

# Wells-Gardner 6100 Vector Monitor FAQ and Guide

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## INTRODUCTION

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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 color 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.**

### Acknowledgements

This document is based on an original text by Rick Schieve. Additional information was compiled by Gregg Woodcock from numerous sources on both the Internet and from StarTech Journal, Play Meter magazine and factory manuals. In many instances I have copied text verbatim from the document Gregg Woodcock compiled.

The following people have also contributed to the development of this document (knowingly or otherwise): Roger Boots, Mark Davidson, Mike Haaland, Mark Jenison, Al Kossow, Noel Johnson, Matt McCullar, Zonn Moore, Phil Morris, Bret Pehrson, Jon Raiford, John Robertson, Matt Rossiter, Mark Spaeth, James Sweet, Andy Warren and Andy Welburn (let me know if you want to see your name here – or don't want to!)

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## HOW DOES A VECTOR MONITOR WORK?

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Vector monitors, also referred to by Atari and others as "XY" or "Quadrascan" monitors, are available in black & white or color. A black & white picture tube has one electron gun that lights just one type of phosphor (usually, but not always, white). Color tubes have 3 electron guns that, when the yoke and neck magnets are aligned properly, each hit their own phosphors only, either red, green, or blue (RGB). Something called a shadow mask is used so each gun hits only one set of phosphors. There is no inherent difference between the tubes used in vector monitors and the tubes used in raster monitors; only the control circuitry differs. That is not to say that you can use any tube in any monitor; there are several different neck pinouts that have been used for picture tubes so you have to find a tube with a matching pinout first. If you have a lot of screen burn, you can replace a Wells-Gardner 6100 color vector picture tube with any compatible "off-the-shelf" 100-degree in-line picture tube that is also used in raster-scan displays.

So far, this has been just basic TV stuff and it holds true for raster monitors too. Now we will diverge. The electron guns in the neck of the tube emit a stream of electrons that bombard the face of the tube that would hit dead center if not for the deflection magnets on the neck of the tube. There are two deflection coils. One for horizontal deflection (X) and one for vertical deflection (Y) of the electron beam. Consider the center of the screen to be (0,0) volts to the deflection magnets. If you want to move the beam to the right you put a positive voltage on the horizontal deflection "X" coil (+,0). A negative voltage moves it to the left. Up and down are accomplished with positive or negative voltages to the vertical deflection (Y) coil.

The deflection coils are driven with the same kind of circuitry some audio amplifiers use. Imagine that the game puts out pre-amp analog levels and that the monitor amplifies and displays the output. There are some vector monitors (the ones used in the Cinematronics games) that are digital in nature and have a significantly different design. Do not assume that anything discussed in this document applies to these monitors since much of it does not.

The third portion of a vector monitor is what (at least by Atari) is called the "Z" amplifier, which controls the brightness. There is a "Z" amplifier for each electron gun, which means that black and white monitors have only one "Z" amp and color monitors have three.

To draw an asteroid or other object, the game shuts off the Z amplifier (or amplifiers) and applies the correct vector information to the X and Y amplifiers driving the deflection coils in order to move the beam to the desired location. Then the appropriate Z amp(s) are turned on to illuminate the screen and the vectors are modified to draw an outlined asteroid. On most monitors you can turn the brightness up to the point where the Z amp(s) do not completely shut down and you can see the full path of the electron beam as it flies around. The designers of Star Wars exploited these traces when laying out the dots for the star field pattern and the Death Star explosion to form "connect-the-dot" messages that says, "MAY THE FORCE BE WITH YOU" on odd waves from 1 to 31 and, "HALLY MARGOLIN RIVERA AVELLAR VICKERS DURFEY" (names of the programmers and other people involved with making the game) on even waves from 2 to 30 and on all waves from 32 to 99.

Multiple intensities are achieved by selectively reducing the output power of the Z amplifier(s). The lower power output, the brighter the screen illumination.

The first black & white vector hardware (Lunar Lander, Asteroids, etc.) allowed the game companies like Atari to produce high-resolution 768 by 1024 images. This was in the late 1970s when the gaming industry was just moving over to color monitors. Dave Theurer programmed the first color vector game, Tempest, specifically for a color vector monitor, but the color mask on color monitors did not permit the same high resolution. Additionally, since you cannot completely fill the screen with color on a vector monitor, vector games died with the advance of raster color games. Poor reliability was only a minor concern for the game companies.

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### How Does That Help Me With Repair?

What has been described so far applies to all vector monitors. Knowing how these things work helps greatly in trouble-shooting. For instance, deflection of the beam to the edges of the screen puts the greatest strain on the X/Y deflection circuits, so if your monitor has problems at the edges of the screen, something is weak in that area. The monitors make their own positive and negative DC from AC inputs so a reasonable thing to check would be the power supply. One of the main root causes of color vector monitor problems is a game lockup causing the monitor to go into extended periods with no input signal which fries it in short order. The two main problems for game board lockups are bad solder joints on the inter-board connectors (Tempest) and also noisy power supplies. You should replace the Audio Reg II power supply filter capacitors with 105 degree Celsius capacitors instead of 85 degree ones; the higher temperature capacitors last much longer and are more stable. The "Big Blue" capacitor in the transformer assembly should also be replaced as it causes numerous problems as it fails.

Vector monitors are also fussy about the quality of certain transistors. The X and Y deflection circuits are very much like audio amplifiers and tend to be hard on the big "bottle cap" transistors used in the final stages of amplification. The Atari vectors use a push/pull arrangement with NPN and PNP transistors for both the horizontal and vertical amplifiers. If you lose one of these transistors, you lose deflection in 1 of 4 directions depending on which transistor goes out.

There is another circuit in vector monitors that is very important and is called the spot killer. The spot killer circuit turns off the Z amp(s) (i.e., intensity of the deflection beam) if the X or Y circuits fail to cause enough deflection of the beam. The phosphors will become permanently damaged if the beam stays in one place for too long. When the spot killer is active a red LED on the deflection board lights. The spot killer is activated if the logic board does not supply the low level X and Y signals for the monitor to amplify, or if the voltage supply for amplification is not present. Therefore, the spot killer does not always indicate a monitor failure.

Along these same lines of protection, the P324 version of the Wells-Gardner has a circuit known as the over-voltage protection circuit. This circuit monitors the voltage at pin 4 of the focus assembly. If this voltage increases beyond a tunable threshold, a transistor fires turning off the oscillator. This shuts off the high-voltage power supply and completely kills the picture. It is

meant to keep your picture tube and other components (such as the high voltage transformer) from being destroyed in the event of a failure involving very large high-voltages.

A detailed Theory of Operation for the Wells-Gardner 19K6100 monitor is included here in Appendix C.

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### How Do Wells-Gardner and Amplifone Differ?

While this document will deal specifically with the Wells-Gardner 19K6100, it is important to note that Atari used two different (but pinout compatible) versions of the color vector monitor. The first and most common (but also the most unreliable) was the Wells-Gardner 19K6100 which was used in Tempest, Space Duel, and most Gravitars, Black Widows, and Major Havoc conversions. The second color vector monitor that Atari used was the Amplifone, which was used in Quantum, Star Wars and dedicated Major Havocs. The Amplifone monitor was also incorporated into a small number of Gravitar and Black Widow games. The Amplifone monitor was designed by Atari as a replacement for the Wells-Gardner 6100 to add (a) more reliability and (b) faster drawing speed.

Each monitor design has a slightly different electrical characteristic and tube shape that will cause games designed for use with the Amplifone to bulge out around the edges (a defect known as "barreling") when using a Wells-Gardner 6100 and similarly will cause games designed for use with the Wells-Gardner monitor to cleave inward around the outer edges (a defect known as "pincushioning") when using an Amplifone. This effect is quite minor and is really only noticeable when viewing the self-test screen as this draws a (perfectly straight) bounding box around the edge of the display. All game PCBs designed to work with an Amplifone monitor (i.e., Quantum, Star Wars and Major Havoc) do not have the pincushioning correction circuitry.

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### CRT Monitor Tubes

Here is the complete pinout of both the Wells-Gardner and Amplifone neck/tube.

1. G3 (focus grid)
2. not used
3. not used
4. not used
5. G1 (control grid)
6. G (green cathode)
7. G2 (screen grid; brightness)
8. R (red cathode)
9. H (heater)
10. H (heater)
11. B (blue cathode)

The Amplifone uses a neck socket that is the same as most other (non-vector) monitors, but the Wells-Gardner uses a different socket.

The Wells-Gardner 6100 series uses a 100-degree RCA picture tube (19VLUP22) while the Amplifone uses a 90-degree medium resolution Rauland tube (M48AAWOOX).

It is pretty easy to check to see if your tube is bad (it does not happen often, but it does happen). Pins on the tube neck are counted counter-clockwise starting at the gap (when looking at the backside of the tube). Pins 9 and 10 are at either end of the heater element. If you want to be absolutely certain about which pin is which, check the socket on your neck board (it should number all the pins). The heater is basically a very low wattage light bulb that emits the electrons, which are shot at the phosphor to make light. You should read a short (all right, not a short but a VERY low resistance) across pins 9 and 10 if your heater is OK. If you read an open, your tube is toast and there is nothing you can do (your light bulb is burned out). If your heater is OK, check to make sure that the heater pins are not shorted to any of the emitter cathodes (pins 6, 8, and 11). If you see a short then your tube has a serious problem but in many cases the short can be burned away. Call your local TV repair shop to see if they can "rejuvenate" it.

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### Deflection Board Pinout

Here is the complete pinout of the main connector (on the deflection board):

1. Red input (4.0V full on; 1.0V black level)
2. Green input (4.0V full on; 1.0V black level)
3. Blue input (4.0V full on; 1.0 black level)
4. Red GND (twisted pair with Red input)
5. Green GND (twisted pair with Green input)
6. Blue GND (twisted pair with Blue input)
7. X input (16V Peak-to-Peak; 2.5Kohms)
8. Y input (12V Peak-to-Peak; 2.5Kohms)
9. Not Used (Key)
10. X GND (twisted pair with X input)
11. Y GND (twisted pair with Y input)
12. Power GND
13. 25V RMS
14. Power GND
15. 25V RMS

**SPECIAL NOTE:** The 2nd printing of the Wells-Gardner Quadrascan Color X-Y Display manual (TM-183) has a typo in Figure 8 on page 11, which incorrectly identifies the heater as existing on pins 5 and 6. Strangely enough, both the 1st and the 3rd printings have the correct numbers.

## Manuals

Some words of caution about the Atari manuals. There are three versions of TM-183. If you are lucky enough to have a copy of the Wells-Gardner service manual for this monitor (as opposed to the Atari manuals), the parts list on page 31 has an error; it lists C916 as 0.35uF when it is really 0.035uF. It is labeled properly in the schematic on page 28. None of the manuals show all the different versions of this monitor.

The following describes the significant differences from the 2nd printing (without noting the layout changes such as replacing the crummy photographs with clear, sketched, exploded-view diagrams and minor rephrasing that are sprinkled throughout). All figures in the 3rd printing show later versions of all boards with the exception of Figure 13, which still shows the old deflection board (even though the parts list and all documentation refers to the newer versions; obviously a mistake). Section 3 (Adjustable Controls) describes a later version of the neck board (P328). Section 5 (Purity, Convergence, and Tracking Adjustments) is completely rewritten and is MUCH less vague and more complete (two pages longer). Section 6 (Details of Operation) has a section, which discusses the Input Protection Circuit and has a schematic (Figure 8), too. There is also a new section G (Over-Voltage Protection) that describes the new circuit in the later version of the HV unit (P324).

The 3rd printing fixes some typos in the deflection PCB parts list:

- "(R606, 706)" split off to "4.7K Ohms, +/-5%, ¼ W Resistor (R606)". (\*)
- "(R612, 613)" changed to "(R612, 613, 712, 713)".
- "(C604, 704)" changed to "(C104, 105, 604, 704)".
- "(C800, 801)" changed to "(C800-803)".
- "7-Circuit Header Connector (P100, 600, 700)" added.
- "(Q600-602)" changed to "(Q600-602, 700-702, 801, 802)".
- "(C600, 601)" changed to "(C600, 601, 605, 700, 701)".
- "4.7K Ohm, +/-5%, ¼ W Resistor (R813)" added.
- "(R602, 603)" changed to "(R602, 603, 607, 702, 703, 707)".
- "Ferrite Bead (FB600)" removed.

(\*) R606 is incorrectly listed in all manual versions as being 1/4W when in reality it is always 1/2W.

Unfortunately, the 3rd printing also introduces one error:

- "D104, 105" is changed from "Type-1N914B" to "Type-1N4001".

**DO NOT MAKE THE ABOVE SUBSTITUTION, AS IT WILL NOT WORK!**

D104 and D105 need to be 1N914Bs.

Some changes in the manual revisions were also due to part upgrades and/or additional circuitry:

- "(Q800)" changed to "(Q800, Q805)".
- "Type MPSA56 PNP Transistor (Q101)" changed to "PNP Transistor (Q101)".
- "Type-1N914B Diode (D104, 105, 600, 601, 700, 701, 801-804)" changed to "Type-1N914B Diode (D600, 601, 700, 701, 801-806, 809-812)".
- "Type-1N4001 Diode (D106, 107, 602, 702)" changed to

- "Type-1N4001 Diode (D104-107, 602, 702)".
- "Type-2N3904 NPN Transistor (Q804)" added.
- "10K Ohm, +/-5%, ¼ W Resistor (R812, 813)" added.
- "...2W Resistor (R106)" changed to "...3W Resistor (R106)".
- "5-Amp ... (F100, F101)" changed to "6.25 Amp ... (F100, F101)".
- "18K Ohm, +/-5%, ¼ W Resistor (R811)" added.
- "30K Ohm, +/-5%, ¼ W Resistor (R810)" added.
- "Germanium-Special Diode (D807, 808)" added.

### **Monitor Board Revisions**

There are several manufactured variations (and many more upgrade variations) of each of the three monitor boards (at least three for the deflection board and two for the neck and HV boards). The original designs are labeled P31X and the newer; more fault tolerant designs are labeled P32X. There are also deflection boards labeled P339 so there may be a whole 33X series as well. To add to the confusion, the Wells-Gardner service manual for the "19K6400 series color vector monitors" shows a P341 version of the neck board, a P324 version of the HV unit, and a P322 version of the deflection board. You will most likely never see any of these boards, as the 19K6400 was only used in Centuri's Aztarac.

Here is how to identify the versions of the Wells-Gardner 6100 boards. The deflection boards are P314, P327 and P339. Some P314s were upgraded most of the way to P327s with a small piggy-back PCB on wire "stilts" at the top of the PCB (see "Input Protection Circuit", described later in this document). The neck boards are P315 and P328 (P328 has a brightness adjustment in one corner) and the HV power supply boards are P316 and P329 (P329 has an LED, HV limit pot, and an extra electrolytic capacitor, C22, which is supposed to be 10uF at 63V). After much very disturbing feedback about the performance of the monitors, Atari had all the boards redesigned to be more robust. The P32X (and P339) versions are the newer versions of the boards.

A close inspection of the P339 deflection boards reveals that they are, in reality, P327s with a P339 sticker covering the part number! Make the following changes to your P327, put a new label on it and you will have a virtual P339! All other components are the same.

Differences between P327 and P339 deflection boards:

- C800-803 changed from .47uF @ 35V to 1uF @ 50V. (\*)
- R701 (1.3K) changed from +/-2%, 1/4W to +/-1%, 5W. (\*)
- R812-813 (1/4W) changed from 10K +/-5% to 5.6K +/-10%. (\*)
- Q604/Q704 (NPN) packages are upgraded from TO-92 to TO-202 (NTE49). (\*)



If you have a P314 deflection board, in addition to the changes listed above, you should upgrade the following parts:

Differences between P314 and P327 (P339) deflection boards:

- "Input Protection Circuit" added (see additional text later on).
- R106 (22 +/-10%) changed from 2W to 3W.
- Q101 (PNP) changed from Type MPSA56 (TO-92) to NTE50 (TO-202). (\*)
- F100, 101 (Slow-Blow) changed from 5A to 6.25A.

(\*) The Zanen "Get Well Kit" uses the original specs and does not include these upgrades.

Since the circuits are essentially the same, you can use 5 Amp fuses in P327/339 deflection boards without any problems. It is safe to say that you can (and more importantly, probably should) put 6.25 amp slow-blow fuses in your P314 boards at those two locations.

The very first run of P314 deflection boards had design defects in them, which were evidently identified after the PCBs were produced but before they were populated. If your deflection board says "85X0147" at the top then it is from the very first batch. Later batches say "85X0147C" (I have never seen an "A" or "B" suffix). The "C" revision has C605 (0.001uF +/-20%, Type-Z5F capacitor) in the upper right corner but since the original version of the deflection board does not have a spot for it, it was soldered piggyback onto R602. Some boards use a 0.005uF capacitor instead but you should change this to a 0.001uF if you have the soldering iron out anyway. The original version of the PCB has ZD100 labeled as R104 and ZD101 as R105, respectively, even though there are always Zener diodes in those spots regardless.

A comparison of the P315 and P329 versions of the HV PCBs and their documentation yields several conflicting differences, which are summarized below. The values marked with an asterisk (\*) are the ones you should use regardless of which PCB you are working on (with the caveat that the resistors should be "matched"; do not just change the value of one without changing the values of all the others. The capacitor changes can be made individually). If you use all of the asterisk marked values, you will upgrade your P315 to a P329 except that you, obviously, will not have the over-voltage protection portion of the P329 HV board.

