The Cinematronics Vector Monitor FAQ and Repair Guide
by McClintock
Version 0.96
February 28, 2003

Table of Contents

INTRODUCTION

Note: Very little, if any, of this document is my own work. Information in this document has been taken from official factory manuals, technical updates, practical experience by others, etc. In many instances I have paraphrased or omitted information from the original documents for readability and/or clarity purposes. I thought it would be helpful, not only to myself, but to others having trouble with their Cinematronic vector monitors. Please read through this entire document before working on your malfunctioning monitor, and make sure you have a set of schematics on-hand. Also, in order to properly test your Cinematronics monitor, it is imperative that you have a known-working game board and power supply to provide a good input signal to the monitor. A bad game board and *not* the monitor can actually cause some of the symptoms of a 'bad' monitor. It is also important to say that an oscilloscope is a piece of test equipment that is necessary to work on Cinematronic vector monitors. Without a scope, you will find it almost impossible to solve your problem(s).

DISCLAIMER

CAUTION!!! LETHAL VOLTAGES ARE PRESENT IN ARCADE MONITORS. SUITABLE PRECAUTIONS SHOULD BE TAKEN BEFORE ATTEMPTING TO SERVICE YOUR MONITOR. REMEMBER, NO WARRANTIES, EXPRESS OR IMPLIED, ARE GIVEN. USE THIS INFORMATION AT YOUR OWN RISK. I AM NOT RESPONSIBLE FOR ANY DAMAGES THAT MAY OCCUR TO YOUR PERSON OR PROPERTY.

Acknowledgements

The following people have contributed to the development of this document (knowingly or otherwise): Gary Akins Jr.; Rodger Boots; David Fish; David Haynes; John Hermann; Mike Inglem; Mark Jenison; Al Kossow; Rich Marquette; Matt McCullar; Zonn Moore; John Robertson; Matt Rossiter; Mike Saul; Mark Shostak; Sam Verlander; Joe Welser; Simon Whittam; and Gregg Woodcock (let me know if you want to see your name here – or don't want to!)

The Cinematronics design was created by one man - Larry Rosenthal. It is very elegant, and astounding that Larry's design could do so much with so little.

Cinematronics – related patents

- 4,053,740 (Video game system)   Rosenthal
- 4,027,148 (Vector generator)   Rosenthal

To do:

EXAMINE THE TAILGUNNER II SCHEMATICS FOR NOTES

Detail Tailgunner joystick interface

Find better scan of HV Oscillator (as seen in Star Tech Journal)

THEORY OF OPERATION

To understand what goes on inside the Cinematronics monitor, we will first examine large general groups of circuits. This will help avoid confusion and aid in a basic, concrete, knowledge of what makes up the Cinematronics vector monitor. Having a good understanding of *how* the monitor operates will greatly assist the reader in diagnosing and repairing their problems.

Unlike other vector monitors such as the Electrohome G05, or Wells-Gardner 6100, the Cinematronics Vectorbeam monitor is comprised of a single PCB that spans the width of the monitor frame. The Cinematronics monitor, while initially looking like a large mess of components, can be divided into two basic sections: one is the deflection amplifier and the other is the voltage and cathode drive circuits (the HV) – just like other vector monitors. Some of the descriptions herein may be a bit confusing at first. Hopefully after reading the entire document, things should become clearer. Grab some schematics and follow along.

DEFLECTION AMPLIFIER CIRCUIT

The deflection amplifier circuit can be further divided into two identical channels: one for the horizontal deflection ("X") and one for the vertical deflection ("Y"). Because both channels are identical, we will only discuss the <mark>horizontal</mark> channel in this document.

The deflection circuit receives digital numbers from the logic board that represent the coordinates for the beginning and end points of each line segment. The deflection circuit output is a current sent to the yoke windings that is proportional to these numbers. So, the purpose of the deflection circuitry is to convert a binary coded number into a current. This conversion is accomplished with the following components.

DAC – Digital to Analog Converter
The first step in creating an image on the screen is to convert the digital coordinate numbers into an analog voltage. The DAC-80 is the device that does this.

Digital information from the Cinematronics CPU (the "CCPU"), in the form of a twelve-bit word, is applied to the input of the DAC-80 digital to analog converter (IC101) on pins one through twelve. The most significant bit is applied to pin one, and the least significant bit is applied to pin twelve. The DAC-80 makes the necessary conversion from digital signals to analog signals, which are outputted as analog voltage signals on pin fifteen (proportional in level depending on the input word applied). The result is a positive and negative voltage signal about its reference voltage. Remember, there is no "sync" signal present, and the signal is not true video as seen in raster scan monitors.

Pins one through twelve of the DAC can represent any number between –2,048 and +2,047. The output voltage range is from –5 volts to +5 volts. When the DAC is operating properly, the output signal is centered about 0 volts and bounded between +/-5 volts.

DAC CIRCUIT
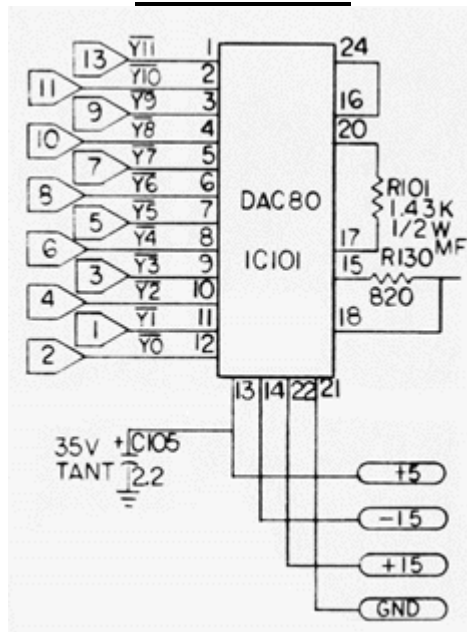
Analog Switch

From the DAC-80 the analog signal is then sent to a high-speed analog switch, ICl. The analog switch has two parallel inputs for the display signal, and two controlling inputs, which select one of two outputs from the switch.

The LF133310 analog switch at location IC1 is the most active component on the monitor. Both the horizontal and vertical DAC output voltages pass through this switch and then become converted into currents to deflect the beam to proper positions on the screen. The chip is mounted in a socket for easy removal and should be a prime suspect for monitor that blows circuit breakers.

The switch passes the voltage output of the DACs through either of 2 channels: the lower channel is for the initial position coordinate of a line segment, and the upper channel is for the final coordinate. The CCPU controls the channels: initial position on pin 8 and line drawing (final coordinate) on pin 1. If the upper channel in the switch is defective, say, in the horizontal section, then there will be no horizontal lines on the display. The same is true for the vertical.

Output fifteen from the switch routes the analog signal through a 5K potentiometer (R102), a 10K resistor, (R103) and to the input of the TL081 op-amp (IC102). The time constant developed by these two resistors and the capacitor (C101) determine the length of the vector line seen on the screen. Adjusting the potentiometer will adjust the *length* of the vertical lines seen on the screen.

Output ten from the analog switch routes the signal directly to the input of the TL081 op-amp, and the resulting voltage across C101 determines the initial starting position of the vector. R130 is there to protect the analog switch from any damage caused by the large inrush currents when charging C101. The CCPU is responsible for waiting until C101 is fully charged to its initial voltage before turning on the Z-axis.

ANALOG SWITCH CIRCUIT
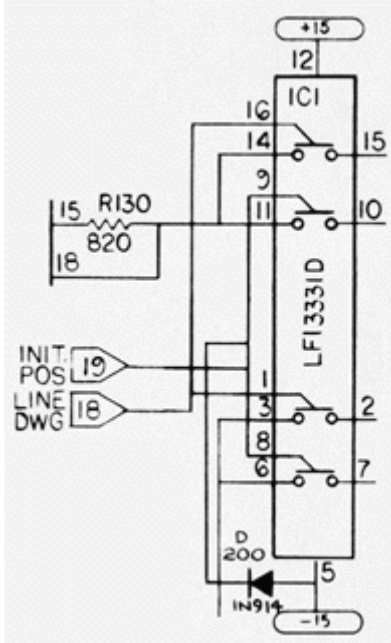
R/C Network

The voltage across a resistance-capacitance ("R/C") network, found at the outputs of the analog switch IC1, is used to draw screen vectors. The R/C network is responsible for drawing smooth, straight and precisely positioned vectors. The voltage across the R/C network, at any given time, determines the actual position of the CRT trace at that time. As the capacitor charges, and the voltage changes, the CRT trace follows, and the vector is drawn.

Initial position voltages enter from the lower switch channel directly across C101, which charges to that voltage level rapidly. The voltage is converted to an initial position current by the deflection amplifiers, positioning the beam at the beginning point of a line segment.

Final position data from the upper switch channel slowly charges C101 through R103 and line length pot R102. As C101 charges from its initial point value to its final value, a straight horizontal vector is drawn. Since all this is happening at the same time in the vertical section, a vertical vector is also being drawn. The combination of both sections moving the CRT beam simultaneously allows for a vector of any angle to be drawn. Both R/C networks charge simultaneously, which allows the CRT trace to simultaneously move in the vertical and horizontal direction, so that a vector can be drawn at any angle.

Pot R102 varies the charge rate of the network, and can lengthen (slower charge) or shorten (faster charge) the vector for the "on" period of the beam.

R/C NETWORK CIRCUIT
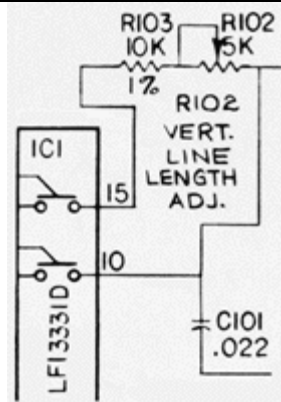
Edge Gain Amplifier
It is a property of the CRT that, near the edges of the screen, the amount of current needed to move the beam, say, an inch, is less than the amount required to deflect the beam an inch off center. Therefore, less gain is required near the edges of the CRT.

The edge gain amplifier is the final stage before the voltage-to-current conversion process. The input on pin 3 of IC102 (or IC202) is a waveform that is the composite initial position and final position data signals. The amplifier has an overall gain of about 2x at output pin 6. The waveform should resemble the DAC output, but is now bounded between +/- 2 volts, centered about 0 volts.

The TL081 op-amp at IC102 serves a dual purpose: it acts as a buffer between the deflection amplifiers and the analog switch, as well as an "edge gain" amplifier (i.e., height).

At the output of IC102, there is a resistor diode network consisting of R105, R106, R107, R108 and D101, D102, D103, D104. This resistor diode network is used to compensate for the non-linear characteristics of the CRT near the edges of the screen. If this circuit were not used, any object displayed on the screen would increase in size as it moved closer to the edges of the screen.

The amplifier circuit reduces gain as the output voltage increases, indicating a larger beam displacement, by switching on diodes D101 and D102 for the upper half of the screen, and D103 and D104 for the lower half. This places R106 and R107 in parallel with R105, reducing its value and consequently the gain. If a figure increases in size near the display edges, a diode in this section is open.

Potentiometer R109 is the vertical picture size control. By picking off larger or smaller voltages, the height of the picture is controlled.

EDGE GAIN AMPLIFIER CIRCUIT
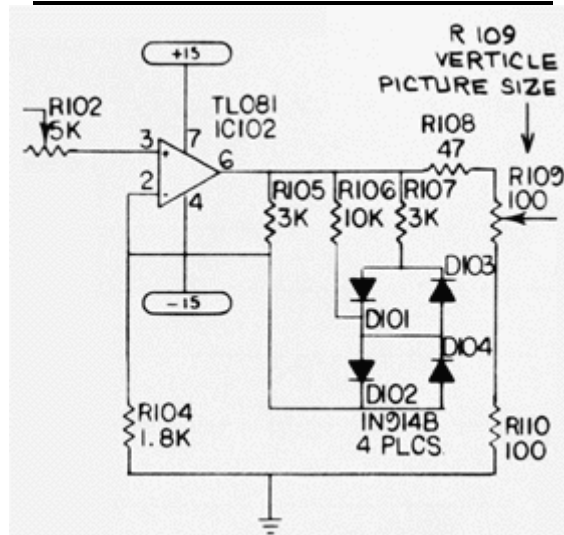
Deflection Amplifier

The deflection amplifier converts the pick off voltages from the size pot (R109) into a current that drives the deflection yoke winding. The input is a differential stage consisting of transistors Q101, Q103 and Q102. Q101 is an emitter coupled with Q103 to provide a degenerative feedback loop from the yoke. Q102 is a reference current source to both emitters and a fixed amount of current always flows through it. If this current varies, the picture will be offset from center. Too much offset will cause the circuit breakers to blow.

This reference current is determined by the voltage drop across R113. Diodes D105 and D106 determine this drop. The voltage across one of the diodes is cancelled by the base-emitted voltage of Q102. R113 should constantly read 0.6 volts DC. This means a constant flow of about 3mA through Q102.

This 3mA bias must come from the emitters of Q102 and Q103. Excess current is picked off at the collector of Q101 and feeds pre-driver Q104. The reference current source for pre-driver Q104 is Q105, D107, D108 and R116. Bias current through R116 is about 0.22mA.

