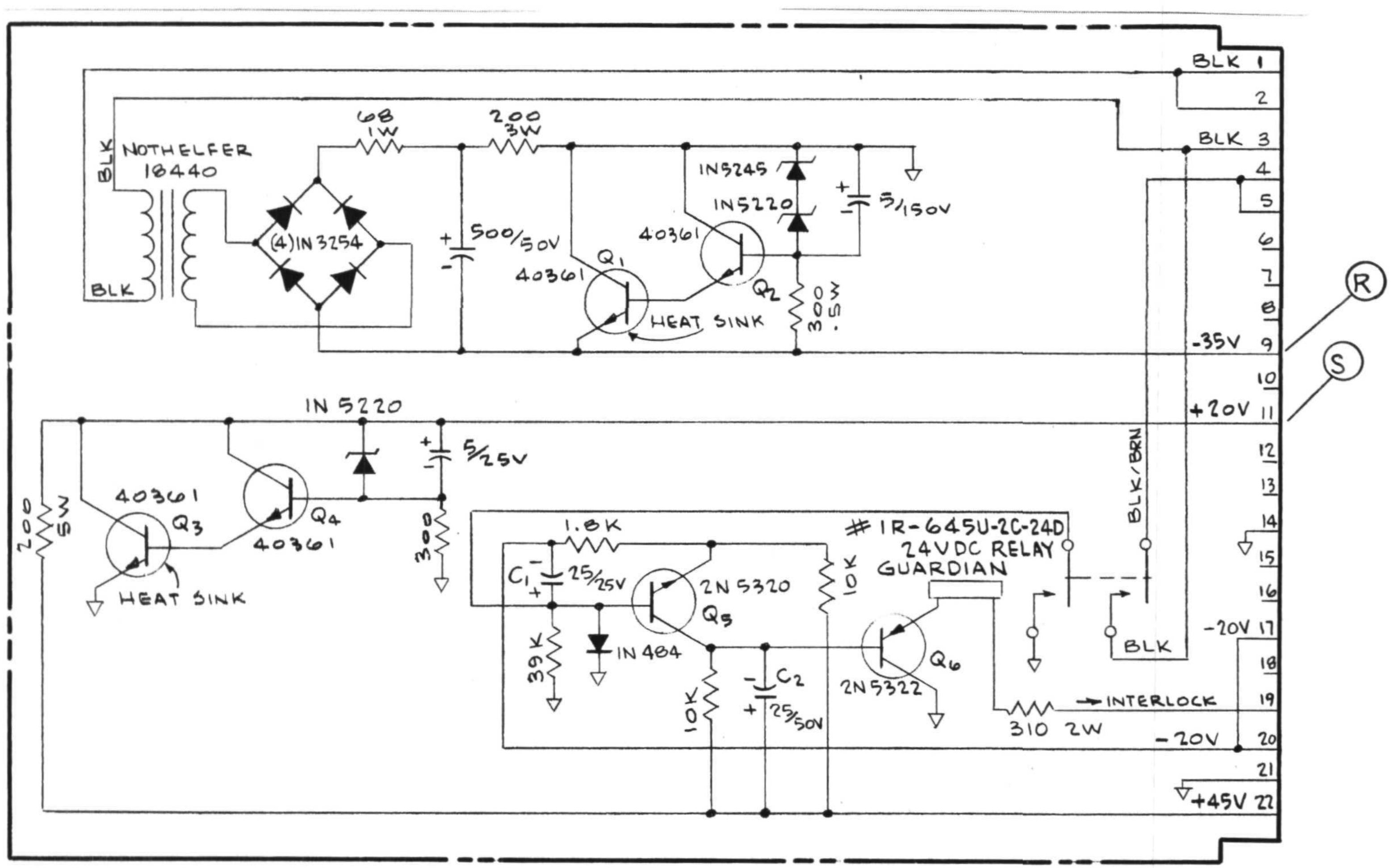
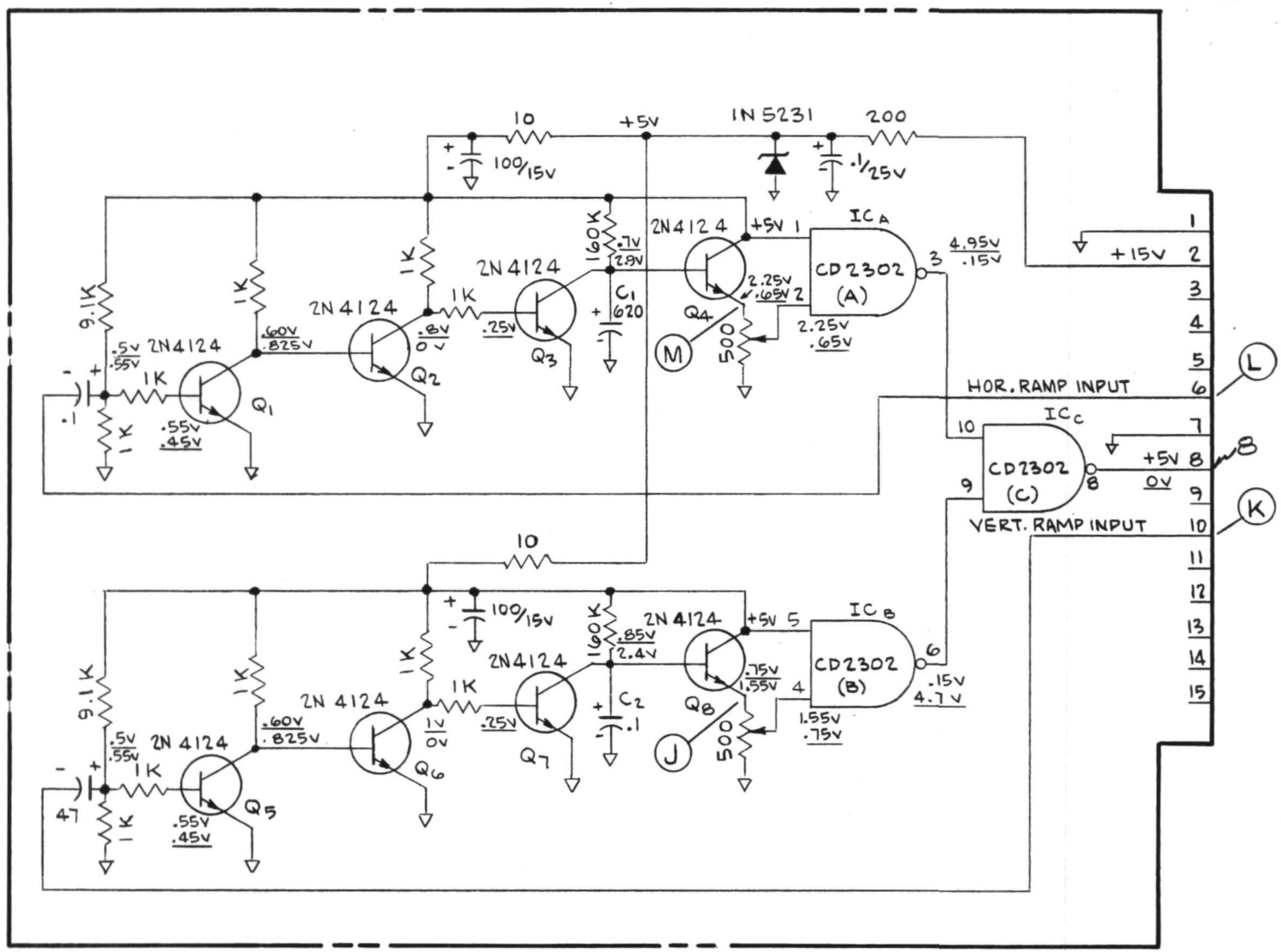


Figure 10. Schematic of -35 V, -20 V, +20 V power supply.



Note: Normal vertical and horizontal ramps being sampled, output (8) will be at zero. If either vertical or horizontal ramp failure, output (8) will go to +5 V to control cutoff of CRT. Underlined voltages were taken with vertical and horizontal ramp 1 V_{pp} applied to both inputs. Other voltages are taken without signal present.

Figure 11. Schematic of target protection circuit.

10. Video Processing Amplifier (Figure 12) - serves two important functions. First, it provides the necessary gain for the input video signal and, second, it processes the signal to make it suitable for presentation to the following high-level driver amplifier. In the processing operation, the sync portion of the input signal is removed and a new "pedestal" or black reference level is established. This results in the black and white portions of the electrical output signal being carefully held at prescribed dc levels.

The input stage of the processing amplifier makes use of a type μH733C integrated circuit. It provides the gain function and also serves for signal polarity inversion. A reed relay at the output of this amplifier makes it possible to select either the normal or inverted writing mode.

The following stage, a type 2N2475 common-emitter amplifier, boosts the level of the signal to approximately 5 V peak-to-peak. This relatively high level is necessary to achieve good dc setting. This dc setting is accomplished on sync tips by means of the hot-carrier diodes in the gate circuit of the MOS-FET following the 2N2475.

In order to handle the signal at the point at which dc setting has taken place, a type 3N138 MOS-FET is used, taking advantage of its extremely high input impedance to avoid loading and distortion of the signal. At the output of the 3N138 source-follower is a simple resistive divider network which serves as a dc level shifter.

At this point, the signal is short-circuited to ground during the blanking interval by a type 2N4126 switching transistor, whose base is driven with the blanking signal. This serves the dual function of removing the sync portion of the signal, and of establishing the black level at a well-defined reference level.

The resulting signal is then fed to the output by the compound emitter-follower circuit comprising a 2N4126 transistor and a 2N2102 transistor. This circuit provides minimum loading of the "blanked" signal at its input, and drives the output load circuit with no dc offset.

The output signal is also fed to a type 2N3638 common-emitter stage which serves as an isolation and inverting amplifier to drive the monitor. Since the processed signal at this point has had the sync removed, sync is again added to the signal prior to being fed to the monitor, so as to provide a full, composite video waveform.

11. Video Driver (Figure 13) - To "write" into the CC storage tube, the video signal is applied to the tube's cathode so as to modulate the writing beam current. This requires a driving amplifier capable of providing the voltage and the current necessary for distortionless drive of the storage tube cathode circuit. Since the cathode circuit represents a complex, varying impedance, the driver should appear as a low output impedance source and should also be dc-coupled to the cathode.

The Video Driver is a direct-coupled negative-feedback amplifier which comprises a type μH733C integrated-circuit input stage and a type 418A vacuum

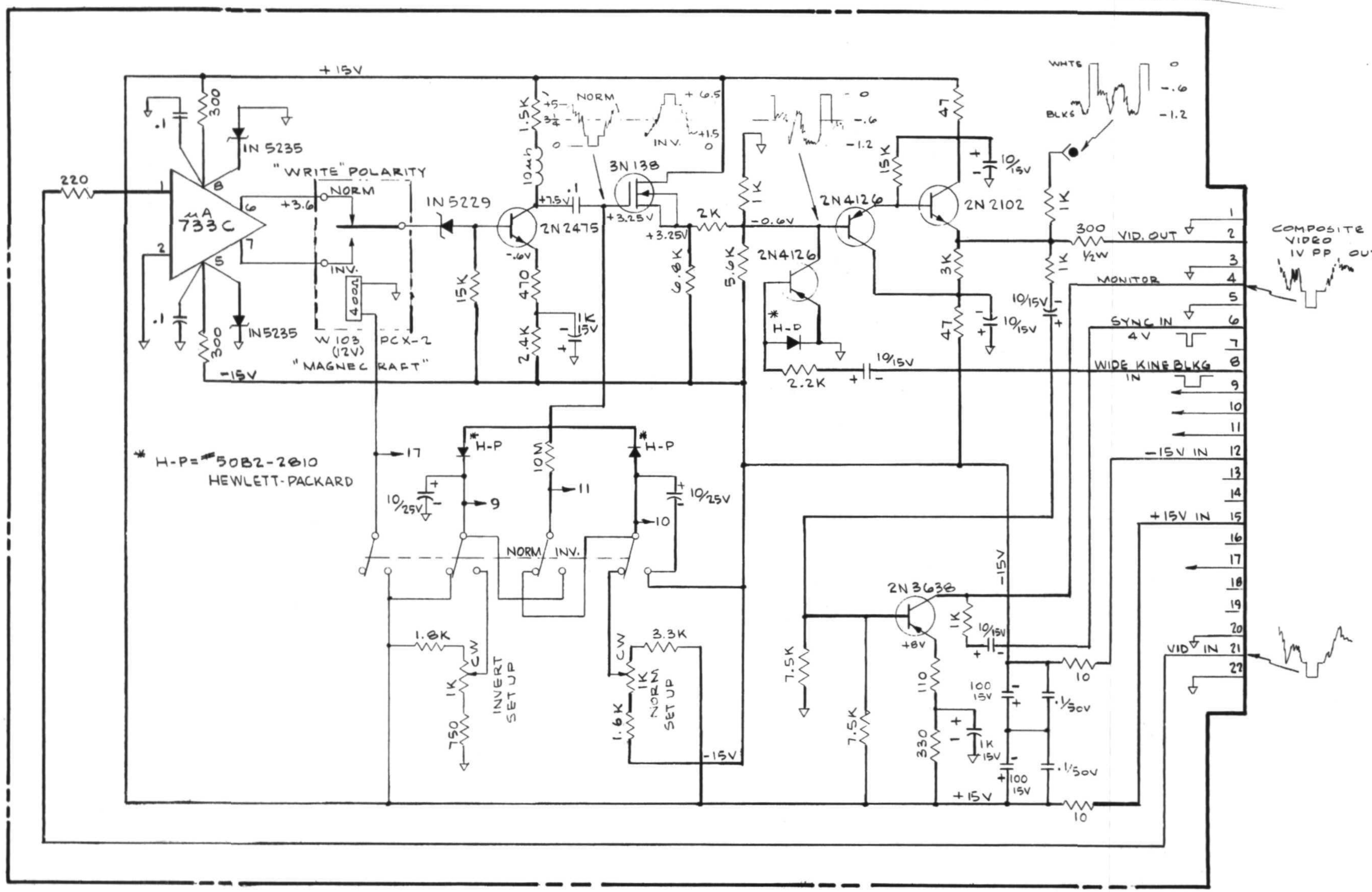


Figure 12. Schematic of video processor.

