The Black & White Vector Monitor FAQ and Guide
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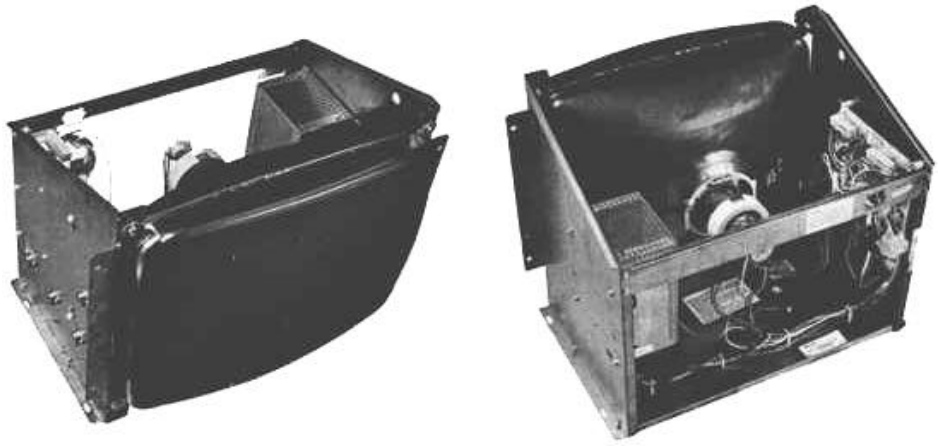

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INTRODUCTION

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 B&W vector monitors. I would strongly suggest downloading and reading through the color vector monitor FAQ and Guide as it will also enlighten you to the world of 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 vector 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.

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.

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What Is A Vector Monitor

(taken f*rom the Bally/Midway Omega Race manual*)

Welcome to the world of the X-Y monitor, an electronic device that strikes terror into the heart of many a technician. The main reason it is so intimidating is that the Vector, Quadrascan, or X-Y monitor is TOTALLY UNLIKE the Rasterscan monitor or T.V. set as you probably call it. Since many technicians are generally unfamiliar with the circuit operation, they may not be able to figure out when a symptom correlates with (points to) a particular circuit. If you are a technician, this section of the manual will certainly be a lifesaver (our modest opinion). If you don't know anything about electronics, just relax because these monitors are a lot simpler than a regular monitor or T.V. set.

Vector or X-Y monitors are used because a regular Rasterscan monitor constructs the picture in a different way. For example, your T.V. set has 525 horizontal lines on the screen from top to bottom. Each line is a slice of the picture. If you stare real close at the edge of a picture of a curved object (a large ball) or an angular object (the peak of a roof) on the screen of your T.V., you will be able to see the individual slices that the objects edge is made up of. The edge of the curved or angular objects will not appear to be completely smooth but will look like they are stepped. However, at normal viewing distance, these same curved or angular lines will appear to be smooth or straight and not stepped. To make sure that the pieces or slices of the picture stay together just like they were transmitted, T.V. sets have synchronization circuits. Vector monitors don't use ANY of this. Here, the electron beam smoothly goes anywhere it is told to paint the picture. It DOES NOT go across the screen 525 times to paint the picture in slices. Because of this shortcut, the circuitry is less complex and the detail in the figures will appear smoother. One drawback is that the brightness level is intentionally designed to be at a level high enough to burn or etch right into the picture tube face. This will be covered in more detail later in this section.

If your X-Y monitor develops a problem, you can go directly to the "SYMPTOM DIAGNOSIS' subsection where you can match up your problem to the problem described and the circuit that may be causing it. From there you go to the schematic diagrams for your particular brand of monitor and troubleshoot the circuits mentioned in the "SYMPTOM DIAGNOSIS" subsection.

If you are a technician who is unfamiliar with X-Y monitors, you may want to read the "THEORY OF OPERATION" subsection first. This section IS NOT a rigorous description of circuit operation, but a simplified general description of major circuit blocks. Some literature has been written on this subject. Electrohome's instruction and service manual on the G05-801 is an analysis on one X-Y monitor (which Midway Mfg. Co. does not use) described from an engineering standpoint. All that is necessary to understand it is a battery of U.N. interpreters. Electrohome's instruction and service manual on the G05-802 and G05-805 monitors (which Midway Mfg. Co. does use) is simpler and more condensed. The best manual we have found on the subject so far is Wells Gardner's publication on their Graphic Display Unit, model 19V2000 (which Midway Mfg. Co. also uses). Most technicians will understand it and it is very complete. The above manuals are available on request from your distributor or monitor manufacturer. [not likely]

THEORY OF OPERATION

To understand what goes on inside the monitor, large general groups of circuits will be examined instead of laboriously analyzing the branches and small circuits that make up these groups. This will help avoid confusion and aid in a basic, concrete, knowledge of what makes up a monitor.

CAUTION!!! LETHAL VOLTAGES ARE PRESENT IN THIS MONITOR, SUITABLE PRECAUTIONS SHOULD BE TAKEN BEFORE ATTEMPTING TO SERVICE YOUR MONITOR.

DEFLECTION PCB

THE POWER SUPPLY

The best way to begin explaining the innards of the X-Y monitor is at its beginning or the inputs to the monitor. Ignoring the ground or common tie points for many of the components, which represents zero voltage, there is 30 volts AC going into P100 - the input jack. The AC input is fused by F100, F101 and applied to bridge rectifier DB100. The 30 volts AC means the voltage and current alternate or jump up and down going positive and negative with zero voltage in between. DB100 and the capacitors immediately after it make up the power supply. Most of the circuits in the monitor can't use power that jumps up and down since your picture would do the same thing. DB100 chops up the waveform and capacitors C100 and C101 build up the power that DB100 chops up. The capacitors roughly filter the power and then leak it out so the power is smooth and not varying. R100 and R101 serve to limit inrush current to the filters and offer some protection to DB100 in case of a fault condition. Typical operating voltages are +/-34V. If any component fails in the circuit, the usual result is blown fuses, burning in this area, or just less power. The power supply starts the whole ball rolling, but remember that other circuits build up voltages that can be tapped for those circuits that need more than this thirty plus thirty volts AC from the game transformer.

The DC voltage to the high voltage supply is taken off before the current limiting resistors and is separately fused by F102. The EHT supply voltage is isolated from the main filter ripple component by D100. With the EHT supply functional, a normal operating voltage at P500-10 would be +40V.

THE "X" AND "Y" AMPLIFIERS

Let's go back to the input jack, P100, again. Along with the grounds and the two 30 volt AC inputs is the "X" and "Y" channel video information. The "X" input is about 10 volts AC and the "Y"

input is about 7.5 volts AC. The “X” channel information represents parts of objects from LEFT to RIGHT on the screen. The “Y” channel information represents parts of objects from TOP to BOTTOM on the screen. To get complete objects, then, you MUST have both the “X” and “Y” inputs. If this is so, then why aren’t the input voltages equal? Well, notice how a T.V. tube is shorter than it is wide? The up and down voltages (“Y” input = +/- 7.5 volts AC) don’t need as much as the side-to-side voltages (“X” input = +/- 10 volts AC).

If we divide the picture into four quadrants, the responsibilities of the "X" and "Y" amplifiers may be seen more clearly:

"-X" and "+Y" information	"+X" and "+Y" information
"-X" and "-Y" information	"+X" and "-Y" information

So let’s say your monitor only has the right side of the picture and the left side is missing. The top and bottom right of the screen has “+X”, “+Y”, and “-Y” information. The left side has “-X”, “+Y”, and “-Y” information. But since the right side is O.K., obviously the only information missing is “-X”. Therefore, there’s got to be a problem somewhere in the “X” amplifier.

From P100, the “X” or “Y” signals each go through a resistor and the linearity control of their respective channels. The Wells Gardner V2000 monitor only has one linearity control per channel while the Electrohome G05 monitor has two linearity controls per channel. These controls are supposed to be set at the factory. But sometimes they need additional adjusting. The best way to do this is to get a test pattern on the monitor screen, remove the glue holding the control adjustments in place, vary the controls until the size is right and the lines are nice and straight, and then re-glue the control adjustments so they cannot move.

After the linearity controls, the rest of the circuitry just corrects the signal for the picture tube and then amplifies it. The output power transistors (two for each channel) are heat-sinked on the bottom or the side of the monitor chassis. These feed the “X” and “Y” signals in the form of current to the yoke. The yoke then puts out two invisible electromagnetic fields or forces. These fields pull the stream of electrons that is spit out of the neck of the picture tube to the various quadrants of the monitor screen where they will write or paint a picture. Just as you may use a magnet to pull nails across a table, so does the yoke’s magnetic field pull the electron beam all over the picture tube screen to write the picture. The “X” and “Y” information we talked about earlier is what tells the electron beam WHERE to write or paint the picture. When the electron beam hits the phosphor coating on the backside of the front of the picture tube or screen, the phosphor glows in proportion to the electron beam intensity. In other words, the more electrons in the beam, the brighter the light that comes from the screen of the picture tube where it is being hit by the electron beam. This varying beam intensity is the function of the “Z” amplifier.

The amplified signal is applied to a cascade stage formed by Q605, Q606 and then applied to the basses of output transistors Q608, Q609. These transistors are operated class B in an emitter follower configuration. Current is coupled through F600 to the yoke and then to ground through the sense resistor R620. Very heavy feedback is applied from R620 to the base of Q603, to correct for any non-linearities in the amplifier. A considerable amount of power supply ripple can be tolerated because of the push-pull arrangement of the output transistors and the canceling effect of such a stage on any common ripple component. R621 serves as a critical yoke-damping resistor.

THE "Z" AMPLIFIER

From P100, the "Z" amplifier signal voltage is sent to the base of Q504 in the "Z" amplifier circuit. This circuit amplifies the AC "Z" signal and is then sent to the cathode of the picture tube. This varying "Z" signal voltage in turn varies the intensity of the electron beam producing at least eight different amounts of brightness or "eight gray scale steps" as the engineers would say.

Transistor Q504 forms a common emitter amplifier. A TTL compatible brightness signal is applied by means of P100-5. An amplified and inverted replica is present at the collector and this is applied to the CRT cathode. AC gain (contrast) is controlled by R514 and fixed resistor R513. Transistor Q503 is normally biased on very hard by means of R511, R512 and may be treated as a low value resistor that plays no significant part in active amplification of the signal.

Brightness is controlled by varying the DC potential at G1 of the CRT, by means of R517. Diode D506 and C504 isolate and hold the cathode voltage high during power down to prevent phosphor burn. At the same time as the 90 volt line is decaying, the bias for Q503 is lowered, turning the transistor off and further retarding the discharge of C504.

THE SPOT KILLER

If the "X" and "Y" signals are missing, or there is a 90 volt DC power failure - from the high voltage circuitry that feeds the "Z" amplifier, or if any other missing signal condition should occur, the "spot killer" circuitry comes on to effectively turn off the electron beam thus keeping the phosphor from being burned. At the same time, the light emitting diode turns on informing you of this.

The deflection signal is sampled for rate of change and amplitude on both channels, by means of R500, R501, C500, C501 and then rectified to form a negative holding voltage on C502, C503. This negative voltage holds Q500 and Q501 off. There is no current flow through Q502 and LED D504 is not lit! When the sampled signal falls below minimum requirement then the positive voltage applied by R506, R507 turns on Q500, Q501. This causes Q502 to conduct, allowing the LED to light up and apply sufficient positive voltage to the emitter of Q503 to cut the transistor off, thereby blanking the display.

If the "spot killer" didn't come on when any of the above conditions exists, the electron beam wouldn't be moved around and the phosphor in the center of the screen would be burned from the intense electron beam that is hitting it without moving. Transistors Q500 through Q502 and their circuitry affect the voltages on Q503 to turn the beam current off. This DOES NOT mean you have automatic protection against CRT burns from too much brightness. In fact, it would probably be a good idea to keep the brightness and contrast controls TURNED DOWN to the point where the game looks good but not too bright. If the picture is way too bright, fine spider web-like retrace lines will follow the figures wherever they move and you are headed for a burnt CRT. The brightness control affects the DC voltage between the cathode and G1 of the picture tube. The contrast control varies the amount of signal to the cathode. Both control picture intensity.

THE HIGH VOLTAGE GENERATOR - OR - EHT SUPPLY

The High Voltage circuit can be broken down into two basic subsystems, the regulator and the high voltage generator.