At this point, the deflection circuit can again be divided into two identical circuits. One circuit, which controls the lower half of the screen, is comprised of Q104, Q106, Q108 and Q110. The other circuit, which controls the upper half of the screen, is comprised of Q105, Q107, Q109 and Q111.[1]

Q104, Q108 and Q110 are three stages of amplification, while Q106 is used as current limiting protection for Q108 and Q110. The same holds true for the other configuration of Q105, Q107, Q109 and Q111.

Current is delivered to the yoke in a push-pull manner by transistor pairs Q108 and Q110 for positive current translations. Q110 and Q111 are power driver transistors mounted on the humongous heatsinks on the left side of the monitor frame.

Diodes D109, D110 and D111 set up a crossover voltage threshold to prevent both halves of the push-pull output from turning on at the same time. Should one of the diodes open, only half of a display will be generated. Should the diodes become resistive, both power transistors will turn on simultaneously and generate excessive heat.

If more than 3 amps are drawn through sense resistors R120 and R121, transistors Q106 and Q107 turn on and shut off the power driver by sinking the base current to drivers Q108 and Q109. This protects the hardware against further damage.

R124 through R129 are used as a current divider network for the yoke. R122, R123, and C102 form a R/C network, which compensates for any counter EMF that may develop by the expanding and collapsing of the deflection coil's electromagnetic field. Revision B and later monitors do not

---

[1] In the horizontal section of the deflection amplifier, Q205, Q207, Q209 and Q210 control the left hand side of the screen, and Q204, Q206, Q208 and Q211 control the right hand side of the screen. By dividing the screen in this manner, four quadrants of deflection area have been developed.

incorporate R122, as it was only required to compensate for non-linearity in the early production yokes. Monitors in Space Wars games utilized R122.

If there is a problem with the upper half of the picture, it is with the circuit elements connected to the –25 volt line in the deflection amplifier. If, say, the lower half of the picture is missing, suspect the elements connected to the +25 volt side of the horizontal deflection amplifier.

DEFLECTION CIRCUIT
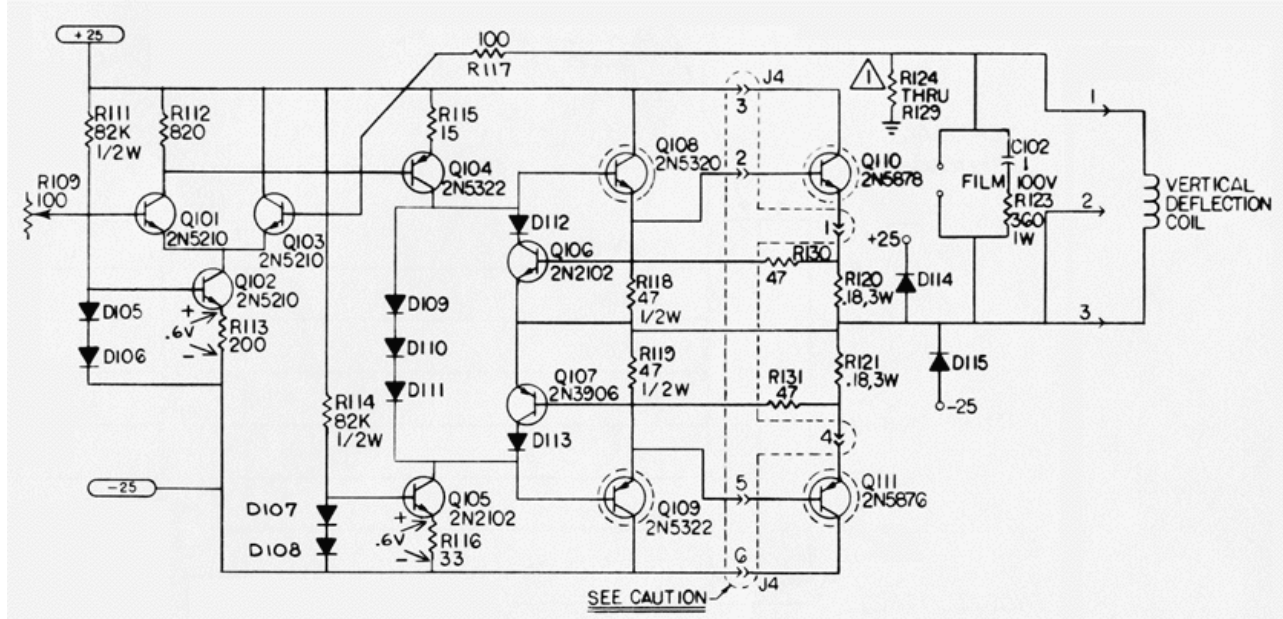
HIGH VOLTAGE SUPPLY

The high voltage and cathode circuitry is the second section of the Cinematronics monitor. This section also contains the necessary voltage regulation to power the ICs located on the display board.

For the early 'discrete' – style monitors, IC3 (7818) and IC5 (7918) provide positive 18V and negative 18V used in the high voltage transformer (T-l) and oscillator (the oscillator circuit is necessary because there is no horizontal sync used to develop the high voltage pulses). The oscillator circuit is comprised of primary windings, Q4 and associated discrete components. For the later 'Keltron' – style monitors, IC4 (7815) and IC6 (7915) provide positive 15V and negative 15V respectively to power the DAC-80s and the TL081 op-amps on the display board.

The high voltage (18KV on discrete HVs and 16KV on non-discrete 'Kelton' HVs) is developed by Transformer T1's secondary windings, and the high voltage tripler in the discrete design. The Keltron contains what is called the high voltage quadrupler – even though it produces less voltage than the discrete version.

Intensity Circuit ('Z' Channel)
The beam can be turned on and off by applying the proper voltage level to the CRT cathode. Beam cut off is +90 volts DC. At this potential, the electrons excited by the filament prefer to remain on the cathode and none make it to the screen of the CRT. Lowering this potential allows more electrons to escape to the anode. We can then produce a NORMAL INTENSITY level by lowering the cathode potential to +40 volts DC, and a HIGH INTENSITY by lowering the potential to, say, +20 volts DC.

The Cinematronics CPU produces two intensity levels by sending low pulses to pins 1 and 3 of IC7 (7406). Pin 1 is the HI INTENSITY channel and consists of IC7 and Q1. The NORMAL INTENSITY channel consists of another part of IC7 and Q3. The CCPU also has a jumper setting to produce variable intensities, but this option is only used on two games - Sundance (16 intensity levels) and Solar Quest (64 intensity levels). These additional intensity levels are produced with additional PCBs that are discussed in the following section.

The intensity and beam blanking control circuitry is composed of IC7, Q1, Q2, Q3, Q7 and Q8 and associated components. A beam blanking voltage of +90 volts DC is generated from pin 8 of the HV transformer secondary winding, D6 and C17. This half wave rectifier supplies the +90 volts to one terminal of the brightness pot. The wiper of this pot picks off the proper voltage and sends it through the yellow cathode wire to the CRT plug socket. R11 adjusts the amplitude of the negative spikes used for brightness and intensification. A greater negative spike creates a brighter picture.

The cathode voltage rides at +90V, and the beam is turned "on" by negative voltage. Using an oscilloscope, negative pulses can be seen at the anode of D4. These are the beam "on" pulses. For normal intensity the pulses will go down to approximately +40V, for double intensity, +20V. Pins 3 and 4 of IC7 are the normal intensity control gate which receives information from the CCPU. Pin 1 and 2 of IC7 are the double intensity control gate. When a Hi going Lo signal is on pin 3 of IC7, pin 4 will be a Lo going Hi, turning on Q3 on the Hi transition. Q3 acts as a switch connecting the series network of R11, R10 and R9 to ground creating a voltage divider network. R11 is the manual intensity control. When pin 2 of IC7 goes Hi, Q1 turns on for the duration of the pulse connecting

just R9 and R11 to ground, thus lowering the voltage at the anode of D4 even more because of the lower resistance, than with normal intensity. Q2 is used as a switch to enable Q1 and Q3. Q2's purpose is to shut off the beam when the power is turned off. Q7 is a beam "on" delay to prevent phosphor burns if someone was to unplug and plug in the machine rapidly. With Q1 and Q3 both off, or Q2 off, current has no path to ground and the wiper voltage will be +90 volts regardless of the brightness pot setting.

For a NORMAL INTENSITY vector, pin 3 of IC7 pulses low. Pin 4 then pulses high to +2.75 volts, turning on Q3. Current flows through R11, R9, R10 and through Q3 to ground via Q2. This drops the voltage at the cathode to about +40 volts with the brightness pot full clockwise.

For a HI INTENSITY vector, pin 1 of IC7 pulses low. Output pin 2 pulses high to 2.75 volts, turning on Q1. Current flows through R11, R9, through Q1 and to ground via Q2. This drops the cathode level to about +20 volts with the brightness pot full clockwise.

The yellow wire to the cathode should show a +90 volt DC base with negative going pulses that vary as the brightness pot it turned. For a no display condition, suspect IC7. The 7406 chip is an open collector inverter and must have a pull-up resistor on its output. Verify that 4 to 5 volts is always present at the junction of R1 and R2. This voltage is supplied by Q8, which is in an R/C delay circuit to allow all voltages to settle on power up before a picture is displayed.

Q2 is designed to open the intensity circuit immediately after power is removed from the game. This prevents the +90 volt blanking voltage from bleeding off before the high voltage bleeds off, thus preventing a spot becoming burned on the CRT screen when the game is unplugged. Q2 is kept on continually by a full wave rectified, unfiltered signal from the power supply through fuse F1 (0.5 amp). For a no display condition, eliminate Q2 as a source of trouble by jumpering it collector to emitter, being careful to remove the short before powering down the monitor, since this short does eliminate the power down spot killer.

INTENSITY CIRCUIT
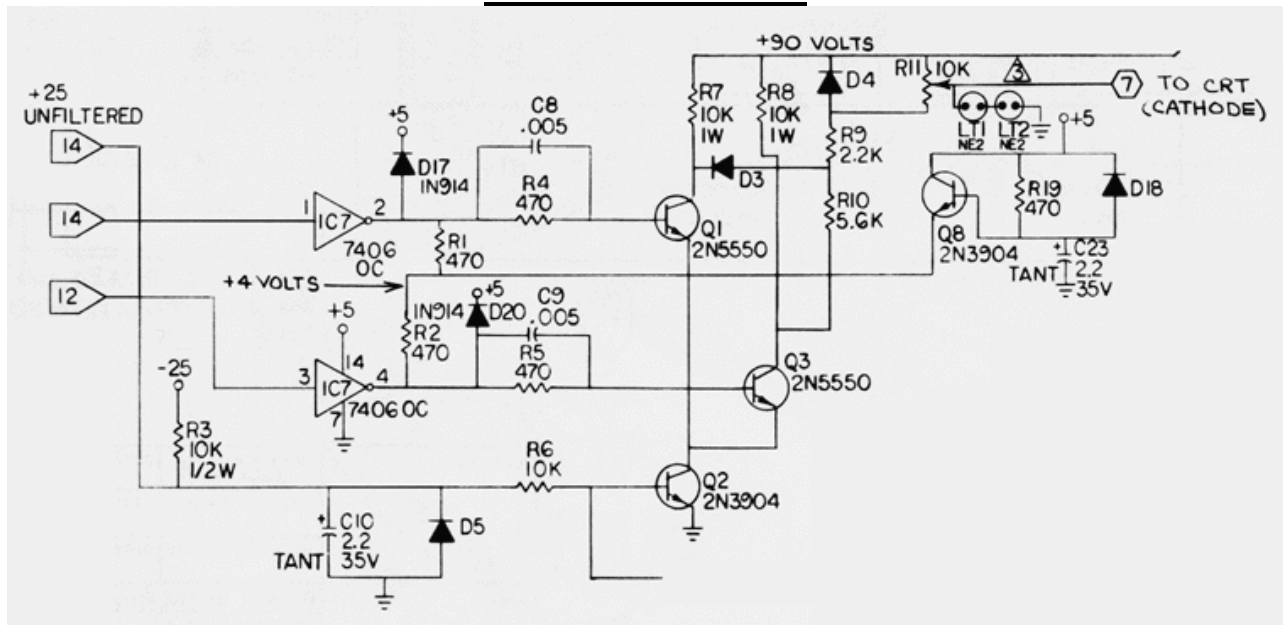
Spot Killer Protection Circuitry
Transistor Q2 can be considered as the master intensity control switch. When it is deprived of its base drive, the collector-emitter junction opens and eliminates the ground path for the intensity channels, cutting off the beam. The game logic board can fail in such a way as to cause the beam to remain on continuously, burning the CRT phosphor.

R25 and C24 form an R/C time constant of about 6.8ms. Since most of the vectors on the display require only microseconds of beam time, any turn on pulse from the CCPU, which is 6.8ms or wider constitutes a failure mode. The outputs of IC7 (pins 2 and 4) are sampled by Q6, which inverts the pulses and feeds them back into IC7 on pin 11.

When the input is high, the output transistor turns on and essentially shorts pin 10 to ground. When the input is low, the transistor turns off and opens the circuits. So, for example, a high pulse at IC7, pin 4 of 10ms duration becomes a low pulse at the collector of Q6. This causes IC7 pin 10 to open the circuit, allowing C24 to charge. Since the pulse width is greater than 6.8ms, C24 has ample time to charge and turns on Q7, which shorts the base of the master intensity switch Q2, killing the display.