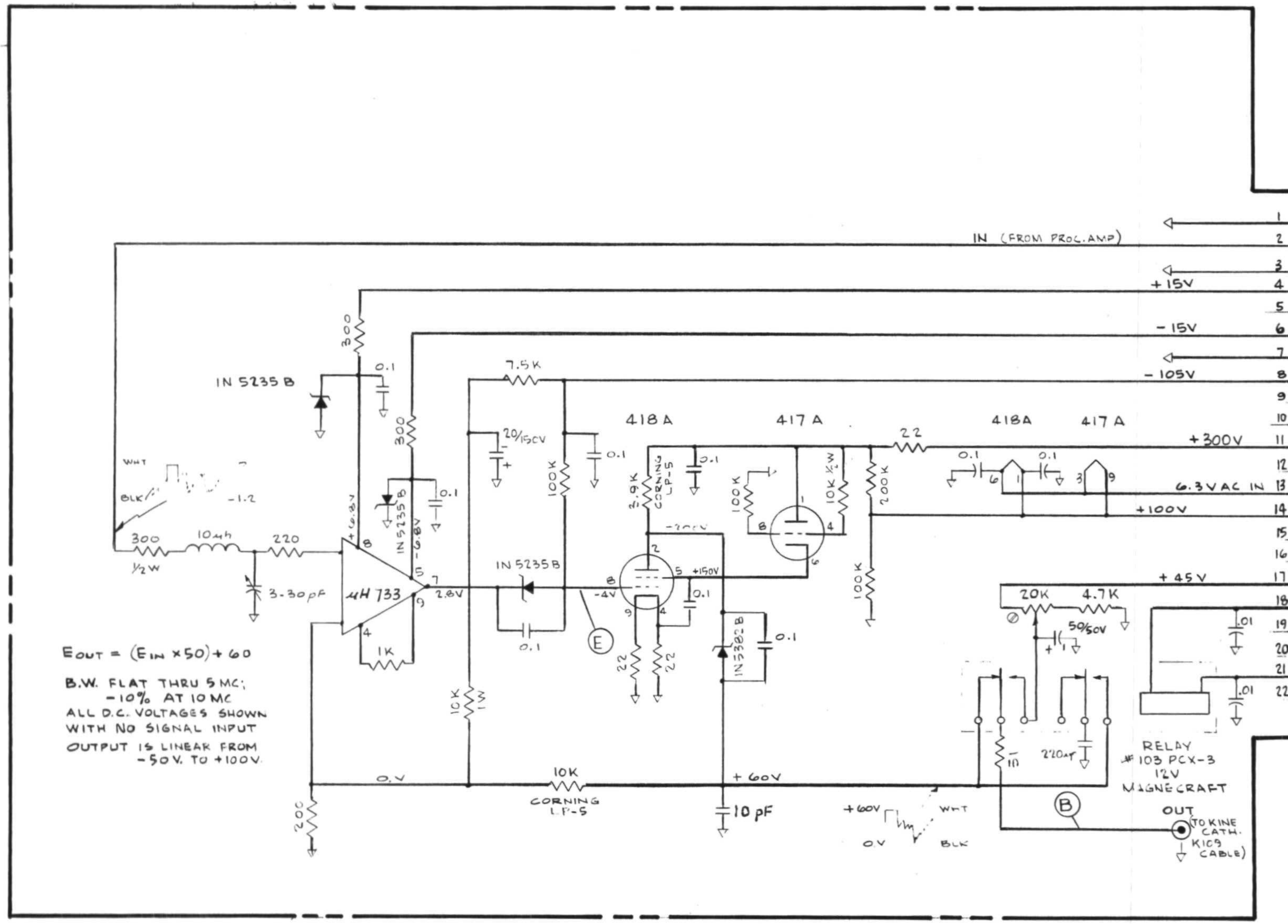


Figure 13. Schematic of video driver.

tube output stage. Although an all-solid-state amplifier could have been designed, a tube-type output stage is used because tubes are inherently more tolerant of high-voltage transients that can be generated by small arcs within the storage tube.

In any wideband feedback system, careful attention must be given to the frequency and phase characteristics of the stages and elements within the feedback loop. The µH733C lends itself well to this application because of its very wide bandwidth (typically 70 MHz) and high available gain. This allows the design of a loop in which there is a single "dominant lag" frequency, that of the vacuum tube plate circuit in this case, which is considerably lower than the cutoff frequency(s) of other stages in the loop. In such a design, complete stability is achieved along with smooth frequency response without the need for any adjustments.

Since the amplifier must have flat response down to dc to faithfully reproduce the signal from the video processing amplifier, another tube is used as a simple cathode-follower regulator for the screen of the 418A output amplifier to avoid a low-frequency time-constant in this circuit.

Because of the relatively slow rate of roll-off of frequencies above 10 MHz in the amplifier, a simple low-pass filter is included at its input to reduce system gain above this range of frequencies and to avoid oscillation.

12. <u>Video Driver Power Supply</u> (Figure 14) - To supply the voltages required by the video drive amplifier, a special power supply was designed. This unit also uses vacuum tubes in a simple circuit which can withstand high-voltage

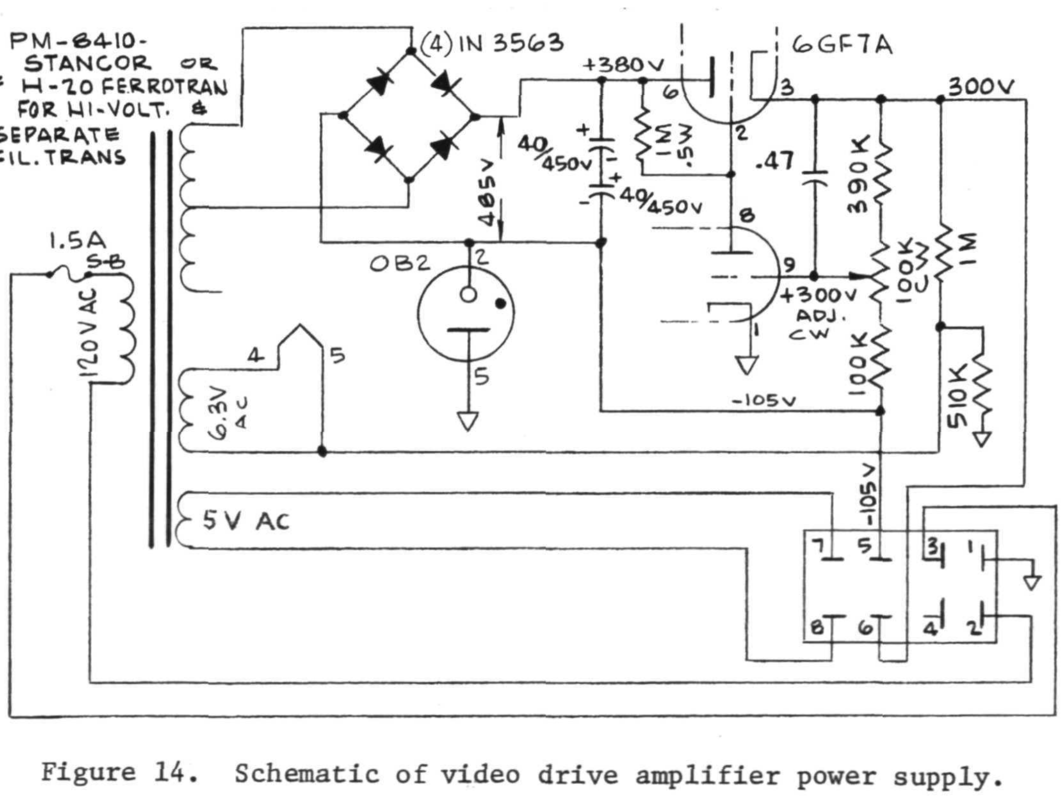


Figure 14. Schematic of video drive amplifier power supply.

transients caused by high-voltage arcs. A type 6GF7A dual triode serves as both the series regulator and the comparison amplifier for the +300 V output. A type OB2 regulator provides the -105 V output to the drive amplifier; this same voltage also is the reference voltage for the +300 V supply. Input dc for the entire supply is developed by 1N3563 silicon rectifiers in a full-wave bridge circuit. The application of voltages to the drive amplifier is automatically delayed by the tube-type regulator used in the power supply until its tube cathodes reach operating temperature.

13. MTI TV Camera - see manufacturer's specifications.

14. Frame Counter and Write Control Circuit (Panel #4, Figure 15) - In the quiescent state, Q (pin 6) of IC_1 is low, thus holding Q_1 (pin 2) of IC_2 low. This in turn keeps Q_3 on and therefore Q_4 off. With Q_3 off there is -110 V on G_1 of the CRT, thereby cutting it off. When the single-frame lever is depressed, C_1 (pin 2) of IC_1 momentarily goes low, thereby setting Q high. The next vertical blanking pulse entering CR_1 (pin 3) of IC_2 causes Q_1 of IC_2 to go high and Q_2 (pin 8) of IC_2 to go low at the next vertical blanking pulse. This resets IC_1 so that Q of IC_1 is again low. At the next vertical blanking pulse Q_1 of IC_2 returns to low. During the time Q_1 of IC_2 is high (two field times) Q_3 is off, causing Q_4 to saturate. This applies the voltage preset by the brightness potentiometer to G_1.

15. Bias and Erase Timer Circuit (Panel #4, Figure 15) - uses an analog timing module (Chronologic's TM-3B) that is activated by the application of a positive pulse to pin 10. Pin 9 immediately goes high which turns on Q_4 and therefore energizes the erase relay to apply erase power to the CRT. Pin 9 stays high for a time determined by the resistance between pins 4 and 5. When the relay is not energized the bias circuit is connected to the heater. The bias heat circuit is a standard SCR circuit that controls the power to the target to a level that will heat the target without erasing the image.

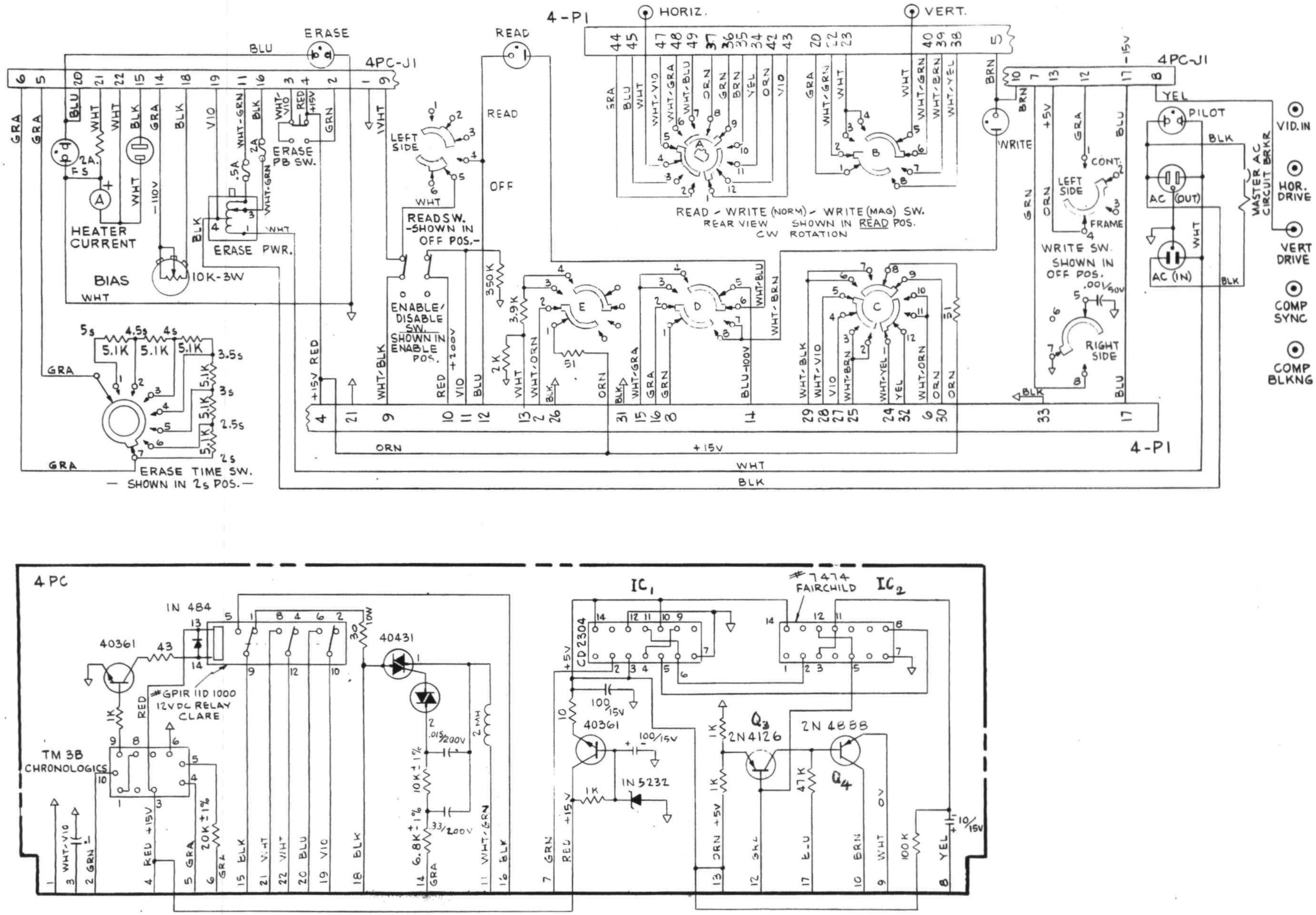


Figure 15. Schematic of Panel #4.