On the side of your monitor is a box-like cage with a wire that goes to the CRT. This is the EHT supply. It performs several functions, one of which is to supply the high voltage for the CRT.

The input to the EHT supply is at pin eight of P900 where 40 volts AC is fed through a large resistor, R900. Actually, this is a VERY important resistor because it limits, or regulates, the current to the oscillator, keeping it from taking off on its own and increasing the high voltage to the point where X-rays are emitted from the CRT, which is DEFINITELY NOT GOOD. The primary function of R900 is to limit the high voltage generated under a regulator failure condition. It also serves to limit dissipation in Q900. The high voltage supply is isolated from the main ripple component of the primary filters by D100 and C900.

The high voltage generator is a free running Hartley oscillator that operates at approximately 30KHz. Did we mention an oscillator? What's an oscillator? Well, in this case, it is made up of: transistor Q903, the primary winding of the "flyback" transformer (T900), and a few other components that toss the voltage back and forth (oscillate) 25,000 times each second. By doing this, it electromagnetically induces a bigger voltage in the "flyback" transformers secondary winding since it is bigger. This voltage is rectified (chopped up) by diode D904 to get 12,000 volts DC in Electrohome monitors and 14,500 volts DC in Wells Gardner monitors. This voltage is used to light up the CRT (picture tube). The other transistors, from Q900 to Q902 and their circuit components keep the power to the oscillator steady or regulated, as they say in engineering. There is an adjustment control, R905, to make certain the oscillator is fed the proper power. The "flyback" transformer also has an additional secondary winding, which generates more voltage to power other circuits. At pin three of P900 there is about 400 volts DC for focus voltage to the CRT. This can be adjusted with R909, the focus control. From pin five at the other side of the "flyback" transformer secondary winding, there is 90 volts DC for the "Z" amplifier circuit. In between pins three and five of P900 there are two diodes and capacitors that change the AC from the "flyback" secondary winding to DC just like the power supply. In fact, that's just what it is, a "mini power

supply'. All of the secondary diodes are fast recovery to operate at the 30KHz oscillator frequency. Using normal diodes are a definite way to fry your flyback!

THE CRT - (PICTURE TUBE)

The CRT has already been described indirectly. However, to make a picture or turn the CRT on, certain voltages are needed. Otherwise it won't work. These are: about 6 volts AC (note that's AC) is needed for the heater filament in the tube neck to light up; the electron beams intensity must be controlled by the "Z" amplifiers signal which is applied to the CRT's cathode; there must be voltage at G1 of the CRT for brightness; there should be about 400 volts DC at G2; there should be focus voltage which varies but can go as high as 400 volts DC; and there should be high voltage at the anode of the CRT which runs into the thousands of volts (this voltage can jump almost one inch through the air - so **BE CAREFUL!!)**

WARNING: That picture tube is a bomb! When it breaks, first it implodes, then it explodes. Large pieces of glass have been known to fly in excess of 20 feet in all directions. DO NOT carry it by the long, thin neck. Discharge its voltage to ground by shorting the anode hole to ground.

Discharging a CRT

Do not forget to discharge the CRT - even if you are just going to be unplugging the socket from the neck of the CRT (i.e., to gain access to another part). A tube that has some air in it can deliver a nasty shock back out of the neck pins.

You should NEVER short the anode of the tube DIRECTLY to common ground. ALWAYS use a resistance of 1 Meg ohm between the anode (underneath the suction cup) and common ground. A direct short without the resistor(s) will cause the HV Rectifier Diode (D903/D904) to fail. Ten 100K-Ohm ½watt resistors in series is the best method. You could use a single 1 Meg ohm, 3W resistor, but the problem is flash over failure. Using a single resistor that is dropping 20KV instead of 10 resistors that are dropping 2KV each increases the likelihood that the single resistor will short out and provide no protection for the HV Rectifier Diode. Make sure the resistors are sheathed in some heat shrink tubing for protection.

I would strongly recommend using a High Voltage Probe to discharge the monitor. This is the safest method, as the probe is designed to withstand extremely high voltages (hence the name, right?).

Lacking an HV probe, you can use this tried and true method, be it a little more dangerous. Use a plastic handled screwdriver; connect one end of a wire with an alligator clip at each end to chassis ground and the other end to the metal shaft of the screwdriver. Be certain you have the ten 100K-Ohm ½watt resistors in your connection at the HV end of the shorting wire. Using ONE HAND ONLY (put the other in your pocket) and touching ONLY the plastic handle of the screwdriver (DO NOT TOUCH THE METAL SHAFT) stick the blade of the screwdriver into the anode hole. Be prepared for a fairly loud pop and a flash. The longer the monitor has been turned off, the

smaller the pop and dimmer the flash. But BE CAREFUL, picture tubes will hold a very healthy charge for at least a week if not longer. Even after you've discharged it once, it may still carry a residual charge. It's better to be too careful than dead, which is why electronic equipment always carries stickers referring servicing to qualified personnel. Handle the side with the viewing screen against your chest when changing it. ALWAYS wear safety goggles when handling the picture tube.

MONITOR TYPES

G05-801 vs. G05-802 vs. G05-805 vs. 19V2000 vs. 15V2000 vs. LAI vs. HOEI vs. Hantarex

The terms vector, vectorbeam, quadrascan and X-Y get tossed around quite liberally. There are a number of different vector monitors – both color and black & white. While some are compatible, many are not and can have disastrous results if the wrong monitors are substituted. Note that while the Cinematronics/Vectorbeam vector monitors are monochromatic (i.e., black & white) they cannot be substituted for any other type of monitor.

The Electrohome G05-801 is the 19" B&W vector monitor that originally came with Atari's Lunar Lander and early versions of Asteroids. The G05-801 monitor has two PCBs with large black heatsinks on the right side of the chassis. The G05-801 monitor expects an input voltage of either 56VAC or 74VAC. The G05-802 is the second revision of the monitor and is much more common. The G05-802 expects a 60VAC input. A third version of the black and white vector monitor, the V2000, was made by Wells-Gardner and is plug compatible with the Electrohome G05-802. In fact, a vast majority of the G05's and V2000's are bastardized monitors with parts from each tossed in, so it is really hard to tell what version of the monitor you might have. A G05-801 is not plug compatible with a G05-802 or V2000 monitor. The G05-801 has two plugs (power and signal) while the 802 and V2000 has just one molex plug connector.

The G05-805 is a 15" version of the G05 vector monitor. Aside from a physically smaller picture tube, the monitor is effectively identical to its larger brother – the G05-802. There is also a 15" version of the V2000. It is called the 15V2000 and, along with the Electrohome G05-805, were primarily used in cocktail and cabaret vector games.

Many distributors in Australia, in an attempt to reduce the initial shipping cost games, sourced vector monitors locally. That company, Leisure & Allied Industries, made a unique black & white vector monitor design, producing both 14" and 20" monitors. The LAI monitors are NOT plug compatible with any Electrohome or Wells-Gardner vector monitors. I have precious little information on the LAI vector monitors and this document will not focus on them for that reason.

HOEI vector monitors were used in Alca's bootleg of asteroids (called 'Planet') as well as other bootlegs of Star Castle and Asteroids. [note: the bootleg Star Castle games had the DACs on the game boards so they could use a 'standard' B&W vector monitor instead of the specialized Cinematronics monitor.]

All the Atari Italian-built vector games - Battlezone and Asteroids, used a vector monitor produced by Hantarex. The Italian-built Elettronolo Star Castle bootleg (Stellar Castle) also used a Hantarex vector monitor.

There were some (factory?) conversion kits for Atari's Football that had you swap the yoke, HV and deflection boards, and play Asteroids on a 25" tube. Does anyone have any further information on this?

Game	**Monitors Used**
Lunar Lander Upright	G05-801
Asteroids Upright (up to serial 18,900)	G05-801
Asteroids Upright (serial #s above 18,900)	G05-802
Asteroids Cocktail	G05-805
Asteroids Deluxe Upright	G05-802 and 19V2000
Asteroids Deluxe Cocktail & Cabaret	G05-805 and 15V2000
Red Baron Upright and Cockpit	G05-802 and 19V2000
Battlezone Upright	G05-802 and 19V2000
Battlezone Cabaret and Cocktail	G05-805 and 15V2000
Omega Race Upright and Cockpit	G05-802 and 19V2000
Omega Race Cabaret	G05-805 and 15V2000
Various games in Australia	LAI-KZ series
Star Castle Bootlegs ((UK and Canada)	HOEI
Asteroids Bootlegs (mostly UK)	HOEI
Italian-built Asteroids & Battlezone	Hantarex

Using a Color vector monitor in place of a B&W vector monitor

If you have an extra Wells-Gardner 6100 color vector monitor (and who doesn't), you can use it as a substitute for a G05-802 or 19V2000. However, you will need to make a harness adapter that converts the 12-pin molex attached to the cabinet harness into a 15-pin molex plug that the Wells-Gardner 6100 expects.

The following information is taken from the Wells-Gardener 19K6100 manual:

"This (color) display differs very little from that used in Atari's black-and-white X-Y video games, such as Asteroids, Battlezone, or Red Barron. The only major difference is that it now has three Z amplifiers to control the three color guns. If you service this color display on a test bench, use only the power supply assembly for Color X-Y Games. You cannot use standard line voltage or a power supply from a black-and-white X-Y game such as Asteroids, since the voltages produced by those sources will damage the Wells-Gardener color X-Y display".

The good news is the color power supply will plug right in place of the B&W one and it's beefier.

The x-gain and y-gain will have to be adjusted a little on the B&W board to make the picture the right size. Connect the Z out from the game to only the Green and Blue inputs of the color monitor if it is behind smoked Plexiglas for a realistic "monochrome" look."

In fact, this is exactly what Atari did with their PAT 9000 test fixture to allow both monochrome and color vector games to be tested on one color monitor.

Manual differences

There are several different manuals for the Electrohome G05, and an additional manual for the Wells-Gardner V2000 series. The following list outlines the manuals:

- G05-801 Preliminary manual (TM-146)
- G05-801 (54-7279-01 Issue 1 August 1979) (TM-146)
- G05-801 (54-7279-01 Issue 2 October 1979) (TM-146)
- G05-801 (54-7279-01 Issue 3 January 1980) (TM-146)
- G05-802/805 (54-7291-01 Issue 1 April 1980) (TM-151)
- G05-802/805 (54-7291-01 Issue 2 September 1980) (TM-151)
- G05-802/805 (54-7291-01 Issue 3 May 1982) (TM-151)
- 19V2000/15V2000 (TM-164)

The following changes were made to the G05-801 manuals. I can find no evidence of any component or layout changes to any portion of the G05-801 monitor.

> Issue 2 - October 1979 changes the Atari Coin-Op Customer Service address on the back of the manual to Bordeaux Drive.
>
> Issue 3 - January 1980 adds an additional safety check on page 4:
> If service is performed on the EHT Module, the EHT overvoltage protective circuit MUST BE VERIFIED AS OPERATING AT 21 KV MAXIMUM.

The Electrohome G05-802 manuals differentiate themselves with different Issue numbers. However, these issue numbers are completely different than, and inconsistent with the Issue numbers of the deflection boards. The G05 deflection board differences are outlined later in this document.

The G05-802/805 Issue 1 and Issue 2 manuals have the following differences:

> <u>Deflection</u>
> Pin assignments of P100 are different between the Issue 4 and Issue 5 Deflection boards
> Issue 1 manual shows an Issue 4 deflection board
> Issue 2 manual shows an Issue 5 deflection board

Issue 2 manual has a revised deflection board parts list noting the following:

- C602 and C603 removed (although these parts are still on the PCB layout)
- C702 and C703 removed (although these parts are still on the PCB layout)
- R100 and R101 removed (although these parts are still on the PCB layout)
- R604 is changed to 910R (910-Ohms)
- R704 is changed to 820R (820-Ohms)
- D604 and D605 changed to 1N100
- D704 and D705 changed to 1N100
- R604 and R704 changed to 750R (on the G05-805 ONLY)

High Voltage

Issue 2 manual has a revised HV board parts list noting the following:

- C906 changed to 0.22 uF 50V (this value is not changed on the schematic)

The G05-802/805 Issue 3 manual is identical to the Issue 2 manual, with the exception of additional Electrohome addresses on the back cover.