Part #	Value in document or on PCB	Document/PCB referenced
<b>*C901</b>	<b>100uF @ 50V Alum Electrolytic</b>	<b>P329 HV unit PCB</b>
C901	100uF @ 35V Alum Electrolytic	P315 HV unit PCB
C901	100uF @ 50V	TM-183 3rd printing Schematic
C901	100uF @ 35V	TM-183 2nd printing Schematic
C901	100uF @ 100V	19K6400 service man Schematic
C901	100uF @ 35V Alum Electrolytic	TM-183 3rd printing Figure
C901	100uF @ 35V Alum Electrolytic	TM-183 2nd printing Figure
C901	100uF @ 50V Alum Electrolytic	TM-183 3rd printing Parts List
C901	100uF @ 35V Alum Electrolytic	TM-183 2nd printing Parts List
C901	100uF @ 100V Alum Electrolytic	19K6400 service man Parts List

<b>*C902</b>	<b>100uF @ 50V Alum Electrolytic</b>	<b>P329 HV unit PCB</b>
C902	100uF @ 35V Alum Electrolytic	P315 HV unit PCB
C902	100uF @ 50V	TM-183 3rd printing Schematic
C902	100uF @ 35V	TM-183 2nd printing Schematic
C902	< part is not referenced >	19K6400 service man Schematic
C902	100uF @ 35V Alum Electrolytic	TM-183 3rd printing Figure
C902	100uF @ 35V Alum Electrolytic	TM-183 2nd printing Figure
C902	100uF @ 50V Alum Electrolytic	TM-183 3rd printing Parts List
C902	100uF @ 35V Alum Electrolytic	TM-183 2nd printing Parts List
C902	< part is not referenced >	19K6400 service man Parts List
<b>*C905</b>	<b>33uF @ 160V Alum Electrolytic</b>	<b>P329 HV unit PCB</b>
C905	33uF @ 160V Alum Electrolytic	P315 HV unit PCB
C905	33uF @ 150V	TM-183 3rd printing Schematic
C905	33uF @ 150V	TM-183 2nd printing Schematic
C905	33uF @ 63V	19K6400 service man Schematic
C905	33uF @ 150V Alum Electrolytic	TM-183 3rd printing Figure
C905	33uF @ 150V Alum Electrolytic	TM-183 2nd printing Figure
C905	33uF @ 63V Alum Electrolytic	TM-183 3rd printing Parts List
C905	33uF @ 150V Alum Electrolytic	TM-183 2nd printing Parts List
C905	33uF @ 63V Alum Electrolytic	19K6400 service man Parts List
<b>*C915</b>	<b>.001uF +/- 20% Type Z5F</b>	<b>P329 HV unit PCB</b>
C915	.001uF +/- 10% Ceramic	P315 HV unit PCB
C915	.001uF	TM-183 3rd printing Schematic
C915	.001uF	TM-183 2nd printing Schematic
C915	.001uF	19K6400 service man Schematic
C915	< part's value is not shown >	TM-183 3rd printing Figure
C915	.001uF	TM-183 2nd printing Figure
C915	.001uF +/- 20% Type Z5F	TM-183 3rd printing Parts List
C915	.001uF +/- 10% @ 500V Ceramic	TM-183 2nd printing Parts List
C915	.001uF +/- 20% Type Z5F	19K6400 service man Parts List
C919	< part is not referenced >	P329 HV unit PCB
C919	< part is not referenced >	P315 HV unit PCB
C919	< part is not referenced >	TM-183 3rd printing Schematic
C919	< part is not referenced >	TM-183 2nd printing Schematic
C919	< part is not referenced >	19K6400 service man Schematic
C919	< part is not referenced >	TM-183 3rd printing Figure
C919	< part is not referenced >	TM-183 2nd printing Figure
C919	< part is not referenced >	TM-183 3rd printing Parts List
C919	10uF @ 300V Alum Electrolytic	TM-183 2nd printing Parts List
C919	< part is not referenced >	19K6400 service man Parts List
<b>*R901</b>	<b>3.9 +/- 5%, 3 W</b>	<b>P329 HV unit PCB</b>
R901	2.2 +/- 5%, 2 W	P315 HV unit PCB
R901	3.9, 3 W	TM-183 3rd printing Schematic
R901	2.2, 2 W	TM-183 2nd printing Schematic
R901	3.9,	19K6400 service man Schematic
R901	2.2 +/- 5%, 2 W	TM-183 3rd printing Figure
R901	2.2 +/- 5%, 2 W	TM-183 2nd printing Figure
R901	3.9 +/- 5%, 3 W	TM-183 3rd printing Parts List
R901	2.2 +/- 5%, 2 W	TM-183 2nd printing Parts List
R901	3.9 +/- 10%, 3 W	19K6400 service man Parts List

<b>*R907</b>	<b>3.9 +/- 5%, 3 W</b>	<b>P329 HV unit PCB</b>
R907	2.2 +/- 5%, 2 W	P315 HV unit PCB
R907	3.9, 3 W	TM-183 3rd printing Schematic
R907	2.2, 2 W	TM-183 2nd printing Schematic
R907	< part is not referenced >	19K6400 service man Schematic
R907	2.2 +/- 5%, 2 W	TM-183 3rd printing Figure
R907	2.2 +/- 5%, 2 W	TM-183 2nd printing Figure
R907	3.9 +/- 5%, 3 W	TM-183 3rd printing Parts List
R907	2.2 +/- 5%, 2 W	TM-183 2nd printing Parts List
R907	< part is not referenced >	19K6400 service man Parts List
<b>*R910</b>	<b>6.8K +/- 5%, 1/4 W</b>	<b>P329 HV unit PCB</b>
R910	12K +/- 5%, 1/4 W	P315 HV unit PCB
R910	6.8K	TM-183 3rd printing Schematic
R910	12K	TM-183 2nd printing Schematic
R910	12K	19K6400 service man Schematic
R910	< part's value is not shown >	TM-183 3rd printing Figure
R910	12K +/- 5%, 1/4 W	TM-183 2nd printing Figure
R910	6.8K +/- 5%, 1/4 W	TM-183 3rd printing Parts List
R910	12K +/- 5%, 1/4 W	TM-183 2nd printing Parts List
R910	12K +/- 5%, 1/4 W	19K6400 service man Parts List
<b>*R911</b>	<b>4.7K +/- 5%, 1/4 W</b>	<b>P329 HV unit PCB</b>
R911	6.8K +/- 5%, 1/4 W	P315 HV unit PCB
R911	4.7K	TM-183 3rd printing Schematic
R911	6.8K	TM-183 2nd printing Schematic
R911	6.8K	19K6400 service man Schematic
R911	< part's value is not shown >	TM-183 3rd printing Figure
R911	6.8K	TM-183 2nd printing Figure
R911	4.7K +/- 5%, 1/4 W	TM-183 3rd printing Parts List
R911	6.8K +/- 5%, 1/4 W	TM-183 2nd printing Parts List
R911	6.8K +/- 5%, 1/4 W	19K6400 service man Parts List
<b>*R926</b>	<b>2.2 +/- 5%, 3 W</b>	<b>P329 HV unit PCB</b>
R926	2.2 +/- 5%, 2 W	P315 HV unit PCB
R926	2.2, 2 W	TM-183 3rd printing Schematic
R926	2.2, 2 W	TM-183 2nd printing Schematic
R926	2.2, 2 W	19K6400 service man Schematic
R926	< part's value is not shown >	TM-183 3rd printing Figure
R926	2.2, 2 W	TM-183 2nd printing Figure
R926	2.2 +/- 5%, 2 W	TM-183 3rd printing Parts List
R926	2.2 +/- 5%, 2 W	TM-183 2nd printing Parts List
R926	2.2 +/- 5%, 2 W	19K6400 service man Parts List

The good part about the three basic monitor components: deflection board, neck board, and HV board is that they are all interchangeable as units and they are all connectorized. In other words, if you have one working monitor you can try the boards from your bad monitor (one at a time) even if the boards are not exactly the same. Also, the most often failing components are common to the different versions of the boards. If you have a vector monitor based game, it is really worth the effort and money to have a spare monitor handy (even if it is being used in another vector game) so that you can isolate exactly which board is bad when (not if) you have a failure.

If you feel uncomfortable about poking around inside a running game cabinet, or you cannot reach certain areas of the monitor, there is a simple solution. Make a monitor 'extender' cable that will plug into the game harness. This way, you can have the vector monitor under test located several feet from the game and potentially in a better/safer working environment.

**NOTE:** There is one small exception to the universal compatibility rule for the neck board PCB. The P328 version uses a third (purple) wire running from the innermost (normally unused) pin of connector J501 to pin 8 of J900 on the HV unit. Without this wire, the new brightness control on P328 is disabled. Also, and this is **VERY** important, if you are using a P328 PCB on a P315 wiring harness (or vice-versa), you have to turn the J501 connector upside down. Do not worry too much about remembering the orientation because the connector's pins are gapped differently so it will only fit onto each PCB one way (the right way) without severely bending the pins on the neck board PCB (i.e., it is idiot-proof). This means that for testing purposes, you can swap boards and everything will be fine, but if you want the functionality that the P328 potentiometer provides, you must remove the associated wiring harness that connects to J501 along with the board (or else add a new wire to the existing harness on the destination monitor). Without this wire, a P328 will behave exactly like a P315 and the brightness control pot will do nothing.

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## DIAGNOSING YOUR WELLS-GARDNER MONITOR

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All the documentation and boards for the Wells-Gardner 6100 monitors refer to "X" as the longer axis and "Y" as the shorter axis, independent of how the monitor is oriented in your game. Confusion arises because the game PCB will refer to "X" as the axis parallel to the floor and "Y" as the axis perpendicular to the floor and this is dependent on how your monitor is oriented. Why is this important to distinguish? Well if you notice that there is a horizontal line on your Te mpest screen and you go to figure out why you are not getting any "Y" deflection, you must check the "Y" portions of the vector generator circuitry on your game PCB but you need to check the "X" portions of your monitor deflection board!

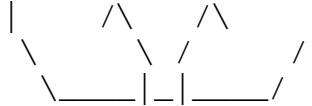
If your monitor is not working, the very first thing you should do is check all the fuses in the machine with a meter. There are four on the deflection board and most Atari machines have seven more in the power supply at the bottom of the machine (six in a fuse block on the left, and one under a black cap on the right). Remember to check resistance on the fuse **HOLDER** not on the fuse itself. Many times a fuse will meter out OK but it is not making good contact with the fuse holder so it is not conducting. If you always put your probes on the fuse holder, a bad contact will never trick you. Many times fuses that are not conducting can be made to do so merely by reseating them after pinching the fuse holder clips tighter. Sometimes the clips are corroded and need to be cleaned first. The wire contacts connecting to the fuse holders may also not be conducting properly so you may want to move your leads and test there to cover all your bases. This rule applies to fuses in general anywhere you find them.

Before you begin work on your monitor, you must 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. It is extremely inadvisable to work on the HV section while the machine is turned on or even plugged in; **always** unplug the game before you work on the HV section.

I would 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 a 1 Meg ohm resistor somewhere in your connection. 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**) work the end of the screwdriver under the big suction cup on the top of the tube until you hit metal. 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.

You may want to leave the game plugged in **BUT TURNED OFF** for this step so that you can ground to the earth instead of just the chassis. If you plan to remove the HV unit, you must disconnect the secondary anode from the tube, which is a little tricky if you have never done it. Under that suction cup is a double-barb connector. The barbs extend perpendicular to the wire as it enters the suction cup. Simply pinch the suction cup as best as you can and wiggle it back and forth while pushing in at the edges and pulling out at the center. It will eventually come off. Here is a cut-away depiction of the anode; the wire will run perpendicular to this view (i.e., towards/away from the reader):



**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.**

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## CHASSIS TRANSISTORS

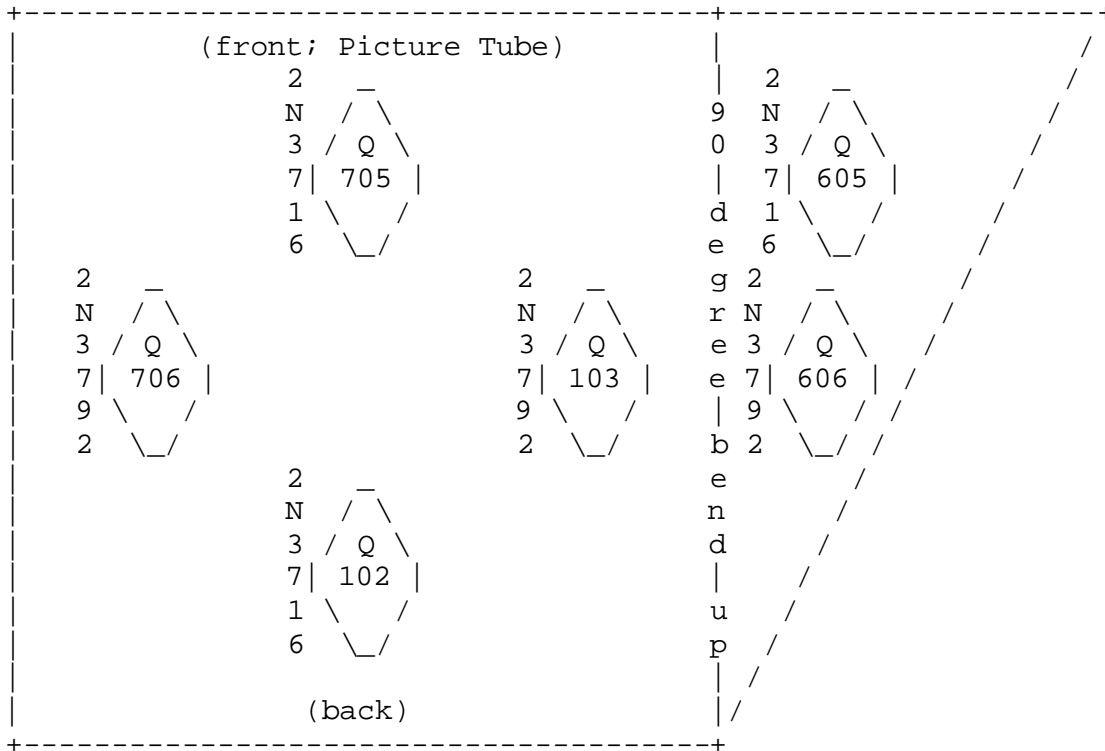
There are two types of the large chassis deflection transistors on the Wells-Gardner 6100. They are the six large TO-3 package transistors mounted to the chassis ("package" refers to the physical description of the transistor, **NOT** the electrical characteristics). The three NPNs are 2N3716s and the three PNPs are 2N3792s, which are all in the final stages of the deflection amplifiers or the power supplies. The deflection amps are like an audio push-pull amplifier and to power these amps the monitor takes AC in and produces plus and minus DC voltages.

- 2N3716 (NPN); widely available replacement is NTE284
  - Q705: +X (right) for horizontal; +Y (top) for vertical
  - Q605: +Y (top) for horizontal; -X (left) for vertical
  - Q102: output positive (+) power supply
  
- 2N3792 (PNP); widely available replacement is NTE285
  - Q706: -X (left) for horizontal; -Y (bottom) for vertical
  - Q606: -Y (bottom) for horizontal; +X (right) for vertical
  - Q103: output negative (-) power supply

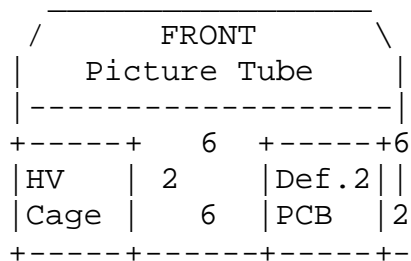
**SPECIAL NOTE:** Q705 and Q102 lie in such close proximity that it is not uncommon for their respective transistor sockets to be switched at some point, which obviously swaps the corresponding functionalities (symptoms).

This gives reference frames for when the monitor is mounted horizontally (for games like Space Duel and Major Havoc conversions) and vertically (for games like Tempest).

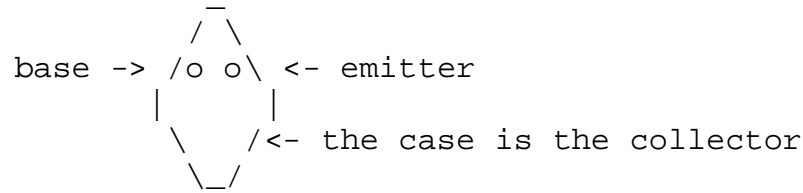
An easy way to remember which kind of transistor goes where is to know that each connector has one of each kind; the 2N3716s are on pins 1, 3, and 4 (key at pin 2) and the 2N3792s are on pins 5, 6, and 7. If the wiring has not been altered, all 2N3716s are connected to the yellow, green, and red wires and all 2N3792s are connected to the purple, blue, and white wires. Here are 2 diagrams of the layout as viewed from the top:



or, more simply (where 2 = 2N3792 and 6 = 2N3716):



These transistors often go bad and here is a quick lesson on how to check a transistor with a meter. Unplug the red plugs from the deflection board to isolate the transistor from the circuit. From the bottom of the transistor, the configuration is:



Pretty crude but you get the idea. Test the deflection transistors as described earlier, one by one, by placing the multi-meter leads on the tops of the pins of the red connectors or on the transistors themselves. Neither method requires the removal of the transistor from its socket so do not bother. You do, however, need to disconnect the associated connector from the deflection board prior to testing. A detailed discussion of transistor testing is included in Appendix F.

