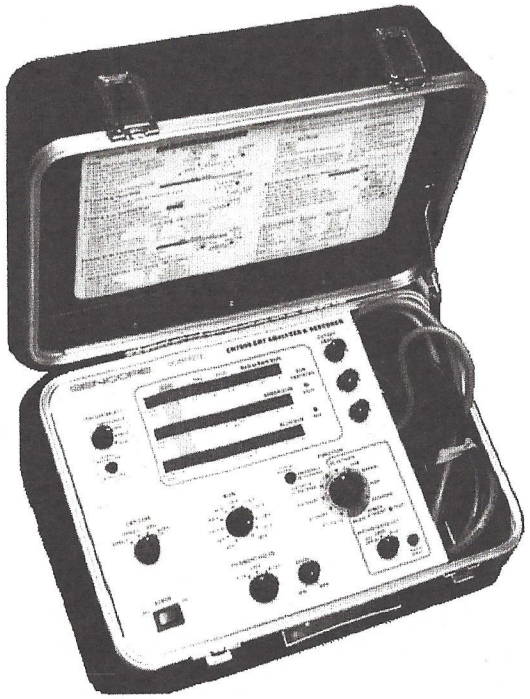
Notes

CR7000

"BEAMRITE"

CRT Analyzer & Restorer
Operation and Application Manual



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DESCRIPTION

INTRODUCTION

Cathode Ray Tubes (CRTs) provide a visual display of information. CRT sizes vary widely from tiny camcorder viewfinder tubes to large direct-view televisions. CRT applications include direct-view and projection televisions and video monitors, computer monitors, data display terminals, medical monitors, electronic test equipment, radar displays and a host of other special applications. While their size, application, resolution, and display color vary greatly, all CRTs have one thing in common - they use a hot cathode to produce an electron beam.

Because they use a hot cathode all CRTs eventually develop weak emission and unacceptable operation. But not all weak CRT displays are caused by a bad CRT. Circuit defects or misalignments produce similar symptoms. A simple, reliable way is needed to determine if the CRT is capable of producing an image that has sufficient brightness and gray scale. When a CRT has weak emission, it can usually be restored to an acceptable level, greatly extending the tube's useful life.

The Sencore CR7000 "BEAM-RITE" Universal CRT Analyzer and Restorer quickly and accurately tests and restores most CRTs. Its tests analyze the electron gun and provide you with accurate information about the gun's condition. These tests help you decide if the CRT is capable of normal output, if you should attempt to improve its operation with the CR7000's restore functions, or if the CRT should be replaced.

FEATURES

The CR7000 allows you to quickly connect to a CRT with minimal setup. Its tests are simple to perform and easy to interpret. The dynamic tests closely duplicate the gun's normal operating conditions. G1 and H-K shorts tests confirm that there are no inter-element shorts inside the gun assembly. An exclusive Cutoff test checks the low level emission current to confirm the gun's luminance linearity. An exclusive emission test measures peak cathode current at manufacturer's test specifications, and uses a sliding Good/Bad scale that is based on the gun's cutoff bias to provide a true indication of the gun's condition. Exclusive Hi and Lo Tracking tests compare the cutoff and peak emission characteristics of each gun in a color CRT to check the tube's ability to produce a good gray scale (white balance).

All test results are displayed on an easy-to-read LED bar graph, complete with Good/Bad indicators. All three guns of a color CRT are tested simultaneously so you can tell at a glance how each gun compares to the others. A full range of Bias and G2 voltages allow you to test all CRT types, including electrostatic deflection Scope, Video and Projection.

When the CRT electron gun does have a problem, six types of cathode restoration plus G1 shorts removal provide the safest and most effective cathode recovery methods possible for bringing extra life back to most weak and shorted electron guns. Progressive restoration steps allow you to use enough restoration to do the job, but not so much as to damage the CRT further or needlessly shorten its life. Automatic current and time limits help prevent over restoring.

The CR7000 comes with a complete set of supplied sockets that provide easy connection to CRTs with minimal setup. When necessary, the supplied Universal Adapter allows you to make connection to uncommon CRT bases.

SPECIFICATIONS

CRT Test Functions

Shorts Tests
Tests inter-element resistance. Result displayed on bar graph.
G1 Shorts: 20 megohm center scale ± 5% ± 1 segment
H-K Shorts: 2 megohm center scale ± 5% ± 1 segment

G2 Voltage
Range: 10-400 VDC Video 1, Proj, and Scope CRT Types;
15-600 VDC Video 2 CRT Type
Accuracy: ± 5% full scale

Bias Voltage (measured "-" with respect to cathode)
Range: Video & Projection: 20, 36, 52, 68, 84, 100, 116,132,
148, 164, 184 VDC;
Scope: all bias voltages divided by 10
Accuracy: Video & Projection: ± 5%; <0.5% ripple at 117 VAC
(or 220 VAC) line voltage; Scope: ± 5%; <0.5% ripple at 117VAC
(or 220 VAC) line voltage; ± 200mV at 2 and 3.6 ranges

Cutoff & Lo Tracking Test
Tests ratio of G2 voltages needed to produce cutoff current in all 3 guns of a color CRT or projection system. Cutoff current measured between K and G1.
Indication: green "Good" LED, red "Bad" LED
Good/Bad indication: "good" indication if the G2 voltages for all 3
guns are within 1.25:1 when adjusted to place the cathode
currents of each gun into the Cutoff Set box.