HIGH VOLTAGE BOARD

It is reported that the weakest part of these monitors is the EHT or High Voltage Unit. This may be because the secondary windings tend to open up or arc due to poor mechanical connections.

The first condition will cause no picture WITH high voltage depending on which secondary opens. The second condition will cause "blooming" – a faded enlarged picture.

G05-801 EHT Supply Issue - 5 Part Number: 50-1410-01	**G05-802/805** EHT Supply Issue - 3 Part Number: 50-1421-01

There is no known substitute or replacement for the G05 High Voltage Transformer. If yours is bad, you will have to find another used HV cage.

Many problems associated with the High Voltage board arise from the HV Rectifier Diode (listed as either D903 or D904). This diode sits in the path of the red anode wire that leads from the HV cage to the suction cup on the picture tube. Often, these diodes fail, and are rather difficult to replace, as the packaging is a bit unusual. The original diodes fit in like a socket into a cap on each end of the anode wire. The HV diode can be replaced with either an SK7333 Silicone Stick Rectifier or an ECG/NTE 527A. The SK7333 is in a different physical package than the original HV diode (squarish instead of cylindrical). Therefore, you will have to solder the new silicon rectifier directly to the wires. You will need some sort of high-voltage insulation -- something that has a dielectric strength that can handle the 10k+ volts. Normal electrical tape can handle around 300v, and the HV will burn through it.

The voltage doubler used on the G05-801 is different than the HV diode used on later G05-802 versions of the HV board. There is no known replacement for this part.

A failing HV diode will cause 'blooming' of your picture. Arcing within the high voltage rectifier connectors causes this condition. To cure this problem, follow this procedure:

1. Switch off AC power and remove the monitor from the game.
2. Remove H.V. cover secured by two screws.
3. Unplug the H.V. rectifier from its holders and inspect the holders to insure that the springs are inside the holder.
4. Replace the bad rectifier with a new rectifier. The leads of the rectifier must be cut and formed in the same manner as the original.
5. Insert the rectifier firmly in its holders, banded side toward CRT.
6. Inspect the lead dress of the transformer H.V. wire. Wire must be dressed.
7. Inspect fuse F102 on main deflection PC board. The fuse value should be 1.5 amp.
8. Replace the H.V. cover, which was removed in step No. 2.

A really good way to remove and replace the HV diode is to use a hair dryer to soften up the housing, then remove the old one and put in the new one. The replacements are a little longer but work well and will fit.

Freeze spray, or component cooler can be useful in finding problems that get worse over time. The HV diode often shows this (the blooming gets worse as it warms up), so the cooler can narrow it down very quickly.

DEFLECTION BOARDS

When working on your deflection board, it is very important to remove the input signal from the game board BEFORE removing power to the monitor. Failure to follow these instructions will result in severe phosphor burn to the picture tube, which cannot be repaired.

In order to properly identify which G05/V2000 Deflection board you have, we first need to determine if yours has been modified to work with a 19" or 15" monitor tube. The only changes made during manufacture of the G05 were two resistors located near the big filter capacitor C101. The differences are:

G05-802 (19") "Issue 4"	G05-802 (19") "Issue 5"
R604 is 1K-Ohm 1/4W resistor R704 is 910-Ohm 1/4W resistor	R604 is 910-Ohm 1/4W resistor R704 is 820-Ohm 1/4W resistor

G05-805 (15") "Issue 4"	G05-805 (15") "Issue 5"
R604 is 910-Ohm 1/4W resistor R704 is 820-Ohm 1/4W resistor	R604 is 750-Ohm 1/4W resistor R704 is 750-Ohm 1/4W resistor

The V2000 deflection boards seem to be identical between the 19" and the 15" varieties. Assuming you have identified your deflection board, we now need to determine which revision it is. There are actually five revisions of the Electrohome G05 deflection board:

"Issue 3" Deflection Board: This is the G05-801. The 801 deflection board can be identified by two big blue capacitors 4-5 inches tall on a power supply board that is completely separate from the deflection board. The deflection board also looks completely different than the G05-802/805. The G05-801 deflection board is not interchangeable with later revisions. Atari did, however, make an adapter harness that would allow the use of a G05-802 monitor in place of a G05-801 (Atari Part Number: AO36240-01).

Unlike all other revisions of this monitor, the G05-801 requires either 56VAC or 74VAC CT.

"Issue 2" Deflections Board: The original G05 design was revised, and the "Issue 2" deflection board was the result. It is presumed that Atari (through their subcontractor Electrohome) redesigned the G05 monitor in order to fit into the Asteroids cocktail cabinet. The 15" chassis would have had a hard time accommodating the three separate boards from the G05-801 design. Atari most likely decided that the design was simpler and more cost effective so they rebuilt the 19" chassis using the same basic parts.

[differences??]

"Issue 4" Deflection Board: Issue 4 deflection boards seem to be almost identical to the later revisions. On Issue 4 deflection boards, pins 4 and 5 are electrically connected, but the wire that connects to pin 4 is purple, and it runs to the CRT neck socket where it terminates since there is no CRT pin that makes a connection to it. This deflection board looks like a "normal" one, but has a unique pinout of P100. Pins 4 and 5 are shorted to ground and the connector is keyed differently. Pin 5 is the key pin.

ISSUE 4 DEFLECTION PCB PINOUTS (P100)	
PIN	**DESCRIPTION**
1	X input +/-10V 1K impedance
2	X signal GND
3	Y input +/-7.5V 1K impedance
4	Y signal GND
5	Z input .5V blanking 1.0V blacklevel 4.0V full on 220-ohm impedance
6	Z signal GND
7	30 VAC RMS
8	Power GND (center tap)
9	Power GND (center tap)
10	30 VAC RMS
11	6.3V AC heater input
12	Heater GND

If you want to upgrade your "Issue 4" board to an "Issue 5" (for use in an Issue 5 harness), it is actually very simple.

1. Remove the keying plug (pin 5) from the P500 molex.
2. Move the wire from Pin 4 to pin 5.
3. Cut the trace leading to pins 4 and 5 on P500 (GND in Issue 4).
4. Solder a jumper from pin 2 to pins 4 and 5 on P500.

If pins 4 and 5 of P500 are left connected to GND, it will ground Grid #3 in the CRT and will reduce the brightness of the trace to the point where it is almost impossible to see.

"Issue 5" Deflection Board: This deflection board is probably the most common G05 deflection board. You will find that Electrohome used several different colors of solder mask on the bottom of these PCBs. I have seen tan, green and orange. The foil diagram for Issue 5 deflection boards more or less matches the actual layout for Issue 4 deflection boards, except for pins 4 and 5 of connector P500.

Issue 5 Deflection boards have additional small jumpers that can be used to replace R101 and R100. These jumpers are labeled W10 and W11 (for R101); W8 and W9 (for R100). Additionally, C602; C603; C702; and C703 are not populated.

ISSUE 5 DEFLECTION PCB PINOUTS (P100)	
PIN	**DESCRIPTION**
1	Z input .5V blanking 1.0V blacklevel 4.0V full on 220-ohm impedance
2	Y input +/-7.5V 1K impedance
3	X input +/-10V 1K impedance
4	Power GND (center tap)
5	Y signal GND
6	X signal GND
7	30 VAC RMS
8	Z signal GND
9	6.3V AC heater input
10	30 VAC RMS
11	Power GND (center tap)
12	Heater GND

"Issue 6" Deflection Board:

Issue 6 Deflection boards are almost identical to Issue 5 boards and they also have the additional small jumpers that are used to replace R100 and R101. These jumpers are labeled W10 and W11 (for R101); W8 and W9 (for R100).

[other differences?]

Wells-Gardner V2000 Deflection Board

The V2000 deflection boards are white, are marked P299 at the "top" of each board between the locations of R101 and R100 and have the contrast knob inset on the board (which is a poor design since the contrast control is so crucial when getting the bright vectors).

There are at least two revisions of the V2000 deflection board - 85X0138 and 85X0138E. The 'E' suffix seems to denote the later revision. Each deflection board is labeled on the solder mask on the reverse. On the earlier 85X0138 deflection PCB, D502 has been factory modified to include a 100-Ohm 1/2W 10% resistor that has been pigtailed to the cathode end of D502. In the later board revisions, D502 and D503 have been relocated and this modification has been eliminated through a different board layout.

The Resistors!

If you look at many G05 and V2000 deflection boards, you will notice that some do not have any resistors installed at R100 and R101, and some do. Both applications will work. Atari Field Service issued an upgrade that instructed operators to remove the 3.9 ohm 15 watt wirewound resistors at

R101 and R100 and (on early revisions of the board) jumper the pads with a length of heavy-gauge wire. Later revisions of the deflection board (Issue 5 and Issue 6) eliminated the resistors all together and had jumpers installed - labeled W10 and W11 (for R101); W8 and W9 (for R100) to provide a current path. Resistors R100 and R101 were eliminated from the schematics, although the PCB layout diagrams in the manuals show both the resistors and the jumpers.

The Wells-Gardner V2000 has two large resistors in the power supply, R100 and R101. R101 just loves to smoke and burn up. WHY? Check the 30-volt lines from the game. If one is open, there will be a NORMAL picture and ONE VERY HOT resistor.

Another symptom that can cause R101 to start smoking is when the Game Board of the game has an "X" or "Y" signal riding on an excessively high DC level.

Then again, any one of the conditions mentioned previously pertaining to problems in the “X” or “Y” amplifiers can cause R101 to burn up. Depending on the problem, it may bum fast or it may bum slow. Jumping these resistors may stop them from burning up but it WILL NOT solve the problem.

Neon Lamps NE501; NE502; NE503

The way these neon lamps work is that they do nothing until about 90v is place across them. At this point, the neon gas breaks down and an "arc" is formed, which causes the gas to glow orange.

The thing about these lights, that makes them useful in monitors, is that below 90v they act like an open circuit. Above 90v, when arcing occurs, they act more like a short circuit. In fact, in order to use them on the 110v power line, you must place a resistor (usually around 1 meg) in series with the neon bulb, to limit the current, or it will try to act like a wire across the A.C. line and explode.

So they are good at clamping circuits to a maximum of 90v volts. If there is any kind of HV bleeding and the point in the circuit, where the neon bulb is placed, reaches 90v, the bulb will light and quickly clamp the voltage back down to below 90v.

Spot Killer

The Spot Killer does not seem to cause much trouble with the exception of the LED, D504. It cannot be checked by the usual ohmmeter method because it reads infinite resistance both ways.

If your dipswitch test pattern does not want to come in, or your brightness just doesn’t seem bright enough, and EVERYTHING EVERYWHERE else checks good, pull out D504. Chances are you will have plenty of brightness.

Poor brightness with retrace lines could mean a defective D504, or perhaps the “Z” signal wire is not connected properly to the base of Q504.

"X" and "Y" Amplifiers

If the top, bottom or sides of the display flutter and try to move toward the center, again, check the power supply. More often, though, this situation is due to a bad transistor in the "X" Amplifier (sides) or the "Y" Amplifier (top and bottom). Sometimes these circuits will check good with an ohmmeter.

So, if a team of engineers with sophisticated test equipment are not available, this is our suggestion: change Q707 and Q706 for the "X" Amplifier - or - Q607 and Q606 for the "Y" Amplifier. Q605 and Q705 are also suspicious characters. If the above doesn't work, try them next.

When changing Q706, Q707, Q606 and Q607, ALWAYS make sure you have each one in its proper place with the correct lead placement. If you do not, you may as well break out the hot dogs because you WILL have a barbecued Deflection P.C. Board.

If you should happen to barbecue a Deflection Board, CHECK ALL SEMICONDUCTORS in that particular amplifier. Also check all resistors from R721 at least as far back as R705 ("X" amplifier circuit) or R621 back as far as R605 ("Y" amplifier circuit). Otherwise, you may live to regret not having done it.

Remember this. If at first you do not get a picture and the LED on the monitor (D504) stays lit, every time you go back to determine what else has failed in this amplifier circuit, ALWAYS check the out-put transistors Q608, Q609, Q708 and Q709 because you can destroy them as fast as you replace them.