So what symptoms go with what? Well if only one of the deflection amplifying transistors goes bad, then you will lose that corresponding half of the screen. For example, if Q705 went bad in a Tempest game, you would be missing the top half of your screen. It will not actually be gone; it will be collapsed into a line across a 0 axis of the screen. If more than one chassis transistor goes or either of the power transistors (Q103 or Q102) goes you will get no picture because the spot killer turns on (and the LED on the deflection board lights) and shuts down the electron beam. Checking these chassis transistors is one of the first things you should do if parts of your screen are missing or your spot killer is on.

When replacing these chassis transistors, make sure the socket is centered. Do not forget the little rubber or clear mica (plastic) insulator that was stuck to the chassis or to the bad transistor you just removed. You need to grease this insulator on both sides with a special grease called Silicone Heat Sink Compound. The grease is not strictly necessary but helps transfer the heat from the transistor to the chassis so the transistors last longer. The grease is relatively expensive, so you may want to just buy new insulators (they should be about 10 cents each) because most come "pre-greased".

Do not be nervous about remembering the orientation of the transistors; the pins are off centered in order to make the connection somewhat idiot-proof (see earlier ASCII picture. They are obviously "handed" but can be put in upside-down; it is a tight fit and hard to do but possible). Also, after you replace any chassis transistors and before you power the game up, use your meter to make sure none of the transistor cases are shorted to the chassis. A continuity test is perfect for this check. Misalignment of the transistor is very common and will cause fuses to blow and will probably destroy the transistor. If any part of the transistor is touching the chassis you are asking for trouble.

If the chassis transistors are OK, most missing pictures are due to problems with the deflection board (whereas most distorted pictures are due to bad capacitors in the HV unit).



### Deflection Board

On the deflection board, the most common failures are Q100 and Q101 and when these fail they take R100 and R101 (respectively) with them. These transistors are part of the + & - power supply circuit and are often bad when the resistors are really burnt. To properly test these transistors, they should be desoldered and removed from the PCB. Even in-circuit and not isolated from other components you can still get a pretty good idea with a multi-meter (analog meters work best since digital meters show infinite resistance most of the time) if the transistors are bad as transistors tend to fail catastrophically. In other words, they usually completely short (0 Ohms) or open. If you see 0 Ohms where there should be an open circuit or 2.5K Ohms, then the transistor is probably shorted. If you see greater than 2.5K Ohms when the reading should be in that range the transistor is probably open. When these transistors are bad, they usually show a large crack in the case if you look closely at them.

Replace Q100 with the same type transistor, but if Q101 is bad (and even if it is not), you are **STRONGLY** suggested to upgrade it to a larger transistor that will handle more current. **ALWAYS** replace Q101 with a TO-202 package instead of the much smaller TO-92 package that the board comes with. In fact, the P327, and P339 versions of the deflection board were manufactured with this upgrade. Use an NTE50 or equivalent.

Even though these transistors (and resistors) are the most common failures on the deflection board, you will most likely **NEVER** see them go bad after Q101 is upgraded to a NTE50. If you cannot find the generic parts, a common modern day replacement for MPSA06 (Q100) is NTE287 and a common modern day replacement for MPSA56 (Q101) is NTE159 (but I cannot stress enough the utility of going with the larger replacement for Q101). Upgrading Q101 should always be the first thing you do to any deflection board; replacing it before it fails will save you from having to replace the other parts that go bad when it does fail.

It is unusual, but sometimes some of the four heat sinked transistors on the deflection board will die (Q603; Q604; Q703; Q704). If any of these transistors are bad, you will usually get no picture at all, but you will see "background brightness" that lets you know some electrons are being thrown at the tube. Be sure to check the resistors and diodes around any bad transistors you find.

Very infrequently, you may have problems with some other transistors in the X/Y amp section of the board. Most of the other transistors that populate the deflection board (Q600-602, 700-702) are type TPS98 and are not easily found anymore. The good news is that TPS98 is equivalent to the PN3569 and the ECG or NTE 194. All Electronics (800-826-5432) usually has PN3569 transistors in stock.

Once in a while you will see D104 or D105 open or shorted as well.

### **Neck Board**

The neck board very seldom has problems. Occasional faults will be caused from mishandling where someone has broken some of the pots that control the RGB drives. Check the pots if you are missing a color. If you are blowing your 5A fuses and your other boards are OK, check C503 (33 uF @ 250V). If this is open, shorted or cold soldered, it will cause the 5A (or 6.25A depending on your board) fuses to blow.

The wire marked GRY next to the tube socket on neck board is a grounding wire. The wire bolts to the aluminum monitor frame between the HV cage and the deflection board.

### **HV Supply**

Last is the HV supply. The HV transformer (or flyback) is fairly robust, and does not fail very often. Normally, HV failures are due to a semiconductor or capacitor failure. Unfortunately, replacement HV transformers are unavailable, although the Atari-designed Disco raster monitor contains an identical HV transformer. The Disco monitors are very difficult to find as well.

You will frequently see HV units with the protective metal shield removed from the case and discarded in attempt to keep it cooler. The shield reduces the EMF emissions and the picture distortions that go along with it. If your picture is slightly distorted, this may be the cause. If you upgrade the HV section as outlined in this document, your monitor should run much cooler and removing the metal shield should be unnecessary. However, it is always a good idea to run your games with the back door removed to allow for proper airflow.

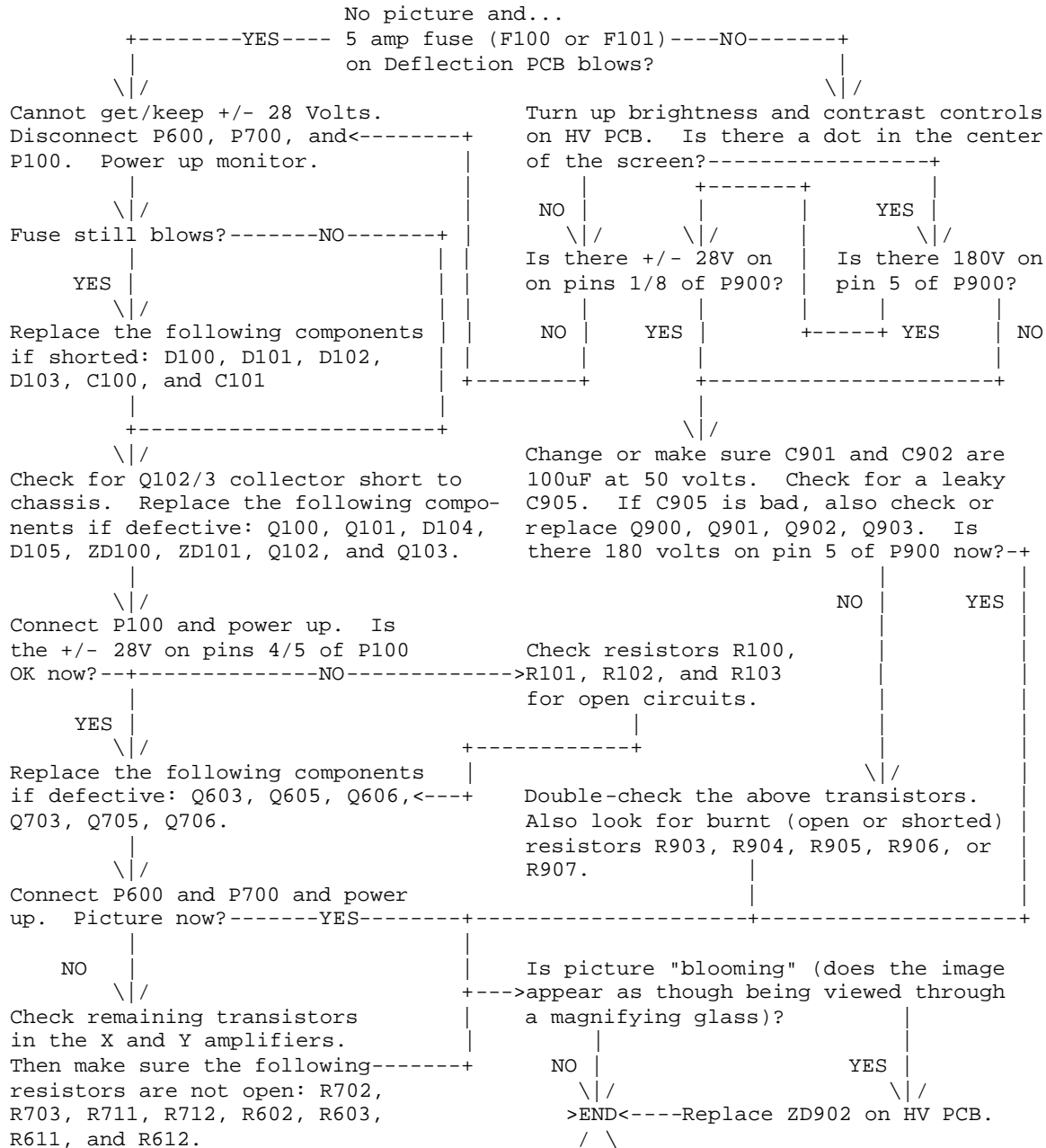
### **Solder Joints**

Also watch for broken solder joints at the base of the connector pins for all the major connectors. You tend to rock the plugs back and forth when you pull the connectors off and this often cracks the solder joints to the circuit boards, which were poorly soldered to begin with. You may also want to check each pin for continuity with the next component on its trace line (and also with adjacent pins), and remove and resolder any dubious connections. While you are at it, resolder the three pins of the PTC thermistor (in the middle, along the left edge of the deflection board) as they are almost always loose for some reason.

## TEMPEST DISPLAY TROUBLESHOOTING (FLOWCHART)

The following flowchart is excerpted from the **Star\*Tech Journal**, which means it was originally in an Atari Field Service Bulletin.

Most problems in the Tempest display can be found by following the procedure shown in the chart below.



**CAUTION:** When replacing the transistors mounted on the chassis, make sure the pins do not short to the chassis. If the chart procedures do not solve your problem, call Atari Field Service.

We will finish off with a troubleshooting guide broken down by symptoms. **Much of the rest of this section is a transcription of repair notes from a Wells-Gardner technician.** Just because your symptom matches something in here is no guarantee that what he found wrong is the same thing that is wrong with your board, but it is a good place to start. Most of the problems he listed in his notes were due to manufacturing defects or incompetent repair work. Obviously, if your monitor was working OK and then simply stopped, those things are not likely be your problem.

---

### GENERAL MONITOR PROBLEMS

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#### **Weirdness between player one and two (Tempest machines only)**

Display "implodes" during intermission screen between player one and player two and sometimes on the "figure 8" levels (Tempest machines only): I thought I knew what was causing this but upon further evaluation, my solution did not make sense (although it did work for me the only time I had this problem). Until I get another board to fix that has this problem, I only have general advice on how to avoid the problem. Adjust your game board and "shrink" the Y deflection some and this should help. There are 3 sets of ROMs for this game and the "compact" ROM set (revision 3 - only half the ROM sockets are used) is slightly different (the intermission screen has some other stuff such as the copyright and credits information at the bottom of the screen which "balances" it out) so the spot killer will not get confused and decide that the bottom half of the screen is wiped out. These PCBs do not normally experience this difficulty.

---

### DEFLECTION PROBLEMS

---

#### **Symptom: Fuses F100 [and F101] blow on power up**

Fuses F100 and/or F101 on the deflection PCB are blowing as soon as game is powered up. This happens to a lot of people after they replace the chassis transistors. Sometimes they forget to put the mica (plastic) insulator on the transistor before installing them, which allows the transistor's case (collector) to short to the chassis (ground). A short can be present even if the insulator was installed if the conditions are just right. Check all chassis transistors, particularly Q102, Q103, to make sure the cases are not shorted to the chassis.

**Symptom: Spot Killer ON and display dead**

Check the fuses first. If they are OK, then check the six transistors mounted on the chassis as described earlier. If you find at least two of the deflection transistors or one of the power transistors bad, then that is definitely tripping the spot killer. A good trick to figure out where the problem exists is to turn your brightness up all the way and see what your picture looks like. The spot killer does not turn the Z signal all the way off so if you turn the brightness all the way up, you should be able to see a very faint picture. Based on what the picture looks like, you can decide which half of the circuit is causing the problem (either the X or Y portion). If you know it is a problem on your deflection board (i.e., swapping in another board makes the monitor work) then check R808 (X) and R809 (Y) to make sure they are not open. These resistors allow current to flow to the spot killer circuitry and if they open then the spot killer thinks something has happened to the amplifier circuitry so it kicks on. You can tell if this is your problem by turning the brightness up all the way; if you see a complete picture, then this may be your problem. If all this is OK then you probably have a game board problem, particularly if you are unable to "play" the game (see the credit lights blink after you punch up credits and hear the game sounds after you push start).

---

**Symptom: Display dead after a Cap Kit**

Cap kit installed but still no picture (spot killer may or may not light).

The problem is most likely Q603. Occasionally you will see Q603 (Q703), or Q604 (Q704) go bad. If one of the transistors does die, be sure to check the resistors and diodes around it, particularly R611 (R711), R612 (R712), and D602 (D702). A common modern day replacement for MPSU57 (Q603/Q703) is NTE189 and the part for MPSU07 (Q604/Q704) is NTE188. These should be greased where they touch the heat sink (like the chassis transistors) to improve heat dissipation. If you are having trouble with these failing, you might want to beef them up by using TO-202 package upgrades to NTE50 (MPSU57) and NTE49 (MPSU07).

---

**Symptom: No X (or Y) deflection**

I have seen two deflection boards like this. On one, the problem was that R710 (R610 for Y) was open. How you fry a 10-Watt resistor and nothing else in the circuit is beyond me; perhaps the PCB was dropped and it landed on R710. Anyways, you can test it in circuit and if you do not see a virtual short then replace it. On the other deflection board, the problem was a loose 1/2 watt, 2.2k resistor (R606) in the Y amp. Its intermittent contact was causing the spot killer to flicker, and was causing picture to collapse. The solder joint did **NOT** look cold or bad, and the resistor tested fine. These resistors take a good deal of heat, and the traces they are on can heat up pretty good. I found that it was loose by pushing on the top of the resistor a bit, and began to hear a "tick" where the resistor lead was touching the solder joint. Probably the trace's

temperature (and the resistors heat) caused the resistor lead to separate in the hole on the board, while it still looked and tested fine.

**NOTE:**

Jeff Young from World Wide Distributors in Grand Rapids, MI reported some words of caution about these resistors on Page 3 of the November 1982 issue of the **Star\*Tech Journal**:

"After fighting a problem in the **Atari** "Tempest" for three days and finding a silly mistake, I thought I should write to you. Wells-Gardner Monitors #19K6101 use a 1.5-ohm 10-watt resistor in location R610-R710. If you replace these resistors with standard wire-wound units, the monitor will exhibit the "shakes" or "jitters" referred to in **S\*TJ**, Vol. 4, No. 7 "Service Tips", but the symptoms will be misleading in that R601 and R701 must be **NON-INDUCTIVE**. Please tell your readers about this problem as **Atari** and Wells do not point out this requirement in the parts listing, and only put down the initials, "N.I" on the schematic."

---

**Symptom: R101 burns on power up**

R101 glows red-hot and burns up to an open circuit every time the game is powered up (known good deflection board; works in good monitor).

The resistor is burning up because of runaway current from the HV unit. You can confirm this by replacing R101 and testing the deflection board in a known good monitor (or by putting a known good HV unit in the monitor that is acting up); if R101 does not burn up then you know the HV unit is the culprit. Whenever this happened to me, R903 on the HV unit has been the cause. It will sometimes short and this causes so much current to flow to the deflection board that the puny 15-Ohm resistor burns up. If this goes on for too long, Q101 may fail or occasionally R901 will burn up to an open circuit.

---

**Symptom: Accidentally shifted P101 over 1 pin and power up machine**

Although most of the connectors/connections are idiot-proof, P101 is not (due to the poor placement of the key pin as the **LAST** pin). It can be connected shifted over 1 or more pins to the right (although it should be obvious if you shift it more than 1 pin). After shifting it 1 pin and frying the PCB, when you hook it up correctly, the spot killer LED will glow at 50% brightness and you will get no video. The following parts will need to be replaced; Q703, R711, D702, and C703 (C703 should be OK but replace it just in case if you can find a new one). Some caps may have blown on the HV board, too.

**Symptom: Display bad only in lower right quadrant**

Distorted image, which exists ONLY in the lower right quadrant of the display.

I have seen this several times and the problem has always been a bad ZD101. Much of the time this causes R101/Q101 to fry and spot killer comes on.

