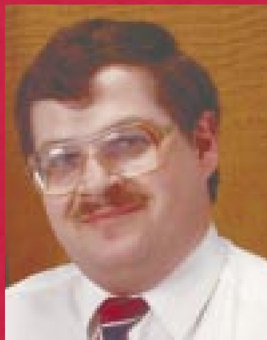
Rejuvenate!

CRT Displays



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Multimedia Producer

"If you are using a CRT tester/restorer other than the CR7000 you are likely incorrectly testing today's CRTs and risk damaging every one you restore."

CR7000 "Beam-Rite"™ CRT Analyzer & Restorer

Do you remember when the neck of a CRT was as big around as your two-year old son's arm and "instant on" meant that voltage was applied to the CRT's filaments even when the television was turned off? Those were the good old days of CRT restorers and rejuvenators. The old delta gun designs allowed plenty of room for big cathodes having thick coatings of barium or thorium. Many servicers made a good day's pay "popping" television CRTs to remove the layer of oxidation that built up on the ever-warm cathode.

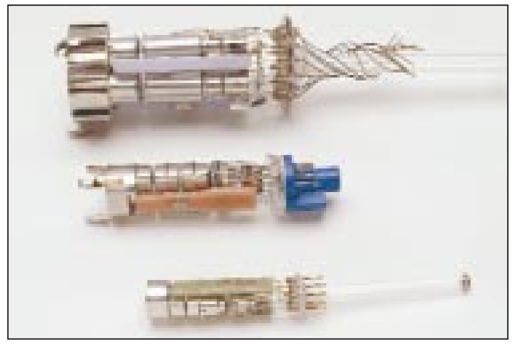

Fig. 1 - Today's electronic guns have gotten smaller and are capable of producing better quality pictures.

CRT testers and rejuvenators back then didn't need to be too elaborate. A simple bias voltage and current meter confirmed if the CRT produced nominal emission. The Shorts test often consisted of a light bulb, and since the picture wasn't all that great in the first place (by today's standards) a Tracking test was seldom necessary or provided.

Restoration was pretty basic too. Since the large cathode surfaces held plenty of extra emitting material, restoration current could be heavy and applied for long periods of time. Often the restore current came simply from a low voltage winding off a filament transformer and current limiting was a light bulb in series between the winding with the cathode. You'd select which cathode to restore, push the restore button, and watch while the restore current turned the selected cathode cherry red. Usually if one gun needed restoration most service technicians would also pop the other two guns just to be safe. In fact, many service shops would routinely clean the CRT guns whenever a television chassis came in for repair.

CRTs have changed a lot over the years in both design and application. Refinements to CRTs such as higher bias voltages, improved focus methods, in-line gun structure and smaller neck diameters provide today's CRTs exceptional picture quality and resolution. One-half of today's new CRTs are used in computer monitors where they commonly offer resolutions of over 1.3 million picture elements.

Fig. 2 - Sizes of CRT's have changed dramatically over the years from the old Delta gun style to today's newest in-line. The smaller in-line gun produces much better convergence.

All the changes in CRT design, however, have not altered the basic operation of a CRT; a hot cathode still emits electrons which are formed in to a thin beam which strikes a phosphor screen to give off light. Today's CRT cathodes still become contaminated and suffer emission loss, just like their ancestors. However, the emission level and current ratios between guns has never been more critical to picture quality than in today's CRTs. A dozen years ago, a 20% decrease in a CRT electron gun's performance had little or no perceivable affect on the displayed picture. Oh, maybe the picture was a bit darker, and the viewer needed to turn up the brightness a bit, but the colors still looked the same and the picture detail or resolution surely wasn't affected. A similar change in an electron gun's output in one of today's high performance CRTs will result in an unacceptable change in the picture's brightness, contrast, or focus.

While they may not become contaminated as often or as badly as the cathodes in yesterday's "instant on" chassis, the cathodes in today's CRTs still become oxidized. The difference is that today's CRT cathodes cannot tolerate anywhere close to the same amount of restore currents that older CRTs could.

What do these changes mean for you as service/maintenance technician, or business owner? It means that if you are using a CRT tester/restorer other than the CR7000 you are likely incorrectly testing today's CRTs and risk damaging every one you restore.

Accurate Tests

In order to properly test a CRT, a CRT tester must:

- check for leakage between elements within the same electron gun, and for leakage between different electron guns
- closely duplicate the circuit's bias voltages for accurate test results
- dynamically test the full range of conduction from back (cutoff) to white to detect contrast problems
- compare the full emission range of each gun relative to the other two guns to detect color tracking problems
- accurately measure current levels and compare them to the CRT manufacturer's specifications to correctly identify emission-related focus, contrast, brightness and smearing problems.