An additional protection circuit involves R20, R21 and pins 9 and 8 of IC7. Pin 9 is normally held negative by the voltage divider of R20 and R21. Should the circuit breakers blow and we lose -25 volts, pin 9 of IC7 goes positive, causing pin 8 to short the base of Q2, again killing the display.

SPOT KILLER PROTECTION CIRCUIT
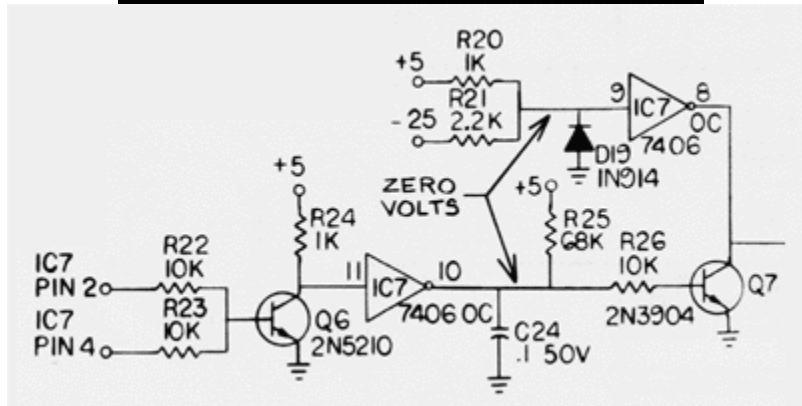
High Voltage Oscillator (early discrete monitor only)

The HV Oscillator only appears in the discrete HV Cinematronics monitors (all monitors prior to Rev.G). This circuit is incorporated into the Keltron HV box for later monitors. The integral elements of the HV oscillator section are IC9, IC5, Q4 and flyback transformer T1. The +/-18V regulators IC9 and IC5 deliver +36 volts across C18. The frequency of oscillation is dependant on the winding characteristics of the HV Transformer, T1. As current begins to flow through pin 4 of T1, a reverse potential is induced in the thicker coil at pins 1 and 2, tending to shut off Q4. Q4 turns on again after the R14/C19 time constant discharges, repeating the cycle. The tank circuit of D8, R15 and C20 provide a protective sink circuit against inductive spikes that must otherwise cripple TIP51C. Diode D7 protects against reverse currents.

The secondary windings of T1 generate an 800-volt peak-to-peak waveform at pin 7 that is half wave rectified by D10 and filtered by C22 to provide +400 volts DC of focus control.

Beam cutoff voltage (+90 volts DC) is supplied by a 200-volt peak-to-peak signal on pin 8, rectified by D6 and filtered by C17.

[insert scan from Rip Off manual]

Voltages

There are several voltage regulators in the monitor: +18V, +15V, -18V, -15V. These are fed by a +25V and a -25V source. If one or more of these voltages were incorrect, that would easily cause deflection problems. The +18V (7818) and –18V (7918) regulators can be replaced with +/-15V regulators. A detailed discussion is included in the Factory Service Upgrade section of this document.

MONITOR TYPES AND DIFFERENCES

Now that we have discussed the operating theory of the Cinematronics monitor, we need to note the different types. There are several revisions of the Cinematronics 'vectorbeam' monitor. However, there are two distinct versions – the "discrete" HV version and the "Keltron" version. The table below outlines the different revisions that are detailed in each schematic package. Do not assume your game has the original or correct monitor in it! Operators (and collectors) are known to swap things around. Also note that these monitor revisions are different and independent from the CCPU revisions. Do not confuse the two!

The monitors produced by Larry Rosenthall's Vectorbeam company are for all intensive purposes identical to the monitors made by Cinematronics and differ in name only.

Cinematronics
Space Wars	Rev. A ('discrete') 19" B&W monitor
Star Hawk	Rev. B ('discrete') 19" B&W monitor (some with 23" B&W monitor)
Sundance	Display with 16 Level Intensity – Rev. ?? ('discrete') 23" B&W monitor
Tail Gunner	Rev. D ('discrete') 19" B&W monitor
Rip Off	Rev. B ('discrete') 19" B&W monitor
Star Castle	Rev. G ('Keltron') 19" B&W monitor
Armor Attack	Rev. G ('Keltron') 19" B&W monitor
Solar Quest	Display with 64 Level Intensity - Rev A. ('Keltron') 19" B&W monitor

Vectorbeam
Space War	Rev. H (effectively a Cinematronics Rev. B 'discrete') 19" B&W monitor
Barrier	Rev. H (effectively a Cinematronics Rev. B 'discrete') 19" B&W monitor
Warrior	Rev. H (effectively a Cinematronics Rev. B 'discrete') 19" B&W monitor
Speed Freak	Rev. H (effectively a Cinematronics Rev. B 'discrete') 19" B&W monitor

[The Vectorbeam monitor has an extra 2n2102 (Q19 on the Vectorbeam monitors; Q8 on a Cinematronics - 2N3904)]

Exidy II
Tailgunner II	?

Rock-Ola
Demon	Rev. ?? ('Keltron') 19" B&W monitor

[Boxing Bugs and QB-3 (you have one of those, right?) each used a Wells-Gardner 6100 color vector monitor. War of the Worlds was supplied as a kit and was intended to be installed into a Star Castle or Armor Attack. A couple War of the Worlds prototypes used the Boxing Bugs color adapter board with a Wells-Gardner 6100 color vector monitor. Therefore, none of these games are included in the above list.]

Analog Joystick Interface [need better description]
The reading of a Joystick is nearly the same as Vectrex. A value is placed in the shared Y axis DAC, a reading from a comparator is taken and returned as a single Hi/Lo bit, it's up to the software to do whatever type of binary search it takes to determine the joysticks value. The joystick shares the DAC.

VARIABLE INTENSITIES

Two Cinematronics games utilized variable intensities – Sundance and Solar Quest. Essentially, these games are able to reproduce continuous fades (in or out) instead of just Normal and Hi intensities. Very cool effect. You can play any variable intensity game (i.e., Sundance or Solar Quest) on a two intensity (Hi/Lo) monitor by changing a jumper on the game CPU board. The variable intensity game ends up playing with all Hi intensity vectors and is therefore monochromatic. For instance you can play Solar Quest on an Armor Attack monitor, but you can't play Armor Attack on the Solar Quest monitor without making a lot of changes to the monitor to remove the add-on intensity board.

However, for testing purposes you *can* use a Solar Quest monitor with a CCPU that does not have the multi-intensity jumper set. Although each time the intensity bit is changed on the CCPU game board you are using, some random value based on the last vector position will be latched as the Z-intensity. If this results in intensities of blank, then you won't see much. It shouldn't hurt anything to try.

Sundance 16-Level Intensity PCB

[??]

Solar Quest 64-Level Intensity PCB
Solar Quest uses a slightly different monitor than all the other games. Most Cinematronics games have a tri-state (2-bit) intensity, which is off/low/high. In Star Castle, for example, walls that have not been hit are "high" intensity and walls that have been hit once are "low" intensity. Solar Quest has a little vertical board mounted on the back of the monitor frame. The ribbon cable from the logic board goes first to this board and then on to the main monitor board. This board has a bunch of transistors, which apparently make up a 6-bit DAC for the 64-level intensity. As with the game boards, they figured they could save money by designing their own circuits instead of using off-the-shelf ICs; Cinematronics really liked discrete components, which is a good thing since replacements for 74-series TTL, and plain transistors will be around for a LONG time and make repair possible.

Intensities for Solar Quest are done by using the same data lines that are used to drive the Y DAC, to send a 6-bit value to a latched intensity DAC. Color apparently uses the same lines, but 12 bits are latched into the R G B level DACs.

Solar Quest Intensity PCB connection
If you want to convert your Rev.G monitor into a Solar Quest monitor (and assuming you have a 64-level intensity PCB) you can follow these steps. First, there are components that will need to be removed: resistors R7, R8, R9, R10 and R22, two transistors (Q1, Q3) and the diode D3. The schematic for the 64-Level board shows the intensity line connecting to the low side of the brightness pot.

The SPOT KILLER is connected in SERIES with Q2. The 13K resistor in series with the brightness pot is ONLY used if the picture tube is an AMPEREX type.

The 9-pin connector needed is a Molex 03-09-1093 and the connections are outlined below.

Pin	Connection	Wire Color	Length	Notes
Pin 1	Male	Violet	11"	Pin 1 connects to the non-banded end of D4.
Pin 3	Female	White	11"	Pin 3 connects to the COLLECTOR of Q2 (Spot Killer)
Pin 4	Female	Yellow	11"	Pin 4 connects to the banded end of D4 (+90V point)
Pin 8	Female	Black	12"	Pin 8 connects to GROUND.
Pin 9	Female	Orange	15"	Pin 9 connects to +5V, pin 13 of J2.

All the points except the +5V connect to the empty thru holes left after removing the above-mentioned resistors, transistors and diode. The +5V wire (15" orange) is run thru a hole an inch or so to the right of the BRIGHTNESS pot (R11) then connected to pin 13 of J2 on the SOLDER SIDE of the PCB.

The 34-pin ribbon cable for the monitor needs another 34-pin mass-term type connector added for the 64-level board. Very similar to an internal IDE cable for a PC.

It is also important to note that a dedicated Solar Quest utilizes a reversed video projected off a half-silvered mirror just like Asteroids Deluxe or Omega Race.

HIGH VOLTAGE SUPPLY

The Cinematronics monitor was manufactured with two slightly different HV designs. The first design – the 'discrete' design for lack of a better description - was used on all games up to Star Castle (Rev. A to F). The discrete HV monitor utilizes the right half of the monitor PCB for HV generation. The High Voltage Transformer ("HVT") and Voltage Tripler are placed at separate points on the PCB and covered with a gold anodized protective cage. Starting with Star Castle, Cinematronics utilized an all-in-one HV module commonly referred to as the 'Keltron' after the manufacturer. To further confuse things, Cinematronics used two different HV modules in production, one was the larger gold anodized aluminum manufactured by Keltron, while the other was a smaller black box with a couple of studs sticking out of it for mounting which was manufactured by PTK. The PTK black boxes have a lower voltage output of 15KV versus the Keltron's 16KV, resulting in a slightly dimmer image on the display.

According to "Joe the Cine Tech," the monitors were originally designed for the lower voltage black boxes. Someone in the company just ran across the Keltron units (which were designed for some medical equipment) and gave them a try. Since the lead time on the black boxes was ridiculous, and Keltron was much more eager to work out problems with connectors etc, they used Keltron as much as possible, switching to the black boxes when the Keltron supplies ran low. There is some sort of adapter that plugs in between the molex connector and the back box units. The PTK black box HVs used 15KV for the desired output, so I would guess the "adapter" was a resistor to drop the output to 15 KV.

Cinematronics part # 82-10841-01
Cinematronics part #??? 82-11083-01
Keltron Part # HP160124A
Black Box #   ??

Rev.A and Rev.B Monitors
There is a significant amount of circuitry added to the power-supply sections between the Rev.A and Rev.B versions of the monitors with the discrete HV section. Rev.B is an "enhanced" version of the Rev.A monitor. This monitor was used in Starhawk, and has some additional circuitry in the power supply section. This revision also has a 7805 regulator added, to generate +5V for the logic chips from the +25V input, instead of relying on the +5V from the CPU board. The Rev.B additions were carried through to the Keltron-type design (a.k.a. "Rev.G", according to the draftsman's block in the corner). Check the schematics for any specifics you require.

HV Replacement
By David Fish

This should be of interest to anyone who has a Cinematronics B/W X-Y monitor (Vectorbeam) that has either died or is dying due to the failure of its Hi-Voltage supply. The supply MUST be the 'off-board' type such as the Keltron HP160124A. This cannot be done (at least not easily) with the Hi-V supply that is part of the big monitor pc board. I've also seen another supply used that does not look like the Keltron, but it's hook-ups were the same, so all this applies to it also.

The supply has three outputs: 16kV, 400VDC (FOCUS) and 90VDC (CATHODE). On several supplies that I have the 90V output will fail and drop down to about 45V. If all the normal intensity lines on your screen disappear leaving only the high intensity lines, there's a good chance your 90V output is dying. The 90V is used in the brightness circuit that drives the picture tube's cathode; controlling the amount of beam current, hence, picture intensity.

The failure, at least in my supplies, is due to a component within the voltage quadrupler circuit; the potted and plastic encased section of the Keltron. I haven't tried to repair one yet, so it may not be possible. For now, assume it's not.

The 'goo' inside the discrete HV is an electrically isolating potting compound. It's injected in at vacuum so as to eliminate any voids (air bubbles) which could cause an electrical breakdown if it was run without the potting but I'd guess that there'd be some corona in there. As I remember it was pretty tight as far as component spacing.

The manufacturer of these supplies, Keltron Corp. of Waltham MA, wants nothing to do with them anymore, and I cannot blame them. The only option you have is to replace it. That is, if you can find one.