---

## NECK (CRT) BOARD PROBLEMS

---

### **Symptom: Colors Drop In and Out (ZD500 open on neck board) or Display is too bright**

On neck board:

- R515 (broken wire to R531)
  - C503 (reversed; may toast R527)
- 

### **Symptom: No Red**

On neck board:

- R500 (open)
  - R502 (shorted to nearby component)
  - R510 (open)
  - R511 (open or wrong value)
  - R520 (open; red color can be seen but is very weak)
  - R529 (open or wrong value)
  - broken wire at R517 control
- 

### **Symptom: Only Red**

On deflection board:

- D802 (reversed)
- 

### **Symptom: Red Too Bright**

On neck board:

- R501 (wired wrong)
  - R504 (open)
  - Q500 (collector shorted to base)
- 

### **Symptom: Red does not turn off when dimmed all the way**

On neck board:

- Q500 (reversed or broken wire)
  - R513 (shorted to C500)
  - R519 (open)
  - R529 (open)
-



**Symptom: No Green**

On neck board:

- R503 (open)
- R513 (wrong value)
- R520 (wrong value; was 22)
- R530 (open)
- Q501 (bad or base shorted to emitter)
- broken wire at R513
- jumper from R511 to R513 missing

On deflection board:

- neck board connector wrong type
  - broken green wire from deflection board to neck board
- 

**Symptom: Only Green**

On neck board:

- Q503 (reversed or wired wrong)
- 

**Symptom: Green Too Bright**

On neck board:

- Q501 (collector shorted to emitter)
- 

**Symptom: No Green + Blue Is Red**

On neck board:

- R500 (shorted to R529 or shorted to R502)
- 

**Symptom: Green Is Red**

On neck board:

- R502 (shorted to R500)
-

**Symptom: Green Does Not Turn Off When Dimmed All The Way**

On neck board:

- R512 (shorted to nearby wire or connecting wires wrong)
- R519 (connecting wires wrong)
- R520 (open)
- Q501 (reversed, open, shorted, or broken wire to base)

---

**Symptom: No Blue**

On neck board:

- R504 (wrong value)
- R515 (open or wrong value or broken wire or swapped with R505)

On deflection board:

- D803 (bad) or neck board connector wired wrong)

---

**Symptom: Only Blue**

On deflection board:

- red lead in neck board connector broken

---

**Symptom: Blue Does Not Turn Off When Dimmed All The Way**

On neck board:

- R504 (open)
- R521 (open)
- R522 (open)
- R529 (open)
- Q502 (reversed, emitter open, or shorted to nearby component)

---

## HIGH VOLTAGE BOARD PROBLEMS

---

### **Symptom: Display Unstable**

The image is extremely shaky and unstable and lines that should be straight have periodic wiggles along their length that make them look like an EKG (the distortion is sort of like when you watch TV with a bad antennae and lines "walk" around on the screen).

Replace C901, C902, and/or C905 in the HV supply. If one of these is bad then the rest of the electrolytic capacitors are probably in pretty poor condition too, so I generally replace all of them. Make sure the replacements are rated at as least as many "working volts DC" WVDC and have as least as many microfarads. It does not hurt to replace a 22uF @ 50V capacitor with a 50uf @ 100V if that is all you have around. More Voltage capacity is equal or better but it is best to keep the capacitance the same if you can. Also when ordering and replacing these, be aware that they are polarized and not idiot-proof; be sure to put them in the circuit so that they are oriented properly. The casing will clearly indicate either the negative or the positive terminal (but typically not both) and the industry convention is for the positive lead of the capacitor to be longer than the negative lead. Be aware that P329 has an extra capacitor (C22) that may not be shown in your manual; its value is 10uf @ 63V.

---

### **Symptom: Picture Too Bright But All Else OK**

The picture is overly bright and all parts check out OK.

Look for a broken circuit board trace between pin 6 of the high voltage transformer and the anode of diode D901. This trace is prone to breaking open. It is probably easier to just add a jumper and see if it solves the problem or else check the connection (with board removed) with a meter to make sure it is a short.

---

### **Symptom: R925, R919, and R917 are Smoked**

- Q905 (shorted; T901 primary may be shorted, too)

---

### **Symptom: R901, R907, R903 are Smoked and Q902 and ZD901 are Shorted**

- Q901 (reversed)

---

**Symptom: Top of Q901 Blowing Off**

- R902 (open)
- Q900 (inserted or wired wrong; if emitter shorted to base then Q901, Q902, and ZD901 get fried)
- Q901 (shorted)
- Q902 (shorted)
- ZD901 (shorted)

---

**Symptom: Top of Q902 Blowing Off**

- Q901 (reversed)

---

**Symptom: R901 and R907 are Smoking**

- Q902 (shorted)
- Q906 (red and white leads interchanged)

---

**Symptom: Only R901 Smokes**

- Q906 (inserted wrong)
- Q900 (missing spacer or black lead open)

---

**Symptom: R903 Smokes**

- Q900 (shorted; will short ZD901, Q901, and Q902, too)

---

**Symptom: R904 Smokes**

- Q902 (shorted)

---

**Symptom: R907 Smokes**

- C902 (reversed)
- broken wire near R902

---

**Symptom: R908 Smokes**

- Q900 (white and black leads interchanged)

---

**Symptom: R912 Smokes**

- C910 (reversed)
- D901 (wrong value; perhaps ZD902)

---

**Symptom: R917 Smokes**

- Q905 (reversed)

If R920 smokes, check:

- C913 (bad; this can damage T901, too)

---

**Symptom: No HV (Very Dead Sound)**

No High Voltage (HV); you do not hear the crackling sound when you first turn the monitor on.

Check the transistors in the HV unit as described earlier. The ones I have seen fail most often are Q903, Q902, and Q901 though they are all suspect. These transistors will usually have cracks in the casing if they are bad so look closely at them. If all this stuff is OK, look at the electrolytic capacitors.

One quick errata: The parts list in Figure 15 of TM-183 lists all capacitors as fixed axial-lead when in reality, C905 is a radial-lead cap. These capacitors are designed to burst open (VENT) when they fail due to overburdening (but they sometimes do not) so as to be obvious to repairpersons. The top (for radial-leads) or the side (for axial-leads) will be open and some of the "guts" will be hanging out. When some capacitors go bad, they sometimes take the final output resistors R901 and/or R907 with them (but the resistors will look perfectly OK unless you check them with a meter).

Also check to make sure that connector J901 inside the HV unit is intact; one person reported that the plastic in his disintegrated on the inside and the wires came loose. If these are OK, check the following:

**Symptom: Waveform At IC901 Outputs; If Missing, Check:**

- R914 and/or R927 (wrong value)
  - R916 (broken wire)
- 

**Symptom: Waveform At Q906; If Missing, Check:**

- R926 (open)
  - Q906 (white wire open)
  - Q905 (emitter open)
- 

**Symptom: Waveform At Q905; If Collector Wrong, Check:**

- Q906 (broken black lead or broken wire at emitter)
- 

**Symptom: Waveform At R921; If Wrong, Check:**

- Q906 (white and black leads interchanged at socket)
- 

**Symptom: IC901; If No Input Voltages, Check:**

- Q900 (red and black leads reversed)
  - ZD901 (check voltage drop)
  - ZD900 (shorted)
- 

**Symptom: IC901; If Input Voltages Present, Check:**

- R914 (may be open; will cause waveform at C911 to not be x1K range)
  - C911 (open)
  - C915 (open)
  - C916 (open)
  - R901 (open)
  - R904 (open)
  - R905 (open)
  - R913 (open)
  - R923 (open)
  - R924 (open)
  - Q900 (shorted; +25 line is grounded by this)
  - Q904 (reversed, open, or missing)
-

- Q905 (reversed or collector wire broken)
- IC901 (defective, reversed, or unseated pins)
- T901 (pins unseated or primary winding shorted)
- Broken wire at R913
- Broken wire at R919
- Broken wire at base or collector of Q905
- Broken wires or pins at P900
- White wire disconnected at Q900
- Red wire disconnected at Q906

---

**Symptom: If You Are Also Blowing Any Fuses, Check:**

- C910 (reversed)
- R907 (open)
- R913 (shorted)
- D902 (wrong value)
- Red and white wires interchanged at Q906

---

**Symptom: F600 Blows Immediately On Powerup**

- Replace R612 if open.

---

**Symptom: ZD902 Keeps Failing**

The two pins of R918 (HV adjustment), which are in series with R910, must be set between 5K-6K volts. Otherwise, ZD902 will keep blowing.

**Symptom: Blooming/"Weak" Brightness/Low HV**

Since most of you do not have a HV probe, the most common symptom of low HV is that the screen looks as though you are looking at the center through a magnifying glass. This visual symptom is known as "blooming". I have seen several HV boards where ZD902 (150 volt Zener diode) goes bad and the HV drops from 19.5 kilovolts to around 10 kV. It is kind of like the electron beam moves slower with less HV giving the deflection magnets on the yoke more time to deflect the beam (but what is really happening is that there is not enough HV to strip all of the electrons off of the phosphor coating which causes the screen to develop a negative charge which then deflects new electrons which are expected to be hitting a screen with no charge on it). A new ZD902 and everything is better. NTE5100A is a common modern day replacement for this part. If ZD902 is OK, check the following:

- R915 (open)
- R922 (open or wrong value)
- Q900 (emitter pin open)
- Q902 (bad)
- Q906; white and black leads reversed (scope pattern is wrong)
- ZD901 (shorted)
- IC901; if scope output is a little high, replace IC901
- P900 (ribbon pin #7 broken)

---

**Symptom: HV Range Wrong, What Causes It?**

Normal HV range is between 16-24 kV

<u>HV Voltage Range</u>	<u>Look at</u>
??.-12.0 kV	Q902 (reversed)
7.0-10.0 kV	ZD902 (bad)
7.0-17.0 kV	ZD902 (bad)
7.0-22.0 kV	Q903 (bad)
9.0-18.0 kV	ZD902 (bad)
11.0-22.0 kV	ZD902 (bad)
15.0-18.0 kV	ZD901 (wrong value)
16.0-19.0 kV	ZD902 (bad)
18.0-27.0 kV	ZD902 (bad)
19.0-27.0 kV	R912 (wrong value)
21.7-30.5 kV	C916 (open)
28.0-20.0 kV	C916 (bad)



---

## FINE-TUNING THE PICTURE

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Now that you have a working monitor (and game board), it is time to fine-tune your picture. Before making any adjustments, turn your game on and let it warm up for at least 10 minutes. R918 is the HV adjust and unless you have an HV probe, you probably should not mess with it. If you have an HV probe, set the HV for 19.5 kV with zero beam current (i.e., with the game boards disconnected from the machine so that no input signals are being supplied).

Here is a trick for adjusting R918 without an HV probe. Hook up power to the monitor (but without any input signals from the game board) and let it warm up for about 10 minutes. Now measure the Video B+ voltage either at pin 5 of P900 on the HV board, or at J501 on the neck board (refer to your schematics). Adjust the HV so the B+ is 181v DC. Since the Video B+ and the 19.5 kV outputs are linked together, you will get the HV pretty close to perfect.

---

### HV Over-Voltage Protection Circuit

The later revision HV supplies (P329) have a circuit called the HV over-voltage protection circuit. It monitors the voltage of the focus assembly in the secondary circuit of T900. If the high-voltage at the anode of the picture tube increases beyond the threshold set by H.V. TRIP adjustment R930, this circuit shuts off the timer of IC901 and LED D903 turns on to indicate the over-voltage condition. Presumably, this was added to help discourage Tempest from eating HV transformers, as it is prone to do since they are by far the most expensive component in the game. If you know your HV is good, adjust R930 so that it is just beyond the point where LED D903 lights (so that the LED is off).

**NOTE:** The following adjustments are a 2-person job (unless you are very handy with mirrors) because it is nearly impossible to view the screen and turn the pots at the same time. When adjusting your monitor, all adjustments should be made exactly in the order as presented below as many of the adjustments have effects on other qualities and will cause you to have to go back and redo them if you change the order.

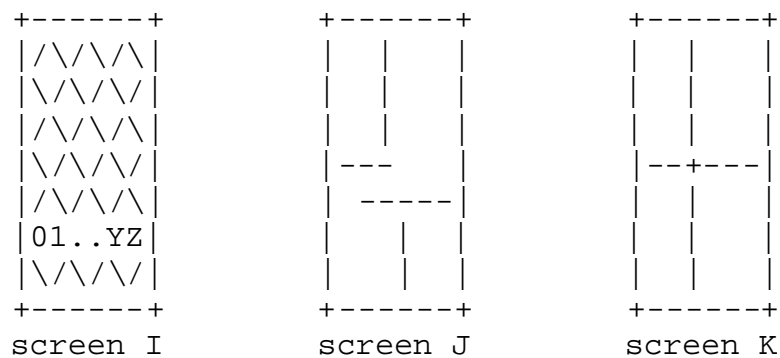
On the outside of the HV assembly are the focus and brightness adjustments. Adjust the focus until the picture is sharp then adjust the brightness just under the point where the dot in the center starts to show or just under the point where you can see the connecting lines between objects. Be careful not to get carried away with the brightness as you can do permanent damage to the phosphors in the tube.

## Size and Position

The manuals do not talk much about adjusting the size and positioning of your screen but that is easy to do. There are small potentiometers on the game board that are clearly labeled which control X and Y centering as well as X and Y size. There are no positioning or size adjustments on the monitor itself.

The following adjustments refer to the eight tiny blue and/or black potentiometers found on the game board. If your lines on the screen are not meeting at the "joints" properly or your text and numbers are not lined up properly on the statistics screen then you need to make these adjustments. This information is directly from the Tempest schematic diagram supplements (sheet 2, side B, 3rd printing) so locations/numbering/labeling of the pots may be different for other vector games but the instructions should be relatively portable...

All of the following controls exist in the Vector Generator section of the game PCB;  
**THEY ARE NOT IN THE MONITOR!**



- Enter self-test and advance screens to the diagonal crosshatch pattern [the one with the line of numbers and letters at the bottom; screen I].
- Adjust "CENTER" pots: Adjust X-CENTER (R147) and Y-CENTER (R167) so that the pattern is located at the middle of the screen.
- Adjust "SIZE" pots: Adjust X-SIZE (R150) and Y-SIZE (R168) so that the pattern exactly covers the whole visible screen.
- Adjust the "BIP" pots ["BIP" stands for "Bipolar." The BIP pots provide the offset current to convert the Unipolar DAC to one that provides a Bipolar output]: Adjust the X-BIP (R118) and Y-BIP (R117) so that the corners of the diagonal lines rest exactly on the sides of the outer rectangle. [NOTE: It may be easier to advance to the screen with the single large cross-hair on it to make the BIP adjustments; just make sure the lines meet at exactly the center. Using the cross-hair screen, you should try to make screen J look like screen K. Be careful when joining the lines in the middle that you do not overlap; it is **VERY** hard to notice this. You might want to make a big gap (go the wrong way) and then converge until the two segments just touch. Screens J, and K were added and are not shown in the original document.]

- Adjust the "LIN" pots: Adjust the X-LINEAR (R169) and Y-LINEAR (R165) so that the diagonal lines are straight. Since the "LIN" pots change the size of the displayed picture on the screen, you may have to readjust the "SIZE" pots in order to get the correct adjustment.

---

### White Balance Adjustment

(From sections of TM-183)

Here is a summary of the white balance adjustment sections of TM-183. This is paraphrased and abridged since the information was spread out over many pages. You should make these adjustments before you adjust the convergence and purity. *Do not adjust the white balance in reverse order because color changes do slightly impact those other adjustments.*

1. Flip the test switch inside the coin door on the top near the hinge (some games may have the self-test switch mounted in a different area such as on a plate near the top of the coin box). Tempest requires you to rotate the spinner until the prompt reads "Press Fire and Zap for Self-Test". (Other games may have similar requirements to get to the self-test screens or they may take you directly to them automatically. Do whatever is required to enter the self-test screens.)
2. Advance the screens with the slam (a.k.a. "tilt") leaf switch (this is typically inside the coin door below the lock) until you get to the diagonal crosshatch pattern screen (see "screen I" in the previous section). For Tempest, this should be the 1st screen.
3. Turn the focus control (one of the two white knobs on the HV unit) until you get the optimum screen sharpness possible. Your goal is the best character appearance without appreciable fuzziness.
4. Advance the screens until you get to one showing seven groups of colored bars of various intensities. For Tempest this should be the 5th screen.
5. Turn all the potentiometers on the neck PCB to the full clockwise position. Turn the brightness control (the other white knob on the HV unit) so that only five lines are visible and sixth line is completely invisible. Adjust the red, green, and blue bias potentiometers (the black ones) until the 5th line from the right is pure white without any hint of color in it (the 5th line is the dimmest one and color bias abnormalities are most visible at lower brightness levels; the goal is to get all five lines to be completely white). Adjust the red, green, and blue drive potentiometers (the white ones) until the first line on the right is pure white. Repeat the bias adjustment if the fifth line from the right is no longer pure white.

## ADJUSTMENT OF CONVERGENCE

In most cases, you should never have to converge, or reconverge your monitor yoke and tube. However, if you are replacing the tube, or your deflection yoke has been knocked loose, you will need to converge (or realign) the yoke.

You will need some rubber wedges and magnetic shunts to perform a convergence. You can order some from your closest Mazzco dealer - <http://www.mazzco.com>. Give them these Wells Gardner part numbers - (wedges) 008X0374-001 and (magnetic shunts or tabs) 009A2808-001. They are approximately \$0.40 cents each. You might also get a hot glue gun.

1. Feed crosshatch signal to the monitor [using either a pattern generator or a working vector game board in self-test mode].
2. Insert a wedge temporarily and fix the Deflection Yoke. **NOTE:** The wedges may need to be moved during adjustments.
3. Adjust the yoke back and forth until all the colors (usually separated at this point) are a clean red, green and blue.
  - Tilting the angle of the yoke up and down adjusts the crossover of both vertical and horizontal red and blue lines (Figures 8a and 8b).
  - Tilting the angle of the yoke sideways adjusts the parallel convergence of both horizontal and vertical lines at the edges of the screen (Figures 9a and 9b).
  - Make sure the crosshatch grid is straight and not warped.
4. Put a rubber wedge temporarily up top to keep the position of the deflection yoke.
5. Adjust the color purity (see below).
6. Install three permanent rubber support wedges for the deflection yoke.
7. Do NOT force the permanent wedges in. They are to be inserted until they just make contact with the yoke - after the yoke has been positioned.
8. Fix the three permanent rubber wedges with chloroprene rubber adhesive (or equivalent).
9. After the adhesive has dried enough to hold the wedges in place, carefully remove the temporarily installed wedge(s).
10. Use your paper magnetic shunts to properly align the beam edges. It is almost impossible to align the edges without using the shunts.

