

Sencore Blows Away CRT Failures With CR7000

Also - How CRTs Fail

By Randy Fromm



I got the call again today. It comes about once a week now. It goes something like this:

"I can't adjust the color on this monitor. It looks real dim. If I try to turn up the pots on the neck board, the picture just smears to the right. If I try to turn up the brightness on the remote

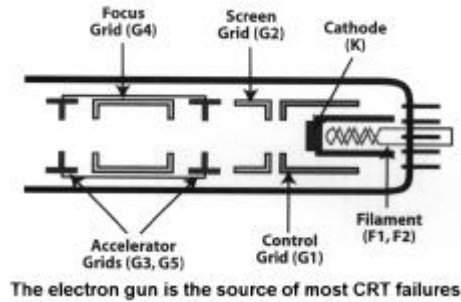
adjustments board, the picture smears to the right. If I try to turn up the contrast, the picture smears to the right. I have the screen pot turned up as high as it can go without seeing raster and vertical retrace lines washing over the whole screen."

Then, as if a sudden revelation has come over the caller, he perks up and queries "Hey! Could it be a bad picture tube?"

The answer, of course, is "Yes." To verify, I ask the age of the CRT. After three or more years in operation, many CRTs begin to fail. With so many CRTs in the world today, the ability to test and repair (yes, repair!) CRTs can be pretty darned handy. Testing and repairing CRTs will save you time and money.

But how can you fix a bad picture tube and what the heck fails, anyway? Those are good questions! As video games get converted and reconverted, the monitors can easily log tens of thousands of hours of operation. As a result, picture tube or CRT (cathode ray tube) failure has become increasingly more common.

Anyway, the answer to the question is yes. Sometimes Kinda Sorta. Maybe. But before we get into repairing picture tubes, let's take a look at some different types of picture tube failures. More specifically, we're going to look at the electron gun assembly that's located in the neck of the picture tube.



Each of the three electron guns in the electron gun assembly uses a heated cathode as a source of electrons. The heater is the element that you see glowing when you look at the neck of a picture tube. The heater must fit closely inside the metal cathode but it must not touch it. If the heater shorts to the cathode, the gun will be stuck "ON" and the screen will appear a

super bright color (red, green or blue depending on which of the three guns is affected) with vertical retrace lines visible throughout the screen. Vertical retrace lines appear as diagonal lines that run from lower left to upper right across the screen.

If you believe you might have a heater-to-cathode short, try unsoldering and removing the associated video output transistor from the neck board of the monitor. Fire up the monitor with the transistor removed. If you still have a brightly colored screen with vertical retrace lines, there's a good chance the CRT has a heater-to-cathode short.

You should be able to verify this with an ohmmeter. With the neck board removed From the CRT, you should have an infinite resistance between heater and cathode of the picture tube .

Although there are many different types of CRTs, you will often find the red cathode at pin 8, the green cathode at pin 6 and the blue cathode at pin 11. Pins 9 and 10 are for the heater.

It is also possible that one of the cathodes might become shorted to the control grid. This can cause a similar symptom as a heater-to-cathode short. If the cathode is shorted to the control grid, you should be able to verify it with your meter. The control grid will often be found at pin 5.

If the cathode has become damaged due to a buildup of oxides and other crud, you will experience a loss of one color (partial or total.) Try grounding the collector of the associated video output transistor. If the color comes on clear and bright (a brightly colored screen with vertical retrace lines) the CRT is okay. If the color does not come on or it is not as bright as the other two colors, the picture tube is bad.

Another type of electron gun failure is a short between the control grid and the screen grid. This will cause an extremely dark picture (even with the screen control at maximum) or no picture at all.

Measure the voltage at the screen grid (often pin 7) of the CRT. You should be able to run it through a range of 250 to 750 volts DC using the screen potentiometer. If the voltage is not high enough, pull the neck board off the CRT and measure the voltage at the CRT socket again. If the voltage is now normal, you probably have a short between the control grid and the screen grid. Use your ohmmeter to verify.

FIXING BAD TUBES

Is it really possible to fix a bad CRT? I have had a fair bit of success using some simple techniques. Shorted electron guns are often caused by small flakes of cathode material that have sloughed off and found their way into the electron gun. This type of failure is common in games with face-up mounted monitors (table games, gun games that use mirrors. etc.) because any crud in the CRT will naturally fall right into the electron gun. By turning the picture tube face down and tapping lightly and repeatedly on the neck with the plastic handle of a screwdriver, the flakes can sometimes be dislodged.

Do not hit the convergence ring assembly and for goodness sake don't hit the glass neck hard enough to break it! Naturally if you manage to shake the shorting particle out of the neck of the CRT, you do not want to use this picture tube for a table game again, EVER!