IV. OPERATING PROCEDURES

While every reasonable attempt has been made to make the operation of this rack foolproof, it may still be possible to damage either the electronics or the CRTs by improper handling. It is therefore strongly recommended that operators familiarize themselves with the operating procedures *prior* to turning on the rack. Do not violate any of the procedures.

The rack comprises the following six panels: dual monitors, CC CRT, CC-phosphor CRT, controls, general electronics, and deflection power supplies. (See Figure 1.)

A. Front Panel Controls

1. Dual Conrac Monitors - have the standard controls behind the front flap doors. These include on-off, width, brightness, contrast, vertical hold, horizontal hold, and height and vertical linearity.

2. Cathodochromic CRT Panel (Panel #2, Figure 16) - The controls on this panel are:

(a) Brightness - adjust the voltage on G_1 of the CRT when the DMS (display mode switch on Panel #4, Figure 15) is in the "write" mode.

(b) Contrast - controls the magnitude of the video signal fed into the processor and thereby the video drive reaching the cathode of the CRT.

(c) Image Polarity - controls the relationship between the video polarity entering the video processor and that leaving it. "Invert" means the image stored on the CC CRT will be opposite to that appearing on Monitor 1.

(d) Pedestal - adjust the relationship between the blanking level and the "gun off" level of the video. There is a separate control for each video polarity. It is used with the write signal.

(e) Focus - adjusts the focus output of the high-voltage power supply and therefore the voltage appearing on G_3 of the CRT while the DMS is in a write position.

(f) Readout Selector - determines the image fed to Monitor 2. In the photomultiplier position the signal to the monitor comes from the video processor. If the DMS is in the write position, the image displayed on Monitor 2 will be opposite to that stored on the tube. If the DMS is in the read position, then the signal from the photomultiplier (located on Panel #3) will be fed to the monitor. In the TV camera position the signal reaching Monitor 2 will be coming from the camera regardless of the DMS setting.

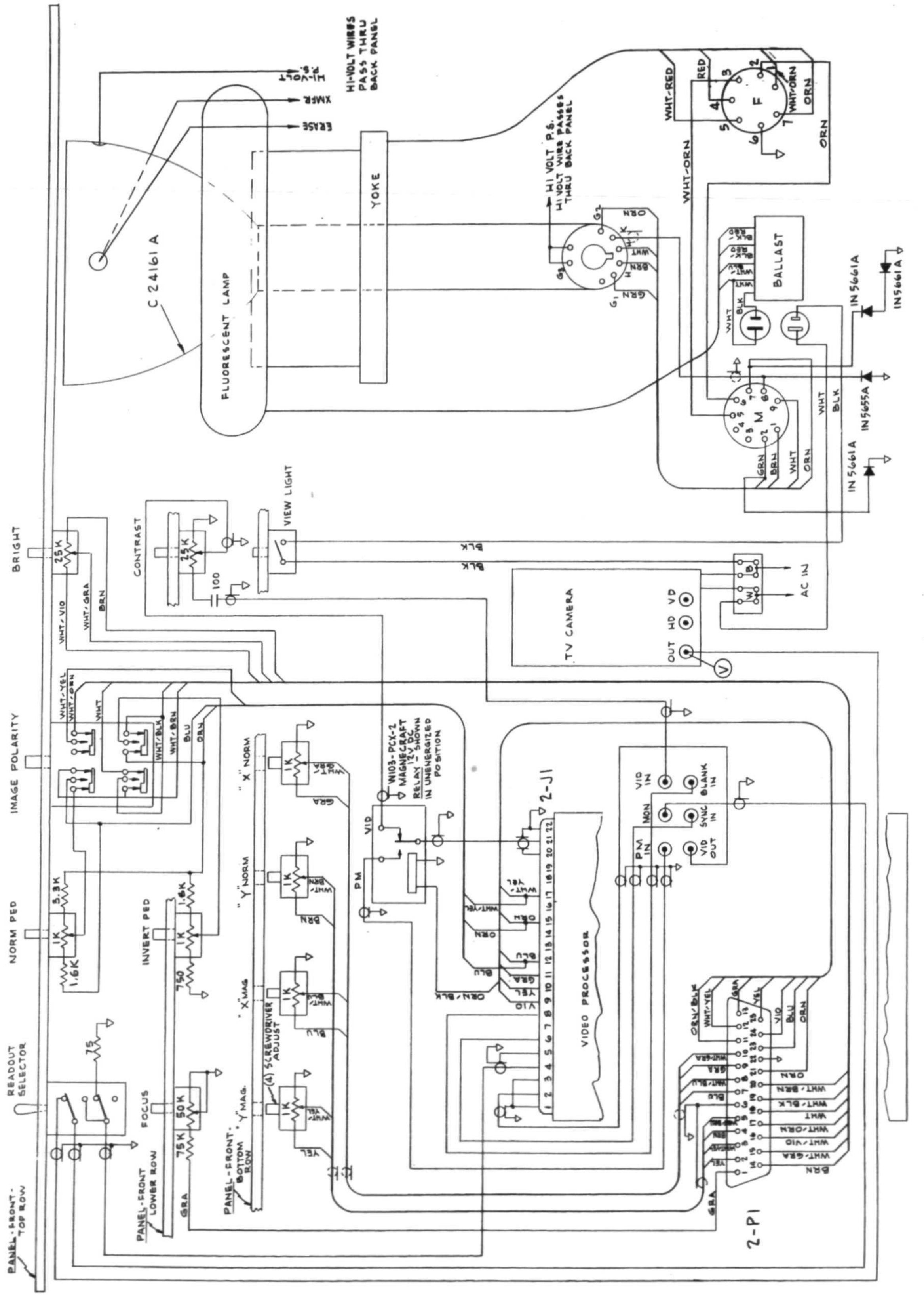


Figure 16. Schematic of Panel #2.

(g) View Light - activates fluorescent lamp behind the CC tube.

(h) Write Normal Size -

vertical *horizontal*	control the magnitude of the deflection signal reaching the deflection amplifiers when the DMS is in the "write normal" position.

(i) Write Magnify Size -

vertical *horizontal*	perform the same function as those mentioned in (h) when the DMS is in the "write magnify" position.

3. Cathodochromic-Phosphor CRT Panel (Panel #3, Figure 17) - The controls on this panel are:

(a) Brightness - adjusts the brightness of the light emitted by the phosphor layer.

(b) Contrast - controls the magnitude of the photomultiplier signal reaching the video processor.

(c) Image Polarity - controls the polarity of the image read out from the CC-phosphor CRT.

(d) Pedestal - adjusts the relationship between the blanking level and the "gun off" level of the video. There is a separate control for each video polarity. It is used with the read signal.

(e) Focus - focuses the flying spot on the phosphor layer.

(f) View Light Switch - activates fluorescent tube behind CRT and deactivates photomultiplier power supply.

(g) Read Size -

vertical *horizontal*	control the magnitude of the deflection signal reaching the deflection amplifiers when the DMS is in the "read" position.

(h) Write Centering -

vertical *horizontal*	adjust the position of the image on the screen.

4. Control Panel (Panel #4, Figure 6) -

(a) Master Power Switch - A 20-A circuit breaker to control ac power to the entire rack.

(b) Inputs - Five input signals are used:

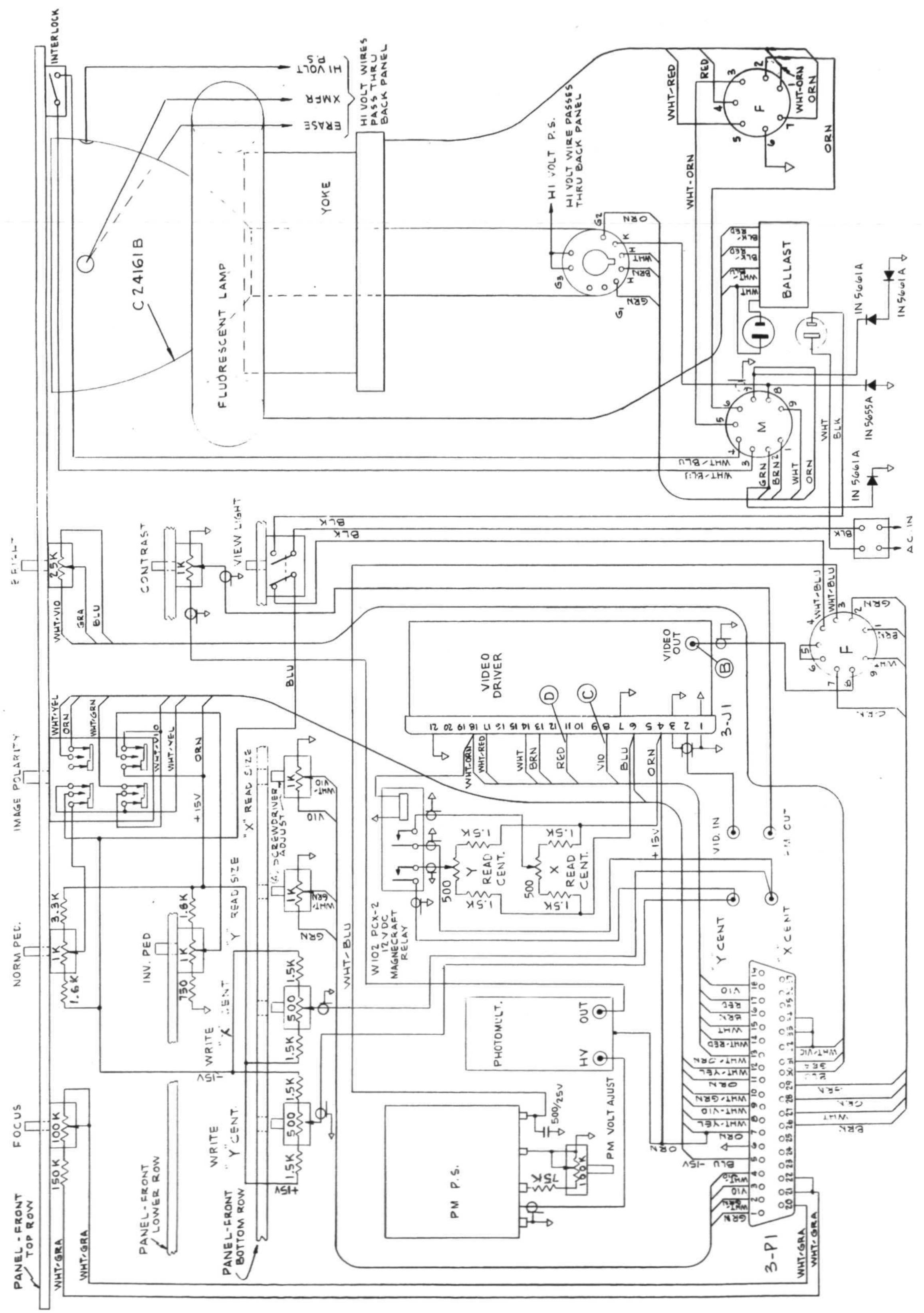


Figure 17. Schematic of Panel #3.

Video	A composite video signal with peak-to-peak amplitude of 1 V.
Horizontal Drive Vertical Drive	Negative-going signals with a peak-to-peak amplitude of 5 V (dc level not important).
Composite Sync Composite Blanking	Standard negative-going composite signals with a peak-to-peak amplitude of 5 V are required.

(c) Display Mode Switch (DMS) - allows the user to select the desired mode of operation; e.g., write normal - where a 500-line image is written on either the CC tube or the CC-phosphor tube; write magnify - where the central 400 lines of the 500-line picture are written on either the CC tube or the CC-phosphor tube; or read - where the phosphor layer of the CC-phosphor tube is scanned.

(d) Enable-Disable Switch - prevents accidental activation of the writing circuit by holding G_1 at -110 V and G_2 at 0 V unless the switch is in Enable.

(e) Write Switch - turns on the writing beam (if the enable-disable switch is in Enable) continuously if the switch is down or, for a single frame, if the switch is moved upward. The DMS must be in a Write position.

(f) Read Switch - turns on the reading beam if the enable-disable switch is in Enable and if the DMS is in Read.

(g) Erase - activates the erase circuitry.

(h) Erase Power - adjusts the voltage applied to the erase heater during the erase cycle.

(i) Erase Time - controls the time during which the erase heater is activated.

(j) Bias Heat - adjusts the power being applied to the erase heater during the portion of the cycle when the erase circuit is not activated.

(k) Heater Current Meter - reads the current in the primary of the heater circuit. When the 2AFS lamp is lit, the meter reads 2 A full scale. When the lamp is off, the indicated markings are correct.

B. Turn-on Procedure

NOTE: The operator should carefully read this section before he turns on the equipment for the first time.