## COLOR PURITY

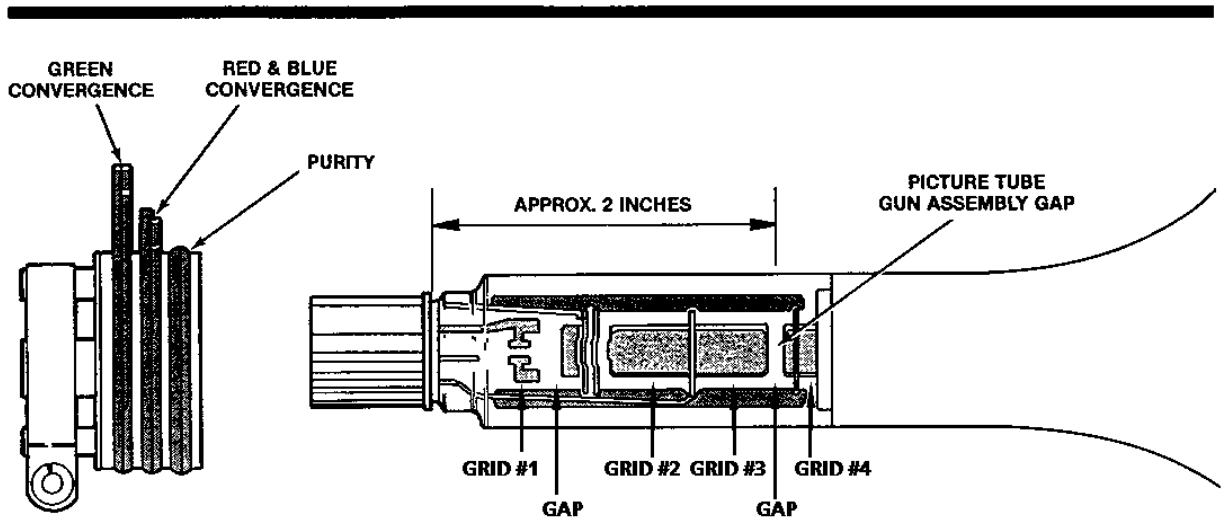
(Figure 6; from sections of the Wells-Gardner Service Manual)

As far as adjusting purity (red gun hits red phosphors only, green gun hits green, etc.) and convergence (red, green, and blue guns hit adjacent dots to make white instead of separate colors), the manual does a decent job of walking you through the procedure.

*For best results, it is recommended that a purity adjustment be made with the monitor facing west or east. The monitor must have been operating 15 minutes or more prior to this procedure.*

1. With the yoke on the CRT neck, place the convergence assembly on CRT neck with the center line (of Purity Adjustment Magnet) over gap between grids No. 3 and No. 4. The convergence assembly consists of three sets of ring magnets with tabs (Figure 6).

FIGURE 6:



### Purity and Convergence Adjustments

2. Tabs of the three magnetic ring-pairs are to be in a vertical position, which will produce a zero-correction state and facilitate adjustments. (see Figure 6 above).
3. Connect a pattern generator or game board (in self-test mode), which can generate a crosshatch pattern of red, green and blue independently and in combination of colors.
4. While displaying *only* a green crosshatch pattern, pull the deflection yoke backward as far as it will go. Remove any glue that may be holding the purity ring magnets in place and rotate one or both purity rings in a line so that they face opposite directions from

each other. Move the 2 purity ring magnets with respect to each other in order to center the green crosshatch on the screen.

5. Push deflection yoke forward gradually, until the crosshatch is a uniform green (pure in color) across the entire pattern. The deflection yoke should now be secured in place.
6. Both red and blue colors are to be checked for uniformity and true color. Slightly reposition the deflection yoke, if necessary, to obtain optimum purity of all colors. Tighten the yoke-retaining clamp to prevent yoke shift or rotation.
7. To make fine adjustments to the purity of each color, turn the purity rings for the best overall purity of each color. With all three colors being displayed, you should get a bright, uniform white color across all areas of the crosshatch pattern. Reglue the purity ring magnets with a small amount of glue.

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## IMPROVING YOUR WELLS-GARDNER 6100 MONITOR

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Now that you have your monitor repaired and adjusted, we will discuss the variety of ways that exist to make your monitor (or rather, your deflection board) more robust and hopefully reduce or eliminate future failures.

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### OFFICIAL ATARI DEFLECTION BOARD UPGRADE

Here is some text from the Major Havoc conversion kit installation instructions (TM-268). It describes the Atari sanctioned upgrades and includes instructions for converting all Wells-Gardner P314 Deflection Board PCB variations to Atari's "official" upgrade. Thanks to Tony Jones for the transcription.

#### Major Havoc Installation Instructions TM-268

##### MODIFY THE WELLS-GARDNER DEFLECTION PCB

**NOTE:** The following procedure applies to those Space Duel, Gravitar, and Black Widow games that used a Wells-Gardner display.

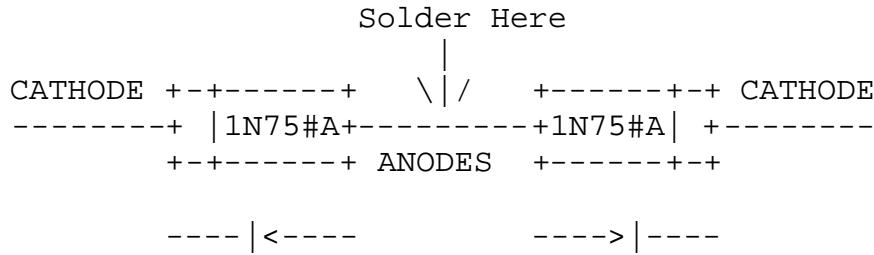
Four versions of the Wells-Gardner display were used in the Tempest, Space Duel, Gravitar, and Black Widow games. Perform the preliminary procedure for all versions of the display, and then refer to Table 3 to determine which version of the four displays was installed in your game and perform the additional procedure for that version. **CAUTION!** When soldering components to the display circuitry, apply just enough heat to provide a proper electrical connection. Excessive heat can damage the semiconductor material.

#### Preliminary Procedure

Perform the following procedure to modify the Deflection PCB (see Figure 6).

1. Set the display on a clean work surface.
2. Disconnect the 15-pin Molex connector from the mounting bracket on the display chassis and the harness connectors from the Deflection PCB and the Neck PCB.
3. Use a 1/4-inch hex driver to remove the two screws securing the Deflection PCB to the display chassis **[NOTE:** there are holes for two more screws in the remaining (rear) two corners of the board which some users decided to fill; if the board will not come out, check for this]
4. Remove the Deflection PCB from the display.
5. Connect two type-1N754A Zener diodes together, anode to anode, as shown in Figure 6. Use a soldering iron to solder the two anode leads together.

Figure 6 - 1N754A and 1N756A Zener-Diode Connections



6. Connect two type-1N756A Zener diodes together and solder as described in step 5.
7. Examine the soldered side of the Deflection PCB removed from the display and determine which of the two PCBs matches your PCB. [either a P314 or a P327/339]
8. On the component side of the Deflection PCB, locate the yellow wire (top right side of the PCB).
9. Solder one cathode lead of the two type-1N754A Zener diodes (soldered together in step 5) to the yellow lead on the soldered side of the PCB as shown in the appropriate illustration in Figure 7.
10. Solder the other cathode lead of the two type-1N754A Zener diodes to ground as shown on the appropriate illustration in Figure 7.
11. On the component side of the Deflection PCB, locate the orange wire (near top center of the PCB).
12. Solder one cathode lead of the two type-1N756A Zener diodes (soldered together in step 6) to the orange lead on the soldered side of the PCB as shown on the appropriate illustration in Figure 7.
13. Solder the other cathode lead of the two type-1N756A Zener diodes to ground as shown on the appropriate illustration in Figure 7.
14. On the component side of the Deflection PCB, locate connector P600 (right center of the PCB).
15. Solder the cathode lead of a type-1N4002 diode to pin 1 and the anode lead to pin 4 of connector P600 on the soldered side of the PCB as shown on the appropriate illustration in Figure 7.
16. Solder the cathode lead of a type-1N4002 diode to pin 5 and the anode lead to pin 7 of connector P600 on the soldered side of the PCB as shown on the appropriate illustration in Figure 7.
17. On the component side of the Deflection PCB, locate connector P700 (left center of the PCB).
18. Solder the cathode lead of a type-1N4002 diode to pin 1 and the anode lead to pin 4 of connector P700 on the soldered side of the PCB as shown on the appropriate illustration in Figure 7.
19. Solder the cathode lead of a type-1N4002 diode to pin 5 and the anode lead to pin 7 of connector P700 on the soldered side of the PCB as shown on the appropriate illustration in Figure 7.
20. Refer to Table 3 to determine which of the four versions of the display has been installed in your Tempest game.



Table 3 - Display Versions

<p><b><u>Version 1</u></b> Deflection PCB has two large, black, tubular capacitors, C804 and C805, installed below top center of PCB.</p>
<p><b><u>Version 2</u></b> Input Protection Circuit PCB is installed (piggyback) WITH A 1K Ohm, +/-5%, 1/4 W RESISTOR CONNECTED BETWEEN THE INPUT PROTECTION CIRCUIT PCB AND THE DEFLECTION PCB.</p>
<p><b><u>Version 3</u></b> Input Protection Circuit PCB is installed (piggyback) BUT DOES <u>NOT</u> HAVE A RESISTOR CONNECTED BETWEEN THE INPUT PROTECTION CIRCUIT PCB AND THE DEFLECTION PCB.</p>
<p><b><u>Version 4</u></b> Deflection PCB DOES NOT HAVE CAPACITORS C804 AND C805 (BELOW TOP CENTER OF PCB) OR AN INPUT PROTECTION CIRCUIT PCB INSTALLED.</p>

21. Perform the procedure as follows for the appropriate version of the display determined from Table 3. (Refer to the display manual, TM-183, for component and connector locations).

**NOTE:** The 30K ohm, 1/4W resistor supplied in the kit is used only for Version 1 of the Wells-Gardner display.

---

### **Version 1 Deflection Board**

Perform the following procedure for Version 1 of the Wells-Gardner 6100 display.

1. Verify that the Preliminary Procedure has been performed. [see above]
2. Use a soldering iron to remove resistor R811 and replace it with the 30K ohm, 1/4W resistor supplied in the kit.
3. Use a 1/4-inch hex driver to secure the modified Deflection PCB to the display chassis. **CAUTION!** Make certain that the harness from Q705 and Q706 is connected to P700 and not P100.
4. Connect the harnesses to the appropriate Deflection PCB connectors.

### Version 2 Deflection Board

Perform the following procedure for Version 2 of the Wells-Gardner 6100 display.

1. Verify that the Preliminary Procedure has been performed. [see above]
2. Use a 1/4-inch hex driver to secure the modified Deflection PCB to the display chassis.  
**CAUTION!** Make certain that the harness from Q705 and Q706 is connected to P700 and not P100.
3. Connect the harnesses to the appropriate Deflection PCB connectors.

---

### Version 3 Deflection Board

Perform the following procedure for Version 3 of the Wells-Gardner 6100 display.

1. Verify that the Preliminary Procedure has been performed. [see above]
2. Locate the wire connected to resistor R1 (22K ohm) and the collectors of transistors Q1 and Q3 (type 2N3904) on the Input Protection Circuit PCB and the point shown in Figure 7 on the Deflection PCB.
3. Use a wire cutter to cut the wire, located in step 2, halfway between the two PCBs.
4. Use a soldering iron to solder a 1K-Ohm, +/-5%, 1/4 W resistor (not included in the kit) between the two ends of the wire cut in step 3.
5. Use a 1/4-inch hex driver to secure the modified Deflection PCB to the display chassis.  
**CAUTION!** Make certain that the harness from Q705 and Q706 is connected to P700 and not P100.
6. Connect the harnesses to the appropriate Deflection PCB connectors.

---

### Version 4 Deflection Board

Perform the following procedure for Version 4 of the Wells-Gardner 6100 display. **NOTE:** This version of the display requires that an Input Protection Circuit PCB assembly be installed on the Deflection PCB as part of the display modification procedure. This PCB assembly is not included in the kit. However, to obtain the Input Protection Circuit PCB assembly, use the order form at the back of this document.

1. Verify that the Preliminary Procedure has been performed. [see above]
2. Install the Input Protection Circuit PCB to the Deflection PCB as described in the instructions supplied with the Input Protection Circuit PCB assembly.
3. Use a 1/4-inch hex driver to secure the modified Deflection PCB to the display chassis.  
**CAUTION!** Make certain that the harness from Q705 and Q706 is connected to P700 and not P100.
4. Connect the harnesses to the appropriate Deflection PCB connectors.

## THE INPUT PROTECTION CIRCUIT (IPC)

This Modification is for P314 versions of the Deflection Board **ONLY**. The P327 and P339 versions already have this circuit designed into the board. Here is the text from Atari CO-183-02 (1st printing) that describes a circuit that was sold by Atari to help make the deflection board more robust. This input protection circuit is unavailable but very simple and easy to recreate from the schematics provided herein.

### New Input Protection Circuit For Wells-Gardner Color X-Y Display (Supplement to TM-183)

This display contains an additional small printed-circuit board (PCB) that is not described in the display manual (TM-183). The PCB is mounted in "piggy-back" style on top of the Deflection PCB.

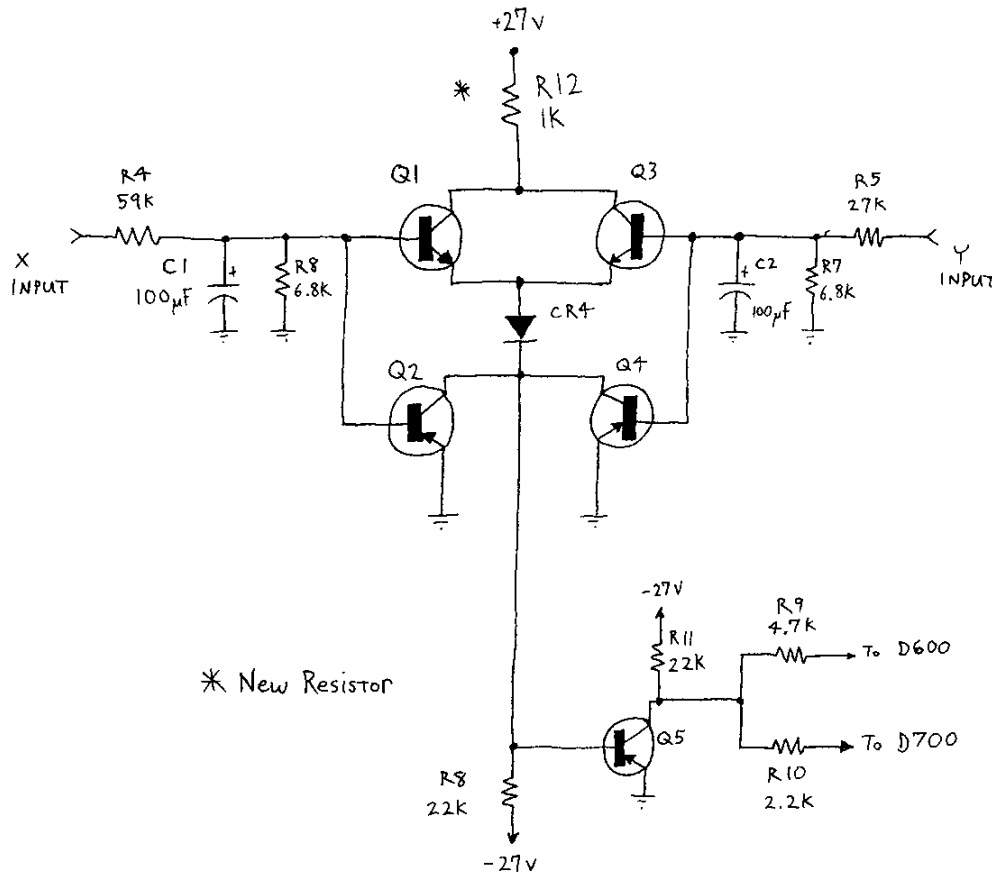
The input protection board was added to protect the fuses in the display from damaging input voltage conditions. Without this board, the display fuses might blow in the event of an intermittent or long-term game PCB failure. With this board, the screen will momentarily go blank if the average X- or Y-axis voltage(s) exceed a certain level. The screen then automatically recovers for normal game play and earning when the voltage(s) return to normal.

If this display is used in a Tempest (TM) game, be sure to correctly adjust the X and Y SIZE and CTR video pots on the Tempest Analog Vector-Generator (main) PCB [see text above]. The instructions for these adjustments are printed on the Tempest schematics - Sheet 2, Side B - 3rd printing or later. Improper adjustment may cause the screen to go blank during normal game play.