There is another trick that you can use to save a shorted CRT. Commercial CRT service equipment uses a technique known as "rejuvenation" to remove shorts from electron guns. The rejuvenating circuit uses a capacitive discharge to blow away any little shorting particle. We'll look at the CRT rejuvenator later but here's a cheap and dirty way to repair some shorted CRTs using just a clip lead or small piece of wire.

CAUTION: The procedures described herein involve potentially lethal voltages and must be performed by qualified personnel or at the very least by a mechanic with a decent sense of self-preservation.

1. Remove the video output transistor associated with the bad color. If in doubt, remove all three video output transistors. I usually remove all three just to be sure.
2. Locate the screen voltage pin of the CRT socket (often pin 7 but check schematic to be sure.) This pin is often labeled "G2."
3. With the neck board installed on the CRT (without the video output transistors installed) turn on the monitor and adjust the screen potentiometer fully clockwise in order to obtain maximum screen voltage.
4. Touch one end of a wire or clip lead to the screen voltage pin of the CRT socket.

5. Momentarily touch the other end of the wire to the shorted cathode pin (red, green or blue) of the picture tube. With luck, you will see a small blue arc in the neck of the CRT as the short is blown away.

6. Use your digital multimeter to verify that the short is gone. You should now read an infinite resistance. If not, repeat steps 1-6.

Cathode to grid shorts and grid to grid shorts can often be removed with this technique. Heater to cathode shorts are another story as the thin filament of the heater can blow out before the short circuit does. I have had about 25% success removing heater to cathode shorts this way.

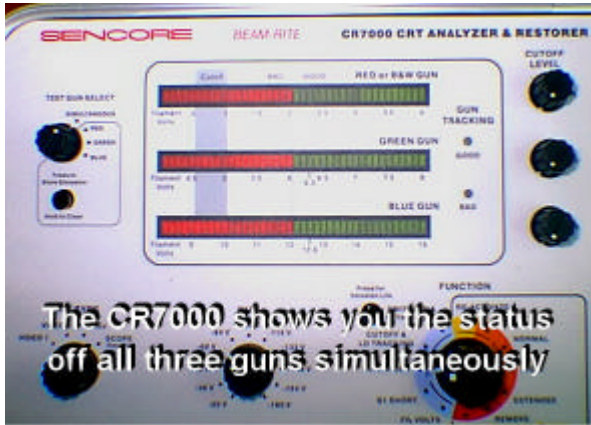
THE RIGHT WAY TO TEST AND RESTORE CRTs

Now let's look at the "correct" way to test and restore CRTs using a remarkable piece of test equipment, the CR7000 "BeamRite" CRT Analyzer and Restorer. Before I begin to describe what the BeamRite does and how it works, let me say that I have repaired and restored dozens of bad video game picture tubes using the predecessor to the CR7000, the CR70. I have taken old CRTs that were dim and virtually unusable and turned them into beautiful, bright displays that look as good as the day they were manufactured. In the process, I have saved operators and Arcade School students hundreds of dollars in CRT replacement costs. I saved \$400 just by restoring one high resolution CRT!

What is it?

First of all. Sencore's CR7000 BeamRite will test all types of picture tubes. Individual tests are made for short circuits in each of the three electron guns. Tests are made for heater-to-cathode (H-K) shorts and cathode-to-grid (G1) shorts as well. The electron guns are also tested for proper cutoff (the level at which the gun stops emitting electrons, producing black on the screen) and "emission" (sufficient beam current to produce a bright color on the screen).

Each of the tests closely duplicates the normal operation of the CRT so you're testing it under typical operating conditions. By the way, you do not need the entire monitor in order to test the picture tube. The CR7000 will test any CRT as a stand-alone unit. Naturally, you do not need to remove the picture tube from the monitor to test it. You simply remove the CRT socket (the neck board) from the monitor in order to connect the picture tube to the BeamRite. The CR7000 comes with adapter sockets for testing all types of picture tubes. Notice I didn't say "most picture tubes" or "all popular tubes." The BeamRite tests 'em all!



Another test checks the "tracking" of the three color guns. In order to produce a picture that is properly color balanced, all three electron guns have to be alike. The emission levels of all three guns are compared by the CR7000, which measures the ratio between the strongest and weakest gun. If the difference is more than 55 per cent, the gun will show as "bad." Don't

worry! Bad guns can be restored by the BeamRite as we'll see later. The CR7000 BeamRite even has a "life test." The life test will tell you how much usable life you can expect from your picture tube.