The rack is fused for 20 A and therefore should be connected only to an outlet (120 V, 60 Hz) that can safely handle 20 A. In normal operation the rack draws somewhat less than 15 A. Before making the power connection, decide which of the two CC tubes is to be used and connect that one into the circuit. There are four in-line high-voltage disconnects (one focus, two erase, and one anode voltage leads), one 7-pin plug, and one 9-pin plug that must be connected. Double-check the high-voltage leads; a mistake here can be disastrous. Check the high-voltage leads inside the CRT mount. Connect the video line and the sync, blanking, and drive signals. The enable-disable switch should be in the disable position and the read and write switches off.

Turn the rack on using the master switch. In 4 to 5 seconds a relay will energize, connecting the deflection power supply to the deflection amplifier and applying ac to the high-voltage power supply. If the relay does not pull in, shut down the rack and consult the trouble-shooting section (VI-D). Approximately 1 minute after the relay closes the high-voltage power supply will come on.

C. Setting the Video Level

Attach high-impedance, low-capacitance oscilloscope probe to test point B on the video driver (on Panel #3). Trigger oscilloscope from the horizontal blanking signal and set the x and t ranges to 10 or 20 V/cm and 10 μsec/cm, respectively. Make sure that the applied video signal has the full range of brightness levels (from full black to full white).

To cut off the electron beam in the cathodochromic CRT requires about +60 V on the cathode with respect to G_1. Since G_1 swings from -100 V to 0 V at full grid drive (0 V) it is still desirable that the gun can be cut off by the video signal. Therefore, the video level at test point B should be adjusted to swing between +60 V and +5 V. The +60 V level is set aside for blanking. The video white level should be set at +55 V whereas the video blacks should be set to +5 V. This can be done by alternately adjusting the contrast (video gain) and pedestal controls (dc level). Be sure to use the pedestal control appropriate to the image polarity selected. Remember that regardless of the polarity selected, +55 V is the white level and +5 V is the black level.

D. Writing an Image on the CC Tube

Connect the CC tube by attaching all the necessary leads (see IV-B). After the rack has been on for approximately 1 minute, place the DMS in the write normal position. Turn the brightness and contrast controls on Panel #2 to the full counterclockwise position and flip on the view light. Enable the write electronics and switch the write switch to the continuous position. The neon write lamp should be lit now but no image should appear on the tube. Increase the contrast to 25% of maximum and slowly increase the brightness until an image appears. Now adjust both controls until a good gray scale image is obtained. In the most intensely colored area a contrast ratio of 3:1 should be attainable in less than 5 sec. Do not write on the target for inordinately long periods of time (>30 sec). Once the controls are properly set, subsequent images can be written by simply enabling the system and turning on the write switch.

E. Erasing an Image Stored on the CC Tube

Erasure is accomplished by passing a current through the transparent conductive heater on the CRT target. Since the typical heater resistance is in the 50- to 100-Ω range and the necessary heater power to effect erase in 5 sec is about 7.5 W/in.^{2}, typical erase current should be in the 1-A range. After ensuring that the write system is disabled and the write switch is off, set the erase timer to 3 sec and the erase power control to 25. Depress the erase button thereby initiating the erase cycle. Adjust the erase power control until the heater current meter reads 1 A. If the target is not completely erased, reactivate the erase circuit. Increase the erase time control by 0.5-sec intervals until the image is completely erased. If, after reaching 5 sec, the image is still not erased, slowly increase the erase power while activating the erase circuit. Erase time can be shortened below 5 sec by increasing the erase power; however, in no case should the erase power and erase time controls be adjusted so that the heater remains on for more than 0.5 sec after the image is erased. To maintain good heater life it is advantageous to operate the heater at low power and long erase. At no time should the image be erased in less than 2 sec.

F. Focusing the Image on the CC Tube

There are two methods by which the image can be focused. The faster method is to use the cathodoluminescence of the CC powder. To do this reduce the ambient light to a minimum and turn off the view light; then write on the tube using the settings arrived at under Section IV-D. Using the focus control on Panel #2, bring the image into focus as you would on a television set. The best image for focusing is one that has good vertical edges so that the best compromise between sharp focus of the vertical lines and sharp focus of the horizontal scan lines can be achieved. The more time-consuming approach is to write an image using the settings of IV-D, erase the image using the settings of IV-E, change the focus slightly, and rewrite the image. Continue writing and erasing until the image is sharply focused.

G. Photographing the CC Image

After writing an image on the CC tube using the methods of IV-D and -F place the readout assembly on the hinge pins on Panel #2. Rotate the mirror mount so that the optical path between the 35-mm camera and tube is not obscured. The 35-mm camera mount is designed to function with a Nikon F camera with a 50-mm f/1.4 lens and #1 and #2 close-up lenses or the Nikon 55-mm f/3.5 macro lens. The camera is mounted by attaching the supplied threaded tube to the front of the Nikon camera and inserting the tube into the "O" ring. (A small quantity of optical grade noncreeping lubricant may be useful.) When the proper distance between the lens and object is obtained, lock the camera in place using the 1/4-20 thumbscrew. With the view light on, the light level is sufficient to photograph the stored image using ASA 125 film at 1/60 sec and f/5.6, or ASA 400 film at 1/60 sec and f/11.

H. Reading Out the Image Stored on the CC Tube

Once an image has been stored on the CC tube, that image can be transmitted electronically by means of the included TV camera. The operation of the camera is covered in the manufacturer's user manual and will not be covered here. (It is recommended that the TV camera be turned off when not in use.) The readout assembly should be mounted on the hinge pins of Panel #2 as for photographing the image, but the movable mirror should be adjusted so as to direct the image to the TV camera. With the view light on and the readout selector in the TV camera position the transmitted image is viewable on Monitor 2. This signal can be delivered to other electronic equipment by connecting to the video terminal on the camera.

I. Writing an Image on the CC-Phosphor Tube

Connect the CC-phosphor tube to the electronics by attaching all the necessary cables (see IV-B). The procedure for setting up the contrast and brightness level is the same as for the CC tube. The controls on Panel #2 govern the writing of an image on <u>both</u> tubes. A contrast ratio of 2:1 should be attainable in 5 sec. Do not write on the target for inordinately long periods of time (>30 sec). When writing on the tube strong green fluorescence will be seen in normal operation.

J. Erasing an Image Stored on the CC-Phosphor Tube

The detailed instructions in IV-E apply in their entirety.

K. Focusing the Image on the CC-Phosphor Tube

Since the cathodoluminescence emitted by this tube is quite bright, focusing can be easily achieved using the "quicker" method given in IV-F. Remember that the focus control on Panel #2 is the one that controls Write Focus.

L. Photographing the CC-Phosphor Tube

Place the readout assembly on the hinge pins of Panel #3 and rotate the movable mirror out of the optical path of the Nikon camera. The incoming image can be photographed directly from the cathodoluminescence of the phosphor just as you would photograph an image on a TV set. As with the CC tube the stored image may be photographed by using the view light as a source of illumination. The exposure here would have to be just slightly longer than with the single-layer CC tube. Somewhat greater contrast may be achieved by going to the read mode (see IV-L) and using the phosphor as the light source.

M. Reading Out the Image Stored on the CC-Phosphor Tube

Readout in this mode is accomplished by switching the DMS to the read mode and placing the readout assembly on Panel #3. Make sure the movable mirror is in position to deflect light from the stored image into the photomultiplier. The photomultiplier power supply is double-interlocked to prevent damage to the photomultiplier. For the supply to be on, the readout assembly must be firmly attached to the rack, and the Panel #3 view light must be off. The power supply voltage is adjustable at the appropriately labeled potentiometer in the rear of Panel #3. To view the image on Monitor 2 the readout selector must be in the photomultiplier position. The controls that govern the readout are found on Panel #3. The brightness (phosphor light level) should be adjusted to produce the maximum signal without photomultiplier saturation when the signal is viewed with an oscilloscope at the photomultiplier output terminal with the contrast control at midrange. The contrast and the appropriate pedestal should be adjusted to produce a reasonable video signal at Monitor 2. Readout image polarity can be selected independently of the writing image polarity. A positive readout can be obtained by writing and reading in either positive polarity or negative polarity.

V. TEST PROCEDURE

Purpose: *The purpose of this test procedure is to determine whether or not the equipment supplied to NASA meets the specifications of Exhibit A. In order to facilitate easy cross-referencing, the paragraph numbering in this test procedure parallels that used in Exhibit A of the contract. All tests must be performed in accordance with the preceding operating procedures. Exhibit A is included herein as an Appendix.*

2.1 Verify by visual observation that the equipment configuration meets the contract requirements.

2.2 Cathodochromic CRT Specifications

2.2.1 Color CC tube to desired contrast ratio, i.e., 5:1 or 10:1 (see 2.2.4). Direct beam from a 500-W photoflood lamp or similar source of high-intensity light on tube for 1 min. The contrast ratio will not be significantly altered. CAUTION: High-power light sources usually develop considerable heat. DO NOT allow the faceplate of the tube to become hot to the touch. Do not allow excess IR from the light source to fall on the target of the tube, thereby heating it.

2.2.2 Color CC tube to a contrast ratio of 10:1 as measured with a Spectra Brightness Spot Meter or similar photometer (see 2.2.4). Turn off rack and expose CC tube to normal ambient light. Remeasure contrast ratio 24 hours later and allow for drifts in measuring equipment and changes in light level (see 2.2.4).

2.2.3 Connect a video signal source to the video input terminal on the rack. Composite sync and composite blanking must always be connected to the appropriate terminals. The bandwidth of the video signal should be at least 5 MHz. This can be checked with a Tektronix 547 oscilloscope and 1A1 plug-in amplifier using the delayed sweep to lock in on the appropriate horizontal line. After storing a 3:1 contrast ratio image (see 2.2.4) observe the target by eye or with a magnifying glass to determine the resolution.

2.2.4 The equipment necessary to perform this test is a Spectra Brightness Spot Meter (BSM) or similar photometer, Moseley 135A X-Y recorder or equivalent, and a video signal that supplies a large area when the CRT gun is turned on fully. Focus the BSM on the region of the target that will be colored by the electron beam and connect the BSM to the recorder, selecting the Y-axis gain such that full scale on the BSM yields full scale on the recorder. Set the X-axis gain to 2 sec/div. Adjust the sensitivity of the BSM to give a convenient reading, I_{BR}, near full scale when the target is uncolored. Close the aperture on the BSM. The recorder should show a reading I_D near 0. Adjust the contrast and brightness controls to produce the darkest picture without overwriting the whites or distorting the gray scale. Starting with a clean screen start the recorder and then throw the continuous write switch.

After 10 sec turn off the continuous write switch and then the recorder; observe the final value, I_F. The contrast ratio is given by $(I_{BR}-I_D)/(I_F-I_D)$. These measurements should be made so as to prevent extraneous light from entering the BSM.

2.2.5 Write image to a contrast ratio of 5:1 using method of 2.2.4. Erase image (see 2.2.6); observe target for damage.

2.2.6 Set erase timer to 5 sec. Push erase initiate switch and set erase current to 1 A. After target has cooled write an image on the CRT to a contrast ratio of 3:1 (see 2.2.4). Push erase initiate switch and observe image. If image does not disappear before the erase light goes out, increase erase current. Heater erase current should not exceed 2 A and erase times should not be shorter than 2 sec.

2.2.7 Verify by inspection.

2.2.8 See 2.2.4 and verify by inspection.

2.2.9 Write an image on the CC-phosphor tube. Switch to read mode and observe written image. Viewable image indicates that phosphor emission band is in the absorption band of the cathodochromic. This fact can also be inferred from the fact that the phosphor emission is green and the cathodochromic absorption is magenta (red and blue), indicating an absorption band in the green.

2.3 Electronic System Specifications

2.3.1 Verify by inspection.

2.3.2 Apply standard composite sync, composite blanking, and horizontal and vertical drive signals to the rack. Observe functioning of rack with video input signal.

2.3.3 Apply all above sync signals to the rack and connect vidicon camera with at least 1-V output to the video input. Observe functioning of rack.

2.3.4 Polarity of image stored on cathodochromic CRT can be selected by a switch on the CC panel. Put switch in positive position, adjust pedestal and gain to produce proper video signal, write and observe image on CC tube. Erase stored image. Switch to negative position, readjust gain and pedestal if necessary, write and observe image on CRT.

2.3.5 Single-frame write switch is on the control panel. Connect one channel of a dual-channel oscilloscope (e.g., Tektronix 547 with 1A1 plug-in or equivalent) to the CRT write test point. Connect the other channel to the vertical drive. Sync the oscilloscope to the vertical drive. Press single-frame write switch and observe that the CRT write duration is one frame (1/30 sec).

2.3.6 Verify by inspection.

2.3.7 Display full nominal 500-line TV frame on underscanned monitor. Display same frame on CC tube, making sure that the mode selector switch is in write-normal position. Compare frame on monitor to stored frame on CRT to verify 500-line TV performance. Erase stored image. Switch to write-magnify position and write with the same video signal as above. Note that stored frame is only 80% of the entire frame but still occupies the full target of the CRT.

2.4 Readout System Specifications

2.4.1 Verify by inspection.

2.4.2 Verify by inspection.

2.4.3 Verify by inspection.

2.4.4 Verify by inspection.

2.4.5 Using a video test signal observe the performance of the detector readout video processor and monitor. Using the same test signal store an image in the CC-phosphor combination tube. Observe the stored image by direct viewing. Switch to photodetector readout and observe image on monitor. Verify that the image quality observed on the monitor is determined by the CC-phosphor combination tube performance and not by the detector circuitry and the monitor. The contrast ratio of the CC-phosphor tube can be measured in the same way that the CC tube is measured (see 2.2.4) except that the electron gun should be off while making a contrast reading.