Semiconductors

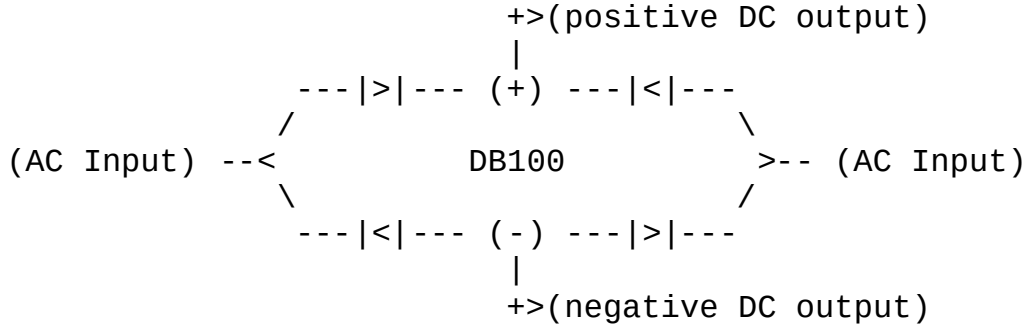
A defective semiconductor that checks good on the ohmmeter may also drag down the power supply voltage. Check the collectors of the output transistors. If two voltages are high and the other two are low, it could be a defective transistor at Q602, Q603, Q702 or Q703.

Power Supply

Trouble with C100 or C101 will cause the lines to brightly streak around, possibly coming from a spot in the center. If a proper picture is present on the monitor but moves around and blooms, it could be a partially open C100 or C101. The other circuits are starving for voltage and not totally doing their jobs.

One part that often fails is the bridge rectifier at location DB100. It is a black square with four posts sticking out of the bottom and it has 4 diodes in it. Using an ohmmeter for testing, each diode should conduct (about 0.65 volts drop, not a dead short type of conduction) in one direction and not at all in the other. You have to figure out polarities first to know where the diodes are. If the bridge rectifier has ~(or AC), +, & - markings that would be helpful. The two AC terminals should work

their way back to the power cord. The - and + terminals head towards the guts of the deflection board. Each of the two AC terminals will have a diode to the + terminal and the - terminal. There is no direct connection between the two AC terminals. There is no direct connection between the two + and - terminals.



Transistors

Transistors that CHECK GOOD with a meter but are NOT GOOD in the circuit is a condition that is generally rare elsewhere. But maybe not so rare in the "X-Y" monitor. This is mentioned because we know it is a problem encountered frequently with the "X-Y" monitor and we want to bring it to your attention.

Voltages

For any of you who would like to try a little voltage measuring to analyze the problem, the following list contains EVERY Electrohome and Wells-Gardner "X-Y" monitor transistor voltage. These voltages were measured on correctly functioning monitors with a hand-held portable digital multimeter. So, these readings are accurate (but not laboratory accurate) and will be closer to your actual expected voltage measurement results.

For a test display, the Omega Race diamond shaped test pattern is used so that the voltage readings will stay stable and not jump around as they would with a moving game picture. Of course, you cannot see a picture with a defective monitor, so connect a DC voltmeter to the "X" channel on the Game Board output. When you have the correct diamond shaped test pattern, you should be reading a steady - 2.32 volts on your meter.

[continued on next page]

All Readings are DC Level Voltages

"X" INPUT DC LEVEL FOR DIAMOND TEST PATTERN = -2.32 VOLTS DC
"Y" INPUT DC LEVEL FOR DIAMOND TEST PATTERN = -0.08 VOLTS DC

B = BASE E= EMITTER C = COLLECTOR

ELECTROHOME G05 MONITOR

Q601	B	-0.3	Q701	B	-1.4	Q500	B	-1.3
	C	-0.6		C	-1.9		C	0.0
	E	+0.5		E	+0.5		E	+38.7
Q602	B	0.0	Q702	B	-0.6	Q501	B	-0.7
	C	-0.6		C	-1.2		C	0.0
	E	+38.8		E	+39.0		E	+38.7
Q603	B	-0.6	Q703	B	-0.6	Q502	B	+38.8
	C	0.0		C	-1.2		C	+39.8
	E	+38.6		E	+38.8		E	+1.4
Q604	B	-39.3	Q704	B	-39.3	Q503	B	+2.1
	C	-39.9		C	-39.9		C	+1.4
	E	-27.4		E	-27.1		E	+1.4
Q605	B	+38.8	Q705	B	+39.0	Q504	B	+2.3
	C	+39.5		C	+39.7		C	+1.8
	E	+36.0		E	+36.2		E	+75.3
Q606	B	+35.4	Q706	B	+34.1	Q900	B	+23
	C	+36.0		C	+36.2		C	+22.1
	E	+0.2		E	-1.0		E	+32.1
Q607	B	-39.4	Q707	B	-39.4	Q901	B	+23.6
	C	-40.0		C	-40.0		C	+22.9
	E	-0.4		E	-1.7		E	+31.8
Q608	B	+0.2	Q708	B	-1.0	Q902	B	+9.2
	C	-0.1		C	-1.3		C	+8.7
	E	+41.1		E	+41.0		E	+24.1
Q609	B	-0.5	Q709	B	-1.7	Q903	B	-3.4
	C	-0.1		C	-1.3		C	0.0
	E	-41.2		E	-41.1		E	+22.4

WELLS-GARDNER V2000 MONITOR

Q602	B	-0.1	Q702	B	-0.8	Q500	B	-3.5
	C	+0.7		C	-1.4		C	0.0
	E	+32.2		E	-28.9		E	+34.6
Q603	B	-0.1	Q703	B	-0.8	Q501	B	-2.6
	C	-0.7		C	-1.4		C	0.0
	E	+32.4		E	+32.4		E	+34.6
Q604	B	-29.5	Q704	B	-29.7	Q502	B	+34.5
	C	-30.2		C	-30.4		C	+1.6
	E	-29.6		E	-28.9		E	+33.2
Q605	B	+32.3	Q705	B	+32.5	Q503	B	+0.7
	C	+32.9		C	+33.2		C	-0.2
	E	+30.5		E	+30.5		E	+0.1
Q606	B	+30	Q706	B	+30.0	Q504	B	+2.3
	C	+30.6		C	-30.4		C	+1.7
	E	+0.2		E	-1.3		E	+77.0
Q607	B	-0.5	Q707	B	-30.4	Q900	B	+16.0
	C	-30.4		C	-29.7		C	+15.3
	E	-29.7		E	-2.1		E	+24.2
Q608	B	+0.2	Q708	B	-1.3	Q901	B	+16.6
	C	-0.1		C	-1.7		C	+16.0
	E	+34.6		E	+34.7		E	+24.0
Q609	B	-0.5	Q709	B	-2.1	Q902	B	+9.7
	C	-0.1		C	-1.7		C	+9.2
	E	-31.5		E	-31.7		E	+16.6
						Q903	B	-3.8
							C	0.0
							E	+15.0

TUBE AND YOKE

Replacement monitor tubes are currently available for the Electrohome G05-802 and Wells Gardner 19V2000, and can be purchased directly from Richardson Electronics, LTD. Visit their web page here: http://www.rell.com

If you ask for a 19VARP4 tube (19" B&W vector), they will send you a Phillips M47EAA7WS bare tube. You will not receive the yoke or adjustment rings, so save all that you have.

G05-805 and 15V2000 15" replacement tubes are available from Richardson Electronics. The original tube is a 15ST4730R, and the Richardson part number is: 15A DATA CRT.

CRT (Neck) Pinout

Here is the complete pinout of both the Electrohome and Wells-Gardner 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+

Inversion for Battlezone, Asteroids Deluxe or Omega Race

Normally, video inversion for games that use mirrors takes place on the game board and not the monitor. Often a pin on the edge connector is grounded, or harness wire is reversed.

Battlezone
The Battlezone game boards normally outputs 'inverted' video. Connect P20-L to P20-P for noninverted video output.

Battlezone P20
Pin K - Y Invert
Pin L - X Invert
Pin P - GND

Asteroids Deluxe

For video inversion on an Asteroids Deluxe upright, Pin 19 on the game board is grounded. For Asteroids Deluxe cocktails, both X-and Y-video inverts are used, so both pins 7 and 19 are grounded. For noninverted video output, pin 19 is unconnected and floats.

Asteroids Deluxe P20
Pin 7 – Y Invert
Pin 19 – X Invert

Omega Race

The Omega Race upright is the only cabinet for that game which uses inverted video. This is handled with the harness that connects from the game board to the monitor. Essentially the "X" output signal and "X" GND are reversed for inverted video. Below is a summary taken from the schematics:

Omega Race Connector to Monitor	
Upright	**Cockpit/Mini/Cocktail**
Pin 1 - Z out	Pin 1 – Z out
Pin 2 - Y out	Pin 2 – Y out
Pin 3 - X GND	Pin 3 – X out
Pin 4 - Z GND	Pin 4 – Z GND
Pin 5 - Y GND	Pin 5 – Y GND
Pin 6 - X out	Pin 6 – X GND

Connector J7 on Game Board	
Upright	**Cockpit/Mini/Cocktail**
Pin 7 – Key	Pin 7 – Key
Pin 8 – Y out (ORN)	Pin 8 – Y out (ORN)
Pin 9 – X GND (Y-W)	Pin 9 – X out (RED)
Pin 10	Pin 10
Pin 11 – Z out (GRN)	Pin 11 – Z out (GRN)
Pin 12	Pin 12
Pin 13	Pin 13
Pin 14	Pin 14
Pin 15 – Z GND (WHT)	Pin 15 – Z GND (WHT)
Pin 16 – X out (RED)	Pin 16 – X GND (WHT)
Pin 17 – Y GND (BRN)	Pin 17 – Y GND (BRN)

You can also invert the video on the monitor itself, although this method leaves you with a monitor that must be altered to run in a non-inverted application (such as Asteroids, cabarets, etc.). You need to reverse the wires leading to the yoke. Care must be taken not to reverse the wrong wires. If you do reverse the wrong wires, you will fry your defection board. You can switch the two "X's" with each other (i.e., black and yellow) or the two "Y's" with each other. But you cannot switch an "X" with a "Y". Typically, you would only need to switch pins 1 and 2 for the "X" axis.

P700 on the Deflection Board
Pin 1 - "X" BLK
Pin 2 - "X" YLO
Pin 3 - "Y" BLU
Pin 4 - Key
Pin 5 - "Y" RED

ADJUSTMENTS

Brightness and Contrast

These controls are preset at the factory, but may be adjusted to audit program material. Caution must be exercised when adjusting the brightness control. This control has more than 100% brightness range on most tubes. This control should be maintained below the point where a center spot appears on the CRT under a no input signal condition. Adjusting the control above this point may result in a phosphor burn.

The brightness and contrast controls for the G05-801 are located on the right hand edge of the deflection amplifier PCB. R516 is the brightness control and R526 is the contrast control. Both are finger adjustment controls. The G05-802/805 has four adjustment pots instead of two, with vertical adjustment at R600 and R602. With a Wells-Gardner V2000, the vertical adjustment is at R600.

To adjust the brightness and contrast on your monitor, turn brightness and contrast all the way down (counterclockwise). Then increase brightness until the images are barely visible. Adjust contrast for proper illumination.

High Voltage Adjustment

Located in the EHT supply module. Hole in screen cover provides access to this control. Caution - use insulated tool to adjust.

Focus Control Adjustment

Located in the EHT supply module. Hole in supply heat sink/wrap provides access to this control.

Centering

Most of Atari's vector games have X and Y centering pots located on the game board to adjust any off-center images. However, most B&W vector boards do not have this feature. If you have a Battlezone or Red Baron board, however, you are in luck.

It looks like Atari did plan to include X and Y centering pots during the engineering stage; why they left these out, I don't know. But it appears easy enough to add.

X channel:	Y channel:
The pot at R101 (XCENTER) should be 50 k. Add a 0.1 uF capacitor at C102. Add a 220k resistor at R100.	The pot at R91 (YCENTER) should be 50 k. Add a 0.1 uF capacitor at C101. Add a 220k resistor at R90.

What you are essentially doing is adding a DC component to the output signal. The pot's leads are connected to +15v and -15v, with the wiper in the middle mixing in the voltage-divided signal with the video signal at the final op-amp output.

Supposedly there is a centering magnet in the Battlezone monitor, but I have been unable to find it. It is mentioned in the manual, but there is no diagram of which one it is.

Why did Atari (and most everyone else) leave off centering electronics in B&W X/Y monitors?