<b>Input Protection Circuit (IPC) PCB Parts List</b>	
<b>Part No.</b>	<b>Description (Reference Designations in parentheses)</b>
24-250107	100 uf Aluminum Elec. Fixed Axial-Lead 25V Capacitor (C1,2)
31-1N914	75V Type-1N914 Switching Diode (CR2-4)
32-1N751A	5.1V 400mW Type-1N751A Zener Diode (CR1)
33-2N3906	PCB Switching and Amplifying Transistor (Q2, 4, 5)
34-2N3904	Type-2N3904 NPN 60V 1-Watt Transistor (Q1, 3)
52-222	22-Gauge Jumper Wire (2 in. required)
110000-223	22K Ohm, +/- 5% 1/4 W Resistor (R1, 8, 11)
110000-273	27K Ohm, +/- 5% 1/4 W Resistor (R5)
110000-393	39K Ohm, +/- 5% 1/4 W Resistor (R4)
110000-682	6.8K Ohm, +/- 5% 1/4 W Resistor (R6, 7)

110001-222	2.2K Ohm, +/- 5% 1/2 W Resistor (R10)
110001-472	4.7K Ohm, +/- 5% 1/2 W Resistor (R9)
110011-122	1.2K Ohm, +/- 1% 1/4 W Metal-Film Resistor (R2, 3)
110000-102	1K Ohm, +/- 5% 1/4 W Resistor (R12)
A038088-01 B	INPUT PROTECTION CIRCUIT PCB ASSEMBLY

Schematic of the Input Protection Circuit PCB



COLOR X-Y DISPLAY 92-053  
INSTALLATION INSTRUCTIONS  
INPUT PROTECTION CIRCUIT PCB

A038088-01

1. Remove R600, R605, R700 and R706.
2. Remove solder from all nine holes indicated in figure 13 [figure not included].
3. Straighten pins of PCB so that they are perpendicular to the board [meaningless to you since you probably do not have the board].
4. Match and insert the numbered holes in figure 13 with the numbered pins in figure 1 [figures not included].
5. Solder.

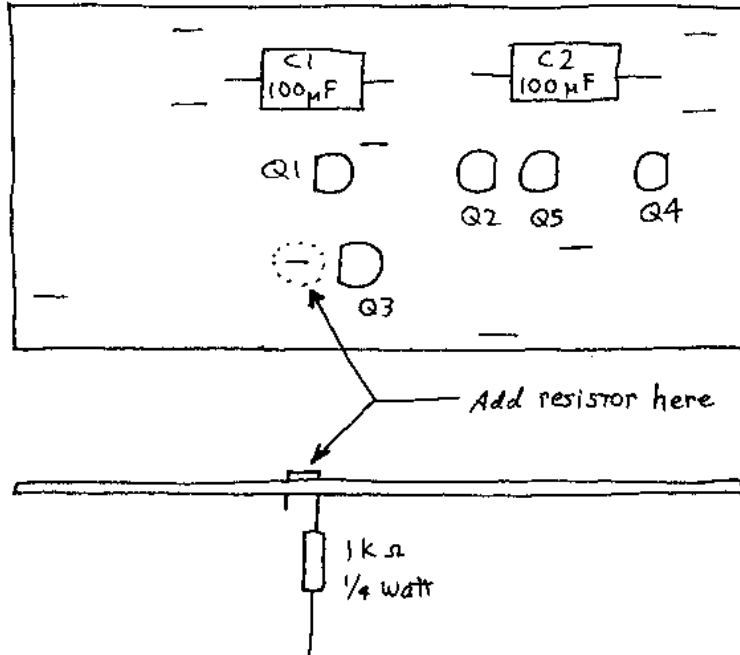
All descriptions refer to a deflection board oriented component side up with the board label "P314" at the top (right-side-up) and the two large electrolytic capacitors at the bottom. This orientation will have the electrolytic capacitors "side by side" and the board will be "taller" than it is "wide".

- J1 is R700's old top pin.
- J2 is R700's old bottom pin.
- J3 is R600's old top pin.
- J4 is R600's old bottom pin.
- J5 is the first "empty"/unused hole to the right of C701.
- J6 is the first "empty"/unused hole to the right of Q701 and below C701.
- J7 is the first "empty"/unused hole to the left of C602 and below D601.
- J8 is R606's old left pin.
- J9 is R706's old left pin.

**SPECIAL NOTE:** According to the Major Havoc manual, this Input Protection board came in 2 versions. Later versions had a 1K-Ohm, +/-5%, 1/4 W resistor as one of the "stilts" on the board instead of a plain piece of wire. If your board does not have this resistor, here is what you need to do.

- Locate the "stilt" wire connected to resistor R1 (22K ohm) and the collectors of transistors Q1 and Q3 (type 2N3904) on the Input Protection Circuit PCB (the other end is connected to the P314 Deflection PCB).
- Use a wire cutter to cut the wire, located in step 1, halfway between the two PCBs.
- Use a soldering iron to solder a 1K-Ohm, +/-5%, 1/4 W resistor between the two ends of the wire cut in step 2.

INPUT PROTECTION CIRCUIT PCB (continued)



## How To Make A 'Tempest' Monitor Trouble-Free

Here is an article from the April 15, 1983 issue of Play Meter magazine (page 191). The article is from a regular feature in the magazine called "FRANK'S CRANKS" by Frank "The Crank" Seninsky. This hack is essentially no different from the Atari Zener diode input protection modifications, except the Zener diodes in this hack are properly biased using resistors to the rails, and 1n914's are dropped into the circuit to clamp the input to the within the +/-8.2V from the 1n4737 Zeners. (thanks to Mark Spaeth for the description)

### HOW TO MAKE A 'TEMPEST' MONITOR TROUBLE-FREE

Atari's Tempest, when it is working, is not a bad game. It's just a shame that the monitors only last a few weeks (sometimes only days) between service calls. Most of the time, the monitor sits neglected on a techroom shelf.

Atari has developed a monitor protection board [included earlier in this text] to protect the monitor's components (2N3716 and 2N3792 "X" OUTput transistors, two each located on chassis frame) if and when there is a RAM lock-up on the Tempest CPU board. I want to clarify that the Wells-Gardner monitor is not at fault. Also note that on the later Atari games, the protection circuit has been incorporated into the board circuitry. [These statements seem to imply that this "fix" is compatible with the Atari upgraded P314s as well as P327s and P339s and will provide additional protection; in fact, I have seen it on a P327 before. It is sufficiently ambiguous that the exact opposite can be inferred. Judging from the areas of the board it alters, I would say it is incompatible (duplicates) the other fixes in this section.]

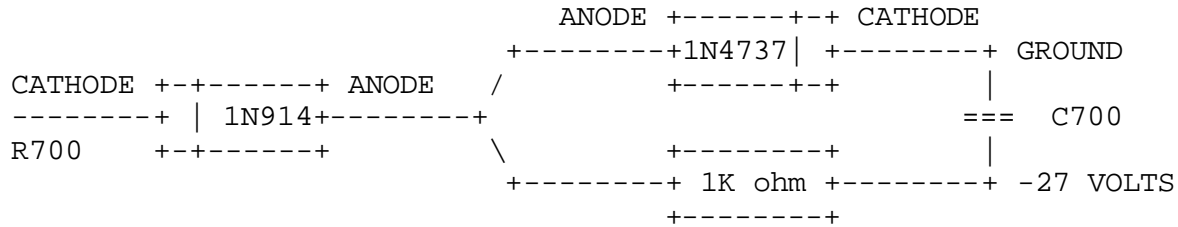
It's common knowledge that you can purchase a broken Tempest game cheap. With about 20 minutes of your time and a couple of dollars in parts, it is possible to add just six common components to the monitor deflection board and have a Tempest that will stay on location and work.

The parts required are:

- two-1N914 diodes
- two-1N4737 diodes
- two-1K OHM 1/4 W resistors

### FIRST HALF

Take the anode ends (the ends opposite from the marked rings) of a 1N914 and a 1N4737, and solder them to one end of a 1K-ohm resistor so that it looks like this:



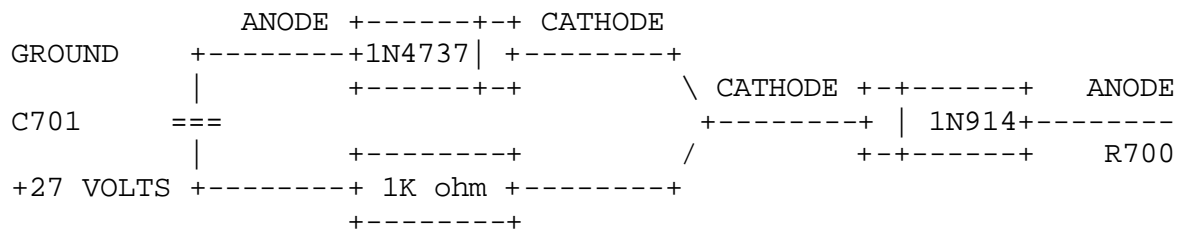
Locate C700 in the top left of the monitor deflection board. (See Figure 13 on page 20 of Atari TM-183 Wells-Gardner Quadrascan service manual; second printing) and solder the cathode of the 1N4737 to the ground side of C700 (right side in Figure 13). Solder the end of the 1K-OHM resistor to the -27 volt side (left side) of C700. Solder the one remaining wire (the cathode of 1N914) to the "X" INput side of R700 (top end of R700). You are now halfway finished.

### HALF TIME

Take a five-minute break; you deserve it.

### SECOND HALF

Take the remaining 1N914 and 1N7437, and solder the cathode ends of each diode together with one end of the 1K-OHM resistor so it looks like this:



Locate C701 (top middle in Figure 13) and solder the anode of 1N4737 to the ground side of C701 (right side). Solder the end of the 1K-OHM resistor to the +27 volt side of C701 (left side). Go back to the same "X" INput side of R700 and solder the remaining wire (the anode of the 1N914) to this connection. Make sure that you have a good solder connection at the "X" INput of R700 as you now have a three-wire joint.



---

**FINAL TWO-MINUTE WARNING**

Make sure that none of the wires of this modification can come into contact with the other board components [easy to do; there is a lot of bare PCB in this area; you may want to tape/glue the leads down], especially the brown ground wire located to the right of R700. If the modification hits this brown wire, you can consider it a fumble and you just blew your lead and the game.

---

**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!

John :-#)#

---

**Appendix A: X-Y Monitor/Final Solution (sort of)**

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**WELLS GARDNER  
X-Y MONITOR/FINAL SOLUTION**

By Wayne McGuire, Brady Dist, Charlotte, NC  
[edited for content by Tom McClintock; additional notes by Zonn Moore]

**STANDARD DISCLAIMER:**

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**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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Source:

Star\*Tech Journal  
December 1983  
Volume 5, Number 10  
Pages 14 and 15  
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We at Brady Distributing Co. pride ourselves on the service we have been able to offer our customers. The following modifications are a product of our shop personnel and, in our estimation, a final solution to the Wells Gardner X-Y monitor problems.

Over the past three months, we have modified every Well Gardner X-Y monitor to cross our bench and the rate of repeated failure is such that only one has returned with a deflection problem. These changes make the 19K6901 and 19K6103 very reliable monitors and much better suited for the environments in which they are operated.

**BRADY MODIFICATIONS FOR WELLS GARDNER QUADRASCAN COLOR X-Y**

**1 - INPUT PROTECTION CIRCUIT PCB ASSEMBLY**

To ensure continued circuit operation, Atari Field Service suggests that you perform the following modification:

- A. Remove the lead connecting the IPC board to +27 volts on the display printed circuit board. The lead is near Q1 and Q3 (see Fig 1.1).
- B. Replace this lead with a 1K ohm, 1/4-watt resistor (see Schematic of Fig 1.1).

## 2 - POWER SUPPLY CIRCUIT

The Low Voltage Power Supply is to be bypassed in this modification. The input stages of the deflection circuits used in this monitor are of the differential type and exhibit a high common mode rejection. This characteristic will filter out any noise or ripple of the power supply.

- A. Cut diodes D104 and D105 out of the power supply circuit (Schematic 2.1)
- B. Cut the wires at P100 leaving about two inches at the plug.
- C. Make a Rat Tail splice connecting the leads at pins 1 and 4; also, splice the leads at pins 5 and 7. [Note that pin 2 is missing from the plug.]
- D. Solder and cover the exposed wire with electrical tape or shrink tubing.
- E. Cut the remaining wires flush with the plug (leads at pins 3 and 6).

[Alternatively, you could make a non-destructive modification by using a 7-position moxex (or comparable) plug and making a wire loop between pins 1 and 4, and 5 and 7. Never a very good idea to cut up your original harness! An interesting benefit of this modification is that it removes two chassis transistors (Q102 and Q103) from the monitor. Please refer to Schematic 2.1]

NOTE: This [Low Voltage Power Supply] modification will require readjustment of the monitor color, focus and signal level from the logic board. This is due to the higher supply voltage now available at the deflection and color stages. This modification will remove about 45 watts of power from the bottom plate of the monitor chassis and cause a noticeable reduction in temperature.

[notes from Zonn:

- \* **Though it claims otherwise, removing the regulator from the low voltage side make for irritating jitters and blooming on the vectors. This might not be so bad from an "operators" point of view, but as a collector is was unacceptable.**
- \* **Removing the regulator increases the voltage across the output yoke drivers. This might have an advantage of a slight increase of vector speeds when moving large distances, but it also means the transistors must dissipate more heat during large movements. Since Tempest was written for the monitor as it was designed, the speed increase is meaningless, but the heat dissipation is critical!**
- \* **The low voltage regulator designed by Atari really sucked, I came up with a re-design that was slightly more complicated than the LV2000 -- I switched to the LV2000. The best thing to do with the low voltage section is to install an LV2000.]**

### 3 - X CHANNEL CURRENT LIMITER

The X channel of this monitor must do more work than the Y channel. This modification limits the amount of current that can be delivered to the load and the X channel output transistors are moved so they may be more efficiently cooled by convection currents.

A. Remove the plug from J700 and reconnect at J600. The cable of P700 will need to be lengthened before this can be done. This move connects the transistors on the bottom chassis plate to the Y channel.

B. Transistors mounted on the side of the chassis panel may now be connected to J700. These are now the X channel outputs transistors. The side panel allows more air currents to pass over the transistors and consequently more efficient cooling. [If this monitor is mounted vertically in a Tempest, the Y channel output transistors are already oriented for optimum convection cooling and do not need to be moved.]

[notes from Zonn:

\* **Moving the transistors seems more like superstition to me. Aluminum is a better conductor of heat than steel, so it could be argued that the X drivers should remain where they are since the aluminum can dissipate heat faster than the steel frame. If things need cooling, install a fan.]**

C. Remove the emitter lead from the transistor sockets on the side and place a 0.2-ohm, 3-watt resistor in series with emitters of Q705 and Q706 (as in Schematic 3.1). [I believe they mean the transistors at physical location Q605 and Q606. If you have just switched the X and Y Channels, it would make little sense to make the modifications to the transistors driving the Y Channel.]

D. Place two SK3081 diodes in parallel with the base-emitter circuits (Schematic 3.1).

NOTE: When the currents through the emitter resistors reach 3 amps the voltage drop is such that the diodes across the base-emitter circuit will start to turn on. This action will drain current away from the base circuit and prevent transistors Q705 and Q706 from passing too much current.

[notes from Zonn:

\* **Limiting the output current on the output transistor may not be a bad idea, if it does not slow down drawing speeds enough to affect the display. Though it seems silly just to do the X transistors. During high-speed moves, both X and Y channels will have to pass the same amount of current. While it's true that the X channel is larger than the Y, and therefore, on the average, will have Longer moves, and therefore possibly get hotter, the instantaneous current peaks on both are the same. Since it's most likely these peaks that would blow the transistors, you'd think both X and Y would be protected.]**

#### **4 - HIGH VOLTAGE POWER SUPPLY**

These changes to the high power supply should reduce incidence of failure due to high temperatures and/or low voltage power supply failures.

- A. Replace capacitors C901 and C902 with 220 F 50V capacitors. [Original capacitors are 100uF 50V.]
- B. Replace transistors Q901 and Q902 with transistor type 2N2102. [Originals are MPSA06.] Place a heat sink for a T0-39 package on Q901. Take care not to allow the two transistors to touch.
- C. Replace C905 with a 50uF 200V capacitor. [Original is a 33uF 160V.]
- D. Solder an SK3081 diode across capacitors C910 and C905 with the polarity of the diodes opposite that of the capacitors.
- E. Cut vents into the aluminum cover of the high voltage unit (as illustrated in Figure 4.2).

NOTE: The last procedure is the most important of [the HV] modifications. The vents will allow convection currents to cool the high voltage section reducing the thermal stress to these circuits. Also, if the power supply modifications are performed, this entire modification becomes mandatory.