2.4.6 The TV camera is located on the CC panel. Verify by inspection. Store a test image on the CC tube, switch rack to vidicon readout mode. Observe readout image on monitor.

2.4.7 Verify by inspection.

VI. MAINTENANCE PROCEDURES

A. Changing the Display-Storage Tube

Both the CC tube and the CC-phosphor tube may be changed in the same way. However, the tube carriers themselves are wired differently and should not be interchanged. To remove the carrier from the rack unscrew the captive thumbscrew found just below the handle on the carrier. Carefully remove all electrical connections from the carrier and extract it from the rack by pulling on the handle. Next, gently remove the high-voltage connectors from the tube and disconnect the socket. Remove the aluminum ring and the "O" ring from the gun end of the tube. Loosen the top screws on the Lucite support at the front of the tube and slide the tube forward. As with any CRT, these tubes must be *handled with extreme care* to prevent dangerous implosions.

In replacing the tube follow the above instructions in reverse, keeping the alignment of the tube in mind. When reconnecting the high voltage leads be sure to attach the anode lead at the 9 o'clock position (as seen from the front). The two erase leads attach at 6 o'clock and 12 o'clock. The face of the tube should be parallel to and no more than 1/32 in. behind the front surface of the carrier. In putting in the new tube it may be necessary to move the yoke to keep it in contact with the tube. This is accomplished by loosening the four binding-head screws holding the yoke plate to the mainframe. Care should be taken to ensure that the yoke axis and tube axis are colinear.

B. Realignment of Image

If the storage display tube has been replaced without touching the yoke mounting, the only adjustment necessary will be centering to compensate for the electron gun alignment differences. In the case of the CC-phosphor tube, both read and write centering must be adjusted. Write centering, which should be set up first, is located on the front of Panel #3 while read centering is found at the rear of Panel #3.

If the yoke was moved, slight adjustments in the various picture sizes may be necessary. It is not likely, however, that the deflection correction electronics will need adjustment. If for some reason it is necessary, follow the scheme listed below.

<u>Adjustment Procedure</u>

1. Apply square or grid pattern signal.

2. Adjust X,Y correction magnitude for optimally straight lines, while adjusting X,Y size to keep full-scale display on screen.

3. Adjust X,Y curvature balance controls to obtain mirror-image curvature about axis.

4. Repeat 2.

5. Turn yoke for properly oriented display.

6. Adjust horizontal and vertical line rotation controls if required.

7. Adjust top/bottom and right/left size controls for perfectly square display.

8. Set horizontal and vertical position controls, horizontal and vertical size.

C. Changing the View Lamp

To change the view lamp the storage display CRT must be removed in accordance with paragraph VI-A. Then loosen the screws holding the four clips by securing the lamp and rotating the clips to free the lamp. Remove the lamp from the socket and by tilting it slightly remove it from the mainframe. (It may be necessary to release the lamp-holding plate by removing the four Allen cap screws securing it to the frame.) Insert the new lamp (G.E. FC 8T9CW) and follow the above instructions in reverse.

D. Trouble-Shooting Aids

1. Deflection power relay does not pull in.

    (a) Seven- and nine-pin cables not plugged into same tube carrier.

    (b) Relay contacts frozen closed - free them.

2. Deflection power relay chatters.

The deflection amplifier is drawing too much current which is causing the deflection power supplies to shut down. The deflection power supplies have been adjusted to be current limiting at a setting just above the maximum needed to drive the rack. Check the input to the deflection amplifier for proper deflection signals (see Figure 18).

3. Cannot write an image on the tube, and write lamp does not light.

    (a) Check for deflection signals at the sampling points on the deflection amplifier. The target protection circuit automatically cuts off the electron gun if deflection is not present.

    (b) Check for proper functioning of the high-voltage power supply. Observe appfopriate precautions; *25 kV can be lethal!*

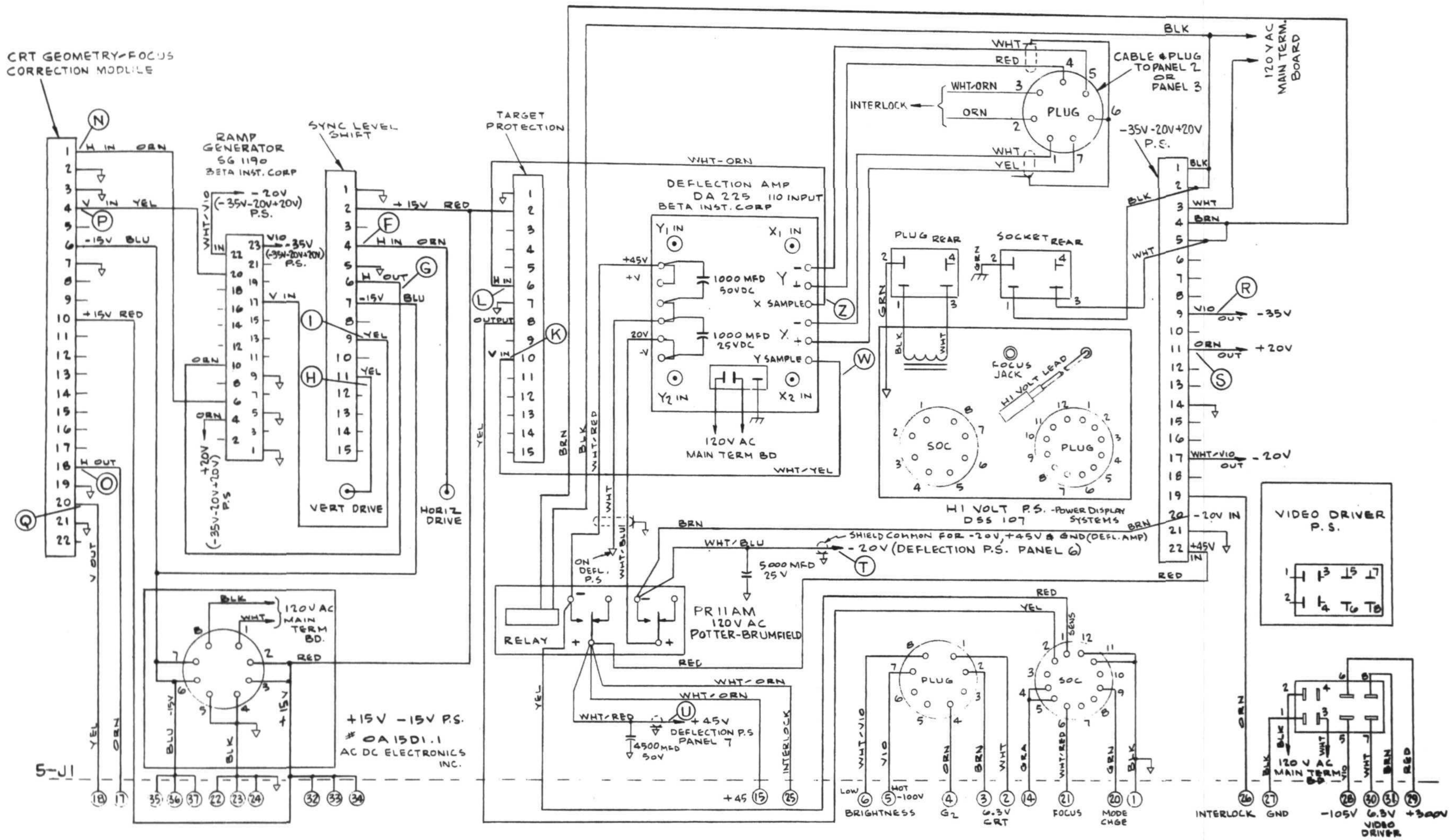


Figure 18. Schematic of Panel #5.

4. Cannot write an image but write lamp lights.

   (a) Check anode voltage. Again, observe appropriate precautions; *25 kV can be lethal.*

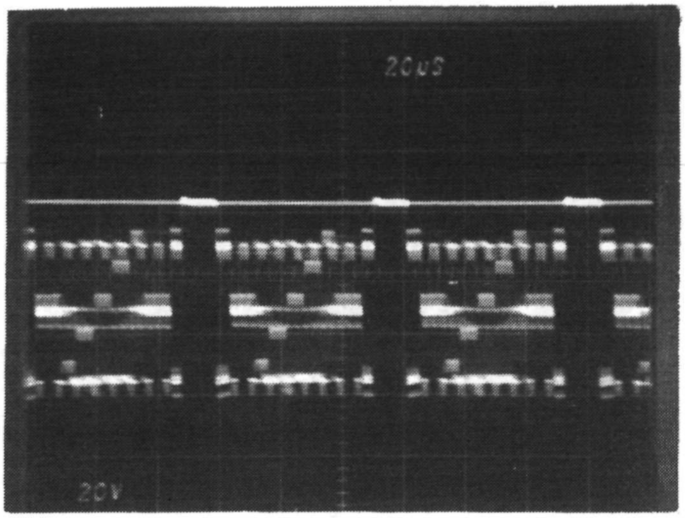
   (b) Check write control circuitry including the frame counter.

5. Photomultiplier does not function.

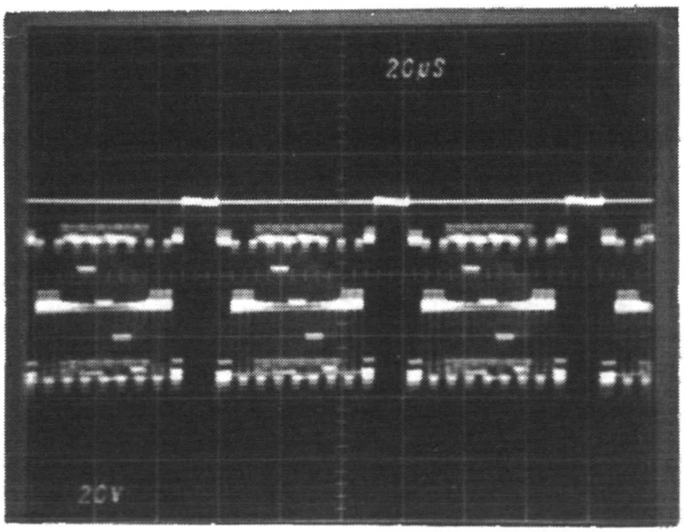
   (a) Check for -15 V at pin 4 of the photomultiplier power supply (Figure 17). If no voltage is present, check that the readout assembly is drawn firmly against the rack and that the tube carrier is in all the way. The view light switch on panel #3 must be off.

   (b) Ensure that +15 V (read phone tip plug) is supplied to the amplifier circuit in the photomultiplier housing.

6. Figures 19B through 19Z are typical waveforms found at the indicated test points on the schematics. These will be helpful in tracing any problems that might arise.

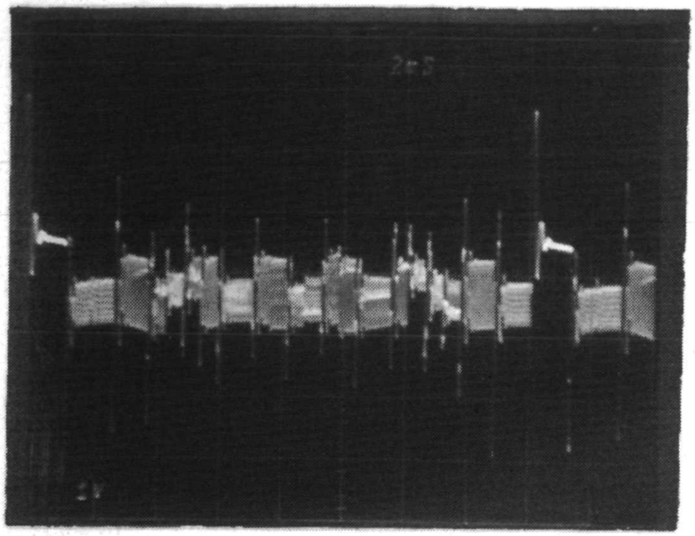


VIDEO DRIVER
(B) VIDEO OUTPUT
(NORMAL)

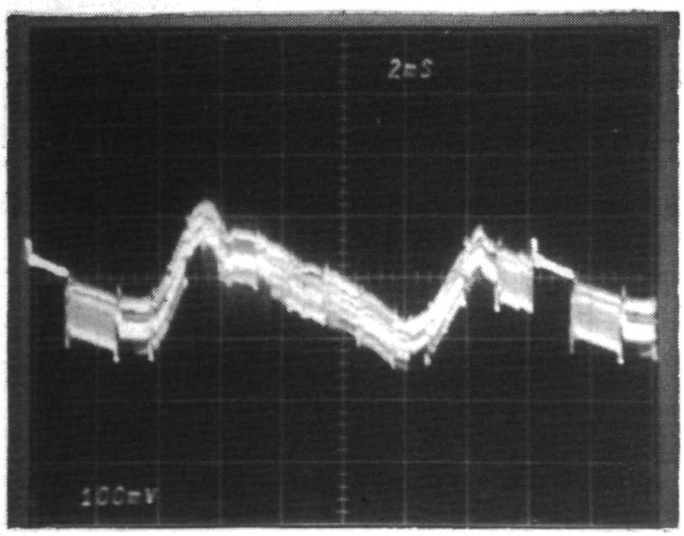


VIDEO DRIVER
(B) VIDEO OUTPUT
(INVERTED)

Figure 19. Waveforms at test points B through Z.