On a color monitor the yoke ring magnets are designed to mostly affect only it's associated gun (Red, Green or Blue). As you move these magnets around they push and pull on the electrons coming from the guns, and by carefully adjusting them you can get all three guns point to the same spot (well in theory ;^), wherever that spot might happen to be. Walla! A nice white spot. After which you adjust the color monitor's centering pots, which move all three guns at once, to bring that white spot back to the center of the screen.

On a B&W screen there is only one gun. And since it does not need to be aligned with any other guns, you can just use magnets to push it around. So instead of color alignment, the magnetic yoke rings on the back of a B&W monitor are there to push and pull on the CRT trace until it is centered. What if the electronics are off a bit? Who cares, just push the trace back where it belongs with a magnet.

Why no electronics? A cheap-o magnetic yoke ring is much less expensive than centering electronics. This is also why it is easy to use just about any B&W tube in X/Y games. There are no

color alignment problems, so the yoke windings are not nearly as critical as they are in color X/Y monitors.

Yoke

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.

Sometimes after 20+ years, the picture will be 'slanted', if the coils have become rotated. This is a relatively simple adjustment, just loosen the deflection yoke and turn the coils.

If further yoke adjustment is necessary, follow the instructions given in the appropriate monitor manual.

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, jail bars, 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 a couple of sources for Cap Kits, which are listed below. Alternatively, you can make one yourself.

Zanen Electronics
5023 52nd Street
Lubbock TX 79414
806-793-6337
Fax: 806-793-9136
Zanen Kit #104

Bob Roberts also sells cap kits. Bob provides a kit for the G05-802/805 Vector Monitor, and can most likely help you with the G05-801 as well.

bob147@bellsouth.net
http://www.therealbobroberts.com

Key:

- Q = Transistor
- R = Resistor
- C = Capacitor (all polarized electrolytic)
- F = Fuse
- D = Diode
- ZD = Zener Diode

DISCHARGE THE CRT

Before you begin on your Cap Kit, you must first discharge the picture tube.

You should NEVER short the anode of the tube DIRECTLY to common ground. ALWAYS use a resistance of 1 Meg ohm between the anode (underneath the suction cup) and common ground. A direct short without the resistor(s) will cause the HV Rectifier Diode (D903/D904) to fail. Ten 100K-Ohm ½watt resistors in series is the best method. You could use a single 1 Meg ohm, 3W resistor, but the problem is flash over failure. Using a single resistor that is dropping 20KV instead of 10 resistors that are dropping 2KV each increases the likelihood that the single resistor will short out and provide no protection for the HV Rectifier Diode. Make sure the resistors are sheathed in some heat shrink tubing for protection.

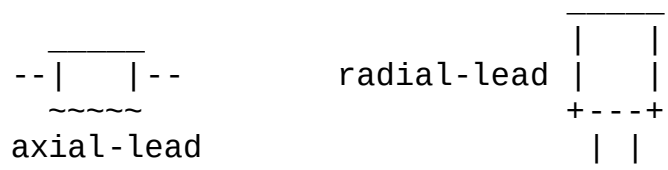
I would strongly recommend using a High Voltage Probe to discharge the monitor. This is the safest method, as the probe is designed to withstand extremely high voltages (hence the name, right?).

Lacking an HV probe, you can use this tried and true method, be it a little more dangerous. Use a plastic handled screwdriver; connect one end of a wire with an alligator clip at each end to chassis ground and the other end to the metal shaft of the screwdriver. Be certain you have the ten 100K-Ohm ½watt resistors in your connection at the HV end of the shorting wire. Using ONE HAND ONLY (put the other in your pocket) and touching ONLY the plastic handle of the screwdriver (DO NOT TOUCH THE METAL SHAFT) stick the blade of the screwdriver into the anode hole. Be prepared for a fairly loud pop and a flash. The longer the monitor has been turned off, the smaller the pop and dimmer the flash. But BE CAREFUL, picture tubes will hold a very healthy charge for at least a week if not longer. Even after you've discharged it once, it may still carry a residual charge. It's better to be too careful than dead, which is why electronic equipment always carries stickers referring servicing to qualified personnel. Handle the side with the viewing screen against your chest when changing it.

CAPACITOR REPLACEMENT

To remove a capacitor, heat the solder and use a solder sucker or de-soldering wick to remove solder from both of the holes. The cap should virtually fall out after you do both sides. Replace the cap with a new one (The polarity is EXTREMELY IMPORTANT) and bend the leads over at about a 45 degree angle to hold the capacitor fully in place. Check off the capacitor as having been replaced on the parts list sheet as you go so you'll know which have yet to be replaced. At that point you can either solder the individual part or wait until you've installed a half dozen or so and do them all at once. The long leads will show you what needs to be soldered. Clip off the leads after you have installed them all. ONLY clip ones with good solder joints. This provides a convenient check and double check of what needs to be done. Replace all the capacitors at once.

Note that the capacitors come in two "types":



The capacitors are usually marked negative (-) but sometimes positive (+). Check the polarity on the existing capacitor (there is a thick bar on the capacitor, 75% of the time, it's the - side). The + side of a capacitor has a longer lead if the outside markings are confusing.

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 G05, 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.

RESOLDERING CONNECTORS

Wherever there is a cable attached to your deflection or HV board there are metal "pins" that that a plug plugs onto. Over time, the connections weaken and you get the kind of intermittent problems or failures you may have been seeing. Resolder ALL of the pins on the back of the boards. Remove the old solder using desoldering wick or a solder sucker, and resolder with new 63/37 solder. This is VERY IMPORTANT as resoldering the header pins fixes many mysterious monitor problems.

CHASSIS TRANSISTORS

All the monitor chassis 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 chassis transistors in backwards; the leads are offset so they will only fit into the chassis and screw down in one direction. 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 monitor chassis. New insulators are not included in the Zanen kit! If you have some white heat sink grease, put a light coating on both sides of the Mica insulator.

Monitor Chassis Parts		
Location	**Part Number**	**Notes**
Q608	2N3716 transistor	
Q609	2N3792 transistor	Q607 on G05-801
Q708	2N3716 transistor	
Q709	2N3792 transistor	Q707 on G05-801

Important: 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! If there is continuity, you will usually burn out R718, R719, and others in the pre-amplification stage. You will probably also take out the 2N3716 or 2N3792 involved too. Note you may have to unplug the monitor chassis transistor connections to the Deflection board to get a good continuity test (if you haven't already removed the Deflection board!).

G05-801 DEFLECTION BOARD

Zanen G05-801 Deflection PCB Parts			
Location	**Part Number**	**Upgrade**	**Notes**
C804	470 uf 50V capacitor		
C806	470 uf 50V capacitor		

NON-Zanen G05-801 Deflection PCB Parts			
Location	**Part Number**	**Upgrade**	**Notes**
C506	45 uF 125V LOW ESR capacitor		
F600	2 amp pico fuse		
F700	2 amp pico fuse		

G05-801 HIGH VOLTAGE BOARD

The High Voltage PCB (in the metal cage with the flyback transformer).

Zanen G05-801 HV PCB Parts			
Location	**Part Number**	**Upgrade**	**Notes**
C901	47 uF 50V capacitor		
C909	4.7 uF 150V capacitor		
C910	470 uF 50V capacitor		

NON-Zanen G05-801 HV PCB Parts			
Location	**Part Number**	**Upgrade**	**Notes**
F901	1 amp fast blow fuse		

G05-801 REGULATOR BOARD

The G05-801 Bottom Panel Regulator PCB.

Zanen G05-801 Regulator Board Parts			
Location	**Part Number**	**Upgrade**	**Notes**
C102	1 uF 50V axial capacitor		
C103	1 uF 50V axial capacitor		

NON-Zanen G05-801 Regulator Board Parts			
Location	**Part Number**	**Upgrade**	**Notes**
C100	7200 uF 50V capacitor		
C101	7200 uF 50V capacitor		
F100	5 amp slo-blo fuse		
F101	5 amp slo-blo fuse		

G05-802 DEFLECTION BOARD

Zanen G05-802 Deflection PCB Parts			
Location	**Part Number**	**Upgrade**	**Notes**
C500	2.2 uF 50V radial capacitor		
C501	2.2 uF 50V radial capacitor		
C502	2.2 uF 50V radial capacitor		
C503	2.2 uF 50V radial capacitor		
C504	47 uF 50V radial capacitor		

NON-Zanen G05-802 Deflection PCB Parts			
Location	**Part Number**	**Upgrade**	**Notes**
F100	5 amp slo-blo fuse		
F101	5 amp slo-blo fuse		
F102	1 amp slo-blo fuse		
F600	2 amp Fast-blo fuse		
F700	2 amp Fast-blo fuse		
DB100	8A 200V SI Bridge Rectifier		Diode bridge (NTE5313)
C100	6800 uF 50V radial capacitor		
C101	6800 uF 50V radial capacitor		
C102	0.1 uF 50V tantalum axial capacitor	Yes	Power filter cap. Original is ceramic.
C103	0.1 uF 50V tantalum axial capacitor	Yes	Power filter cap. Original is ceramic.

G05-802 HIGH VOLTAGE BOARD

The High Voltage PCB (in the metal cage with the flyback transformer).

Zanen G05-802 HV PCB Parts			
Location	**Part Number**	**Upgrade**	**Notes**
C900	1000 uF 50V radial capacitor		
C901	1000 uF 50V radial capacitor		
C904	47 uF 50V radial capacitor		
C908	4.7 uF 250V radial capacitor		

NON-Zanen G05-802 HV PCB Parts			
Location	**Part Number**	**Upgrade**	**Notes**
D900	SK3998/NTE558 Fast Recovery 1500 Volt 1-Amp Rectifier Diode	Yes	Original is a BY208-600 (600 Volt)
D901	SK3998/NTE558 Fast Recovery 1500 Volt 1-Amp Rectifier Diode	Yes	Original is a BY208-600 (600 Volt)
D902	SK3998/NTE558 Fast Recovery 1500 Volt 1-Amp Rectifier Diode	Yes	Original is a BY208-1000 (1,000 Volt)

V2000 DEFLECTION BOARD

Zanen V2000 Deflection PCB Parts			
Location	**Part Number**	**Upgrade**	**Notes**
C500	1 uF 50V radial capacitor		
C501	1 uF 50V radial capacitor		
C502	1 uF 50V radial capacitor		
C503	1 uF 50V radial capacitor		
C504	22 uF 250V radial capacitor		
C603	2.2 uF 50V radial capacitor		
C703	2.2 uF 50V radial capacitor		

NON-Zanen V2000 Deflection PCB Parts			
Location	**Part Number**	**Upgrade**	**Notes**
F100	5 amp slo-blo fuse		
F101	5 amp slo-blo fuse		
F102	1 amp slo-blo fuse		
F600	2 amp Fast-blo fuse		
F700	2 amp Fast-blo fuse		
DB100	8A 200V SI Bridge Rectifier		Diode bridge (NTE5313)
C100	6800 uF 50V radial capacitor		
C101	6800 uF 50V radial capacitor		
C102	0.1 uF 50V tantalum axial capacitor	Yes	Power filter cap. Original is ceramic.
C103	0.1 uF 50V tantalum axial capacitor	Yes	Power filter cap. Original is ceramic.

V2000 HIGH VOLTAGE BOARD

The High Voltage PCB (in the metal cage with the flyback transformer).

Zanen V2000 HV PCB Parts			
Location	**Part Number**	**Upgrade**	**Notes**
C900	1000 uF 50V radial capacitor		
C901	1000 uF 50V radial capacitor		
C904	47 uF 50V radial capacitor		
C907	4.7 uF 160V radial capacitor		
C908	4.7 uF 250V radial capacitor		

NON-Zanen V2000 HV PCB Parts			
Location	**Part Number**	**Upgrade**	**Notes**
D900	SK3998/NTE558 Fast Recovery 1500 Volt 1-Amp Rectifier Diode	Yes	Original is a BY208-600 (600 Volt)
D901	SK3998/NTE558 Fast Recovery 1500 Volt 1-Amp Rectifier Diode	Yes	Original is a BY208-600 (600 Volt)
D902	SK3998/NTE558 Fast Recovery 1500 Volt 1-Amp Rectifier Diode	Yes	Original is a BY208-1000 (1,000 Volt)

TROUBLESHOOTING

Troubleshooting monitors requires experience, patience, and luck. The first step is to match the symptom the monitor displays to the diagnosis next to it in the "SYMPTOM-DIAGNOSIS" subsection. This will pinpoint the circuit the problem is probably in, and often the parts to check. Next, the circuit should be visually inspected to see if there are any parts broken, burned, or if something is there that shouldn't be, like a loose screw, etc. Some parts go bad before others, and should be checked first. In fact, following is the general order in which parts usually go bad:

1. Semiconductors (like transistors, diodes, and integrated circuits).
2. Fusible resistors.
3. Electrolytic capacitors.
4. Resistors.
5. Capacitors and coils.