Another option is to replace the Keltron unit with a similar power supply. Not that many to choose from. What I've found is that the Electrohome G05's Hi-Voltage supply can be used as a replacement. This <u>MUST</u> be the older version from the G05-801 (Assy #02-160007-01 with the PC Assy #02-160008-01 Issue 5). The newer version of the G05 HV, Assy #05-160006-01, with the PC Assy #02-160016-01 (02-160027-01 ?) will not work. The former is rated for up to 16KV where the latter is rated for 12kV (different design). The Wells-Gardner V2000 version of this supply [38A5583-000 using PCB300] is rated for 14.5KV. I've got one ready to go but I haven't tried it yet.

Connecting the Electrohome supply to the Vectorbeam monitor is trivial. The drawback is that new mounting holes will need to be drilled in the monitor's metal side panel. The new cable needed is simple enough to show below. The only caution here is that the wire for the +400V connection MUST have insulation rated for 600 Volts or greater.

```
 Cinematronics                    Electrohome
 Deflection board                 HV Power Supply
 PCB connector                    Connector P900

    +90V       1 <----------------------------<5
               2 >   [ not connected ]
    +400V      3 >----------------------------<1
    +25V       4 >----------------------------<8
    GND        5 >----------------------------<7
               6 >   [ not connected ]


   Chassis -------------------------------------<P901-9 Aquadag GND
```

Before connecting the new supply, check the voltage level of the +25V supply. The Electrohome EHT supply was designed to operate over an input voltage range of +23VDC to +38VDC but it's better to be sure. When you do power up the Hi-V supply you will probably need to adjust the anode voltage. The FOCUS voltage will also need to be adjusted to +400VDC. Its adjustable limits are -140V to +400V so definitely check it.

RESULTS:
The CATHODE output voltage (and the FIXED 400V, P900-3) track the adjustment potentiometer so when you adjust the anode voltage, the 90V & 400V also change. This is why I chose to use the variable FOCUS output. I have my supply set so that I get 116V, 400V and 15.4kV. If the anode voltage is set lower than 15kV the picture expands past the edges of the tube due to the slower electrons being deflected for a longer time than they should. The 116V is almost 30% higher than what the intensity circuit normally expects but the 2N5550 transistors, which do the level switching, can handle this without any problems.

I have my supply running at its maximum output but according to it's specs it should be able to handle it. So far, I've only had the machine running for a few hours and it seems fine. Only time will tell whether this replacement will hold up.

HV 'Upgrade'

If you have the discrete HV monitor it should be possible to fix it unless it's a fault of the HV transformer itself. I've never had to repair one of the 'old' style displays. The Keltron supply is the gold box that is mounted on the side of the chassis, Keltron was the manufacturer. There is no write-up on how to retrofit a Keltron box into the older style chassis although it is do-able. You would have to remove enough components from the discrete Hi-V supply so that it's completely disconnected from the rest of the circuit. Then a connector for the Keltron would have to be wired into the monitor PCB as it is in the newer version. A working Keltron would have to be mounted to the chassis then connected up. Probably sounds easier than it is. Since the Keltron supplies a lower voltage than the original HV, the overall brightness of the picture will be greater.

[Include image with replacement points]

TUBE AND YOKE

Cinematronics utilized both a Sylvania 19VARP4 and an AMPEREX M50-102W picture tube in it's games. New replacement 19" Black & White tubes are available from Richardson Electronics for about $115 each (www.rell.com).

There were two different yoke designs on the Cine monitors. The earlier design used on Space Wars required an extra set of 1.2k resistors across the yoke windings noted as R122 and R222 on the schematics. These resistors were placed there to compensate for non-linearity in the yoke. The later yoke design required these resistors to NOT be there.

If someone in the past replaced the yoke/CRT assembly with one that is different than the one the monitor board is configured for, you will not be able to line up the drawn vectors.

(yoke parts numbers ?? _____)

If your image is too dim even when the brightness adjustment is all the way up then you most likely have a bad picture tube, which should be replaced since it is going bad. For some reason, there are a lot of Star Castles with dim tubes but never any other game. Even though Star Castle (undoubtedly) got much more use than the other titles, poor initial tube quality, not on-time, is generally the cause of this kind of tube failure so perhaps the Star Castle production run(s) used a different (worse) tube supplier. Rick claims that this dimness in Star Castles was prevalent even when the games first hit the arcades, which would also point to manufacturing defects in the tubes. There are dim Star Castles that have an Amperex M50-102W tube, but bright Rip Offs that have a Sylvania tube. Strangely enough, there are bright Armor Attacks that also have the Amperex tube so it would seem that not all Amperex tubes go bad even though most (if not all) tubes that go bad are Amperex.

Wondering what the big capacitors hanging off the monitor board do? They are there to help protect against static discharges from the picture tube. The static was supposed to charge the caps instead of blowing some DACs or whatever else might be sensitive to static electricity. Cinematronics had a big problem with this and it is not clear how well these caps worked.
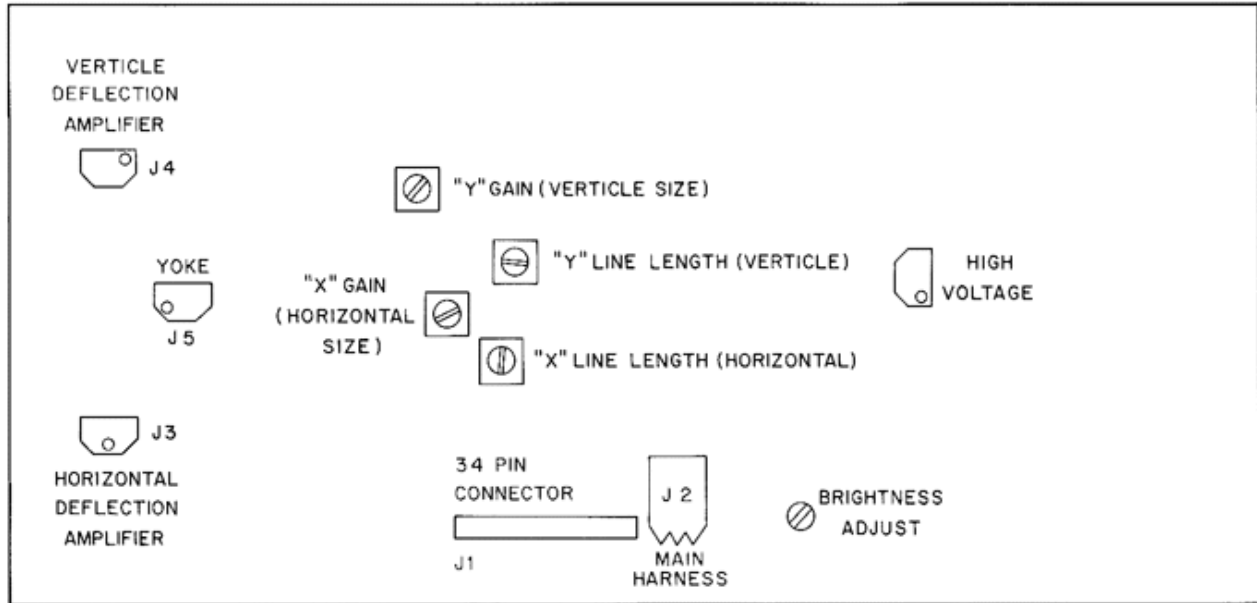
CRT (Neck) Pinout

Here is the complete pinout of both the Sylvania and Amperex neck/tube.

> Pin 1 - Filament GND
> Pin 2 - G1 30V
> Pin 3 - G2 410V
> Pin 4 - G3 300V
> Pin 5 -
> Pin 6 -
> Pin 7 - K 94.5V
> Pin 8 - Filament B+

MONITOR ADJUSTMENTS

Cinematronics Monitor PCB

All picture adjustments for a Cinematronics game are made on the monitor itself. There are no adjustments possible on the CCPU. The graphic above details the adjustment types and locations.

There exists a test pattern in most games that is enabled by dipswitch 7, located at position E2 of the main CCPU board. The test pattern is for alignment purposes and should be adjusted to fill the playfield.

Display Monitor Adjustment Procedure
This procedure adjusts the linearity and convergence of the video display.

    Test Pattern Adjustment Procedure
    (X and Y R/C Time Constant Adjustment or the Inner Ends of X and Y Line Segments.)
    (a) Turn the "X" R/C time constant trimpot R209, and adjust the X (horizontal) lines until the two inner ends of each line segment just meet.
    (b) Turn the "Y" R/C time constant trimpot R109, and adjust the Y (vertical) lines until the two inner ends of each line segment just meet.
    (c) The X and Y lines should meet at the center of the TV monitor screen, if not, check the related display electronics.
    (d) The ends of the two "L" shaped line segments around the center of the display must meet to form a square.

X and Y Gain Adjustment

Adjust potentiometers R102 and R202 so that all vectors (line segments) neatly intersect. R102 adjusts the length of all vertical lines. R202 controls horizontal line lengths.

(a) Turn the X gain trimpot R202, and adjust the X (horizontal) lines until the two outer ends of each X line segments are ¼ inch from the edge of the TV monitor screen.

(b) Turn the Y gain trimpot R102, adjust the Y (vertical) lines until the outer ends of each Y line segments are ¼ inch from the edge of the TV monitor screen.

(c) If the outer ends of the line segment are not properly adjusting to l/4 inch from the edge of the screen, center the display.

Centering the Display. If your picture needs centering, use the 2 metal rings on the neck of the tube with tabs on them. They control the screen position only and are used for centering. Each controls a magnet that will "pull" the picture in the direction the tab points. To move the image to one side, make the tab on a ring point towards that direction. The 2 rings are used in conjunction to create varying degrees of pull in a particular direction. To pull the screen as strongly as possible to a side, point both tabs to that side. If you then adjust 1 ring 45 degrees up and the other 45 degrees down, you are still pulling in the same direction as before but you are now pulling with ½ the intensity since the other ½ intensity is cancelled out by one magnet pulling up and the other magnet pulling down. Turn the two CRT magnet rings, located on the neck of the CRT, until the point where the X and the Y lines meet is centered on the monitor screen.

Generally speaking, do not touch the yoke adjustment unless you are a qualified TV repair technician! The yoke should never require adjustment unless the monitor has been installed in a different type of game or the adjustment magnets have been tampered with. In either case, if the entire picture appears to be offset, and normal adjusting does not restore it to its proper position, then you will have to spend some time (a lot of time actually) adjusting the yoke assembly. The two yoke adjusters are located on neck of the monitor, and they affect the vertical and horizontal deflection of the electron beam. If yoke adjustment is necessary, follow the instructions given in the appropriate monitor manual.

Contrast Adjustment. There is no factory supplied contrast adjustment for the Cinematronics monitor. If you find that the difference in intensities is too great, you can insert a variable resistor in the intensity network.

Replace R10 (5.6K) with a 5K-ohm potentiometer. This will allow the high-intensity vectors to be adjusted to an acceptable level.

High Voltage Adjustment

[Can this be done?]

Focus Control Adjustment

[Can this be done?]

FACTORY SERVICE UPGRADES

The following are a list of the recommended factory service upgrades that Cinematronics sent out to all distributors, and operators who sent in their warranty cards. It is safe to assume that not all games had these modifications made and you should verify each one as it relates to your game.

July, 1980
ATTN: Distributors/Operators
RE: High Speed Analog Switch (LF13331) modification

Dear Serviceperson(s):
The Analog switch in Cinematronics monitors can be damaged if the -15 volt supply line reaches the chip before the +15 volt line. Addition of a 1N914 diode protects against this condition.

Attach the cathode (banded end) of the diode to pin 4 of the Analog Switch socket. Attach the anode to pin 5. After soldering, clean thoroughly with proper solvent or resin remover solution.

September 24, 1980
Attn: Distributors/ Operators
Re: DAC-80 Modification

Dear Serviceperson(s):
In order to assure prolonged reliability of IC1 (LF13331) on Cinematronics' monitors, a current limiting resistor is being added to the outputs of the horizontal and vertical DAC's. This is a recommended retrofit for all existing systems.

Add 1 each 820 ohm, 1/4 watt resistor to underside of board between pins 15 -- and 18, per follow& diagram; Be sure to sever trace at the indicated location.

Vertical DAC -- IC101
Horizontal DAC -- IC201

This modification does not apply to units equipped with analog switch substitution board.

September 24, 1980
Attn: Distributors/ Operators
Re: High Voltage Section Regulators

Serviceperson(s):

On older Cinematronics' monitors incorporating a high voltage cage and associated components, a substitution may be made for the +18 (7818) and –18 (7918) volt regulators if unavailable.

IC3, the +18 volt regulator, may be replaced by a +15 volt regulator, 7815. IC5, the −18 volt regulator, may be replaced by a −15 volt regulator, 7915.

There will be a 20% decrease in overall output levels that does not degrade game performance. Potentiometers R102 and R209 may be adjusted to compensate for increased screen size. Verify that resistors R12 and R13 are rated at 4 watts as there will be a 20% increase in power dissipation.

RECOMMENDED MONITOR UPGRADES

It is often suggested that the very first thing one does when repairing a Cinematronics monitor is to remove and replace all the tantalum capacitors without question. There is some validity to this.

As power supply filter caps, tantalums are generally superior to electrolytics. They are generally smaller for a given capacitance. They are often manufactured using a porous slug as opposed to the layers of aluminum foil used in regular electrolytics. Therefore, ESR and inductance in tantalums is generally minimized. That is almost always a very good thing.