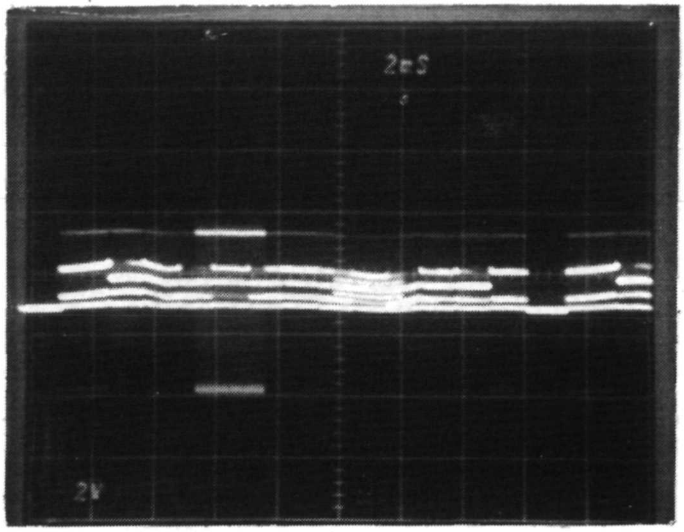


C VIDEO DRIVER
-105V SUPPLY BUSS

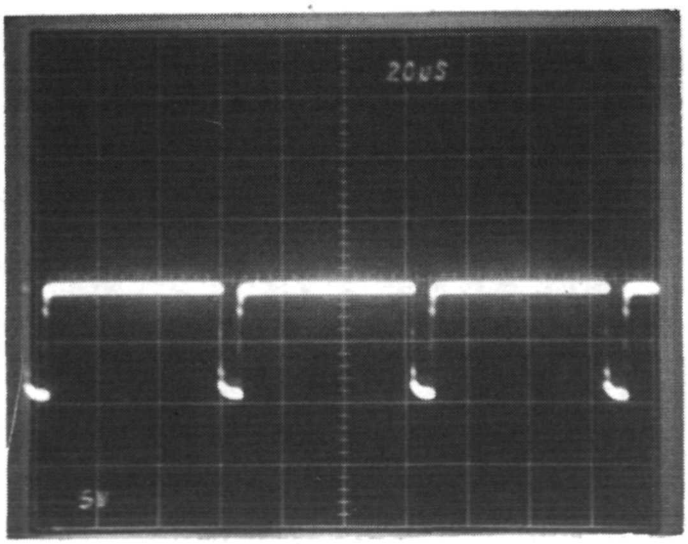


D VIDEO DRIVER
+300V SUPPLY BUSS

Figure 19. (Continued)

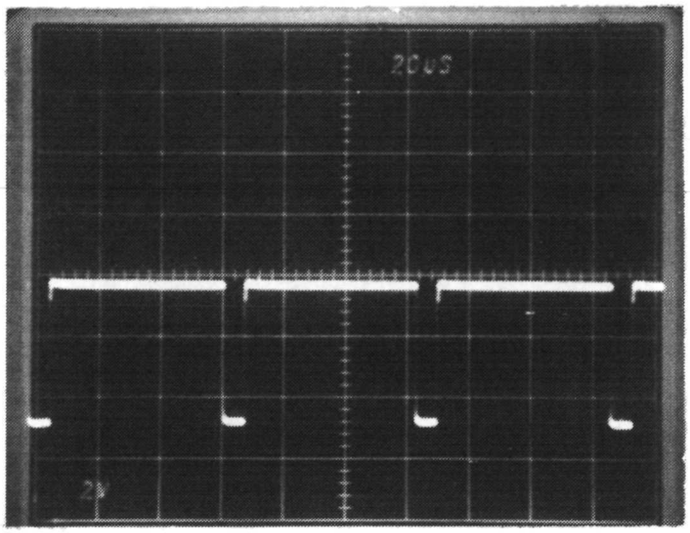


Ⓔ VIDEO DRIVER
VIDEO OUTPUT
μA 733
INTEGRATED CIRCUIT

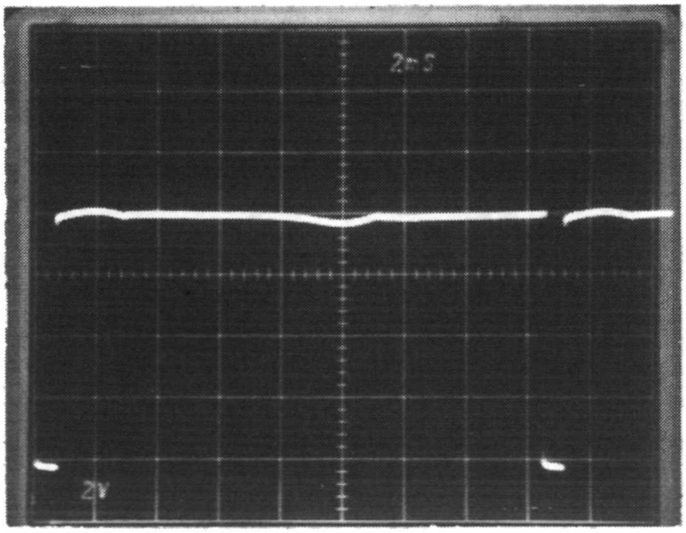


Ⓕ SYNC LEVEL SHIFT
HORIZONTAL SYNC
INPUT

Figure 19. (Continued)

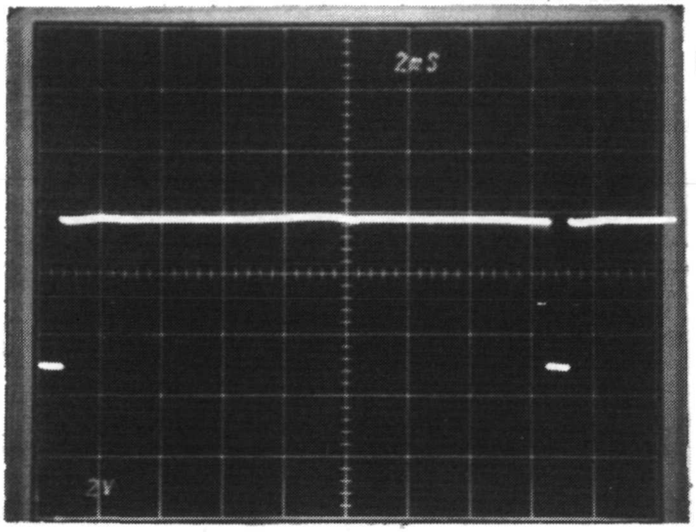


SYNC LEVEL SHIFT
(G) HORIZONTAL SYNC
OUTPUT



SYNC LEVEL SHIFT
(H) VERTICAL SYNC
INPUT

Figure 19. (Continued)



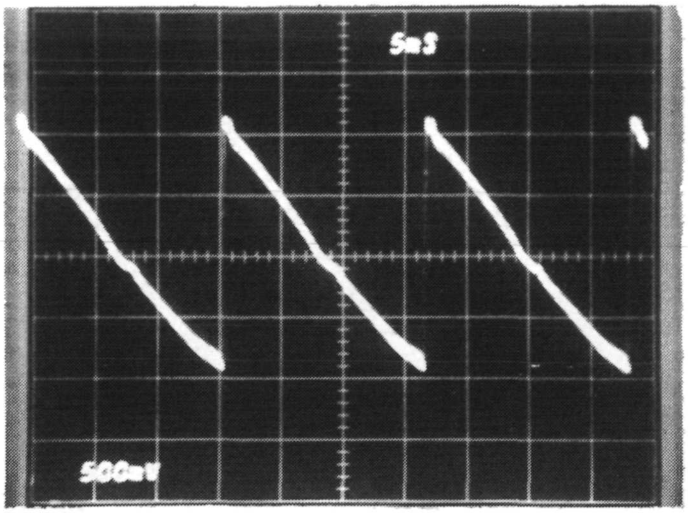
(I) SYNC LEVEL SHIFT

VERTICAL SYNC OUTPUT

(J) TARGET PROTECTION BOARD

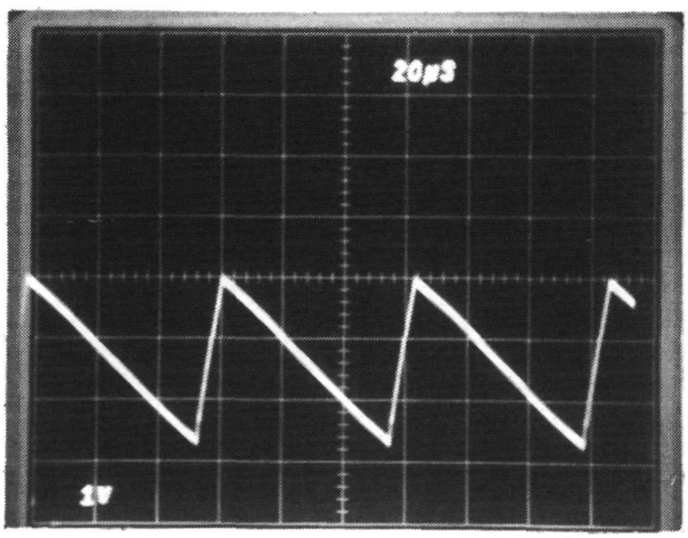
VERTICAL RAMP LEVEL

Figure 19. (Continued)



(K) TARGET PROTECTION BOARD

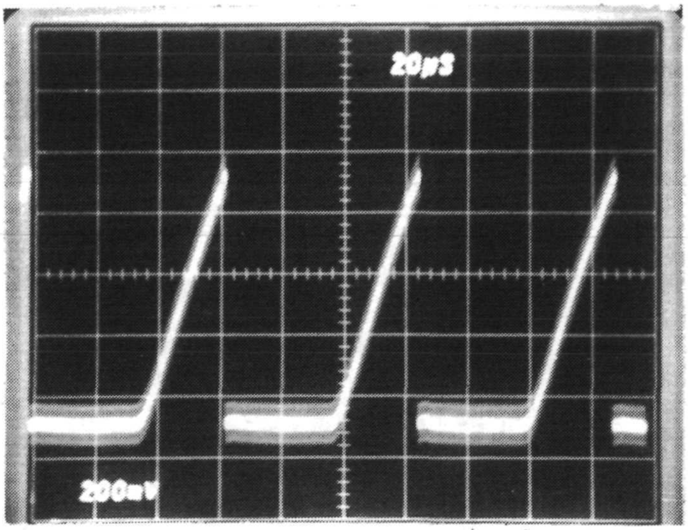
VERTICAL RAMP INPUT



(L) TARGET PROTECTION BOARD

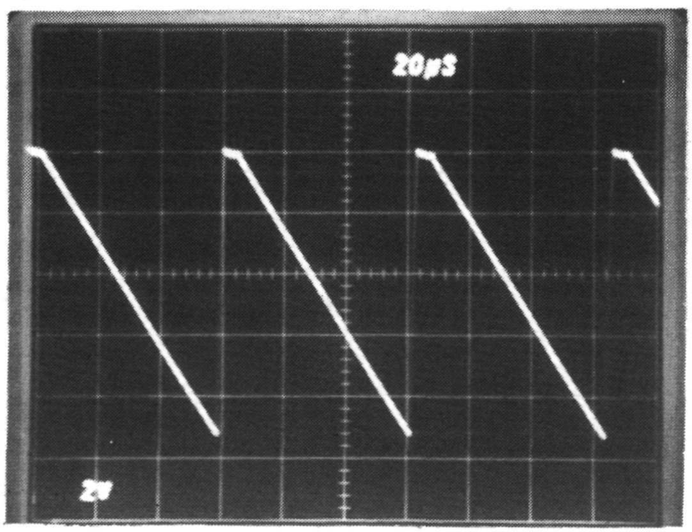
HORIZONTAL RAMP INPUT

Figure 19. (Continued)



(M) TARGET PROTECTION BOARD

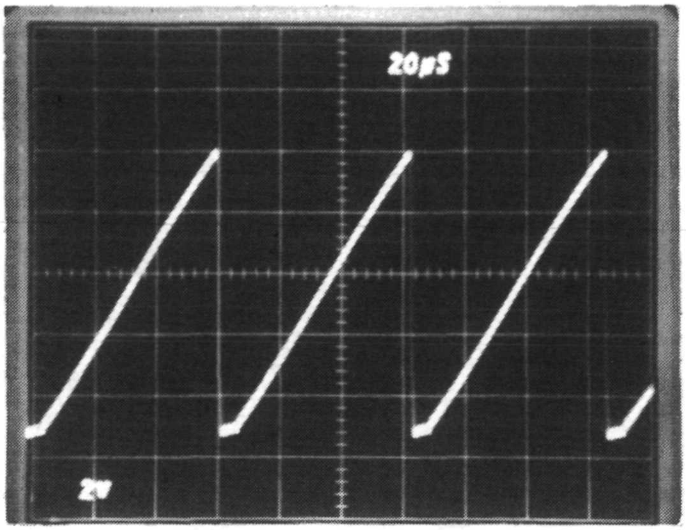
HORIZONTAL RAMP LEVEL



(N) CRT GEOMETRY FOCUS CORRECTION MODULE

HORIZONTAL INPUT

Figure 19. (Continued)