REMOVING SHORTS

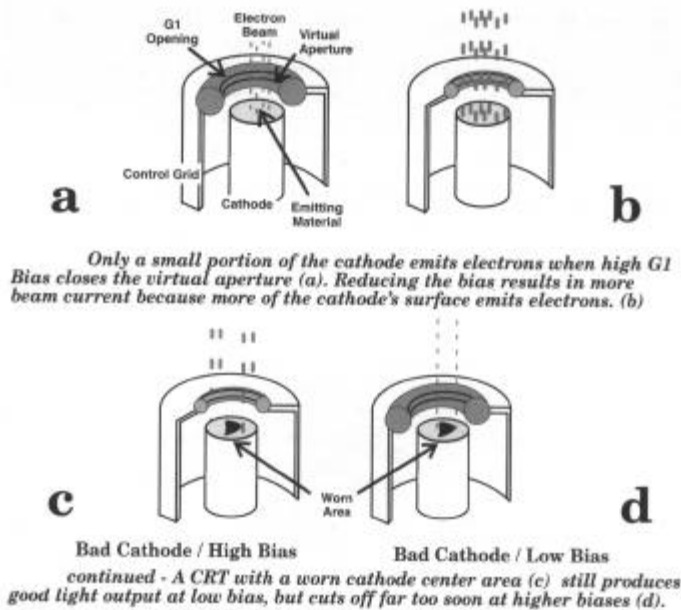
Heater-to-cathode shorts are caused by contact between the CRT heater and the cathode. The CR7000 is not designed to correct this fault as the surge current provided by the BeamRite will often blow out the filament completely.

Control grid (G1) shorts are often caused by flakes of material that have become lodged between the cathode and the control grid. A G1 short can cause loss of control of the CRT beam, resulting in a bright screen with visible retrace lines.

G1 shorts also result in CRTs that cannot be controlled by the brightness control or the incoming video or blanking signals. The CR7000 "REMOVE G1 SHORT" function will vaporize most shorting particles, resulting in normal CRT operation.

CUTOFF RELATED FAILURES In order to understand the cutoff test, let's take a closer look at the way the cathode works. The cathode is the source of the electron beam. It is coated with a material (such as barium or thorium) which gives off large numbers of electrons when it is heated by a filament. Believe it or not, there is a finite amount of this electron emitting material and it gets used up or "stripped" after years of extended use. Once the barium is used up, the picture tube cannot be completely restored.

The hot cathode emits electrons which form a cloud around the cathode until they're attracted toward the front of the screen by a positive voltage on the screen grid of the electron gun assembly. Between the cathode and the screen grid lies the control grid. In most video game monitors, the control grid is grounded, giving the control grid a negative bias with respect to the cathode. The video signal modulates (changes) the voltage of the cathode. It is the



voltage difference between the cathode and the control grid that controls the beam current and the brightness of the color.

The entire surface of the cathode is not always used to supply the electrons that make up the electron beam. When the electron gun is

only partially turned on, just the center part of the cathode is used. This means that the emitting material at the center of the cathode is used up faster than the material at the edges. The outer areas only supply electrons during peak brightness periods. When the center part becomes worn, the CRT screen still lights brightly during peak brightness but the beam cuts off too soon because the brightness drops and the worn-out center of the cathode is the only part being used. This results in a picture that's a combination of over-driven, smearing color and black, with no intermediate shades of color. Many technicians call this a "gassy" tube. Actually, the tube is exhibiting poor gamma; the ability to correctly reproduce shades of gray or color.

The CR7000 tests for proper cutoff. The cutoff test, combined with the emission test that follows, indicate the next steps to be taken in the restoration process.

EMISSION TEST

The emission test indicates if the edges of the cathode are poisoned. Poisoning occurs when positive ions coat the emitting material on the cathode. The ions are a result of a minute amount of air that's left inside the CRT during manufacturing. These ions react with the hot cathode surface over a period of time and reduce (in some cases completely shut off) the number of electrons emitted by the CRT. Cathode poisoning is similar to rust on a piece of steel.

If the tube fails both the emission test and the cutoff test, the entire surface is poisoned or stripped of emitting material. An emission life test reduces the

filament voltage to detect cathodes that are overly temperature dependent, indicating short life expectancy.

CRT REJUVENATION AND RESTORATION

The CR7000 uses a number of different methods to fix picture tubes. The method used varies from tube to tube, depending on the nature of the CRT failure. The BeamRite uses a "progressive restoration" technique that allows you to carry out CRT restoration one step at a time, using just the right combination of voltage, current and heater voltage to get the job done while avoiding the tendency to "overdo it" that many technicians have when restoring a CRT. The process of restoring a CRT is often referred to as "shooting the tube."

After removing any shorts and testing each gun for cutoff and emission, you're ready to try restoring any weak guns. The CR7000 does this by boosting the CRT heater voltage. This makes the cathode super hot. Then, a 40 to 100 milliamp current is passed through the cathode. The combination of high temperature and high cathode current removes the cathode poisoning, exposing fresh cathode material.