However, tantalum capacitors are relatively expensive and two out of a thousand will fail without provocation even in a perfectly designed circuit. The number one failure in these monitors, failures that cause the breakers to blow, damage the DACs and or LF13331 analog switch and burn-out of the output transistors are those damned tantalum capacitors. If they get reverse voltage for just a microsecond, they become wires. When they fail, they usually short out, dragging the power supply down close to ground. That is almost always a very a bad thing.

The following is a list of recommended Cinematronics monitor upgrades:

- You will want to replace the tantalum capacitors with something that has a low ESR. That being said, you should replace them with an electrolytic -- 33uF @ 50V is a perfect replacement value. Spend the extra money and get the smallest capacitor with the highest ESR rating you can find. Your monitor will thank you for it. The only other thing to remember when replacing these capacitors is to pay close attention to the polarity. You may leave the tantalum capacitors C12, C13, C15, and C16 as they are at the output of the +/- 15V voltage regulators (IC4 and IC6). You can also leave C25 and C26 as they are at the +5V regulator (IC8).

- Replace resistors R118, R119 R218 and R219 with 47 Ohm, 5W resistors. To do this, place them on the underside of the PCB where there is more room.

- Replace al 1N4003 diodes with 1N4004 or higher rating, which includes D105-115/205-215. There are 31 diodes on the monitor board.

- Replace the deflection transistors with the 2N3716/2N3792 pairs that are used in all the Wells-Gardner 6100 vector monitors. These transistors are rated at higher specs than the originals and are most likely easier to source. Just make sure that you replace BOTH transistors on the heat sink even if you only need to replace one. These transistors must be replaced in pairs.

- There is a *required* update that all the older monitors should have installed. A single diode that prevents the LF13331 from being back driven if the +/- power supplies do not startup or shutdown at the same time. The newer monitors have this diode already installed. In the older monitors that do not work, death of the LF13331 is the number one reason.

- Make all Factory Upgrades, including the LF13331 modification above.

General Monitor Repair That Should Always Be Performed

- There are 4 neck wires (Yellow, Red, Green, and Blue) with white "things" inline with each wire. Inside the 'things' are 1K ½ watt resistors. The resistor wires will break at some point. You can either replace them, or cut them off and splice around them. While you are working on these wires, ensure that none of them have broken off the monitor PCB, as this is very common.

- Resolder all the connector pins on J1 and J2. Cracks from connector wiggling are quite common. Also resolder the connections of the yoke wires where they meet the monitor PCB.

- Check C102/202 for broken legs.

- Check the outputs of the voltage regulators (IC4, IC6, IC8). They should be +15V, -15V, +5V respectively.

- Check the output damping diodes D114, D115, D214, D215.

- Make very good ground (common) connections between the monitor, CCPU and power supply for reliability. Solder fat conductors with nasty heavy gauge connectors between each component in the system. Replace any components on your game power supply that need it such as the electrolytic capacitors.

- When replacing any resistors, use only Metal Film resistors as they have much higher tolerances and are not much more expensive than the common carbon composition resistors.

TROUBLESHOOTING AND TEST PROCEEDURES

The basic methodology in troubleshooting a Cinematronics monitor is to assume NOTHING. If your monitor is not working properly, take the following steps.

1. Disconnect the monitor from both video and power. Always remove the ribbon cable <u>first</u> before you remove power.

2. Disconnect the CCPU and sound board from power.

<div style="border:1px solid black">

WHEN DISCONNECTING RIBBON CABLES, BE SURE TO NOTE CONNECTOR LOCATIONS AND ORIENTATIONS.

</div>

3. Test the system power supply and repair as required.

4. Reconnect <u>only</u> the CCPU to the power supply and test. This test amounts to ensuring the red led lights when power is applied and goes out a fraction of a second later. If the light stays lit, flickers, or doesn't light at all, you have a CCPU problem. Repairing the CCPU is beyond the scope of this document.

5. Once the CCPU is working, reconnect the sound board. If you can play the game blind (with correct sounds) move on to the next step. If not, you may STILL have a CCPU problem or a sound board problem or both. Repair as required.

6. Once you can play the game blind, turn the power off and reconnect the monitor to both power and input signals. Be certain the ribbon cable is properly oriented. Proper orientation of the ribbon cable cannot be stressed enough.

7. Time to troubleshoot! You will need a good meter, a logic probe and an oscilloscope. Without these tools, you will find that fixing your Cinematronics monitor to be exceedingly difficult.

Troubleshooting Tips to Remember:

- Before working on your Cinematronics monitor, be certain your problems actually lie in the monitor.

- Never power up the monitor board if the deflection transistors on the heatsinks are disconnected from the monitor PCB.

- Never power up the monitor board with the ribbon cable (leading to the CCPU board) disconnected. If you do this, there are undefined values going into the digital-to-analog

converters on the monitor board. These undefined values may (and usually will!) cause the deflection circuits to drive very hard and burn out components.

- Be careful with the orientation of the ribbon cables used to attach the CCPU board to the video board. On many games, the connectors are not keyed, and if you install the cable incorrectly, damage to the video board and/or the CCPU board can result. This is a very common problem.

- If you know you have a monitor board failure and are actively working on the monitor, you can disconnect the CRT plug from the neck of the picture tube. This will prevent any chance of phosphor burns from occurring while you are running tests, etc. You obviously will not be able to see any of the tests on the monitor screen, but that is ok for most tests.

> Never work on the High Voltage unit unless you know what you are doing.
> It is dangerous and **can** kill you.

Cinematronics vector games require a pure +5VDC for the CCPU to function correctly, and you MUST NOT plug the monitor in until you have proper game sounds when you coin and then start the game. This requires that you have +5VDC on the CPU board near the eproms/roms. Next (after checking the monitor for shorted/open transistors and resistors) using your logic probe, check for activity on the data lines going to the monitor to ensure that there is a changing signal on all data lines. Now you can plug the monitor in. Listening closely to the yoke of the monitor, turn on the game for about five seconds. There MUST be a "chattering" noise coming from the yoke area. If this yoke chatter is not present then turn game off, disconnect the driver transistors and the yoke from the monitor chassis, and get out your oscilloscope to test for signal flow. If chattering is present, then move around to front of game to watch for a picture.

Waveforms From Manual

In order to diagnose the monitor board, you can check various spots on the PCB for predetermined oscilloscope waveforms. All scope waveforms are generated with the game in diagnostic mode (CCPU dip switch # 7) and with the yoke connector unplugged. For the x and y amplifier sections, trace through each amplifier with an oscilloscope and narrow down where the problem lies. At that point you can always do a diode test on the transistor in question and verify if it is good.

Set your scope to trigger at 50% of the peak output voltage (you can usually use the +V side) of each section of the amplifier or DAC output and look for a 'decent' amount of activity (i.e., voltage swings similar to those pictured below).

The main points of reference you can check are:

1. The collector of Q104/Q204 (although it is easier to look at the diodes)
2. Output of each DAC-80 (pin 15)
3. Input of each TL081 (pin 3)

4. Output of each TL081 (pin 6)

You can see the output from each stage as the signal goes through and you can usually spot which stage has a bad component in it this way. Make certain you have disconnected the yoke when you check the signal path. If you try running the monitor with the yoke connected and the chassis mounted output transistors plugged in, you will blow something.

Begin troubleshooting with Q104/204 (2N5322), as these are the most likely failures. If one channel is working, test Q104 against Q204 using an analog meter in "ohms/resistance" setting. Test all 6 combinations of the 3 legs and make sure both transistors "look" the same on the meter deflections. If not, remove it and retest out of circuit (should have some resistance in 2 combinations and infinite in the other 4). If it tests badly out of circuit, replace it. If it tests OK out of circuit, check adjacent transistors in the same manner until you find the all the ones which are bad and make the non-working channel's transistors all mimic the deflections of the working channel's transistors. You will find that about 80% of the bad transistors are shorted and about 20% are open.

Next, start by looking at the output of the DAC 80s, and then follow the waveform through the LF13331 and so forth. Check to see where the signal starts looking bad (i.e., chopped off to only the top/bottom/left/right half).

To further isolate the problem in your monitor, you can cross the horizontal and vertical stages between the control and power sides. Notice those two long jumper wires going from the area with the pots, over to the power amp sections? Those carry the final deflection signals to the amps. By crossing them, you turn the display 90 degrees, and you can isolate the problem to either the control or power sections.
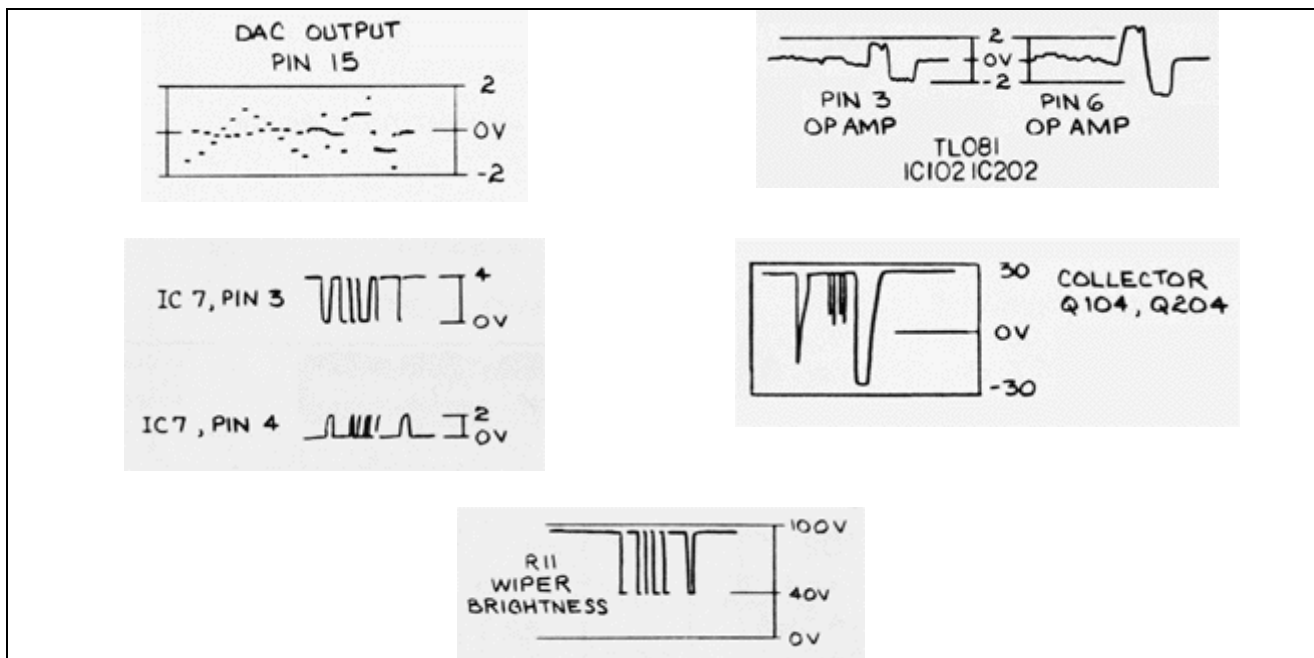
Test Procedures

Deflection Circuit Test Procedure. To test each DAC-80, you must first verify proper power on pins 13, 14 and 22. Remove the LF13331 analog switch at IC1. A DC meter should read approximately 0 volts at pin 15 of the DAC. Check pins 1 through 12 with a logic probe, most of the lines should be pulsing.

Analog Switch Test Procedure. The LF13331 at IC1 should produce a charging waveform centered about 0 volts on the switch output pins. The upper channel waveform should be of greater peak-to-peak magnitude than the lower channel. You will need an oscilloscope to see these waveforms. If in doubt, replace the switch.

R/C Network Test Procedure. If the line segments on the monitor are adjustable but bowed, replace C101. If the line segments cannot be adjusted to intersect, verify proper resistance of R103 and R102 as R102 is rotated.

Edge Gain Amplifier Test Procedure. Observe the input signal on pin 3 of IC102 or IC202. The waveform at pin 6 should be the same with an average gain of 2. The signal should be centered and bounded between +/- 2 volts. If these signals are correct, check diodes D201-D204.

Deflection Amplifier Test Procedure. If the game is blowing circuit breakers the problem is almost always a transistor in the deflection section. Recommended test procedure is to check each transistor in circuit with a transistor checker. Lift diodes D112 and D113 to check transistors Q106 and Q107. In the horizontal section, lift diodes D212 and D213 to check Q206 and Q207.

Check the 4 transistors on the heatsink with an ohmmeter. I found it easer to remove the heatsinks one at a time to gain access to the pins of the transistors but I guess you can test at the connector if you know which wire goes to which pin. If you can hear deflection noises when your monitor is powered up, your output transistors are *probably* working. Be careful though, you can still hear the noise even if one channel is dead.

If a scope is available, the defective channel can easily be located. Step 1: Remove the deflection yoke connector (J5) from the display board. Step 2: Reset the breakers and power up the game. With the scope, probe the cases of transistors Q104 and Q204. There should be pulses clipped at +25 volts and –25 volts. The defective channel will not have these pulses. Once the defective channel is located, start at the appropriate DAC and proceed forward through the circuit until you find the bad component(s).

Replace the LF13331 analog switch at IC1. This is the quickest manner to verify proper operation of the deflection circuit.