**[notes from Zonn:**

**The experiments I did on the high voltage were different than those described.**

**One thing I noticed about the high voltage sections is that transistor Q900 is dropping 19.6 volts! Based on a 2.1v drop across R901, Q900 is passing .538 amps, at 19.6 volts that's ~10 watts. (This could be a bit high since R900 supplies more than just Q900 with current.)**

**That was quite a bit, and since I did not see anything else that needed the full 25v, except for T901, (It looks like they run the output HV transformer with ~30v), I installed a pre-regulator on the +V side. Since they were using a 13v zener as a voltage reference, I chose a 15v regulator (7815 or equivalent).**

**This was a few years ago, but I remember it working pretty well. The heat dissipation on Q900 went \*way\* down (everything ran nice and cool), and I do not remember any adverse effects on the HV output (vectors were fine and nice and stable.). With a +15v pre-regulator, Q901 would only be dropping 6.9v, or less than 4 watts. This also significantly drops the current demands on Q901.**

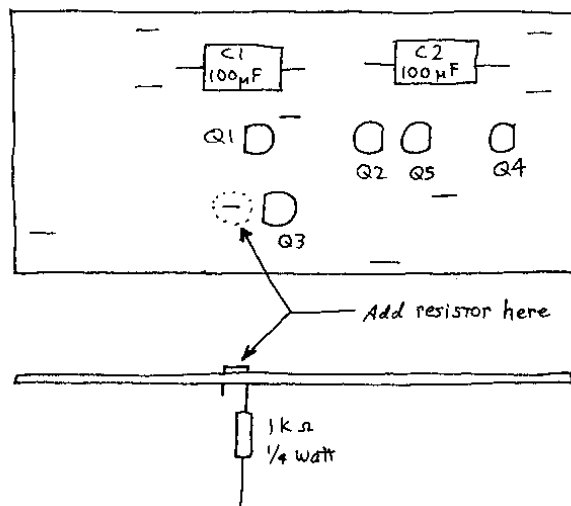
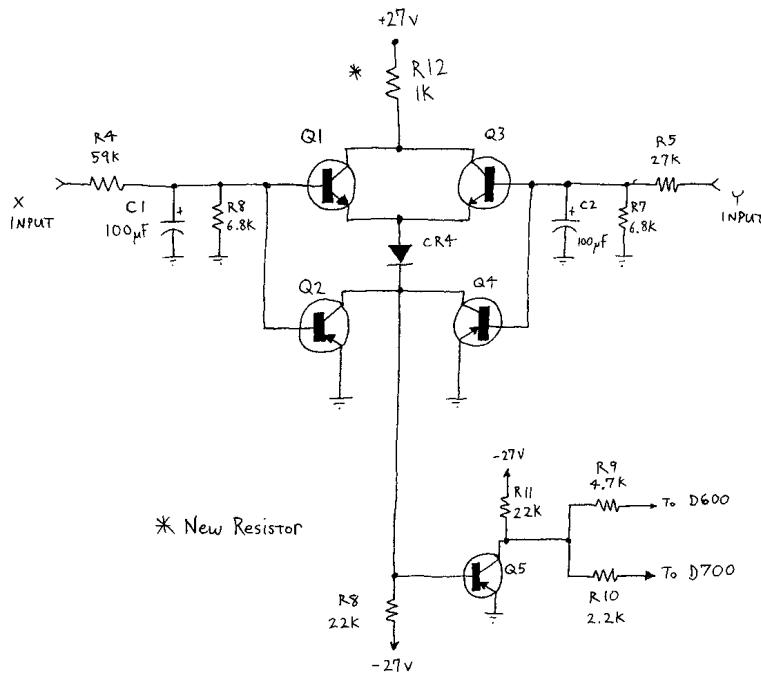
**I do not currently do this since it was just "tacked on". I got really busy at that point and never pursued it any further, so I never tested things like the Star Wars explosion, etc. --**

mostly just the tempest attract mode. So there could be some unknown problems with this. It is also very possible that some other resistor values might need changing in the voltage regulator to compensate for the lower input voltage. (Lowering R905, R906 and R913 come to mind. And it might be a good idea to re-route R917 to a position in front of the pre-regulator.)

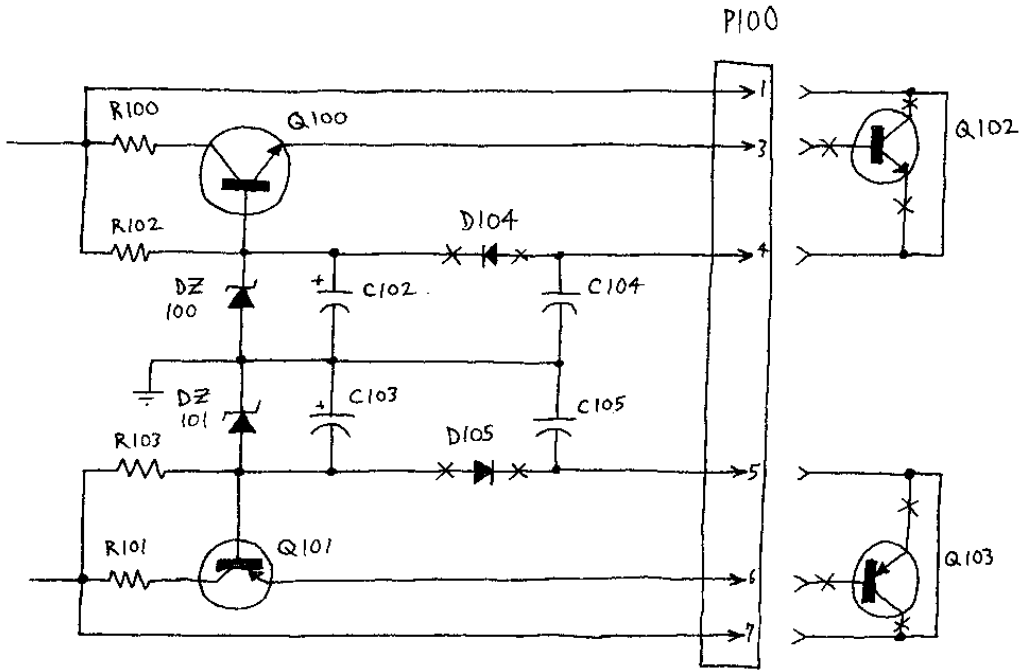
By dropping the voltage with a pre-regulator you move much of the heat dissipation to the regulator and away from the HV regulator. This seems like a good idea and should probably be investigated further.]

(Schematic redrafting courtesy of Matt McCullar)

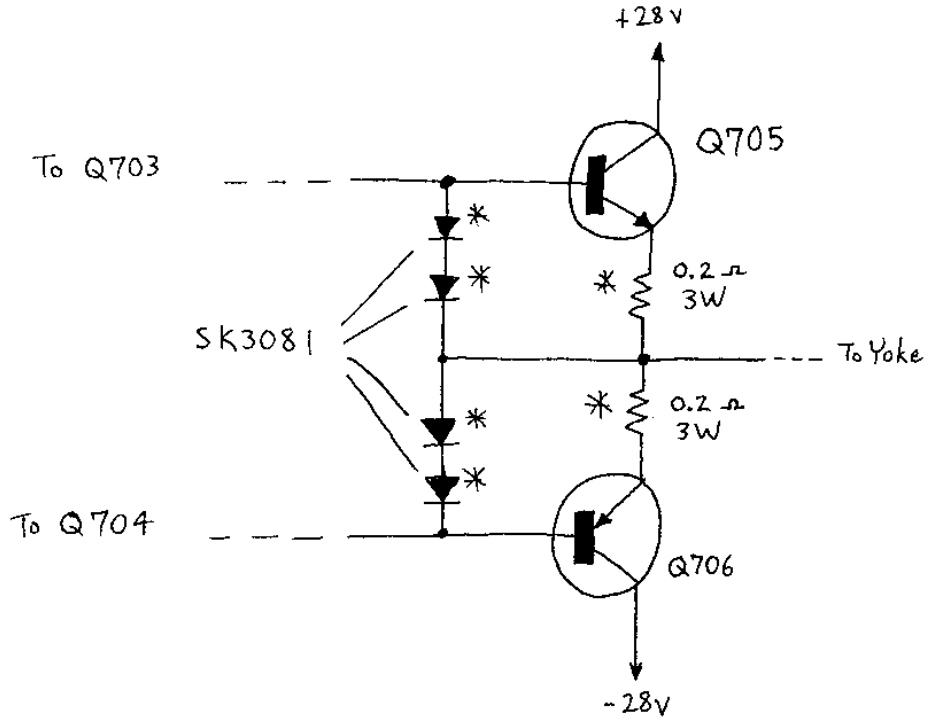
**Schematic 1.1**



**Schematic 2.1**



**Schematic 3.1**



**Schematic 4.1**

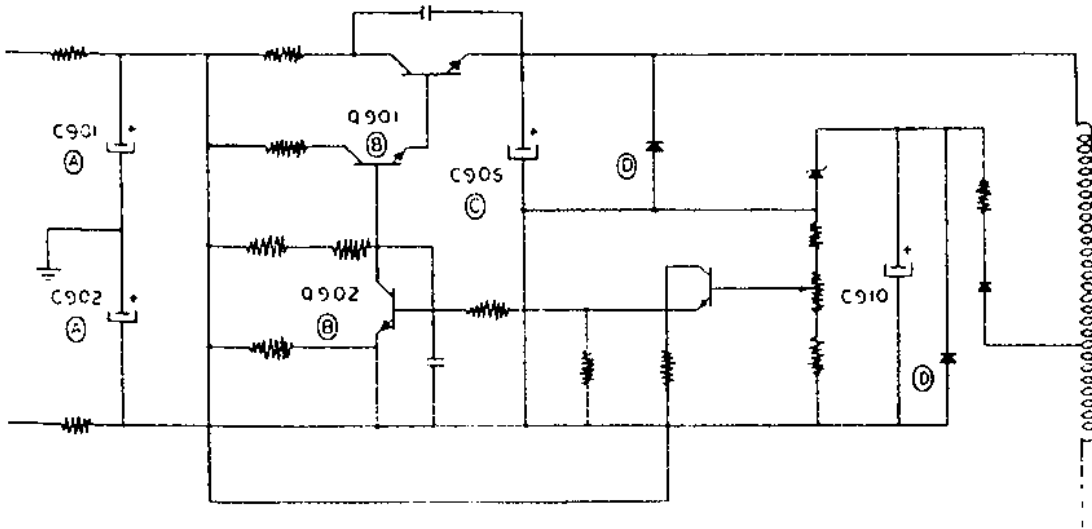
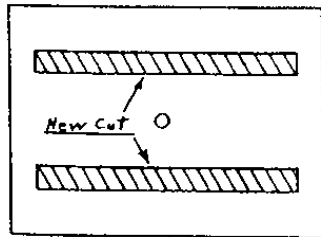
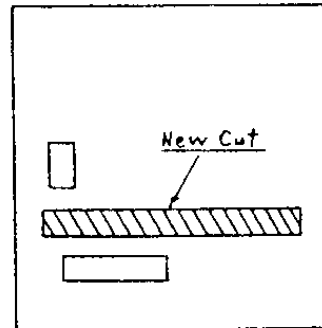


Figure 4.2



H. V. COVER -SIDE VIEW-



H. V. COVER -TOP VIEW-



## Appendix B: Theory of Operation

### THEORY OF OPERATION: Wells Gardner "Quadrascan" Color X-Y Monitor

**CAUTION!!! LETHAL VOLTAGES ARE PRESENT IN THIS MONITOR, IF YOU HAVE ANY DOUBTS ABOUT YOUR ABILITY DO NOT ATTEMPT TO REPAIR YOUR MONITOR!!**

The "Quadrascan" color X-Y display was designed and built by Wells Gardner Electronics Corp. This display differs VERY LITTLE from the Electrohome G-05 Black and White X-Y monitor. The only difference is that this monitor has three Z amplifiers to control three color guns. Refer to the G-05 theory if there is any confusion on operating principles.

### PINOUTS

<u>Pin</u>	<u>Description</u>	<u>Notes</u>
1.	Red input	4.0V full on; 1.0V black level
2.	Green input	4.0V full on; 1.0V black level
3.	Blue input	4.0V full on; 1.0 black level
4.	Red GND	
5.	Green GND	
6.	Blue GND	
7.	X input	16V P/P 2.5Kohms
8.	Y input	12V P/P 2.5Kohms
9.	Not Used	
10.	X GND	
11.	Y GND	
12.	Power GND	
13.	25VRMS	
14.	Power GND	
15.	25VRMS	

### LOW VOLTAGE POWER SUPPLY

The input voltage of 48 VAC from the game power supply enters through fuses F100 and F101. Diodes D100 through D104 form a rectifier bridge that converts the AC input to an unfiltered

DC (about 35V). Capacitors C100 and C101 form the first stage of filtering. Resistors R102 and R103 and capacitors C102 and C103 form two low-pass filters which help filter out AC ripple. Transistors Q100 through Q103 form an active filter that provides the stable, filtered DC voltages.

The degaussing coil operates when power is first applied to the display, when the PTP(positive temperature coefficient) thermistor is cool. Diodes D106 and D107 form a protective barrier from any residual current that might enter the degaussing coil during normal game play. The output voltages from the low voltage power supply should be as follows:

J101-2	ground
J101-3	+25 volts
J101-4	-25 volts

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

### **X AND Y AMPLIFIERS**

Both the X and Y amps are nearly identical. Only the Y amp is described.

The Y deflection signal from the game board is applied to the base circuit of transistor Q600. Transistors Q600 and Q601 form a differential amplifier. Transistor Q602 is a constant current source providing current to the differential amplifier. Transistor Q603 is the driver transistor that provides current to the emitter-follower transistors Q605 and Q606. Transistor Q604 is a constant current source that provides current to the driver transistor Q603. Fuse F600 can open in case of circuit failure, protecting the deflection coil in the yoke from damage.

### **Z AMPLIFIERS**

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

Transistor Q502 is a common emitter amplifier used to provide gain for the blue intensity signal. Resistor R509 is the blue drive pot, which determines the amount of gain in the blue amplifier. Resistor R513 is the blue bias pot, which determines the cut-off characteristics of the blue amplifier. The output of the Z amplifiers bias the cathodes of the three electron guns within the picture tube.

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

### **SPOT KILLER**

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

The two signal input voltages to the spot killer are taken from resistors R610 and R710 in the X and Y deflection circuits. Diodes D801 through D804 and Capacitors C800 through C803 form two separate voltage doublers. The output of the voltage doublers are applied to the bases of transistors Q801 and Q802.

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

### **HIGH VOLTAGE POWER SUPPLY**

Integrated circuit IC901 is a timer circuit that produces a 20 KHz output, which drives transistors Q904 and Q905. These transistors are current amplifiers that drive the primary winding of the Step down transformer T901. The output of T901 is used to turn on the main driver transistor Q906 that in turn drives the High Voltage Step-up transformer T900. The output of the secondary winding is applied to the picture tube at the focus and intensity grids and the 19.5KV anode.

Diode D901 allows capacitor C910 to charge to +180V during the discharge of the primary's magnetic field. Transistors Q900 through Q903 are error amplifiers that regulate the +180V video B+. Pot R918 provides an adjustment to the video B+ and hence the high voltage. To adjust the high voltage, you will need a high voltage probe, a voltmeter, and an insulated screwdriver tipped adjustment tool. Turn off power to the display. Connect the high-voltage probe to the voltmeter, and insert the tip of the probe under the high voltage anode rubber shield.

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

**NOTE:** Mark Spaeth has written a very informative description of the Wells-Gardner 6100 vector monitor and the input protections described in this document. Download your copy from <http://rgvac.978.org>

## Appendix E: Vector Monitor Slew Rates

### Vector Monitor Slew Rates

Courtesy of Jon Raiford

Here is a table of Vector Monitor Slew Rates. Slew rate is a measure of the maximum rate-of-change of the voltage output. Put into context, a slew rate is the measure of how fast the deflection amplifier can make FULL-SCALE transitions, driving the CRT beam around the screen. As the slew rate increases, more objects can be drawn on-screen at the same time and the amount of flicker is reduced. If a monitor is not listed, we do not have any available data on its speed.

	<b>6400 X</b>	<b>6400 Y</b>	<b>Amp X</b>	<b>Amp Y</b>	<b>6100 X</b>	<b>6100 Y</b>	<b>19V2000</b>	<b>G05</b>
<b>.5"</b>	6us	6us	?	?	10us	13us	4us	5us
<b>1.0"</b>	8us	8us	?	?	20us	27us	8us	10us
<b>2.0"</b>	16us	21us	?	?	40us	53us	16us	20us
<b>4.0"</b>	30us	42us	?	?	80us	106us	32us	40us
<b>8.0"</b>	62us	94us	?	?	160us	213us	64us	80us
<b>10.5"</b>	84us	131us	?	?	210us	279us	84us	105us
<b>14.5"</b>	110us	179us	?	?	290us	385us	120us	150us
<b>.05 inches per usec</b>	<b>0.1325</b>	<b>0.08</b>			<b>0.05</b>	<b>0.0375</b>	<b>0.12</b>	<b>0.0975</b>

The X-axis is obviously the Monitor, the Y-axis is the amount of deflection, and the value is the time in microseconds to deflect that far. The last row is the number of 0.05 inches per microsecond.

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## Appendix F: Testing Transistors

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Most of the failures in the Wells-Gardner 6100 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.

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## Appendix G: Installing A Cap Kit

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If you do not have a manual for this monitor, get a copy, as it does a good job of explaining how each section works and also how to adjust it.

For those who do not like reading manuals, or who do not feel like locating local sources for specific parts or who do not want to hunt through a huge catalog to put together part numbers for an order, you can probably order everything you need (except for the upgrade parts and the extra capacitor for P329 versions of the HV unit) bundled together in one package from Zanen Electronics. I suggest you order a couple of these to keep as spares since you never know when you might need to do a rush repair job and the price simply cannot be beat.

Call Zanen at +1.806.793.6337 and ask for "get well kit #206" which at last count had thirty pieces including all the capacitors that go bad, six replacement chassis transistors, several of the smaller transistors (and their corresponding resistors), several diodes (including ZD902), and somewhat sparse documentation on how to replace the parts.

Ordering a kit from Zanen also entitles you to FREE technical assistance and they seem to be very experienced and knowledgeable. As of January 2002, the price for this kit was \$15, which is probably cheaper than any deal you could put together yourself.