Restoration

The CR7000 "BEAM-RITE" offers four automatic CRT "Restore" functions to return near normal performance to the CRT cathode. The four functions are progressive levels of current and current durations including Low, Normal, High, and Extended. Progressive restoration allows you to use only what the gun needs to restore its operation.

- Re-activate 30 sec. (1 mA)
- Low - 2 sec. (40 mA)
- Normal - 2 cycles (80 mA)
- High - 3 cycles (100 mA)
- Extended - 15 sec. (100 mA)

Re-activate The CR7000 "Re-activate" function safely activates the existing cathode emitting material with little or no threat to the CRT gun. Re-activation also works well on some CRT guns that have aged causing minor cathode contamination or poisoning. You can use the Re-activate function repeatedly with little threat of damaging the CRT cathode.

The Low Restore function uses a brief two second current, limited to 40 mA, to heal the contaminated cathode surface. The Low Restore function uses a much lower current and shorter current duration than offered by any other CRT tester. On many weak cathodes, this is enough to be effective while eliminating the cathode damage that would result from other testers and higher levels of restore currents.

The Normal Restore function offers additional restore current, limited to 80 mA, and two automatic cycles lasting three seconds each. The higher current and duration removes the contamination more aggressively from the cathode while permitting a three second pause between current cycles. The High Restore functions boost the filament voltage to superheat the cathode while increasing the maximum current to 100 mA. The High Restore function is effective in removing thicker cathode contamination. For tougher cathode contamination, the Extended Function draws continuous restore current up to 15 seconds.

This has worked like a charm every time I've used it.

If you cannot get any cathode current to flow due to complete poisoning of the cathode, the CR7000 has a "rejuvenate" function. The rejuvenate function is used when the CRT cathode is so totally encrusted that no restore current can be drawn by any of the other restore functions.

In the rejuvenate function, a charged capacitor is connected between the cathode and the control grid (G1). When the sudden positive voltage from the capacitor is applied to G1, the electrons under the poison crust break free, essentially cracking the layer of contamination. Once the layer of contamination has been cracked, the other restore functions can be used successfully.

Other CRT Gun Problems and Tests

G1 & H-K Short Tests When testing a color CRT gun, the G1 Short and H-K Short tests are performed simultaneously on the red, green, and blue electron guns. The three-bar graph display indicates the resistance of the respective guns simultaneously. You know at a glance if any of the color guns has an inter-element short.

G1 Shorts Test These common shorts are automatically tested with the CR7000 and the display shows which elements have the short.

In the "Remove G1 Short" function, the cathode (K) and G2 grids are connected together. The filament voltage is removed to cool the cathode and prevent filament or cathode damage. After a delay, pressing the "Press To Restore" button discharges a 350 volt capacitor through the short path between the G1 and the K/G2 connection.

Cutoff Test The CR7000 simulates cutoff bias conditions relating to the manufacturer's specified range and circuit bias conditions.

Lo Tracking The Lo Tracking test compares the level of G2 voltage needed by each gun to produce cutoff current. It is automatically performed while testing cutoff of all three guns of a color CRT. The "Good" GUN TRACKING LED lights when all three guns are conducting within the "Cutoff" area of the display

and the G2 voltages are within a ratio of 1.25:1.

Emission Test First, the CR7000 measures "true beam" current or the current passing from the cathode through the opening in G1 and on to G2. This provides the best representation of the actual CRT beam current that strikes the phosphor screen. A second and exclusive feature of the CR7000 is a "sliding" Good/Bad scale for testing emission to manufacturer specifications.

The CR7000's Emission Life Test cools the cathodes slightly by decreasing the filament voltage by 25%. A cooled cathode produces less emission, but most good cathodes are capable of producing more current than is needed for full beam current (white picture level).

Hi Tracking The CR7000's Hi Tracking test compares the peak emission levels of each gun of the color CRT. The Hi Tracking test automatically calculates the tracking ratio as it simultaneously displays the emission readings for all three guns. The "Good" GUN TRACKING LED lights when all three guns have emission currents resulting in a ratio within 1.55:1.

FREE VIDEO TAPE AND TECHNICAL NEWSLETTER A very informative videotape on CRT failures is available from Sencore. Ask for Tech Tape #861A. The tape is free. Sencore's toll-free number is **(800)SENCORE**. The address is 3200 Sencore Drive, Sioux Falls, SD 57107. They have a website at <http://www.sencore.com>. Ask to be put on their mailing list and you'll receive a free subscription to Sencore's technical newsletter on troubleshooting monitors and VCRs. Please tell them Randy Fromm at Play Meter Magazine recommended you call.