Intensity Circuit Test Procedures. To isolate a no display condition to the intensity circuit, probe the yellow cathode wire at the CRT plug, turn the brightness full clockwise and observe a +90 volt base with pulses at +40 volts. If pulses are missing, jumper Q2 collector to emitter. If the picture returns, check F1 in the power supply and replace Q2 (2N3904).

Observe +2.75 volt pulses at pin 4 of IC7. If the pulses or voltage is missing, verify pulses at input pin 3 of IC7. Check for +5 volts at the junction of R1 and R2. Replace IC7. If you observe pulses at +4 volts, replace Q2. The output of pin 4 will exceed 2.75 volts if there is no load due to a failed transistor.

High Voltage Oscillator Test Procedures – discrete HV monitor only. The vast majority of HV failures will be the TIP41C (Q4). When this component fails, it will cause the +18 volt regulator to shut down internally due to a now excessive load request, such as if Q4 were to have shorted. Remove pin 3 of the transformer windings. With the load removed, the +18 volt regulator should read +18 volts. The -18 volt regulator will read -18 or -25 volts. Replace Q4, C17, D7 and the defective regulator all at once.

D10 and D6 are high voltage, fast recovery diodes that will not read with an ordinary meter. To test, lift the cathode from the circuit and observe rectifying properties.

SYMPTOM DIAGNOSIS

**The following symptoms and diagnosis come from various people and sources.
I cannot verify any of these will work for you.**

<u>Symptom</u>: **Monitor trips breaker.**

- Check transistor Q211 (2N5876)
- Check diodes D107-D111 if there is a loss of Y (or X) deflection just before breaker trips.

Here is a systematic guide to trouble shooting a monitor that blows breakers. Monitor must be connected to a good CPU. Check for burned components. The first thing we want to do is be able to power up the monitor without blowing breakers - then do the troubleshooting.

1. POWER OFF. Unplug yoke from monitor board. Unplug socket from CRT.
2. POWER ON.

   If breakers blow: POWER OFF. See A.
   If breakers hold: Check outputs of -15v, +15v, and +5v regulators. Output must be within +/-0.5 volt tolerance.

   A. POWER OFF. Unplug heat sink wiring harnesses from monitor board. POWER ON. Breakers blow: POWER OFF See B. Breakers hold: one or more of Q110, Q111, Q210, Q211 are shorted. Damage elsewhere is likely. Follow procedure at 3.

   B. Problem is most likely Video High Voltage module. Unplug from board and POWER ON. Breakers hold: replace or repair Video power supply. Breakers blow: Maybe a shorted tantalum capacitor.

3. Use an oscilloscope to check deflection circuits for proper signal. 1mv/div time base is a good scope setting. Between the DAC-80 output and input of Q101 or Q201, the signal amplitude is about +/-3 volts peak. The DC component should be less than +/-200mv. Too much DC component will trip the breakers. If the signal into Q101/Q201 is good, problem is most likely in the deflection amps. With the yoke disconnected, a good deflection amplifier will put out an odd looking "square wave", swinging between +25 volts. To check a bad deflection amp, check all transistors. Look for burned resistors at R118, R119, R113, R117, or R218, R219, R213, R217. Resistors R115, R116, R120, R121 may open with no burn marks. For test purposes, protection transistors Q106, Q107, Q206, Q207 may be removed from the circuit and amplifier can be powered up. Always replace protection transistors before returning monitor to normal service.

If you have a bad ROM image, the breakers will almost always pop. Is this bad for the game? YES! The breakers pop because the beam was deflected clear off the screen. This is VERY hard on output transistors in the deflection circuits.

Lets say you have a monitor popping breakers. Some would suggest that you disconnect the power transistor and see if everything runs ok without them. But what are the possible problems for blowing a breaker?

1) Bad power transistors.
2) Bad LF13331
3) Bad DAC80
4) Bad CPU board drivers
5) Bad voltage regulator
6) Bad built in HV unit

There are assuredly more things than that which may cause a breaker to pop, but these are the main reasons. If 2, 3, or 4 and possibly 5 were the problem, the CRT trace is going to be sent to the extreme edges of the screen, and that's going to burn up a pre-driver transistor/resistor. If you keep running your monitor with the power transistors disconnected, you are now going to have *two* problems, the original and the one just created by removing the power transistors and running the monitor.

At this point you might ask "has anyone ever set up inline fuses to the deflection transistors to protect the display board components should the deflection transistors go?"

Careful there. Anything that partially disconnects the output transistors from the drivers will cause driver damage (like unplugging the output transistors). If you add fuses they should be in series with the yoke, but I'm not too certain what benefit – if any – can be achieved by fusing the yoke.

You can try running the monitor without the Yoke plugged in, this is ok. But **DO NOT** run it with the yoke plugged in and without the power transistors plugged in! The outputs are darlingtons and if you unplug the output transistors, the pre-drivers will try to drive the whole monitor, and they just can't do it! If you had an output blow, you might want to test these pre-drivers as well. (Q108, Q109, Q208 and Q209).

If the circuit breakers quit blowing when you unplug the yoke, you may want to put a scope on the outputs of IC102 and IC202. If the output just sits at some negative voltage (like -5V) then something is wrong. If one of the transistors is blown, you might be driving an output maximally negative. If this is the case, trace back through the OP amps and analog switch and find the bad part. If you suspect a bad DAC, try swapping them. If the trouble moves it's a DAC, if not it could be the CPU itself.

You can unplug the deflection coil and put a multimeter across the X or Y coil outputs and see what kind of voltages are being sent to the coil, which helps greatly in debugging. You can also

unplug the yoke, leaving the HORZ and VERT transistors plugged in, and use a light bulb as a load to determine what axis are blowing breakers.

Symptom: No Picture. CCPU board is known good. Power Supply tests good.

First, check for visibly damaged components. Replace as necessary. Listen for audible "clatter" from the deflection yoke on the CRT neck. If the clatter is present, deflection circuitry is working and the problem is in the intensity circuit. If there is no "clatter", start by examining the DAC and then deflection sections. Also check for a bad 7400 series inverter, IC7, which should be socketed.

Symptom: No picture. RF Chokes are Fried.

The RF Chokes are 0.18 ohm, 2W NON-INDUCTIVE power resistors and are on the monitor board between the output transistor emitters and the deflection yoke. The RF chokes are in series with the final stage power transistors. They are current sensing resistors that form part of the feedback network going back to the output pre-driver.

If these smoked, chances are that your deflection transistors shorted. Check the transistors after you replace the RF Chokes. Make sure you replace the chokes (and the resistor from the other side of the yoke to ground) with NON-INDUCTIVE power resistors (i.e., not wire-wound)!

Symptom: No Picture.
Check the several 3-pin regulators that supply the various voltages on the monitor PCB. These go bad frequently so check each one for proper output DC voltage at the 3rd pin. You might get some indication of a problem with these by looking at the neon lamps clustered around the center of the board a little off to the right. They are normally supposed to be off; if any is on, it indicates an overvoltage condition. If your low voltages are OK, check your HV.

Symptom: Half a Picture.

Left Half [is present]: Check Q206, 208, 210
Right Half [is present]: Check Q207, 209, 211
Top Half [is present]: Check Q107, 109, 111
Left Half [is present]: Check Q106, 108, 110

- Check solder connections on heat sink molex plugs J3 & J4.
- Check diodes CR109, 110, 111
- Check diodes CR209, 210, 211
- Check transistors Q105, Q205

- Check resistors R116, R216.

An example. If the picture would start out OK, but after a few minutes the Y heat sink would get super hot and this would cause the weaker of the two TO-3 transistors to fail, which then caused a loss of -Y deflection followed shortly thereafter by both breakers tripping.

Feel the heat sinks. If either deflection heat sink is too hot to touch then suspect that the cluster of 5 diodes (D107-D111) in the center of the monitor PCB has at least 1 bad diode. They are type 1N4003 and are VERY inexpensive so rather than figure out which one is bad, just replace all five and upgrade them to 1N4004s. When I had this problem, the Freeze spray narrowed the bad part to those diodes and now everything runs cool and steady.

Symptom: Narrow Line on Display.

- Check Analog Switch IC1.
- Check Q110, Q210, Q111, and Q211 with ohmmeter or transistor tester. Inspect solder connections on circuit board molex connector socket pins.
- Verify continuity between display board and heat sunk power transistors Q110, Q210, Q111 and Q211.
- Check for bad solder & crimp connections to yoke wires.
- Check for open yoke windings with ohmmeter.

Symptom: No Hi-Intensity Vectors.

If you can see vectors but the intensity is too low, that means the oscillator section of the Hi-V circuit is *probably* working and the 16kV is being generated. The 90V is simply the half-wave rectified and filtered output of a separate secondary winding on the XFMR. Check the filter cap C17 (10/100V if I'm reading the schematic right) and the diode CR6 (MR818). Also pull and check the two intensity control transistors, Q1 and Q3. I would try pulling these transistors, and then powering up the monitor to check the +90V again, pulling the transistors removes the load from the +90V supply. Unless the transformer toast you should be able to get this fixed.

Well, you can safely short the emitter-collector of the transistors in that circuit to see if they are the problem. The transistors are forming a switch function here so shorting the emitter to collector is just doing the same thing (albeit a continuous instead of controlled action) you should see the screen come on full strength for the beams, with no blanking (rather busy picture) but at least you will know that the tube is emitting, and that the electron gun is OK. Next, a logic probe on the outputs of the 7406 should indicate if signal is getting through. You should have about +96VDC on the pot. That is its bias voltage. Turn the pot so that the wiper is set fully clockwise and short the wiper to ground momentarily, you should see the screen light up with the game lines. Next, check the SPOT KILL circuitry. It may be active (Low) and killing the screen drive transistor.

Symptom: Picture on the right side of the screen only. Game plays, but some of the vectors are a little 'off'. Vectors seem correct horizontally but zigzag vertically downwards from the drawn object.

This can be caused by a few things: bad connections between the monitor and the ribbon cable that runs between the game board and the monitor, bad transistors in the deflection circuit. Try wiggling the ribbon cable at both the CCPU end and the monitor end. Since there are misdrawn vectors, perhaps there is a bad DAC or a bad LF13331 analog switch. This problem can best be checked with a scope.

Using your scope, check the DAC output at the TL081s. If you see a perfect copy of the game in XY-mode (comparing outputs of TL081s), you know the DACs/analog switch and op amps are working OK. Follow the signal through to the collector of Q104 (vertical) or Q204 (horizontal) and keep the scope in XY mode. Once you find the same image that is being mis-drawn on your monitor screen, you will have found the portion of the monitor that is not working correctly.

Also check all the resistors around where the deflection transistors plug into the board. They get burned up frequently. Check the solder joints of the molexes that these transistors plug into; plugging/unplugging of these connectors often weakens the joints.

Try switching the molexes of the heatsink-mounted transistors to see if the distortion changes 'position' on the screen. I would suggest trying this even if you know that both sets of transistors are good.

Symptom: Picture on Display Jitters.

- Replace analog switch IC1.
- Check size pots R109 and R209 for wiper noise by turning briskly while observing the screen.
- Readjust for proper screen size.
- Check for bad solder connections on R109 & R209.
- Check DAC IC101 & IC201 for bad solder connections.
- Ensure that all molex connectors are properly seated.

Symptom: Dotted Display.

- Check IC7 pins 2 and 4.
- Verify proper operation of IC1.
- Check for proper +25 and -25 volts DC.
- Check operation of DAC's IC101 and IC201.
- On CCPU logic board, check IC8 pin 2 for pulses.
- Verify signal presence at analog switch IC1.

Symptom: Vectors do not line up straight. Vectors at the screen edge are bigger.

It is unlikely the DACs are bad. Things are drawn pretty dramatically wrong, when they go.

- Start by adjusting the line length pots on the monitor – R102 and R202.
- Check the feed back diodes on the monitor (near the TL081).
- Step through the edge-gain amplifier section of the monitor looking for bad components.

Symptom: Strange graphics when my ship moves horizontally. The space between the vectors that represents the ships expands and contracts vertically as it moves across the screen horizontally.

Try swapping the two DACs and see if the problem moves to the other axis. Replace the DACs as necessary. Also suspect the Analog Switch IC1. This problem can best be checked with a scope.

Symptom: No brightness control.

- Check intensity pot R11 for open wiper or internal short.
- Check for bad solder connections to R11.
- Check C17. Note: the only Cinematronics manual that shows C17 is Rip Off. All the other manuals list C17 as a possible cause in the troubleshooting section, but they do not show the capacitor on any of the schematics. Although the Rip Off manual shows C17 as a 10uF 150V cap tied to one of the three terminals on the brightness pot on the monitor board diagram, the capacitor is not on the schematics.

Symptom: Monitor is extremely bright; no focus. Retrace lines are visible.

Although a very rare occurrence, you might have a heater to cathode short in the picture tube. If you can find one, a CRT isolation transformer will fix that. A heater-cathode short like this will take the brightness to supernova levels! You will be unable to reduce the brightness to a usable level.

Symptom: No high voltage. CCPU board is known good. Power Supply tests good.