Let's take a closer look at each of these to see why the CR7000 is the only CRT tester that accurately tests today's high performance CRTs.

G1 & H-K Shorts Tests

During the H-K and G1 Shorts tests the CR7000 functions as a sensitive ohmmeter to isolate inter-element and inter-gun leakage current paths that can cause bias problems that result in a bad picture display. A bar graph for each gun indicates the severity of the short or leakage path. All three bar graphs are displayed simultaneously so you know immediately if a gun has inter-element leakage.

CRT Bias Range and Cutoff Test

The point at which an electron gun just begins to conduct a small amount of current is called cutoff. This small current corresponds to black video. At the opposite end of a gun's conduction is full emission, or white video level. The only way to determine the condition of a CRT is to test its cutoff and full emission currents at the manufacturer's specified operating conditions. The CR7000 provides bias voltages in 16-volt steps from -20 to -180 volts, and variable G2 voltage up to 600 volts. These voltages properly test all CRTs within manufacturer's specifications.

Figure 3 shows a typical manufacturer's cutoff design chart that specifies the combination of bias (G1) and G2 voltages that should produce cutoff current (black video level) in a good CRT. Any combination of bias and G2 voltage that produces current within the shaded area is good. If more G2 voltage than specified is needed to produce cutoff current, the electron gun is bad and will have a contrast problem, as indicated by a bad CR7000 cutoff test.

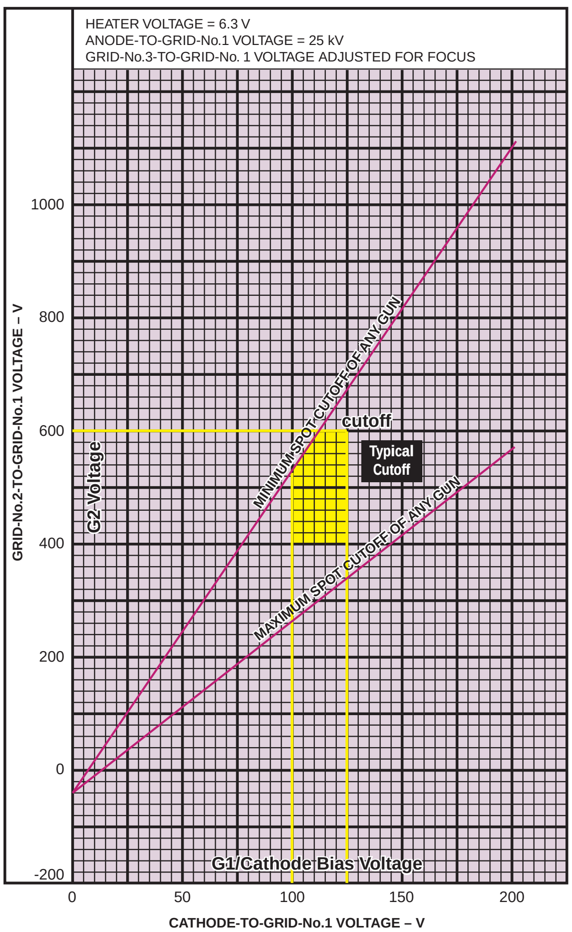

Fig. 3 - The conduction of a CRT changes with applied bias.

Most of today's high-performance CRTs operate at a high negative bias (typically -100 to -132) and corresponding high G2 voltage (400-600 volts). This produces a very fine, tightly focused electron beam that results in very high resolution.

Other CRT testers provide a maximum negative bias of just -68 volts. As you can see on the cutoff chart, this bias voltage tests the CRT at the low end of its operating range, well below the normal chassis operating bias. These testers incorrectly identify cutoff related contrast problems, and cannot pinpoint emission-related focus problems. The CR7000 is the only CRT tester that accurately simulates manufacturers bias conditions to pinpoint these CRT failures.

Color Tracking Tests

In order to produce proper colors and a proper gray scale, all three electron guns must produce similar amounts of beam current with the same applied bias and G2 voltages. All CRT manufacturers specify the maximum difference in G2 voltage that is needed to produced cutoff (black video) between the weakest and strongest guns. The CR7000 tests for this ratio of 1.25:1. A "bad" Lo Tracking indication indicates that one of the guns requires over 25% more G2 voltage to reach cutoff current than the other two guns. A CRT that has this condition cannot be set for color balance correctly at low luminance levels.