Always remember that a monitor can bite like a snake. Even when it is turned off, capacitors hold voltage and will discharge it to you should you be touching chassis ground. The picture tube or CRT, itself, is a giant capacitor, so avoid the flyback anode plug hole. With the monitor on, the power supply circuit and/or the flyback, which puts out at least 12,000 volts, **CAN BE KILLERS!!** Avoid handling power transistors (usually output transistors), yoke terminals, and other high power components when the monitor is on.

WARNING: That picture tube is a bomb! When it breaks, first it implodes, then it explodes. Large pieces of glass have been known to fly in excess of 20 feet in all directions. DO NOT carry it by the long, thin neck.

Do not forget to discharge the CRT - even if you are just going to be unplugging the socket from the neck of the CRT (i.e., to gain access to another part). A tube that has some air in it can deliver a nasty shock back out of the neck pins.

You should NEVER short the anode of the tube DIRECTLY to common ground. ALWAYS use a resistance of 1 Meg ohm between the anode (underneath the suction cup) and common ground. A direct short without the resistor(s) will cause the HV Rectifier Diode (D903/D904) to fail. Ten 100K-Ohm ½watt resistors in series is the best method. You could use a single 1 Meg ohm, 3W resistor, but the problem is flash over failure. Using a single resistor that is dropping 20KV instead of 10 resistors that are dropping 2KV each increases the likelihood that the single resistor will short out and provide no protection for the HV Rectifier Diode. Make sure the resistors are sheathed in some heat shrink tubing for protection.

I would strongly recommend using a High Voltage Probe to discharge the monitor. This is the safest method, as the probe is designed to withstand extremely high voltages (hence the name, right?).

Lacking an HV probe, you can use this tried and true method, be it a little more dangerous. Use a plastic handled screwdriver; connect one end of a wire with an alligator clip at each end to chassis ground and the other end to the metal shaft of the screwdriver. Be certain you have the ten 100K-Ohm ½watt resistors in your connection at the HV end of the shorting wire. Using ONE HAND ONLY (put the other in your pocket) and touching ONLY the plastic handle of the screwdriver (DO NOT TOUCH THE METAL SHAFT) stick the blade of the screwdriver into the anode hole. Be prepared for a fairly loud pop and a flash. The longer the monitor has been turned off, the smaller the pop and dimmer the flash. But BE CAREFUL, picture tubes will hold a very healthy charge for at least a week if not longer. Even after you've discharged it once, it may still carry a residual charge. It's better to be too careful than dead, which is why electronic equipment always carries stickers referring servicing to qualified personnel. Handle the side with the viewing screen against your chest when changing it. ALWAYS wear safety goggles when handling the picture tube.

To maintain the safety and performance of the monitor, always use exact replacement parts. For instance, the wrong components in the power supply can cause a fire, or picture distortion may result from the wrong transistor being placed in the deflection circuitry. Component manufacturers offer specification sheets, which are useful for "mixing and matching", but why go through all the trouble? Order exact replacement parts! Service your monitor on a nonconductive firm table like wood, **NOT METAL,** and take off all of your jewelry just in case. With all this in mind, you are ready to begin troubleshooting. Observe the picture carefully. Try to vary the appropriate control that would most likely affect your particular symptom. For example, if there is poor brightness or no picture, try turning up the bright-ness or contrast control. If the controls have no effect at all, chances are there is trouble with the control itself, the circuit it controls, or a nearby circuit that may be upsetting voltages. Go to the list of symptoms and determine with the schematic where the bad circuit is.

First, check for obvious visual defects such as broken or frayed wires, solder where it is not supposed to be, missing components, burned components, or cracked printed circuit boards. If everything looks good up to this point, make sure that diodes, electrolytic capacitors, and transistors have their leads connected in the right polarity as shown on the schematic and the circuit board.

Turn on the power and measure the voltages at the leads of the active devices such as tubes, transistors, or integrated circuits. Any voltage that does not come within at least 10% to 15% of the voltage specified on the schematic indicates either a problem with that device or a component connected with it in the circuit. The next step is to use the ohmmeter to narrow down the field of possible offenders.

To test a transistor, one lead of the ohmmeter is placed on the base; and the other lead placed just on the emitter, then on the collector. A normal transistor will read either high resistance (infinite), or little resistance (400 to 900 ohms), depending on the polarity of this type transistor. Then the leads should be switched, one remaining on the base, and the other switched from the emitter to the collector. Now the opposite condition should result: the resistance should be infinite if it was lower when the other lead was on the base. Consistently infinite readings indicate an open, and a short is demonstrated by 0-30 ohms on most of these test readings. Finally, place one lead on the collector,

then the other on the emitter. No matter which lead is used, there should be infinite resistance. Any lower reading, such as 50 ohms (which is typical on a bad transistor), indicates a short.

This all sounds pretty confusing, but a little experience on a good transistor will make you an expert in no time. Usually, the lowest ohmmeter setting is used for testing transistors. Once in a great while a transistor may check out good on this test, but may actually be “leaky” or break down only on higher voltages. If in doubt, change it. It is also wise to check the transistor out of the circuit just in case some component in the circuit is affecting the ohmmeter reading.

A diode is tested like a transistor except it only has two leads. Again, there should be high resistance one way and little resistance the other. If it tests bad, take one lead out of the circuit in case some component is messing up the ohmmeter reading.

NOTE: DO NOT leave soldering equipment on the leads too long since all semiconductors, especially integrated circuits, are easily destroyed by heat.

Without special equipment, integrated circuits are checked by verifying the proper DC voltage on the pins and the correct AC waveform using an oscilloscope. **BE CAREFUL:** Shorting their pins can easily destroy them.

Resistors are checked with an ohmmeter and should usually be within ten percent of the value stated on them and on the schematic. You may have to desolder one lead from the printed circuit board. If you wreck the foil on the board, carefully solder a small wire over the break to reconnect the conductive foil.

Capacitors are tricky. Their resistance goes up when checked with an ohmmeter, which shows a charging action. As they suck up current from the meter, the voltage goes up and so does the resistance. If you are sure a particular circuit is giving you a problem and everything else checks out O.K., Electrolytic capacitors are prime suspects. Substitute a new one and keep your fingers crossed.

One final note. If you have purchased or acquired a monitor that is not working, suspect ALL previous work, especially if the person said they tried to fix it but could not. If they knew what they were doing, it would be working, right? :-) Check any component that looks like it has been replaced and make sure it is the right type/value.

SYMPTOM DIAGNOSIS

1. Insufficient width or height:

A. Horizontal line (due to "Y" amplifier defection).

- Bad "Y" amplifier output transistors.
- Blown "Y" amplifier fuse.
- Open fusible resistor in the "Y" amplifier.
- Yoke pins not making good contact (very common).
- Bad yoke.

B. Vertical line (due to "X" amplifier defect).

- Bad "X" amplifier output transistors.
- Blown “X” amplifier fuse.
- Open fusible resistor in the "X" amplifier.
- Yoke pins not making good contact (very common).
- Bad yoke.

2. Picture spread out too far and/or crushed in certain areas:

A. Controls for linearity (located on the deflection board and set at the factory) are misadjusted.
B. Bad yoke.

3. Poor focus:

A. Low focus voltage from the high voltage board.
B. Defective diode off the flyback.
C. Defective focus control.
D. Defective picture tube (CRT), although the chances of this are unlikely.

4. Picture not bright enough:

A. If the CRT voltages are present, the picture tube might be bad, although the chances of this are unlikely.
B. Weak 90-volt supply from the EHT power supply.
C. Loose wire to socket of CRT for G2 voltage.

5. Silvery effect to the white lines, or picture looks dim, washed out:

A. If the CRT voltages are present, the picture tube is probably bad. The surest way to cure this on an X-Y monitor is to replace the picture tube (CRT), although the chances of this are unlikely.

6. Increasing brightness causes an increase in picture size and weakens focus:

A. For the most part, this is normal in X-Y monitors. But if this should occur at normal viewing levels, either:

- The CRT is defective (again, unlikely).
- The high voltage rectifier is weak.
- Or the high voltage circuitry has poor regulation.

7. Picture rapidly blinks on and off:

A. Internal short in the picture tube (arcing).

8. A dot on the middle of the screen - Red LED is turned on (located on the deflection board):

A. The "X" and "Y" signals are not making it into the monitor.
B. Check cabling, jacks, and logic boards.
C. "X" and "Y" amplifier failure. See Number 1 above and *check the fuses first.*

9. Monitor won't turn on:

A. Open fuse(s).

B. A defect in the power supply; check:

- Fuse(s).
- Transistors.
- Open fusible resistor.

C. Check jack to make certain all pins are obtaining their voltage from the other game circuitry.

D. Check for loose foil, especially by D100.

10. Blown 5 amp fuses:

A. Caused by bad luck. Change fuses.

B. If they keep blowing, check all power transistors that are heat-sinked on the side (as in the 19" version) or the bottom (as in the 13" version) of the monitor.

11. Extremely bright picture; spider-web like retrace lines floating around on the picture:

A. Defective "Z" amplifier circuitry; check:

- The brightness and contrast controls.
- For peeled foil on the deflection board.
- Semiconductors, etc.

B. See symptom 4, diagnosis "B" and "C" ONLY. A bad EHT power supply or loose G2 wire can cause the same thing.

12. Hazy blob of light that shimmers on the screen.

A. Failure of some component in the high voltage section.

B. Open secondary on flyback winding.

13. Corners of the picture are missing:

A. Yoke is too far back on the picture tube neck.

14. Picture is too far up, down, or not centered properly:

A. Metallic yoke tabs-need to be adjusted.

15. A shadowy image of the game remains on the screen, even after monitor is off:

A. Picture tube has burnt phosphor.

16. 2 amp fuses keep blowing:

A. Check the large heat-sinked power transistors.

B. Check D608 and D708 (1N4001)

C. Check semiconductors, especially the transistors in the "X" and "Y" amplifiers.

D. Bad yoke.

17. Video information is distorted: letters and figures are "crinkly" - like crumpled paper, and it shakes slightly:

A. Bad 90-volt power being supplied by the EHT unit. If everything looks good, check the electrolytic capacitors.

B. The regulator control (R905) may need adjusting.

On the Wells-Gardner 19V2000 monitor, the anode voltage is supposed to read 14.5KV High Voltage. That's 14,500 volts with the beam current at zero. R905 adjusts this output voltage. To read this voltage, your meter needs a separate high voltage probe. Follow the directions **EXACTLY** as stated with the literature that comes with the probe.

In the case of the Electrohome G05 monitor, the adjustment is complex and, of course, potentially dangerous. Basically, the Electrohome anode voltage from the "flyback" and rectifier is supposed to be set at 12,000 volts with the beam current at zero. To read this voltage, your meter needs a separate high voltage probe. Follow the directions **EXACTLY** as stated with the literature that comes with the probe.

If you are still unsure, it may be best if you call Electrohome at (519) 744-7111 and obtain exact information from one of their staff engineers. [NOT LIKELY!]

[continued on next page]

The following symptoms and diagnosis come from various people and sources. I cannot verify any of these will work for you. All references are made to the G05-802/V2000 monitor, unless specifically noted.

If you have a scope, Electrohome has an EXCELLENT section in the manual showing you various test points on the boards and exactly what the scope trace should look like.

First, you must verify that you are getting good signals from the game board. To do this, disconnect the 12-pin Molex connector at the monitor. It has a pinout like this (use pin 11 to get oriented; pins 1, 3, and 11 are shaped like a "D" instead of an "O"):

1	2	3
4	5	6
7	8	9
10	11	12

Flip the test switch inside the coin door and hit the reset button on the game PCB (or power cycle the machine). This will put you into the test mode, which will draw a very stable, all white screen (white is ideal since the RGB values should be identical to each other).