A Cap Kit is a good way to go if you do not feel like doing any testing to find out what exactly is bad. If you replace all the parts included in this kit, you may be throwing out a lot of parts that still work OK (but which may be on their last legs, anyway), but in most cases you will have a working monitor when you are done. If you replace all these parts and the monitor still does not work, then go through the flowchart shown later in this document. It is quite likely that you have a bad HV transformer and you will have a heck of a time locating a replacement.

Be aware that some of the parts that Zanen will send you are from the original specifications and should not be used, as this spec is known to be deficient. Consult the section below about how to upgrade the deflection board and switch out the indicated parts for the upgraded replacements.

### **Zanen Cap Kit #206 Installation Instructions** **Includes Updated Instructions by cfh@provide.net (03/12/99)**

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

Bob Roberts also sells cap kits. Bob provides a complete 'updated' kit for the WG6100 Vector Monitor.

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

### Zanen's Standard Instructions:

This monitor repair kit is designed for the Wells-Gardner 19K6100 X-Y color monitor, as used in Tempest, Space Duel, and other Atari color X-Y games.

Be sure to install **all** the parts on the monitor even though many of the original parts seem to be working fine. Age, humidity, and temperature will cause the value of electrolytic capacitors to change. Also the other semi-conductors included fail often. Install them all.

Each capacitor is polarized and should only be inserted in the proper direction. Watch the polarity markings on each capacitor. On the topside of the monitor board where each capacitor is located is a circle with a plus sign next to one of the holes. The plus sign indicates where the positive (+) lead of each capacitor is to be installed.

**Important:** It is possible for a failure on the game logic board to cause the monitor to fail. There is a simple test to find out if the game board caused the monitor to fail. To perform the test you will need a voltmeter. Set the voltmeter on the DC voltage scale and measure the voltage on the lead of R600 and R700 (fuses) of the deflection board. These are connected to the plug with wire colors yellow (R600) and orange (R700). The correct voltage should be in the +0.5 to -0.5 volt range (basically zero volts). The voltage will fluctuate because of changing deflection signals. If the measured voltage is between 5 and 15 volts (positive or negative), then check the X and Y amplifiers on the GAME board. Also check for broken potentiometers on the game board.

**Important:** It is very important to resolder all the molex connectors soldered to the monitor circuit boards. Plugging and unplugging these connectors can crack the solder joints.

*End of original Zanen installation instructions*



## THE REAL INSTALLATION/UPGRADE STORY

When I ordered the Zanen #206 cap kit, I felt the instructions were rather brief and disorganized. There are over 30 parts to install on three PCB's! Which ones go where? These instructions should help correct that.

Also note the Zanen cap kit #206 is based on specs for the original revision of the Wells-Gardner 19K6100 X-Y Color monitor. There have been three revisions of this monitor, to address some of its shortcomings. Although these upgrade parts are not included in the Zanen cap kit, I would highly recommend you install the upgrade parts while the monitor is apart. You will have to buy some additional parts, which are listed at the end of this section. It is unknown why Zanen will not assemble a 'proper' cap kit for vector collectors. Bob Roberts offers a 'complete' cap kit for the Wells-Gardner 6100 vector monitor.

If your WG6100 does not work, installing a Zanen cap kit #206 can solve many problems without you knowing exactly what is wrong. For most people not familiar with this monitor, it is an excellent starting point to fix your monitor. And at \$15 per kit, you cannot purchase these parts that cheaply anywhere else.

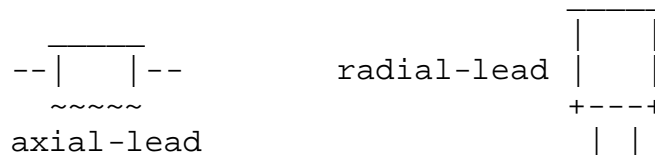
To finalize your WG6100 repair, I would recommend installing a LV2000 low voltage board. At \$35 each, this will also save you considerable time, trouble and money in the end. Between the Zanen kit #206, the upgrades described here, and the LV2000, you should end up with a working (!) and "bullet proof" Wells-Gardner 19K6100 X-Y color monitor. Even if your monitor is completely dead, installing these two kits and doing the upgrades should give you a working monitor (without you knowing anything about fixing monitors too!). For more information on this upgrade, see <http://www.geocities.com/jeffhendrix67/lv2000/> .

It is also important to note that the replacement capacitors should be low ESR, 105°C electrolytic capacitors for better performance. Most electrolytic capacitors are not marked 'Low ESR'. However, in most cases low ESR caps will have an 'X' stamped in the metal casing and is something to look for if you are buying capacitors over the counter.

Key:

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

Note that the capacitors come in two "types":



## 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 ones 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.

<b>WG6100 Monitor Chassis Parts</b>		
<b><u>Location</u></b>	<b><u>Part Number</u></b>	<b><u>Notes</u></b>
Q102	2N3716 transistor	Power
Q103	2N3792 transistor	Power
Q605	2N3716 transistor	Deflection
Q606	2N3792 transistor	Deflection
Q705	2N3716 transistor	Deflection
Q706	2N3792 transistor	Deflection

**Important**: after replacing the above transistors, use your meter set to Ohms and check the continuity between the metal monitor chassis and the metal case of the above transistors. If there is continuity, you need to either replace the thin clear plastic Mica insulator that goes between the transistor and the monitor chassis, or readjust the transistor so the pins are not in contact with the monitor chassis. There should be NO continuity! If there is continuity, you will usually blow R100 or R101 (assuming you do not have an LV2000 installed). You will probably also take out the 2N3716 or 2N3792 transistors involved, and they are not cheap!

## DEFLECTION BOARD

The Deflection board is the main PCB mounted right behind and below the monitor tube.

<b>Zanen WG6100 Deflection PCB Parts</b>			
<u>Location</u>	<u>Part Number</u>	<u>Upgrade?</u>	<u>Notes</u>
R100	15 ohm ½watt resistor		Brn/Grn/Blk
R101	15 ohm ½watt resistor		Brn/Grn/Blk
R102	330 ohm ¼ watt resistor		Org/Org/Brn
R103	330 ohm ¼ watt resistor		Org/Org/Brn
D104	1N4148 diode		
D105	1N4148 diode		
ZD100	1N4750 diode 27v		Some boards mislabel this diode as "R104".
ZD101	1N4750 diode 27v		Some boards mislabel this diode as "R105".
Q100	MPSA06 (NTE287)		
Q101	MPSA56 (NTE159)	Yes	Upgrade to NTE50 if not using LV2000

**Note:** All the above parts are located in the low voltage section of the Deflection board.

**Important:** if you are installing an LV2000 (highly recommended), you do not need to install **ANY** of the above parts. They will all be removed and replaced by the LV2000 installation.

## DEFLECTION BOARD (cont.)

The following Deflection board parts should also be replaced, and are **not** included in the Zanen kit, and are **not** replaced by the LV2000. I would recommend installing these upgraded parts. These will bring your deflection board to the last revision created by Wells-Gardner.

<b><u>NON-Zanen Deflection PCB Upgrade Parts</u></b>			
<b><u>Location</u></b>	<b><u>Part Number</u></b>	<b><u>Upgrade</u></b>	<b><u>Notes</u></b>
Q604	NTE49 transistor	Yes	Replaces MPSU07 (NTE188)
Q704	NTE49 transistor	Yes	Replaces MPSU07 (NTE188)
R106	22 ohm 3 watt resistor	Yes	Replaces 2 watt versions
R701	1.3k ohm 5 watt resistor	Yes	Replaces 1/4 watt versions
R812*	5.6k ohm 1/4 watt resistor	Yes	Replaces 10k ohm versions
R813*	5.6k ohm 1/4 watt resistor	Yes	Replaces 10k ohm versions
C100	4700 uF 50v radial capacitor		Not an upgrade, but a good idea to replace
C101	4700 uF 50v radial capacitor		Not an upgrade, but a good idea to replace
C800	1 uF 50v radial capacitor	Yes	Replaces 0.47 uF 35v cap
C801	1 uF 50v radial capacitor	Yes	Replaces 0.47 uF 35v cap
C802	1 uF 50v radial capacitor	Yes	Replaces 0.47 uF 35v cap
C803	1 uF 50v radial capacitor	Yes	Replaces 0.47 uF 35v cap
D100	1N4007 (NTE125) diode	Yes	Replaces 5A2 (1N4005/NTE116)
D101	1N4007 (NTE125) diode	Yes	Replaces 5A2 (1N4005/NTE116)
D102	1N4007 (NTE125) diode	Yes	Replaces 5A2 (1N4005/NTE116)
D103	1N4007 (NTE125) diode	Yes	Replaces 5A2 (1N4005/NTE116)
F100	6.25 amp Slo-Blo Fuse	Yes	Replaces 5 amp fuse
F101	6.25 amp Slo-Blo Fuse	Yes	Replaces 5 amp fuse

\* these parts may be optional for your monitor.

### **Deflection Board Notes.**

R812 and R813 are only used in the 2nd (P327) and 3rd (P339) revisions of the Deflection board. If you have the 1st revision (P314), these parts will not be present.

Although not included in the Zanen kit, you should check the Deflection board capacitors at C100 and C101 (both are 4700 uF, 50v). Also test the 5A2 (1N4005 or NTE116) rectifier diodes at D100, D101, D102, D103. These rectifiers are 600v, 1-amp components. You can upgrade them to 5A8 (1N4007 or NTE125) diodes that spec at 1,000v, 2.5-amps.

## DEFLECTION BOARD (cont.)

To test the capacitors you will need a meter that has this option. Most do not, and the ones that do often will not go up to 4,700 mfd. If in doubt, just replace them, as they are relatively inexpensive.

To test diodes, you must remove one lead of the diode from the board. Then put your meter on the diode setting. Put your test leads on the diode and note reading. Reverse the leads and test again. In one direction you should get a null reading (no activity on the meter). In the other direction you should get between 0.4 and 0.8 volts. If in doubt, replace the diode. They are cheap!

Note that the new 1N4007 diodes used at locations D100 to D103 will be considerably smaller than the 15-year-old original diodes. Do not worry about this; new products are smaller, yet more durable.

## HIGH VOLTAGE

The High Voltage PCB (in the metal cage with the flyback transformer) had several revisions too. I would recommend doing the "upgrade" parts here as well. This brings your HV PCB to the latest revision.

<b>Zanen High Voltage (caged) PCB Parts</b>			
<u>Location</u>	<u>Part Number</u>	<u>Upgrade?</u>	<u>Notes</u>
C901	220 uF 50v Low ESR radial capacitor	<b>Yes</b>	<b>Upgrade to 220 uF 50v</b> ; 100 uF is included with Zanen kit
C902	220 uF 50v Low ESR radial capacitor	<b>Yes</b>	<b>Upgrade to 220 uF 50v</b> ; 100 uF is included with Zanen kit
C905	33 uF 160v axial capacitor		
C909	22 uF 50v radial capacitor		
C910	10 uF 350v radial capacitor		
C914	47 uF 50v radial capacitor		
ZD902	Z150B zener diode 150v		install at ZD902, not D902!
Q901	MPSA06 (NTE287) transistor		
Q902	MPSA06 (NTE287) transistor		
Q903	2N3904 transistor		
R901	2.2 ohm 2 watt resistor	<b>Yes</b>	<b>Upgrade to 3.9 ohm @ 3 watt</b> ; 2.2 ohm is included in the Zanen kit
R907	2.2 ohm 2 watt resistor	<b>Yes</b>	<b>Upgrade to 3.9 ohm @ 3 watt</b> ; 2.2 ohm is included in the Zanen kit
R918	25k Pot		Do not install unless necessary: pre-adjust to 5.5k ohms on the upper 2 contacts

<b><u>NON-Zanen High Voltage (caged) PCB Parts</u></b>			
<u>Location</u>	<u>Part Number</u>	<u>Upgrade?</u>	<u>Notes</u>
R903	3.9 ohm ½watt resistor	No, but...	replace anyway
R910	6.8k ohm ¼ watt resistor	Yes	replaces 12k ohm original
R911	4.7k ohm ¼ watt resistor	Yes	replaces 6.8k ohm original
R926	2.2 ohm 3 watt resistor	Yes	replaces 2 watt original

**HV Board Notes.**

On the HV circuit board there are two diodes D901 and D902, which the Atari TM-183 manual does not identify. They are just referred to as "silicon diodes". Apparently the replacement for these is NTE558 – a 1500V general-purpose silicon rectifier in a DO41 package. Also be careful installing the zener diode ZD902. Apparently some people mistakenly install this at D902 instead of ZD902. The monitor will **not** work if you make this mistake!

Please be careful if you decide to replace R918 (25K potentiometer) in the HV unit. R918 needs to start out adjusted to an in-circuit resistance of 5.5K when testing the upper two contacts of the three. This is the average of the normal adjustment range, which is always between 5K and 6K. If you have the potentiometer maxed out you will probably damage your unit when you turn it on.

R915 on later revisions of the HV board is the same as R908 (1K Ohm, 1/4W resistor).

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**NECK BOARD**

The Neck Board is the PCB attached to the neck of the monitor tube.

<b>Zanen Neck Board Parts</b>	
<b><u>Location</u></b>	<b><u>Part Number</u></b>
C503	33 mfd 250v axial capacitor

## TESTING YOUR WORK

### **Test the Game Board Outputs before Turning the Monitor On.**

Make sure the game board is outputting correct voltages before you power the monitor on! Otherwise you can waste the monitor and all the above work. To test the outputs, set your meter on DC volts and measure the leads of R600 and R700 (fuses) of the deflection board. These are connected to the plug with wire colors yellow (R600) and orange (R700). The correct voltage should be in the +0.5 to -0.5 volt range (basically zero volts). The voltage will fluctuate because of changing deflection signals. If the measured voltage is between 5 and 15 volts (positive or negative), then check the X and Y amplifiers on the GAME board. Also check for broken potentiometers on the game board.

### **Spot Killer On.**

If the "spot killer" LED lights on the monitor's deflection board, this indicates there is a problem. First test the voltages going to the large chassis-mounted transistors (2N3716 and 2N3792). Set your meter on DC volts. With the monitor powered on, put the black lead on ground (the metal monitor chassis), and put the red lead on the metal case of each of the chassis-mounted transistors. You should get either +30 or -30 volts DC. If you do not, there's a good chance one of those chassis-mounted transistors is bad. With the monitor off, use your meter (set to continuity ohms) and make sure the metal monitor chassis is not shorted to the metal case of each chassis mounted transistor. If it is, the mica insulator is probably damaged (and the transistor is probably blown).

### **Screen Glitters After the Game Warms Up.**

The small XY adjustment trim pots on the game boardset are probably at fault. These trim pots are factory adjusted and sealed with some hot-melt glue. As the board warms up, the expansion rate of the trim pots and the hot-melt glue is different. The glue can expand enough to separate and damage the small plastic pots! You can try removing the glue, but often you will have to replace the small trim pots (10k, 2k, 200 ohms). The only hard value to find is the 200-ohm pot (the 10k trim pots you can get at Radio Shack). You can get the 2k and 200-ohm trim pots from Mouser Electronics, or other electronic parts houses.



**CAP KIT SUMMARY:**

Parts you need to buy in addition to the Zanen cap kit.

<b>Summary: Parts you need to buy <u>in addition</u> to the Zanen cap kit</b>		
<b><u>Quantity</u></b>	<b><u>Description</u></b>	<b><u>Location</u></b>
(1)	LV2000 board ( <a href="http://www.geocities.com/jeffhendrix67/lv2000/">http://www.geocities.com/jeffhendrix67/lv2000/</a> )	
(1)*	NTE50 (do not buy if you are installing an LV2000)	Q101
(2)	NTE49 (or MPSU07 (NTE188)) if the heavier duty NTE49 can not be found)	Q604, Q704
(1)	3.9 ohm ½watt resistor	R903
(2)	3.9 ohm 3 watt resistor	R901, R907
(1)	22 ohm 3 watt resistor	R106
(1)	1.3k ohm 5 watt resistor	R701
(1)	2.2 ohm 3 watt resistor	R926
(1)	4.7k ohm ¼ watt resistor	R911
(1)	6.8k ohm ¼ watt resistor	R910
(2)*	5.6k ohm ¼ watt resistor (only needed for revision P327 or P339 Deflection board; not needed if you have revision P314)	R812, R813
(4)	1 mfd 50v radial capacitor	C800-C803
(2)	220 uF 50v radial capacitor	C901, C902
(2)	4700 uF 50v radial capacitor	C100, C101
(4)	1N4007 (NTE125) rectifier diode	D100-D103
(2)	6.25 amp slo-blo fuse	F100, F101

\* these parts may be optional for your monitor.

Here are some good parts places to get the big transistors (and other things):

- Allied Electronics; +1.800.433.5700; [www.alliedelec.com](http://www.alliedelec.com)
- Digi-Key; +1.800.344.4539; [www.digikey.com](http://www.digikey.com)
- Mouser Electronics; +1.800.346.6873; [www.mouser.com](http://www.mouser.com)
- Newark Electronics; +1.708.495.7740; [www.newark.com](http://www.newark.com)
- Circuit Specialists; +1.800.528.1417; [www.web-tronics.com](http://www.web-tronics.com)

Here are a few surplus type places that have great prices on things like electrolytic capacitors:

- All Electronics; +1.818.904.0524; [www.allelectronics.com](http://www.allelectronics.com)
- BG Micro; +1.972.205.9447; [www.bgmicro.com](http://www.bgmicro.com)
- Marlin P. Jones; +1.407.848.8236; [www.mpja.com](http://www.mpja.com)
- HSC Electronic Supply; +1.408.732.1573; [www.halted.com](http://www.halted.com)

**END**