The CRT manufacturers also specify how the three guns of a color CRT track each other at full emission. Here, the manufacturers specify that the maximum difference in currents must be less than 1.55:1. If one gun produces less than 55% of the current produced by the strongest gun the CRT, you will not be able to adjust the CRT setup controls properly and the picture will have poor gray scale tracking and color balance at high luminance levels. The CR7000 is the only CRT tester that provides both a Lo and Hi Tracking test to thoroughly test gun tracking across the entire video range.

Sliding Good/Bad Scale

For many years CRT testers simply fixed a point on a current meter scale and marked the current greater than this point "good emission" and currents lower than this point "bad emission". Some CRT testers used 300 uA as this dividing line, and others used 500 uA. This fixed Good/Bad point worked for good as long as CRTs used -52 or -68 bias. But most CRTs today use a much higher negative bias. A CRT tester that uses a fixed Good/Bad emission scale will not identify CRT guns that have marginal emission. In fact, these testers may call a CRT "Good" even if the emission has dropped to 10% or less of normal current! Here's why you need a CRT tester that uses a sliding Good/Bad emission scale.

Fig. 4 - The CR7000 provides a sliding Good/Bad scale based on the CRT's actual operating bias.

The maximum emission current (Ikmax) produced by a CRT varies directly with the amount of negative bias (Vcutoff) applied to the CRT, bias (Vcutoff) applied to the CRT, according to the formula Ikmax = $(Vcutoff)^{1.5}$. This relationship is summarized in Fig. 5 for various CRT biases. As you can see, the higher the operating bias, the more current a gun produces. All CRT manufacturers use a table very similar to this to decide if a new CRT is good.

Bias Voltage	Ik max (“new” emission)	CR7000 “Good/Bad”
20	268 µA	134 µA
36	648 µA	324 µA
52	1125 µA	563 µA
68	1682 µA	841 µA
84	2310 µA	1155 µA
100	3000 µA	1500 µA
116	3748 µA	1874 µA
132	4550 µA	2275 µA
148	5401 µA	2700 µA
164	6301 µA	3150 µA
180	7245 µA	3622 µA

Fig. 5 - The emission current produced by a CRT gun corresponds to its cut-off voltage. The CR7000’s Good/Bad dividing line represents 50% of “new” emission current.

To understand why a sliding Good/Bad emission scale is necessary, consider a CRT that operates at -84 bias. At this bias, each gun will produce at least 2,310 uA of beam current at full emission. As the tube ages or the cathode becomes contaminated, the CRT’s emission drops and the picture it produces becomes noticeably poorer. When the emission has dropped to about 50-60% of normal the picture is no longer useable. (How far the emission can drop before the picture is adversely affected varies somewhat with CRT type and application. Some high resolution displays develop poor focus when the emission drops to 75%. Other television CRTs produce a weak, but acceptable picture with as little as 40% of normal emission). At 50% normal output, this CRT still produces 1155 uA of current - well beyond the 300 or 500 uA Good/Bad point on all other CRT testers. The emission in this CRT has to drop off over 85% before most CRT testers call the CRT bad. To make matters still worse, consider what happens with a CRT that operates at -100, -116 or -132 volt bias!

The CR7000’s sliding Good/Bad scale changes with bias to accurately test electron gun emission. As Fig. 5 shows, the CR7000’s Emission test center scale good/bad dividing line is always 50% of the normal “new” emission. In addition, the CR7000’s emission scale is linear so that you can accurately determine how much current each gun is producing. This allows you to determine if a focus problem could be the result of decreased emission and accurately determine if a weak or poor contract picture is caused by low emission.

Safe, Effective Restoration

Chances are very good that if you restore one of today’s CRTs with an old CRT restorer you will destroy the CRT. There several reasons why older restorers won’t do the job today.

The electron gun structures in today’s CRTs are much smaller and the elements are much closer spaced than old style delta and early in-line types. Heavy restore currents quickly warp these elements, causing them to short or misalign when they cool. Because the cathodes are smaller, they contain less surface area and less reserve emitting material. Even moderate restore currents can quickly strip these delicate cathodes of their emitting material.

Many of the CRTs you test and restore today are used in computer monitors. Computer monitor CRTs have somewhat different failure conditions than television CRTs. Television CRTs more often develop poor color tracking and contrast problems, while computer monitor CRTs fail due to low brightness or poor focus. The biggest reason for this is that a computer monitor CRT is almost always fully conducting, whereas a television CRT continually changes from no to full conduction. Take a look at the closest operating computer. Chances are that the monitor is producing a nearly all white raster, except for some gray borders and black text. To produce this image, the entire cathode’s surface is producing elections almost all the time, as illustrated in Fig. 6a.