- Connect an oscilloscope to the yellow wire leading to the CRT connector. Set the brightness full clockwise. When viewing your scope, there should be an 80 to 100 volt DC base with

pulses dropping down to a 40-volt level. If no pulses, probe IC7 pin 4 with a scope and observe data pulses. If the pulses are present on IC7, check Q2 & Q3 with an ohmmeter or transistor checker.

- Check the cathode of diode D5 for a full wave rectified, unfiltered voltage signal floating at +25 volts.

- Check seating of CRT plug. Remove and probe with scope to verify presence of proper signals.

- Check the neck of the CRT for a glowing filament. If there is no glow, check the brown & black twisted pair of the CRT plug for 6.3 volts AC.

- Be sure all connections to the CPU board and monitor are firmly seated.

Symptom: High Voltage Too High/Too Low.

An accurate High Voltage meter will read 16KV to 18KV if high voltage is good (depending on which version of the monitor you have). Self-contained HV meters vary widely in accuracy. If +90 and +400 volts out of the high voltage supply are good, chances are 16KV/18KV is good. If +90 or +400 volts are bad, repair or replace high voltage supply.

Symptom Summary: Discrete HV monitor stays up for about 10 seconds, with deflection chatter, no picture. Then the -25V breaker pops (then shortly after, the +25V breaker).

Measuring voltages, all regulators are outputting the correct voltages (+/-18VDC, +/-15VDC). However, the +25VDC seems high (about 28 volts). The -25VDC is right on the money. However, when the -25 pops, the +25VDC line dips down to +25VDC.

Unplugging the yoke and retrying, the breakers do not pop, and I get a nice white dot in the center of the screen. I've checked the tantalum capacitors, diodes and transistors; they all seem fine.

With the yoke disconnected and neck harness disconnected, I decided to take a voltage reading across the yoke inputs. As was Zonn's suspicions, one of the yokes was pegged to the -25VDC side. So I had it narrowed down to an axis.

Then I tried the trick with swapping the wires that led from the DAC/Switch/OP amp section to the deflection section. Unsoldering and resoldering new jumper wires from near the pots location to the deflection side, I verified that the same problem exists, and that the working side was still good. So I had narrowed it down to one axis deflection side.

First I thought something might be breaking down and connecting the -25VDC directly to the yoke output, so I shotgun replaced all the diodes in that section. No change.

Then I took voltage measurements during running and changed any part where a reading was different from the other side. That wasn't helping.

Finally, I took out my logic probe (from Radio Shack, makes nice beeping noises :-)) and decided to trace the input from the DAC side to the deflection side. I followed it through the 2N5210s and I could actually hear through my logic probe, the deflection "chatter". So I followed that while comparing to the other side occasionally, and it led me to the 2N5322 from the 2N5210s. There the chatter stopped and was just a constant "low".

I replaced it, fired it back up, and now there was deflection chatter coming from it!

Hooking up the yoke and the neck harness, the monitor worked! I would tell you the part replaced, but it would be meaningless, as Cinematronics tended to use different screening numbers for different deflection boards (which really sucks, especially if you are trying to write a fix-it document. The particular part is Q3 on some versions, and Q204 on others.)

Symptom Summary: I'm working on getting a Tailgunner monitor running. When I got it, it had a couple burned out components. C3 or C4 (a 2.2 uF 35v tantalum cap) was popped open and R118 or R119 (a 47 ohm 1/4 watt resistor) was burnt to a crisp. C3/C4 is right next to the 7918 voltage regulator which appear fine (tests very similar to a 7915 anyway) and R119/R119 is right next to the large vertical deflection transistors (which also tests out fine). I've checked pretty much everything else on the board and nothing seems bad.

Noting the above, you will want to replace the final output transistors (the ones mounted in the heatsink) for the channel that the other components were burned on. It easy to tell which heatsink as the connector is the one next to the 47-ohm resistor that burned. What usually happens is one of the final output transistors shorts and causes the other components to burn.

Appendix A: Operator's Guide To Troubleshooting

(taken from the Cinematronics Star Castle manual)

O.K. - this is where we get technical on you - but don't panic! We'll keep this as simple as possible so you can figure out which board to send out for repair. For some of the steps in this section you will need a simple VOM [multi-meter], and know how to use it.

Here are two important procedures we will refer back to in this section:

Checking the LED:
Whenever there is a problem with the game, a good place to start is the LED (light-emitting diode) on the CPU board near the Molex power plug. This LED indicates whether most of the CPU circuit is working. When everything works right, here's what happens: Power to the game is turned on, the LED flashes on, then stays off. If the LED is flickering or on continuously, there is a problem with the CPU or the +5 volt supply. Check +5 volts on the logic board (follow procedures in this section). If the +5 is O.K., have CPU repaired.

Checking the +5 Volt Supply:
To check the +5 volts, you need a voltmeter. Turn power on in the game. Notice on the upper corner of the logic board nearest you is a little pin marked GND. This is a great place to put the negative probe of the voltmeter. Near this pin in position T13 (see CPU layout, pg. A-8) is a 20 pin IC marked 74LS377. Ignore the other numbers on this chip. We can measure the +5 volt supply at pin 20. Pin 20 is the bottom pin on the far side of the chip. Put your positive probe there, without touching any other pins, and you should get a reading. Anything between +4.8 volts and +5.1 volts is ok, otherwise, adjust the voltage.

The adjustment is located on the power supply, and it is the only screwdriver adjustment on the power supply. Adjust *slowly* WHILE READING THE VOLTAGE. Too much voltage will destroy IC's fast. If voltage cannot be adjusted into the correct range (+4.8 - +5.1 volts), repair power supply.

The following is a guide compiled from experience. It cannot be right 100% of the time:

Symptom**: Circuit breakers trip.**

1. Unplug game. Unplug Molex power plug from monitor and reset breakers. Turn POWER ON.
If breakers trip: POWER OFF, see 2.
If breakers don't trip: Coin-up game and "play" it. Are all sound effects normal?
     Yes - Repair monitor.
     No - Problem is probably in CPU or power supply. Check LED on CPU. Check +5 volts
          on CPU (see procedure) If +5 volts is good, repair CPU.

2. Unplug Molex power connector from audio board, reset breakers and turn POWER ON.

If breakers trip: Problem is in coin meter circuit or call factory for help.

If breakers don't trip: Repair audio board. POWER OFF, reconnect molex plug to monitor. Turn power on to see if there is a good picture. If the picture is bad, problem is probably in the monitor. If breakers trip: Check LED and +5 volt supply. If LED and + 5 volts is O.K., problem is probably in monitor.

Symptom: No Audio.
- Check for open speaker coil.

- Check transistors 2N6292 and 2N6107 and nearby output components on audio board with ohmmeter or transistor checker.

- Check 7815 and 7915 outputs.

- Check for open wiper on volume control mounted

- Refer to audio board theory of operation and troubleshooting guide.

- Replace F2 on logic board.

Symptom: Coin Counter is Inoperative.
- Check 2N6292 transistor on logic board with ohmmeter or transistor tester. Verify proper operation of A4 by grounding A4 pin 1. Coin counter should click.

- Disconnect coin counter molex connector.

- Measure DC voltage on red wire. Meter should read +25 volts DC.

Symptom: Gives No Credits.
- Tie E4 pin 12 to ground. If credits fail to appear, replace E4. If credits appear, disconnect logic board ribbon J3. Measure +5 volts on A4 pins 1 & 5. If missing, replace pull up resistor pack C2.

- Alternately ground A4 pins 1 & 5. If credits appear, problem is in switches on coin door.

- Verify proper coin door microswitch operation.

- Reconnect J3. Observe A4 pins 3 & 6 alternately while depressing microswitch lever on coin mechanism. Pins 3 & 6 should change states. Replace A4 (if they do not change states).

- Replace F2 (74LS259) on logic board.

Symptom: Player Control Button(s) Inoperative.
- Refer to player control schematic in APPENDIX.

- Verify with ohmmeter proper closure of player control leaf blade switches.

- Remove J3 connector. Measure +5 volts on D4 - 1, 2, 3, 4, 12, 13, 14, and 15. If missing, replace D4. Replace pull up resistor pack D2.

- Measure +5 volts on C4 - 1, 2, 3, 4, 12, 13, 14, and 15. If missing, replace C4. Replace pull up resistor pack C2.

- Coin up a game and, with J3 disconnected, ground aforementioned pins on C4 & D4. If display responds, problem is in continuity from J3 to player control switches [i.e., in the wiring harness].

Appendix B: Replacement Parts

While the majority of the Cinematronics monitors are comprised of TTL and other discrete components, there are a few items that are difficult to find or exceedingly expensive to replace. Hopefully the following list of replacements will give you some options.

LF13331 Replacement
By Rodger Boots

Yup, it's an obsolete part. It's getting hard to find. How about making your own? If I had any ambition I'd be making these myself and selling them to anyone that wants them. But someone else can do that, not me.

You will need an IC socket and a not-the-best analog switch IC such as a DG212, DG202, or MAX332. (Something with a similar on-resistance to the LF13331 and can handle the power supply voltage).

Put the IC UPSIDE DOWN on the IC socket. Pin 1 of the IC socket will be pin 8 of the IC and vice versa. Solder it to the socket. Trim off the extra pin length. Flipping it puts the power supply pins in the right places. ALL the parts have all the switches open with the control pins low.

Now plug it into the game. Pin 1 of the SOCKET plugs in to the pin 1 position of the game (you might want to paint a dot on the IC (pin 1 of socket, pin 8 of IC).

The disable pin of the LF13331 no longer works on this retrofit, but according to Cinematronics schematics it isn't used anyway.

One last thing, the reason your LF13331 died in the first place is probably because of the power up sequence. If -15V supply arrives before the +15V, then device will be knocked out. To prevent this, add a diode between pins 4 and 5 of the socket for the analog switch. The cathode (banded end) goes to pin 4, and the tail/anode goes to pin 5. Just about any diode will work, but a 1N914 is recommended; I think I used a 1N1418. I added the diode to the bottom side of the PCB.

The pinout for the two devices are as follows:

	LF13331				**DG201**		
Control1	1	16	Control4	Control1	1	16	Control4
source1	2	15	Drain4	source1	2	15	Drain4
drain1	3	14	Source4	drain1	3	14	Source4
Vr (GND)	4	13	Disable (*)	V- (-15V)	4	13	V+ (+15V)
V- (-15V)	5	12	Vcc (+15V)	GND	5	12	Not connected/used
source2	6	11	source3	source2	6	11	source3
drain2	7	10	drain3	drain2	7	10	drain3
Control2	8	9	Control3	Control2	8	9	Control3

DAC80s

The Burr-Brown DAC80 used in the Cinematronics monitor comes in two "flavors"; the DAC-80-CBI-V "voltage output", and the DAC-80-CBI-I "current output" type.

All Cinematronics monitors used the <u>voltage</u> version - the DAC-80-CBI-V.

The following are drop in replacements for the DAC-80-CBI-V:

- National Semiconductor DAC1280
- Burr-Brown DAC800-CBI-V
- Burr-Brown DAC800P-CBI-V
- Beckman 7580V (needs some resistors changed)
- Analog Devices ADDAC80N-CBI-V

The Beckman DAC (7580VS) is not directly compatible with the Burr-Brown DAC-80. If using a Beckman 7580VS, R101 must be changed to 11.0k 1% metal film, and R201 must be changed to 7.5k 1% metal film.

The DAC811 and DAC813 on TI's website (they bought Burr Brown) look like they could replace the DAC80 on the Cinematronics board. However, the pinout is different (it has more pins), and some resistor changes would need to be made on the Cine monitor to get the offsets and gains right. But at first glance it looks like one of these (if not both) could be made to work as a DAC-80 substitute. Each one has its advantage and disadvantages. But by holding low the WR, LDAC, and NA, NB, NC, LMSB and LLSB lines, the data lines are passed directly through to the DAC, making it act like the DAC-80.

Ribbon Cables

Ribbon cable specs and part numbers (AMP �) If you decide to replace your ribbon cable(s) you might think about keying each end. For some reason, Cinematronics did not originally key each connector. This will require the removal of at least one pin from the monitor PCB connector as well as one pin from the CCPU connector. Read your schematics to determine if this can be done on your monitor.

Appendix D: Testing Transistors

Most of the failures in the Cinematronics Vectorbeam monitor (as is the case with most electronic devices) are semiconductor failures, specifically, the transistors. All transistors discussed in this document can be tested in the same way; it does not matter if they are the large chassis-mounted transistors or the tiny PCB-mounted transistors. With the transistors out of circuit, set your multi-meter on Rx1K scale and use the following procedures.

NOTE: ANALOG AND DIGITAL MULTI-METERS REQUIRE DIFFERENT TESTING PROCEDURES FOR TRANSISTORS! Digital meters always show infinite resistance for all 6 combinations (if you accidentally get your skin involved it will show something around 2M Ohms). The best way to test transistors with a DMM is to make use of the "diode test" function, which will be described after the analog test. For both methods, if you read a short circuit (0 Ohms or voltage drop of 0) or the transistor fails any of the readings, it is bad and must be replaced.

Why do Digital Voltmeters read open circuits on diodes and transistors?

Because of the ability to use amplifiers, DVM can use much smaller voltages to check resistance. For the most part this is a good thing. It allows you to check resistors in circuit, without turning on things, like transistors.