Set your meter for AC Volts and put the black lead into pin 8 of the game harness (this is a ground and should be black). You should get readings similar to the following:

G05-802/805 "Issue 4" Deflection Board		
Pin #	Description	AC Voltage
1	X Out	6.68
2	X Ground	6.68
3	Y Out	6.69
4	Y Ground	6.69
5	Z Out	6.70
6	Z Ground	6.70
7	30VAC Center Tap	30.3
8	Ground Center Tap	0
9	Ground Center Tap	0
10	30VAC Center Tap	30.3
11	6.3VAC Center Tap	9.7
12	Heater Ground	3.0

G05-802/805 "Issue 5" Deflection Board		
Pin #	Description	AC Voltage
1	Z Out	6.70
2	Y Out	6.69
3	X Out	6.68
4	Ground Center Tap	0
5	Y Ground	6.69
6	X Ground	6.68
7	30VAC Center Tap	30.3
8	Z Ground	6.70
9	6.3VAC Center Tap	9.70
10	30VAC Center Tap	30.3
11	Ground Center Tap	0
12	Heater Ground	3.0

Bad game boards will usually have X/Y/Z Out = 0 VAC. If you get 6-7 VAC on all of them, then your game board is probably OK.

SPECIAL NOTE: Omega Race games for some really strange reason do not use pin 12. They have a separate wire soldered directly to the monitor board bypassing the connector and bridging the heater voltage from another point.

Symptom: Fuses F100 and F101 blow on powerup.

Test the diode bridge (DB100) with the monitor unhooked from the power input. The diodes take the AC and convert it to DC. If one or more are shorted you will get blown fuses. The diodes, or legs of the bridge should conduct one way, and be open the other way. Verify that b+ and b- are not shorted to ground. If the diodes are all good, both fuses should blow if there is a short.

Check C100 and C101 for shorts. If one or the other measures shorted, unplug the chassis output transistors and try again. The output stage transistors should be 2N3716 for Q708 and Q608 and 2N3792 for Q709 and Q609. Make sure they are the correct type, and make certain the transistors have the mica insulators installed.

If C100 and/or C101 is still shorted, remove the shorted capacitor(s) and check to see if the fuses still blow. If C100 and/or C101 are not shorted, it could be an overload in the output stage.

Unplug the yoke and power up the monitor without any input from the game board. Measure the voltage from chassis to F700 and F600. It should be close to zero. If it is as much as 10 volts it's not a problem (with the yoke unplugged the feedback loop isn't what it should be). But if it reads something like 40 volts you have a bad driver stage. Look for Q706 to be shorted. It is a MPSU57.

Symptom: Screen Comes Up And Slowly Gets Bigger And Bigger.

Probably a bad HV diode. That is a symptom of Low high voltage called blooming. Clean the connections of the transistors mounted on the outside of the high voltage cage before replacing the HV diode.

Symptom: No Vertical Deflection; Spot Killer On.

Check R100, R101 (if installed).

Symptom: Deflection Transistor(s) Continuously Shorts.

On the V2000, a shorted D608 (“Y”) or D708 (“X”) will fry the pre-amps Q607 or Q706 respectively. Replacing the shorted transistors will not help if the diodes are still bad.

Also, check the transistors that drive the base of the shorted transistor. When a negative deflection transistor shorts it almost always shorts the one driving its base.

This is also the symptom that is present if the X or Y signal coming off of the board is stuck (+) or (-). These signals will have to be tested while disconnected from the monitor. Ideally, you should check the game board outputs in the test mode with a scope. The game board outputs can be checked with a digital multimeter on the a/c scale if the game is NOT in the test mode. The reading while the game is in attract mode is one that is constantly changing, usually more than 1.5v but less than 3v. A game board output that is stuck positive or negative will read 0v a/c on a DMM. An output that is stuck will usually read +15 or -15 on the d/c scale. This condition must be corrected before the X and Y signals are reconnected to the monitor or that pile of shorted transistors will get pretty tall.

Symptom: No Picture. Fuses On Deflection Board Test Good. Frame-Mount Transistors Not Shorted. Spot Killer Off. Neck Glows. Can Hear Vector Chatter.

A bad HV diode most likely suspect here. There should be something like 400VDC going to the tube for the screen.

Symptom: No Picture. F101 On Deflection Board Blows Instantly. Frame-Mount Transistors Not Shorted. Spot Killer Is Off. Neck Does Not Glow. No Vector Chatter Heard.

This sounds like a bad/shorted diode on one of the four bridge rectifier diodes at DB100, or a piece of metal shorting the monitor mother board to the chassis, OR a transistor that is NOT insulated from the metal chassis. They all need an insulator and should show a relatively high resistance to the metal chassis.

Symptom: Game Plays Blind. Spot Killer Is On. Raster Can Be Seen By Turning Up The Brightness.

If you have screen brightness with the screen turned all the way up you can probably rule out the EHT voltage supply.

Your problem sounds like a z-drive problem either from the main PCB or the monitor.

Verify normal operation of the spot killer circuit by grounding the reset pin on the game board and you should hear the yoke chatter stop and the spot killer led on the deflection board will turn on. When you unground the pin, the led goes out, and yoke chatter resumes. This test is important because it eliminates 50 % of the circuits in the monitor that would give those symptoms, such as the deflection system.

The problem could be a bad spot killer circuit (leaky transistors in the spot killer circuit). Never bypass the spot killer, get it fixed right. It will probably take an oscilloscope to track it down, or just replace the four transistors: Q500; Q501; Q502; and Q503.

Chasing thru the Z-drive is easy after verifying proper operation of the HV board and deflection systems. Verify the HV system by checking the B+ voltage on pin 1 on the connector P500 to the deflection board. It should be 90-100 volts pulsed DC. If you do not have this voltage, the HV unit must be troubleshot. All of the outputs from the flyback are "geared" together. You can set the high-voltage by precisely setting the lower taps coming off the transformer.

Verify that z-drive is coming off the game board. (I am assuming you do not have a scope) The Z signal is a pulsed DC signal coming into the deflection board on a wire connected the board near R520 and R522 (it is marked "5" on the schematics). The side of the resistors closest to #5 wire is a test point. With the test pattern on the screen the z-signal will be 75% at 2Volts and 25% at 0Volts. You will read at least +1Volt at this test point with a voltmeter.

If it's dead 0, the problem is on the game board.

Symptom: Game Plays Blind With Deflection Chatter.

If you can hear deflection chatter, and the game plays "blind", then there are two things you must check: (1) Low / no voltage to the tube filament; and (2) A failure in the HV supply.

Look for the 6.3v AC heater filament voltage coming from the transformer block. This can be intermittent.

With the monitor disconnected from the game board, I could measure a good 6.3v AC at the heater element with my meter, but when the monitor was plugged in, I got nothing under load. Leave the monitor connected and try and measure off the actual connector pins on the deflection PCB. Check the molex connector for good contact, as they can gum up causing intermittent contact.

There is a fuse in the power supply that controls the 6.3 VAC for both the picture tube's heater and also the lamps in the coin door. It can weaken and create a nice voltage drop if it doesn't flat-out open.

Symptom: No Picture. Spot Killer On. No Blown Fuses. R100 'Hot'.

Check for a shorted diode in the bridge rectifier (DB100) and shorted filter capacitors (C100 & C101).

You might try unplugging the high voltage supply and see if that cools things down. Also check the fuses. F100 and F101 should be 5 Amp slow-blow. F700 and F600 should be 2 Amp fast-blow. F102 should be 1 Amp slow-blow.

If the fuse values are all correct, try unplugging the output transistor connectors (P700 and P600). If unplugging either of those helps, check the output transistors that connect to those connectors. They are mounted on the chassis.

Symptom: No Picture. Spot Killer is Off. Game Plays Blind With Deflection Chatter.

Check the female connector connecting the HV cage to the deflection board.

Symptom: Monitor Powers Up, Spot Killer On. If The Brightness Is Turned Up, A Complete Screen Is Seen, But It Looks Like A Spider Web.

Check and replace as necessary the brightness or the contrast pot. Also check for bad solder joint, or a bad tantalum capacitor in the spot killer circuit.

Symptom: Picture Will Come And Go.

My 19V2000 had a bad contrast pot and I could jiggle it to get/loose the picture. Try messing with it to see if it needs replacing.

Symptom: No 6.3v at P900.

Check for cracked solder joint(s) on the connector.

Symptom: Image Has Ripples Or Zigzags. Vectors Are Wavy.

Either of these symptoms could point to either regular wirewound resistors being used instead of the non-inductive wirewound resistors in the yoke feedback circuit (yoke to ground) OR a bad filter capacitor allowing high-voltage power supply noise to get back into the deflection circuits. If your deflection board does not have R100 and R101, then there is probably too much ripple on the power supply for the monitor's deflection circuit. Check the small filter caps on the monitor board (C102 and C103).

Symptom: Slight Vertical Size Changes Back And Forth In The Picture.

This is often caused by a flaky linearity POT on the monitor deflection board. With a Wells-Gardner V2000, the vertical adjustment is at R600. The Electrohome G05 has four POTS instead of two, with vertical adjustments at R600 and R602.

Symptom: Fuzzy Picture.

The picture getting fuzzy implies fading capacitors. Replace all the capacitors in the HV cage. Get low ESR and 105-degree capacitors. These cost a little more, but are well worth it.

Symptom: Picture Is Faint, or Has A Slight Glow.

If your game uses a black light (Asteroids Deluxe or Omega Race), the black light can actually energize the phosphors in the CRT. Installing some automotive UV tint over any exposed areas of the tube should eliminate your problems.

Symptom: Always Have A Bright Dot In The Middle Of The Screen.

The contrast should do about the same thing as a Black Level control. I have seen monitors where a dried out capacitor in the black level/contrast area has caused similar symptoms.

Using a scope, you should be able to start at the Z out on the game board and make sure you have some good variability (full range swing) of the signal. Follow it through the monitor and see where the signal compresses/expands into being turned on all the time.

Symptom: Image Too Bright.

Check the electrolytic capacitors to make sure none have been put in backwards.

Symptom: Resistor R610 Is Fried.

Check R620 and Q603. If necessary, replace R620 with a 20-Ohm 7W wirewound resistor.

Symptom: R613 and R618 Are Fried.

Check to be certain that none of the leads (including the heatsink) of Q606 or Q607 is shorted to ground. Also check D606 or D607 to see if they have opened. This would crank all the currents up and destroy R613 and R618.

Also check for bad solder joints or a hairline crack in a trace. I would check the pins that connect to the large transistors mounted on the side REALLY closely. I would also do a continuity test on all the pins.

Symptom: No Picture. Neck Glows. Damage To C100, P701 And C102. Fuses Blow.

Check the chassis transistors for shorts. If one is shorted the right way (emitter to base) or (collector to base) it will destroy the new deflection board when you power it up. (they usually short all 3 together).

You must also verify that the X and Y outputs from the game board are not stuck (+) or (-). This will damage any monitor you plug into it.

Symptom: Adjustment Of The HV Pot In Both Directions Does Nothing To Affect Brightness.

This is frequently caused by poor solder connections on the connectors on the deflection and HV boards.

Symptom: No Picture On The Screen. HV Was Present, But The Heater Would Not Light Up.

(text by Matt McCullar August, 1989): The G05 has separate supplies for heater and high voltage, so I checked the 3-amp slo-blo fuse in the transformer heater circuit. Removing the fuse, and using the continuity function on my DMM, the fuse looked good. The heater inside the neck of the CRT had not opened up, and was also good. With no fuse in the circuit, I got 6.3 volts A.C. from the transformer, which was normal. But every time I reconnected everything, the voltage to the heater dropped about 3 volts. I checked all the wiring and it was good.

I did run across one interesting thing: the coin door lamps use the 6.3 volts A.C. to light up, and their sockets appeared a bit faulty, so I cut their wires and took them out of the circuit. But that did not help light up the picture tube's heater.

I finally got a break a few days later when the heater fuse blew. When I replaced it, the heater came on! What happened? I concluded that the fuse's internal resistance had increased, thereby dropping the voltage across it. Instead of blowing the way it should have, this [fuse] just weakened. I didn't notice this before because the beeper continuity function on my DMM turns on the beeper when it finds anything under 30 Ohms across the meter leads. Ideally, a fuse should be close to zero Ohms (although some fuses with very small current ratings are about 10-Ohms), but this fuse had apparently slowly increased to several times what it should have been. Since its overall resistance had not yet gone over 30-Ohms, however, the beeper on my meter turned on and I assumed the fuse was good. So now when I check a fuse, I don't use the continuity test, and instead get a direct resistance measurement.