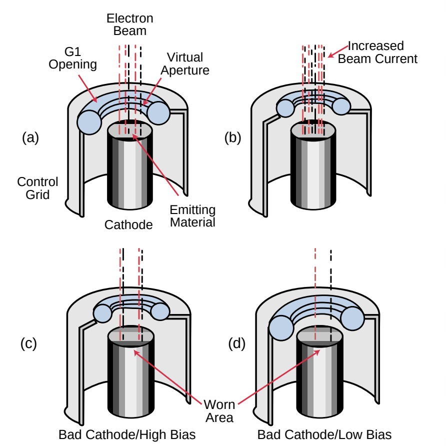

Fig. 6a - (a) Only a small portion of the cathode emits electrons when high GI Bias closes the virtual aperture; (b) Reducing the Bias results in more beam current because more of the cathode’s surface emits electrodes; (c) A CRT with worn cathode center area (c) still produces good light output at low bias; (d) but cuts off far too soon at higher biases.

Now take a look at a television picture. The scene is continually varying in color and luminance levels. Seldom is the picture all white, or is one color fully saturated. To produce this image, only a small portion of the cathodes continually conduct as the bias opens and closes the virtual aperture to mach the picture scene, as illustrated in Fig. 6b. This operation allows part of the cathode's surface to become oxidized over a period of time which lowers emission and causes a dark picture. Because the center of the cathode is always conducting, it wears more quickly than the outer edges. This leads to poor contrast and low level luminance tracking.

A computer monitor CRT fails differently. Because the entire cathode surface is continually emitting electrons, there is little change for oxidation to build up anywhere the cathode's surface. This also means that the cathode surface wears more evenly, so contrast and low luminance tracking are less of a problem. Additionally, since computer monitors usually display a mostly white image, all three cathodes tend to wear equally.

To effectively restore today's CRTs, the CR7000 was designed with six levels of progressive restoration. These levels are based on extensive field use and feedback from our customers. The best way to use these restoration levels is to start low and step up as needed. Of course you should never restore a CRT unless the CR7000's tests indicate that the CRT has a problem, and you should always re-test the CRT after every restoration attempt.

Re-activate

This restore function closely duplicates the process that manufacturers use to initially activate a new cathode. This is the lowest restore level provided by any CRT restorer. It produces restore current of 1 mA, which is very near the normal "white" emission level of the CRT gun, and poses little threat to the gun. Many CRTs are successfully restored with one application of Re-activate.

Restore

The CR7000 provides four levels of Restore current: Lo, Normal, High and Extended. These levels differ in the amount and duration of restore current applied to the CRT. You'll use Lo Restoration if the Re-Activate function fails to return the CRT to acceptable operation. The Restore functions are effective for bringing fresh emitting material to the cathode's surface by effectively removing old emitting material and contamination from the cathode's surface. The amount of restore current and duration needed to restore a cathode varies. The CR7000's four progressive Restore functions provide the necessary current, while minimizing unnecessary strain on the CRT. The lowest level of restoration provided by other CRT restorers is about equal to the CR7000's High restoration level. These restorers will destroy today's CRTs before you have a chance to stop.

Remove G1 Short

CRTs sometimes develop a short between either the cathode and G1, or between G1 and G2. Most shorts are small pieces of material that wedge between the elements. This material may be fragments from one of the elements, but are usually flakes of oxidation from the cathode's surface. Occasionally a short is the result of the elements physically touching.

The CR7000's Remove G1 short function provides a safe and effective way of removing most of these shorts. In the Remove G1 Shorts function, the filament voltage is removed to protect the delicate cathode. (The CR7000 waits 20 seconds to insure that the filaments are cooled). Then, a capacitor is discharged through the short and a current limiting resistor. This capacitor discharge safely removes most shorts.

Rejuvenation

Rejuvenation is by far the most aggressive form of restoration provided by the CR7000. When used on a cathode that is capable of producing emission or Restore current, it can almost instantly stripe the emitting material from the cathode's surface. Yet, surprisingly Rejuvenation is the main restoration method offered by some CRT restorers. Rejuvenation should only be used on CRTs that have extremely contaminated cathodes where the oxidation layer prevents restore current in any of the other Restore functions.

Here's Your Green Light To Go For Profits & Security!

CR7000 CRT ANALYZER

> *"We paid for the CR7000 while it was still on evaluation! Six of eight monitors were restored and placed back in service."*
>
> *Bob Politza*
> *Major Regional Telecommunications Carrier*

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