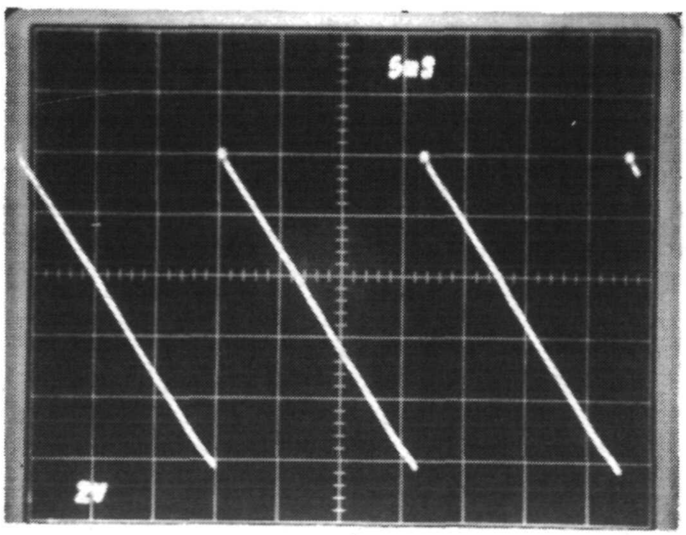
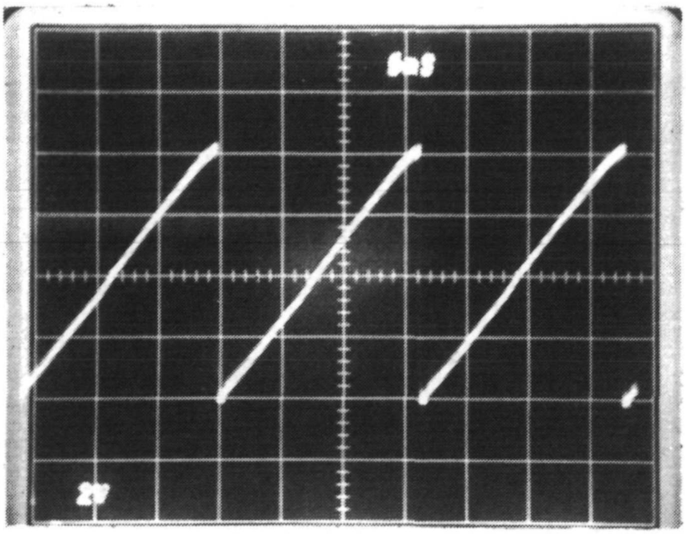
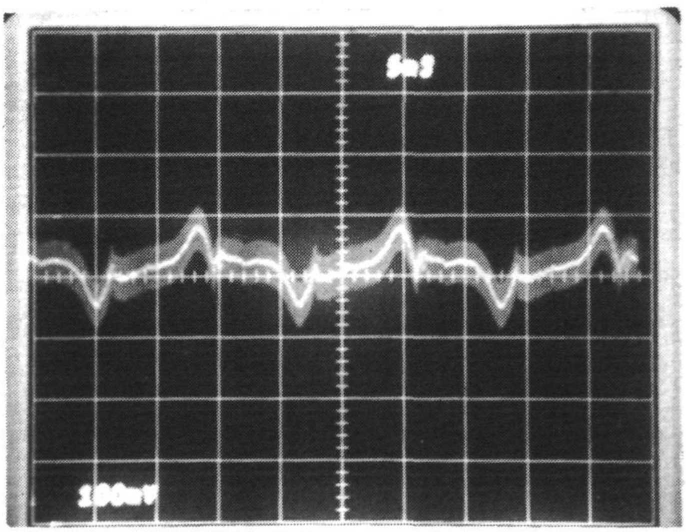


Figure 19. (Continued)



Ⓠ CRT GEOMETRY FOCUS CORRECTION MODULE

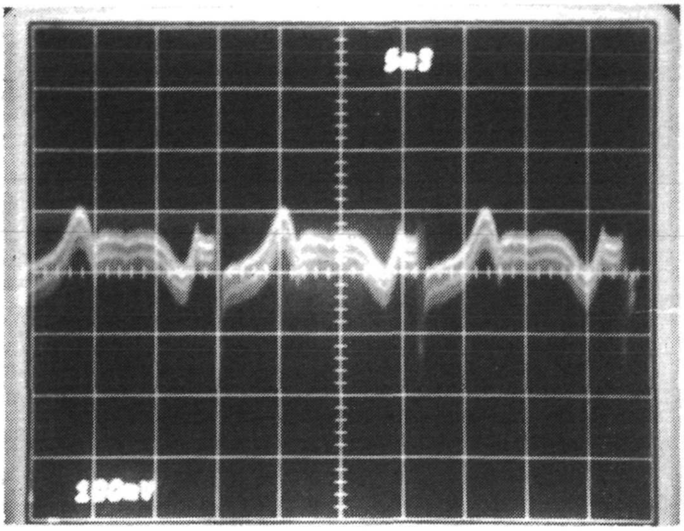
VERTICAL OUTPUT



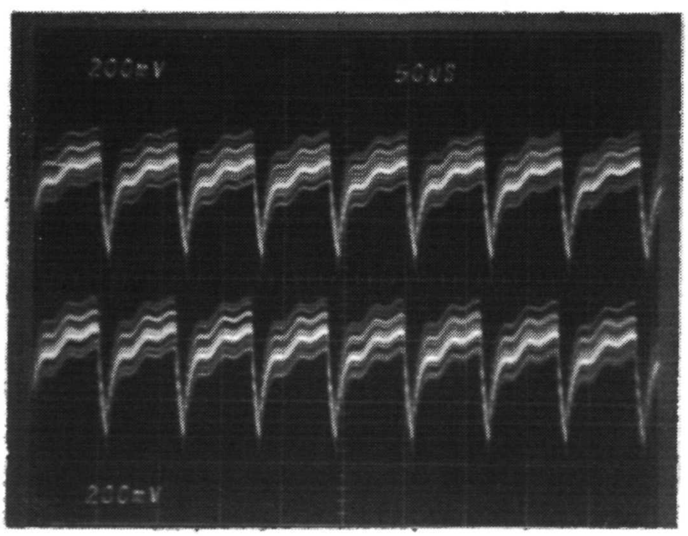
Ⓡ -35V +20V -20V POWER SUPPLY

-35V POWER BUSS

Figure 19. (Continued)

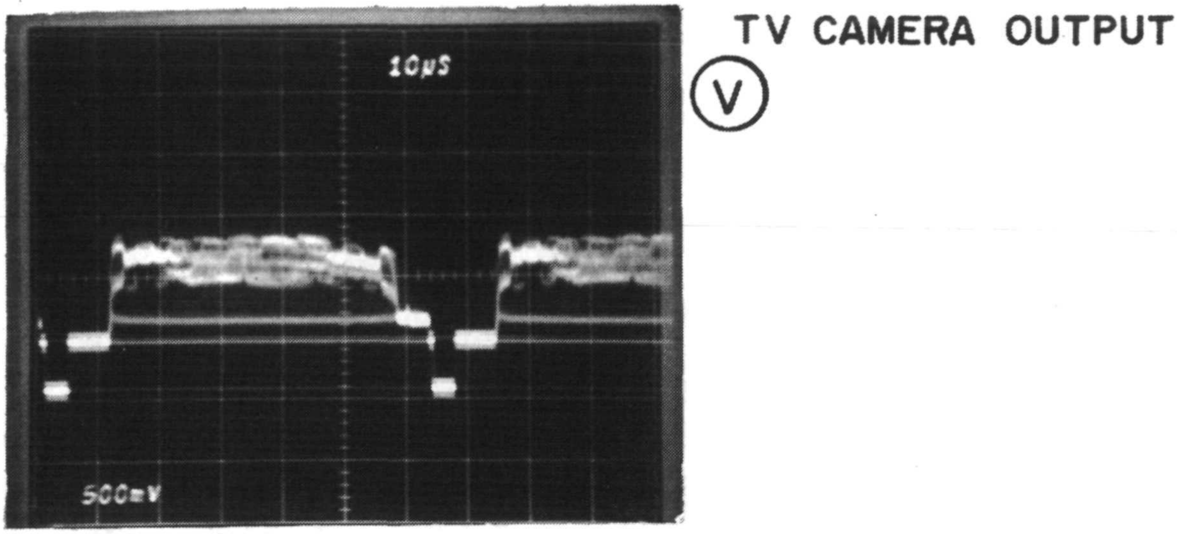


-35V +20V -20
(S) POWER SUPPLY
+20V POWER BUSS



DEFLECTION
POWER SUPPLY
(T) TOP TRACE
-20 V
(U) BOTTOM TRACE
+45V

Figure 19. (Continued)



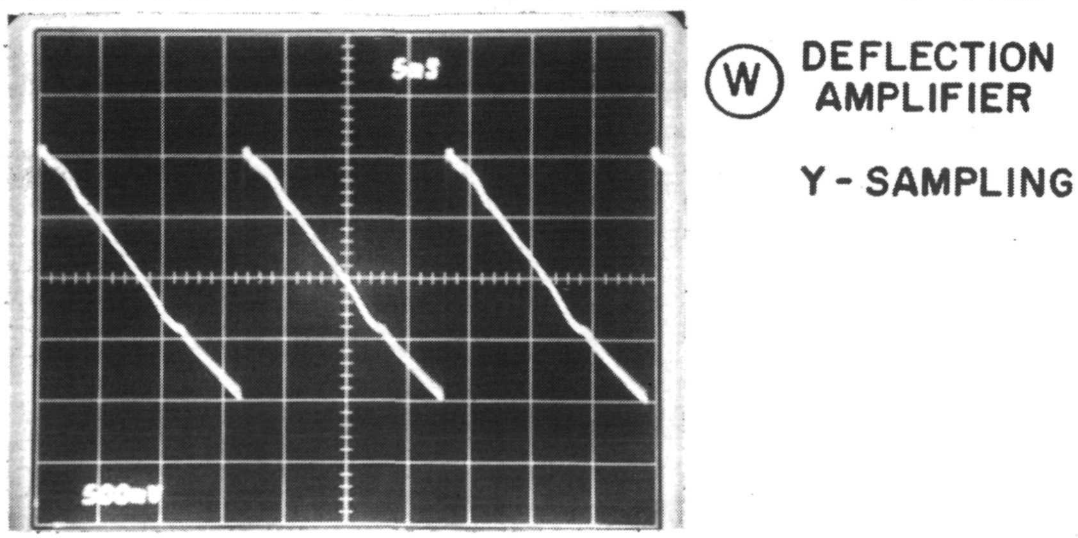
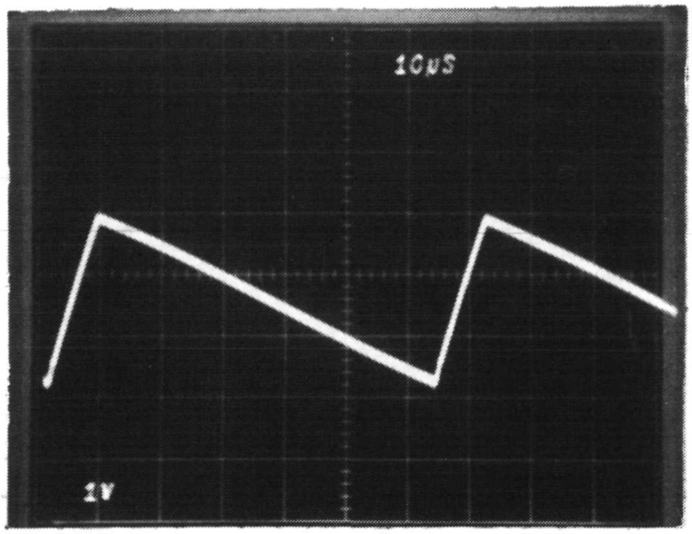


Figure 19. (Continued)



Ⓩ DEFLECTION AMPLIFIER

X-SAMPLING

Figure 19. (Continued)

VII. PANEL CONNECTIONS

The connections shown on the following pages must be made to operate the equipment.

PANEL #2

Pin #	Connected to: Female	Connected to: Male	Panel #2 Color
1	3-22	Focus	Gray
2	4-34	V-Mag	Yellow
3	4-38	V-Mag	White/Yellow
4	4-35	V-Norm	Brown
5	4-39	V-Norm	White/Brown
6	No Conn.	GND	
7	4-45	H-Mag	Blue
8	4-49	H-Mag	White/Blue
9	4-44	H-Norm	Gray
10	4-48	H-Norm	White/Gray
11	4-2	Vid Proc Relay	Brown/Black
12	3-12	VP 17	White/Yellow
13	4-20	VP 11	Green
14	4-5	Brite	Brown
15	4-15	Brite	Green/White
16	3-33	Brite	White/Violet
17	4-6	Im. Pol.	Orange/White
18	4-23	Im. Pol.	White
19	4-29	Im. Pol.	Black/White
20	4-25	Im. Pol.	Brown/White
21	5-32	+15 V Bus	Orange
22	5-22	GND	
23	5-35	-15 V Bus	Blue
24	4-27	VP 9	Violet
25	4-32	VP 10	Yellow

PANEL #3

Pin #	Connected to: Female	Male	Panel #3 Color
1	4-36	Y-Read	Green
2	4-40	Y-Read	White/Green
3	4-43	X-Read	Violet
4	4-47	X-Read	White/Violet
5	5-36	-15 V Bus	Blue
6	5-27	GND	
7	5-33	+15 V Bus	Orange
8	4-24	Im. Pol.	White/Yellow
9	4-28	Im. Pol.	White/Violet
10	4-22	Im. Pol.	White/Green
11	4-30	Im. Pol.	Orange
12	2-12	Im. Pol.	White/Yellow
13	4-2	VD 18	White/Orange
14	5-15	VD 17	White/Red
15	5-30	VD 14	White
16	5-31	VD 13	Brown
17	5-29	VD 11	Red
18	5-28	VD 8	Violet
19	No Conn.		
20	5-14	Focus	White/Gray
21	5-21	Focus	White/Gray
22	2-1	Focus	White/Gray
23	No Conn.		
24	No Conn.		
25	No Conn.		
26	5-3	CRT H	Brown
27	5-2	CRT H	White
28	4-11	CRT G_2	Orange
29	4-8	CRT G_1	Green
30	4-12	Brite Low	Blue
31	4-16	Brite wiper	Gray
32	5-5	Brite -110 V	White/Violet
33	2-16	Brite -110 V	White/Violet
34	4-14	Brite -110 V	White/Violet
35	No Conn.		
36	No Conn.		
37	No Conn.		