G05-801 troubleshooting information

(from Atari's "The Book")

G05-801 Power Supply Board

The following procedure is for the +25 volt power supply. Components in parentheses are for the –25 volt power supply. All voltage measurements are to the chassis.

Symptom: Fuse 100 (101) open

Check bridge rectifier DB100 for shorted diodes. Check capacitor C100 (101) for short. Check ZD100 and ZD101.

Symptom: 25VDC measures 40V

Zener diode ZD100 (101) open. Check Current Limiting resistors R102 and R103.

Symptom: 25VDC is too low

Measure the voltage on the emitter of the transistor 0100 (101). Should read 40V. If this voltage is 30V or less, capacitor C100 (101) is open or one diode in DB100 bridge rectifier is open.

Remove the two screws holding the transistor Q100 (101) to the heat sink. Measure the base voltage. If 27V, replace Q100 (101). If less than 27V, Zener diode ZD100 (101) is defective or capacitor C102 (103) is leaky.

Symptom: 25VDC is too high

ZD100 or ZD101 is open. Check the Current Limiting resistors R102 and R103.

Symptom: CRT Neck is Dead

Check resistor R104

G05-801 High-Voltage Board

Symptom: Fuse open (F900)

This may be a matter of adjustment. Locate the high-voltage adjustment pot R912 (next to Q901). Rotate it completely clockwise. Replace fuse and apply power. Place positive lead of meter on pin 5 (gray wire) of the harness input connector P900. Slowly turn the high-voltage adjustment until the meter reads 90V. If the fuse opens again, check the following components.

Opens: ZD900, ZD901, and Q901. Shorts: Q900, Q902, Q903, and ZD903.

Symptom: 90V measures less than 80V

Measure the voltage on the anode of the Zener diode ZD900 or the emitter of Q901. Should read 9V. If less, replace the diode.

Locate resistor R901 near the top edge of the board between Q900 and 0901. This 1.2K-ohm resistor stands up about a half inch off the board. Place positive voltmeter lead on the resistor lead closest to the edge of the board.

Voltage Reading	Probable Cause
9V	Q901 shorted
Less than 15V	ZD901 shorted, or Q900 or Q902 has low gain
25V	Open Q900. Q902, Q903, R906 or T900

If all components are OK, the oscillator circuit (Q903) may be loaded down by a defective component in the secondary of T900. With an ohmmeter, check the following components for leakage: D903, C909, C906 and C907.

The other components D901, D902 and the doubler cannot be checked with an ohm-meter. Use the following procedure instead. Note: When working with the doubler, always make certain that the CRT anode is discharged to ground! Unsolder the wire going from the high-voltage transformer to the terminal of the doubler. Apply power and measure the 90V (pin 5 of R900). If the 90V comes up, replace the doubler. To determine if D901 or D902 are loading down the oscillator, unsolder one end of the diode and note if the 90V actually measures 90V.

G05-801 Deflection Board

Missing information can either be caused by the logic (game) PCB or the X-Y amplifier. The easiest approach is with an oscilloscope. However, a scope is generally not available on location.

Follow the steps listed below to determine which is the faulty board. The Y measuring points are in parentheses.

Missing X (Y) information

1. Set your voltmeter on "AC" and on the 10-volt scale.
2. Measure the voltage at pin 1 (3) of P703. The meter should read 4.5V +/- 1V. If less than 3.5V or even zero, the game PCB is defective and the monitor is probably OK.
3. Measure the voltage at pin 2 (3) of P702. The meter should read 4.5V +/- 1 V. If zero, check for open fuse F700 (F600). This is a small pica fuse located near the side of P702. Replace with a 2-amp, fast-blow fuse.

If the fuse is OK and the voltage is low, check Q705, Q706, Q707 and Q708 (Q605, Q606, Q607 and Q608). You could swap the +X driver transistor Q708 with the + Y driver transistor Q608 to see if the problem follows the transistor. Similarly, the -X (Q707) and -Y (Q607) can be swapped.

Z Amplifier

Proper adjustment of the brightness and contrast controls is the same as for the raster-scan monitor.

1. Turn both brightness and contrast controls to minimum.
2. Turn up brightness until picture is barely visible.
3. Turn up contrast for desired picture.

Problems related to the Z amplifier are few. Remember! Make sure all power supplies are operating and that the filaments in the picture tube are glowing.

Symptom: Black screen

Turn up the brightness control. One of three symptoms will appear: no picture, a dot in the middle of picture, or interconnecting lines between objects. Proceed to troubleshoot, based on what appears:

Symptom: No picture

R515 or brightness control (R516) is open.

Symptom: A dot

If the red LED (D507) is on, proceed to X-Y amplifier procedure.
Interconnecting lines

If the red LED (D507) is on, check the following components for shorts or open circuits: D504, D505, D506 and C510.

If the red LED is off: 0504 is open, Q503 is shorted, contrast control R526 is open or there is no Z input from the game PCB.

G05-801 Transistor data

Alrighty, then, let's look at the schematics for the G05-801 monitor. Q701 and Q702 is a differential amp powered by Q703, a constant current supply. Q703 is being run at about 3.6 mA (0.65 volts through 180 ohms). Q701 and Q702 normally share this current equally, so about 1.8 mA average through each of those.

Maximum voltage drop across Q703 (assuming +35 and -35 power supplies) would be 20.74 volts (35 - 0.65 through R704 - 0.65 volt drop at Q701/Q702 emitters - 12.96 volts drop across R740). Power dissipated in Q703 is about 75 mW. So Q703 needs to be able to handle 20.74 volts, 3.6 mA, and 0.075 Watt. Good design practice would be to have Q703 handle the ENTIRE power supply of 70 volts (but for that much voltage to be present there would have to be multiple failures happening at the same time -- unlikely to happen, 35 volts is sufficient but would also represent failures happening elsewhere), at least double its operating current - 7.2 mA, and at least double its operating power - .15 watt. So for our purposes, anything that can handle the voltage rating will do. Even if it can't handle the voltage R740 will protect it from destruction.

Now for Q701 and Q702. Current is 1.8 mA average, 3.6 mA peak. Voltage peaks out at 35.65, averages 33.85 (1.8 volts dropped through collector resistor). Average power is 60 mW. Once again, current and power are insignificant and the main spec here is voltage.

Speed of Q703 doesn't matter, but you want something fairly fast in the Q701 and Q702 positions.

What does it all mean? Use a fairly fast (over 1 MHz) NPN transistor with good gain in the 1-5 mA range and a voltage rating of at least 40 volts (the more the merrier). Whatever you use - USE THE SAME PART FOR BOTH Q701 AND Q702. Why? You want these two as close to matched as you can get. Most important matching is emitter to base voltage. If these aren't the same you get something called "offset voltage" which will cause centering to be off. With no offset voltage, zero voltage from the game board will give you zero current through the yoke (and that's a good thing!).

WHAT TO DO WHEN YOU DON'T KNOW WHAT TO DO

If you are totally confused about where to begin to hunt for a problem, and can't find the problem in the "SYMPTOM DIAGNOSIS" subsection, there may be another way to proceed.

Take a VOLTMETER and (if possible) an oscilloscope and begin probing the jacks. You can start with the input jack to the monitor. Using the oscilloscope, make sure both the "X" and "Y" information is present (which it isn't during the "SOUND" test).

NOTE: It is advisable to use one of the games test patterns (obtained when you put the game into the Self-Test mode) when using the oscilloscope. The simple diamond one is a good choice. This way the "X" and "Y" information at the above jack isn't changing and a recognizable waveform is easy to see if it's there. The DC voltages tend to jump around like crazy when the game is being played or is running through its ATTRACT mode, so, using the test pattern tends to keep them still.

Next, use the voltmeter to make sure the other voltages are present at each pin. Similarly, you proceed to P500 on the deflection board, and P900 on the EHT unit to make sure all the correct voltages are present. Use the schematic to determine what the correct voltages should be.

Check the pins on the CRT to be sure the voltages are getting this far. If everything looks good to this point, perhaps the CRT is bad. DO NOT check the anode voltage unless you have a special high voltage probe or you may wind up repairing X-Y monitors in heaven.

DO NOT BE FOOLED by the silent operation of the monitor. Regular T.V. sets and monitors buzz and crackle a lot when they're operating - this is normal, for them. BUT, Vector monitors are noiseless unless something is wrong.

Whatever you do, ALWAYS read the literature that comes with any test equipment you use so that you will not damage the equipment, the monitor, and most of all YOURSELF.

Quite a few of the parts between the Electrohome and the Wells Gardner monitors may be swapped. The CRT's for example are completely interchangeable. Also, many of the transistors used in each monitor are the same. Certain critical components in the power supply and the EHT unit are dangerous to interchange. The best thing to do is to compare both monitors' parts lists to see if the descriptions of any two particular parts you want to swap match exactly. Substitution manuals are available for transistors and semiconductors, but you never know about them. Sometimes they work and sometimes they don't, depending on the critical circuit parameters. If in doubt, order exact replacement parts.

Appendix A: Common Ground Connections

From: John Robertson <jrr@flippers.com>
Newsgroups: rec.games.video.arcade.collecting
Subject: TechTIP: How to make VECTOR MONITORS very RELIABLE!
Date: 22 Oct 2001

It's been a little while since my last Tech Tip, but this is something that's been on my mind for a while now, and a posting in the Vector mail-list got the following response from me...:

Vector monitors blow up because the ground reference for the monitor drifts relative to the logic boards (MPU and video) when the power supply connections overheat. This will then bias the input signals offset enough to overdrive the outputs. Hence my argument for chucking the original power supply and putting in a switching supply. I started doing that about ten years ago and have not lost a single Electrohome/Sega monitor since. I assume this also kills Tempest/Star Wars/Major Havoc/... monitors etc. Those pesky grounds get a few ohms resistance and all sorts of nasty things happen.

I first discovered this on Gottlieb pinballs over ten years ago-the ground for the regulator would overheat the pin/wiper contact which would become a small resistor and thus the ground of the MPU would drift up relative to the cabinet ground, which also happened to be the ground path for the driver transistors. When the MPU ground would change to about 0.5 to 0.7VDC above cabinet ground the base of the transistors would then start to conduct as the MPU would be trying to turn off the transistors, but the Emitters are tied to the cabinet ground. Hence the transistors would start to conduct... You will recall that transistors generate far more heat when they are used at the beginning of their working range rather when they are switched completely on and off as in regular vector monitors (or solenoid drivers, etc.). So in a little while, it croaks. No obvious cause...replace the transistors and everything works. For now...

So get VERY GOOD GROUND (COMMON) CONNECTIONS BETWEEN THE MONITOR, MPU AND POWER SUPPLY for reliability!!!!!!!!!!!!!!!!!!!!!!!! Solder fat conductors with nasty heavy gauge connectors between each component in the system. Put in healthy SWITCHING SUPPLIES!

Happy vectors will result.

John :-#)#

Appendix B: Testing Transistors

Most of the failures in the Electrohome G05 or Wells-Gardner V2000 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 C: Using a B&W Vector Monitor with a Color Game Board

From: Steve <zarco@sonic.net>
Newsgroups: rec.games.video.arcade.collecting
Subject: using B&W vector monitor with color vector board
Date: Thu, 21 Feb 2002

Hi Gang,
Hope this will be useful to someone.

Last week I finally fixed my Star Wars boards and wanted to hook up a monitor to verify that they were working OK. Didn't have a spare color vector display and didn't want to hack into my working vids.

What I did have laying around was my spare B&W vector monitor (and power supply, harness) from an Asteroids Deluxe.

Hooking the monitor to the board was pretty straightforward. The X and Y ouputs went directly from the board to the monitor. The trick was combining the red/blue/green Z outputs. What I did was connect the anodes of three switching diodes (1N914's) to the R,G, and B outputs from the board. I then tie the cathodes of the three diodes together, and connect a 2K-ohm resistor to ground. The junction of the diodes and resistor are then connected to the Z input of the monitor.

Don't forget to connect a good ground between the monitor and the boards.

Pretty simple, and it works great! One thing I had to deal with was the image was backward, so I had to play with the "invert X" and "Y" test points (pull them low to invert) to get the image set-up correctly.

END