Diode junctions (which there are two of in a transistor) do not "turn on" until they reach somewhere around 0.4 ~ 0.7 volts, depending upon what they are made of, and a lot of other stuff. In a way, diode junctions are similar to neon light bulbs, they act like open circuits until the right voltage is reached, and then they act like shorts, until the voltage drops below the critical threshold. Without proper current limiting, the diode junctions explode. The thing about diodes is that they only do this in one direction, if you switch the test leads, they do not conduct at all. (Well, until the voltage gets **much** higher, and then it is a bad thing. ;^)

Sometimes you want to be able to "turn on" the diode junctions (to test them), so DVMs have a "Diode" test mode. This places enough voltage on the test leads to turn on the diode junction. The number you read on most meters is the actual turn on voltage threshold across the diode.

TESTING TRANSISTORS WITH AN ANALOG OHMMETER

For type NPN transistors, lead "A" is black and lead "B" is red; for type PNP transistors, lead "A" is red and lead "B" is black (**NOTE**: this is the standard polarity for resistance but many multi-meters have the colors reversed; if the readings do not jive this way, switch the leads and try it again). Start with lead "A" of your multi-meter on the base and lead "B" on the emitter. You should get a reading of 2.5K Ohms. Now move lead "B" to the collector. You should get the same reading. Now try the other 4 combinations and you should get a reading of infinite Ohms (open circuit). If any of these resistances is wrong, replace the transistor. Only 2 of the 6 possible combinations should show a resistance and that value should be 2.5K Ohms; none of the resistances should be 0 Ohms (shorted).

TESTING TRANSISTORS WITH A DIGITAL MULTI-METER

Set your meter to the diode test. Connect the red meter lead to the base of the transistor. Connect the black meter lead to the emitter. A good NPN transistor will read a JUNCTION DROP voltage of between 0.45v and 0.9v. A good PNP transistor will read OPEN. Leave the red meter lead on the base and move the black lead to the collector. The reading should be the same as the previous test. Reverse the meter leads in your hands and repeat the test. This time, connect the black meter lead to the base of the transistor. Connect the red meter lead to the emitter. A good PNP transistor will read a JUNCTION DROP voltage of between 0.45v and 0.9v. A good NPN transistor will read OPEN. Leave the black meter lead on the base and move the red lead to the collector. The reading should be the same as the previous test. Place one meter lead on the collector, the other on the emitter. The meter should read OPEN. Reverse your meter leads. The meter should read OPEN. This is the same for both NPN and PNP transistors. Thanks to Randy Fromm <randy@randyfromm.com> for this excellent summary of the diode test method.

Appendix E: Using an Electrohome G05 or Wells-Gardner V2000

What? You have read all this and you say you don't have a Cinematronics monitor to play with, but you still want to play Star Castle, Rip Off or Space Wars? If you have more money than sense, follow along as we discuss using an Electrohome G05 or Wells-Gardner V2000 vector monitor in place of a Cinematronics vector monitor!

[MORE TO BE ADDED]

Notes from Zonn:

Your biggest problem with doing a Cine->WG board is that you are forced to use 12 bit parallel DACs, which are expensive. The Cine design is pretty much going to force you to find ~1 to 2 us settling time parts.

You might be able to save some money by using single supply 12 bit DACs and shifting the voltage after the analog switch and R/C stuff. This also allows the use of the much more available and less expensive 74HC4066 switches, which are only single polarity switches. The LF13331 switches are bi-polar, and also expensive (when they were available).

You cannot, however, use serial DACs. They would require a parallel to serial conversion and there is no time allocated in the hardware to allow this. The DACs are latched and the Z-axis is turned on for the draw, there's no "clock data into DACs" time, which at minimum would take 16 clock cycles, if both DACs were simultaneously clocked.

When building a Cine->WG replacement, one has no control over the timing, this is all done on the CCPU board. Same with the voltage values being sent to the DACs. The CCPU is sending out 12-bit DAC information, and is expecting to time the charge of a preset R/C constant. Changing any of the parameters: DAC voltages, R or C, will result in screwed up timings and vectors of incorrect lengths.
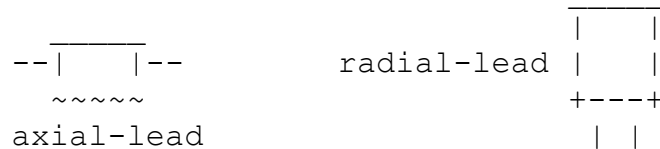-------------------------------

Appendix F: Installing A Cap Kit

Time and heat have "dried out" the electrolytic capacitors in your monitor reducing their capacitance values. Without the capacitors doing their job you get problems like wavy picture, smearing, warping, etc. The other problem that occurs is that over the years the solder joints at connectors develop little cracks in the solder. These cracks reduce the surface area that the electricity can flow over and sometime stop it completely. The best way to fix this is to remove the old solder and resolder the connectors, preferably with 63/37 electronics solder (available at Radio Shack). This is called reflowing. There are currently no sources for Cinematronics Cap Kits, so you will have to make one yourself.

Key:
- Q = Transistor
- R = Resistor
- C = Capacitor (all polarized electrolytic)
- D = Diode

Note that the capacitors come in two "types":

```
                                            _____
            _____                         |      |
         --|      |--        radial-lead   |      |
           ~~~~~                            +---+
         axial-lead                          | |
```

Note: if you cannot find an exact replacement for one of the capacitors, you may keep this in mind. A capacitor with a difference that is less than 5% of the original value should work just fine. Back in the days of the Cinematronics monitor, electrolytic capacitors had tolerances that were typically over 20%. So a modern capacitor will probably be a lot closer to the ideal value than the original cap that was in the chassis when it was new.

DEFLECTION TRANSISTORS

All the monitor deflection transistors are mounted in a socket with two Phillips head machine screws. No soldering necessary; just unscrew the old one and replace. You cannot put these deflection transistors in backwards; the leads are offset so they will only fit into the heatsinks one-way. If you put the transistors in backwards, the screw holes will not line up.

Make sure you install a new clear plastic Mica insulator between the transistor and the metal heatsinks. If you have some white heat sink grease, put a light coating on both sides of the Mica insulator.

Deflection Parts			
Location	**Part Number**	**Upgrade?**	**Notes**
Q110; Q210	2N3716	Yes	Original was 2N5878
Q111; Q211	2N3792	Yes	Original was 2N5876

Important: These transistors must be replaced in pairs. After replacing the above transistors, use your DMM set to Ohms and check the continuity between the metal monitor chassis and the metal case of the above transistors. If there is continuity (zero ohms), you need to replace the thin clear plastic Mica insulator that goes between the transistor and the monitor chassis. There should be NO continuity!

MONITOR BOARD

Note monitor revisions!

Cinematronics Monitor PCB - Rev. G - Cap Kit Parts			
Location	**Part Number**	**Upgrade**	**Notes**
C4; C10; C23; C105; C211	33 uF 50V radial cap	Yes	Original was 2.2uF 35V tantalum
C26	4.7uF 50V radial cap	Yes	Original was 4.7 uF 35V tantalum
C205	47uF 50V axial cap		
C1	0.33uF 50V film cap	Yes	Original was 35V
C25	0.47uF 50V tantalum	Yes	Original was 35V
C12; C13; C16	1uF 50V tantalum	Yes	Original was 35V
C15	2.2uF 50V tantalum	Yes	Original was 35V
R118; R119; R218; R219	47 Ohm, 5W resistor	Yes	Original was 1/2W
(see diagram)	820 Ohm, 1/4W resistor	Yes	Factory mod for DAC-80s
(see diagram)	1N914	Yes	Factory mod for LF13331
(31 diodes in all)	1N4004	Yes	Original was 1N4003

Cinematronics Monitor PCB - Rev. G – Parts to have on hand			
Location	**Part Number**	**Upgrade**	**Notes**
IC101; IC102	TL081		
IC7	7406		Inverter Buffer/Driver (Open Collector)
IC4	7815C		Voltage regulator
IC6	7915C		Voltage regulator
IC8	7805C		Voltage regulator
Q2; Q7; Q8	2N3904		
Q107; Q207	2N3906		
Q6; Q101; Q102; Q103; Q201; Q202; Q203	2N5210		
Q108; Q208	2N5320		
Q104; Q109; Q204; Q209	2N5322		
Q1	2N5550		
R109; R209	100-Ohm pot		
R102; R202	5K-Ohm pot		

END

September 24, 1980

Attn: Distributors/ Operators
Re: Burned 47ohm Resistors in Current Amplifiers

Serviceperson(s):

A common failure of the current amplifier, especially on older monitors, is blowing of circuit breakers CB1 and CB2 accompanied by burning of 47 ohm resistors around the power transistor molex.

The power drivers should not be unplugged during game operation, or the same resistors will be overdriven and eventually burn. Check for cracked solder around the molex pins. With an ohmeter or transistor tester, verify that the power transistors are operational: this is best accomplished by disconnecting the molex plug and checking right at the pins. The row of pins with the lone male pin always indicates the 2N5878 driver. The row of all female pins indicates the 2N5876 power drive.

Check on board drivers Q108, Q109, Q208 and Q209 with ohmeter or in-circuit transistor tester. Upgrade 47 ohm resistors from ¼ watt to ½ watt if not so equipped.
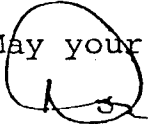
Customer Service

DW/tl

ATTN: Distributors/Operators
RE: High Speed Analog Switch
    (LF13331) modification

Dear Serviceperson(s):
    The Analog switch in Cinematronics monitors can be damaged
if the -15 volt supply line reaches the chip before the +15
volt line. Addition of a 1N914 diode protects against this
condition.
    Attach the cathode (banded end) of the diode to pin 4
of the Analog switch socket. Attach the anode to pin 5.
After soldering, clean thoroughly with proper solvent or resin
remover solution.

                                    May your scores be high,

                                    Don Wright
                                    Customer Service Dept.

CINEMATRONICS INC.

1466 Pioneer Way • El Cajon, California 92020
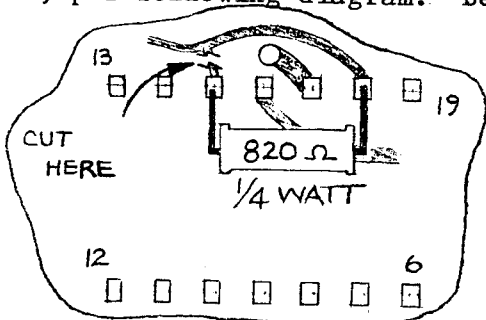
Telex—Cinemat 697891

(714) 440-2933

September 24, 1980

Attn: Distributors/Operators
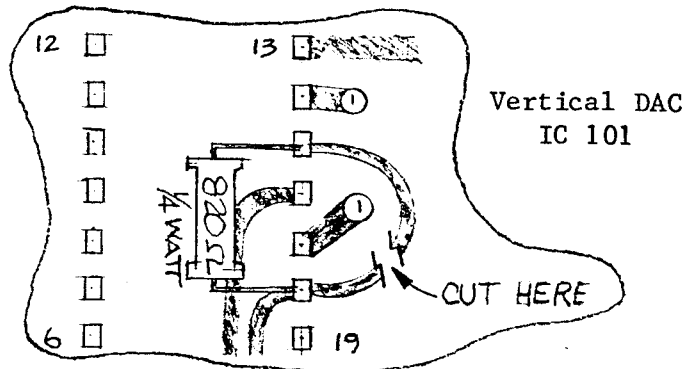Re: DAC-80 Modification

Serviceperson(s):

In order to assure prolonged reliability of IC1 (LF13331) on Cinematronics' monitors, a current limiting resistor is being added to the outputs of the horizontal and vertical DAC's. This is a recommended retrofit for all existing systems.

Add 1 each 820 ohm, ¼ watt resistor to underside of board between pins 15 and 18, per following diagram. Be sure to sever trace at the indicated location.

Horizontal DAC -- IC201

Vertical DAC
IC 101

This modification does not apply to units equipped with analog switch substitution board.

Customer Service

DW/tl

CINEMATRONICS INC.

1466 Pioneer Way • El Cajon, California 92020

Telex—Cinemat 697891

(714) 440-2933

September 24, 1980

Attn: Distributors/ Operators
Re: High Voltage Section - Regulators

Serviceperson(s):

On older Cinematronics' monitors incorporating a high voltage cage and associated components, a substitution may be made for the +18 (7818) and -18 (7918) volt regulators if unavailable.
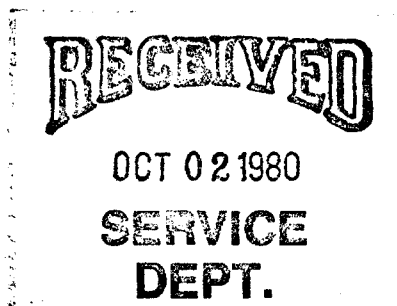
IC3, the +18 volt regulator, may be replaced by a +15 volt regulator, 7815. IC 5, the -18 volt regulator, may be replaced by a -15 volt regulator, 7915.

There will be a 20% decrease in overall output levels that does not degrade game performance. Potentiometers R102 and R209 may be adjusted to compensate for increase screen size. Verify that resistors R12 and R13 are rated at 4 watts as there will be a 20% increase in power dissipation.

Customer Service

DW/tl