PANEL #4

Pin #	Connected to Female	Connected to Male	Panel #4 Color
1	No Conn.		
2	2-11 & 3-13	#2(E) Read-write sw.	White/Orange
3	No Conn.		
4	5-34	PCB #4 - Erase sw.	Red
5	2-14	PCB #10 - Write lamp	Brown
6	2-17	#10 & #11(C) Read-write sw.	White/Orange
7	No Conn.		
8	3-29	#1(D) Read-write sw.	Green
9	5-6	PCB #9 Enable sw. #5 Read sw.	White/Black
10	5-4	+200 V Enable sw.	Red
11	3-28	330 K - Enable sw.	Violet
12	3-30	#4 Read sw. Read lamp	Blue
13	5-20	#3 & #4(E) Read-write sw.	White
14	3-34	#5(D) Read-write sw.	Blue
15	2-15	#3 & #4(D) Read-write sw.	White/Green
16	3-31	#2(D) Read-write sw.	Gray
17	5-37	PCB #17 -15 V	Blue
18	No Conn.		
19	No Conn.		
20	2-13	#1(B) Read-write sw.	Gray
21	No Conn.	GND	
22	3-10	#2(B) Read-write sw.	White/Green
23	2-18	#3 & #4 Read-write sw.	White
24	3-8	#1(C) Read-write sw.	White/Yellow
25	2-20	#2 & #3(C) Read-write sw.	White/Brown
26	5-1	+200 V GND	Black
27	2-24	#4(C) Read-write sw.	Violet
28	3-9	#5(C) Read-write sw.	White/Violet
29	2-19	#6 & #7(C) Read-write sw.	White/Black
30	3-11	#9(C) Read-write sw.	Orange
31	No Conn.	GND	
32	2-25	#12(C) Read-write sw.	Yellow
33	5-24	-15 V GND	Black
34	2-2	#11(A) Read-write sw. (V)	Yellow
35	2-4	#10(A) Read-write sw. (V)	Brown
36	3-1	#9(A) Read-write sw. (V)	Green
37	5-18	#8(A) Read-write sw. (V)	Orange
38	2-3	#8(B) Read-write sw. (V)	White/Yellow
39	2-5	#7(B) Read-write sw. (V)	White/Brown
40	3-2	#6(B) Read-write sw. (V)	White/Green
41	No Conn.		
42	5-17	#12(A) Read-write sw. (H)	Orange
43	3-3	#1(A) Read-write sw. (H)	Violet
44	2-9	#2(A) Read-write sw. (H)	Gray
45	2-7	#3(A) Read-write sw. (H)	Blue
46	No Conn.		
47	3-4	#5(A) Read-write sw. (H)	White/Violet
48	2-10	#6(A) Read-write sw. (H)	White/Violet
49	2-8	#7(A) Read-write sw. (H)	White/Blue
50	No Conn.		
DA 225	BNC	#5(B) Read-write sw. (V)	White
DA 225	BNC	#4(A) Read-write sw. (H)	White

PANEL #5

Pin #	Male	Female	Panel #5 Color
1	4-26	GND Hi Volt. P.S.	Black
2	3-27	CRT Heater 6.3 V AC	White
3	3-26	CRT Heater 6.3 V AC	Brown
4	4-10	CRT G2 +200 V	Orange
5	3-32	Brightness -110 V	Violet
6	4-9	Brightness Low Side	White/Violet
7	No Conn.		
8	No Conn.		
9	No Conn.		
10	No Conn.		
11	No Conn.		
12	No Conn.		
13	No Conn.		
14	3-20	Pin #4 & 5 Socket Hi Volt. P.S.	Gray
15	3-14	+45 V	White/Orange
16	No Conn.		
17	4-42 Hor.Defl.	Correction Out	Orange
18	4-37	Vert. Defl. Correction Out	Yellow
19	No Conn.		
20	4-13	Pin #9 Hi Volt. P.S. Mode(Socket)	Green
21	3-21	Pin #6 Hi Volt. P.S. Focus(Socket)	White/Red
22	2-22	GND +15/-15 V P.S.	Black
23	No Conn.	GND +15/-15 V P.S.	Black
24	4-33	GND +15/-15 V P.S.	Black
25	No Conn.		
26	No Conn.		
27	3-6	GND Videodriver P.S.	Black
28	3-18	-150 V Videodriver P.S.	Violet
29	3-17	+300 V Videodriver P.S.	Red
30	3-15	6.3 V AC Videodriver P.S.	White
31	3-16	6.3 V AC Videodriver P.S.	Brown
32	2-21	+15 V	Red
33	3-7	+15 V	Red
34	4-4	+15 V	Red
35	2-23	+15 V	Blue
36	3-5	-15 V	Blue
37	4-17	-15 V	Blue

APPENDIX

Contract NAS5-20231

EXHIBIT

SPECIFICATION FOR A CATHODOCHROMIC CRT

STORAGE AND DISPLAY SYSTEM

1. INTRODUCTION

The cathodochromic CRT system is to be used to store images introduced in the form of standard television signals (e.g., from vidicon). The image storage in this system will utilize the inherent memory of cathodochromic materials (i.e., photochromics which are switchable by an electron beam). Erasure of a stored image will be accomplished by resistive heating of a transparent conductive layer in contact with the cathodochromic material. An image stored in the cathodochromic CRT will be read out using a light source external to the CRT by direct viewing, vidicon detection, and photographic recording. Readout will also be possible by photographic or photodetector monitoring of transmitted light produced by a phosphor internal to a cathodochromic CRT. The system configuration shall be such that two CRT's are mounted in the equipment rack, and operation of one or the other is accomplished by switching the necessary signals from a single electronic system. The two mounted CRT's will differ in that only one will contain the internal phosphor for photodetector readout. That is, both CRT's will have the capability of storage, readout by an external light source, and internal thermal erasure; but only one of the CRT's will have the additional capability of emitting light from an internal phosphor.

2. REQUIREMENTS

2.1 General Description

The cathodochromic CRT system shall consist of a single rack of equipment with provisions for mounting two cathodochromic CRT's (one with internal phosphor and one without). The electronic subsystems shall be complete and sufficient for operating either one of the CRT's selected by switching the electronic signal cables from one CRT panel to the other. A readout assembly will be included, which allows any of the readout modes to be selected without demounting the separate readout devices or the assembly itself. Since two CRT's will be mounted in the system, the readout assembly must be easily mounted and demounted for operation of either CRT.

2.2 Cathodochromic CRT Specifications

2.2.1 Cathodochromic materials with a thermal erase mode shall be used internal to the CRT's.

2.2.2 An image shall be stored with a minimum persistence of 24 hours in a light environment approximating normal office light conditions. No significant change in contrast ratio of the image shall occur during the 24-hour period.

2.2.3 Minimum resolution - 500 lines.

2.2.4 Maximum of ten seconds to store an image with contrast of 3:1 using an external light source for viewing CRT's without phosphor, and 2:1 for CRT's with phosphor. Images produced (film or video) using phosphor shall have contrasts greater than 2.5:1.

2.2.5 Contrasts of greater than 3:1 shall be possible without damage to CRT. CRT minimum life design goal is 50,000 cycles.

2.2.6 A stored image with contrast of 3:1 using external light source shall be erasable in a maximum of 5 seconds.

2.2.7 Erasure shall be accomplished by resistive heating of an internal conductive layer.

2.2.8 Image stored on CRT shall be conveniently read out using a light source external to the CRT (e.g., photographic).

2.2.9 Internal phosphor layer shall emit light in absorption band of cathodochromic for photodetector readout of stored image. (This capability is not required in all CRT's.)

2.3 Electronic System Specifications

2.3.1 Electronic system shall include all functions necessary to operate CRT's.

2.3.2 Standard television frame times and sync signals will be used.

2.3.3 Input will accept signal from a vidicon.

2.3.4 Capability of selecting positive or negative image of input signal must be included.

2.3.5 Selection of a single frame scan will be provided.

2.3.6 Capability of switching control cables to operate either one of the two cathodochromic CRT's in the system (one with internal phosphor; one without).

2.3.7 Capability of selecting two raster sizes.

2.3.7.1 Normal size - 500 lines.

2.3.7.2 Magnified size - 400 lines (400 of the normal 500 line image will fill screen producing magnified image of 0.8 of original image.)

2.4 Readout System Specifications*

2.4.1 Readout assembly shall be demountable and compatible with two CRT panels.

2.4.2 Readout assembly will include photodetector system and mounts for vidicon and Nikon F camera. The expected film to be used in the Nikon F camera is Plus X (ASA 125) or equivalent. Other off-the-shelf films may be used, including high contrast films.

2.4.3 Selection of any of the three readout modes will be accomplished by directing image to desired detector and must not require demounting of readout assembly or readout devices.

2.4.4 Light source for readout shall be incorporated into assembly in such a manner as to minimize extraneous reflections.

2.4.5 Photodetector readout shall provide an electronic readout compatible with the input to a television monitor. The detector and associated circuitry, including monitor, shall have sufficient resolution to maintain image quality. Phosphor CRT shall have a minimum contrast ratio of 2:1, with a design goal of 3:1.

2.4.6 Vidicon and television monitor shall be provided for use in readout mode using external light source.

2.4.7 Camera mount should be located so that CRT image can be focused with a 50 mm, f/1.4 lens plus a No. 2 closeup lens on a Nikon F camera. This Nikon F camera shall be furnished by GSFC for testing purposes as required by the Contractor, times to be coordinated with the GSFC Technical Officer.

2.5 Fabrication Specifications

2.5.1 All controlling electronic and two CRT panels shall be mounted in a single standard 19-inch rack.

2.5.2 CRT panels shall be incorporated in a way that allows either panel to be removed from the system without affecting operation of the remainder of the system.

2.5.3 One CRT panel will be designed for a cathodochromic CRT with internal erase capabilities and internal phosphor capability.

2.5.4 One CRT panel will be designed for a cathodochromic CRT with internal erase capabilities, but without internal phosphor.

2.5.5 All controls shall be incorporated and labeled with simplicity of operation as a main requirement.

*See copy of memo dated December 13, 1971, p. 60 of this manual.

2.6 Deliverable Items

1 each	Rack of electronics with two panels as specified under paragraph 2.3 and paragraph 2.5.
1 each	Readout assembly with photodetector as specified under paragraph 2.4.
2 each	Cathodochromic CRT's with internal erase and internal phosphor as specified under paragraph 2.2.
2 each	Cathodochromic CRT's with internal erase, but without phosphor as specified under paragraph 2.2 excluding 2.2.9.
1 each	Vidicon and television monitor compatible with input requirement 2.3.3 and readout requirements 2.4.2 and 2.4.6.

2.7 Test Specifications

2.7.1 Determine write time for contrasts using external light source for 4:1 and 10:1.

2.7.2 Determine what precautions, if any, are necessary to provide safe operation in terms of X-rays and limits on duration of heating for erasure.

2.8 Reports

2.8.1 Written monthly progress reports.

2.8.2 Final Report in accordance with GSFC Specification S-250-P-1B.

2.8.2.1 Specification of materials and techniques used to implement system.

2.8.2.2 Complete system description with schematics.

2.8.2.3 Complete operating procedures.

2.8.2.4 Detailed evaluation of system operation including test description and results.

2.8.2.5 Maintenance procedures.

3. APPLICABLE DOCUMENTS

To the extent described in the Contract Schedule, the following documents are applicable to this procurement.

3.1 NASA Quality Publication NPC 200-3, "Inspection System Provisions for Suppliers of Space Materials, Parts, Components, and Services."

3.2 Reliability and Quality Assurance Publication, NHB 5300.4(3A), "Requirements for Soldered Electrical Connections."

3.3 GSFC Specification S-250-P-1B, March 1970, "Contractor-Prepared Monthly, Periodic, and Final Reports," as amended by Amendment No. 1 dated November 14, 1970.

Internal Correspondence

RCA

To	G.V. Charbonneau	Location	SW-235B	Date	Dec. 13, 1971
From	I. Gorog	Location	W-208	Telephone	#3202

Subject Modification of Contract NAS5-20231

In accordance with our discussions with the NASA Technical Monitor, a modified design (DESIGN B) is offered. DESIGN B is the same as original (DESIGN A) except for paragraphs 2.4.2, 2.4.3 and 2.4.7. The appropriate paragraphs for DESIGN B read as follows:

2.4.2 Readout system will include photodetector system and mounts for vidicon and Nikon F camera. The readout assembly itself will contain the mounts for the Nikon and mirrors to deflect the tube image to the appropriate detector (photodetector for phosphor cathodochromic tube and vidicon for cathodochromic tube). The expected film to be used in the Nikon F camera is Plus X (ASA 125) or equivalent. Other off-the-shelf films may be used, including high contrast films.

2.4.3 Selection of any of the applicable readout modes will be accomplished by directing image to desired detector and must not require demounting of readout assembly or readout devices.

2.4.7 Camera mount should be located so that CRT image can be focused with a 50 mm, f/1.4 lens plus a No. 1 and No. 2 closeup lens, or other standard Nikon lens. This Nikon F camera shall be furnished by GSFC for testing purposes as required by the Contractor, times to be coordinated with the GSFC Technical Officer.

I. Gorog

afg

RCA 32