Good/Bad current (Cutoff Box) calibration: 10-15 uA video; 0.35-0.60 uA scope; 30-50 uA Proj
Resolution: 1 uA video; 0.05 uA Scope; 4 uA Proj
Accuracy: ± 5% G2; current ± 5% ± 1 segment

Emission Test

Measures true beam current reaching G2.

Method: successively cycle guns to momentary 0 bias with a 25% duty cycle pulse. G2 voltage for each gun set to cutoff current level at normal bias.
Display: Simultaneous bar graph display of all 3 guns in "Simultaneous" Gun Select
Update speed: Automatically cycles between guns at approximately 25 Hz rate
Test duration: testing ceases after 15 seconds, display holds last measurement. Time-out indicated by flashing Tracking LED.
Accuracy: ± 5% ± 1 segment
Center Scale Calibration Current: varies with CRT Type;
Video 1, Video 2: sliding scale based on formula:
$Ikmax = 3 \times Vco^{3/2} \times 50\%$; resolution varies with bias
Scope: 10 uA; resolution: 0.4 uA
Projection: 800 uA; resolution: 40 uA

Life Test

Provides approximate indication of cathode reserve current by lowering filament voltage 25%

Hi Tracking Test

Automatically compares emission currents between highest and lowest guns in "Simultaneous" gun test and indicates Good/Bad result with LED.

Indication: green "Good" LED, red "Bad" LED
Good/Bad calibration: 1.55:1
Accuracy: ± 5% ± 1 segment

Filament Voltage

Range: 0 - 4; 4 - 8; 8 - 16 VDC; continuously variable within selected range.
Display: voltages marked along bar graph
Accuracy: ± 5% ± 1 segment at 117 VAC (or 220 VAC) line voltage
Resolution: 0.1 volt 0-4 and 4-8 ranges, 0.2 volt in 8-16 range
Current limiting: 2.25 amps, 25 watts minimum

Restore Functions

Progressive restore functions apply positive biases and increased filament voltages for cathode super-heating.

Reactivate Restore

Filament voltage: 50% boost, ± 5%
Current limit: 1 mA max. all CRT types at 117 VAC (or 220 VAC) line voltage
Time: user controlled button, automatic time-out after 30 seconds
Display: 1 mA center scale +5% -15%

Low Restore

Filament voltage: normal, (no boost)
Current limit: 40 mA max. all CRT types at 117 VAC (or 220 VAC) line voltage
Time: user controlled; automatic time-out after 2 seconds
Display: 40 mA center scale +5% -15%, 2 mA resolution

Normal Restore

Filament voltage: normal, (no boost)
Current limit: 80 mA max. all CRT types at 117 VAC (or 220 VAC) line voltage
Time: 2 automatic cycles of 3 seconds ON and 3 seconds OFF while Restore button is pressed
Display: 80 mA center scale +5% -15%, 4 mA resolution

High Restore

Filament voltage: 50% boost ± 5%
Current limit: 100 mA max. Video & Projection, 80 mA scope type at 117 VAC (or 220 VAC) line voltage
Time: 3 automatic cycles of 4 seconds ON and 2 seconds OFF while Restore button is pressed
Display: 100 mA center scale + 5% -15%, 5 mA resolution

Extended Restore

Filament voltage: 50% boost, ± 5%
Current limit: 100 mA max. Video & Proj, 80 mA Scope at 117VAC (or 220 VAC) line voltage
Time: user controlled; automatic time-out after 15 seconds
Display: 100 mA center scale + 5% -15%; ± 1 sec, 5 mA resolution

Remove G1 Short

Method: Capacitive discharge between G1 & K/G2 occurs after 20 second delay for filaments to cool
Applied voltage: 400 VDC
Discharge time: determined by severity of CRT short

Rejuv

Method: Capacitive discharge between G1 & K (positive bias) with normal filament voltage
Applied voltage: 400 VDC
Discharge time: determined by condition of CRT cathode

General

Display: Three, 40 segment LED bar graphs (20 green and 20 red segments) with Filament voltage scale and Cutoff set box markings.
Size: 7 fl" x 12 fi" x 8 fl" HWD
Weight: 13 lb..
Power: 105-125 VAC 50/60 Hz, 90 watts max.
210-230VAC operation is available.

Controls

1. DISPLAY

Shows the results of the Test and Restore functions selected by the FUNCTION switch.

a, b, c. FILAMENT VOLTS scales - Display the filament voltage set by the FILAMENT VOLTS controls (7a,b). Read the "a" scale when the FILAMENT VOLTS range control (7a) is set to "0-4 V"; read the "b" scale for the "4-8 V" setting; read the "c" scale for the "8-16 V" setting.

d. CUTOFF SET BOX - Set the bar graph for each respective gun into this area with the corresponding CUTOFF LEVEL control (2a,b,c) when the CUTOFF TEST (3d) is selected.

e, f, g. BAR GRAPHs - ***Test Functions:*** Display the results of the G1 SHORT (3b), H-K SHORT (3c), CUTOFF & LOW TRACKING (3d), and EMISSION & HI TRACKING (3e) tests for the Red (e), Green (f) and Blue (g) guns of a color CRT or projection system. The active graph(s) corresponds to the setting of the TEST GUN SELECT switch. ***Restore Functions:*** Indicates the amount of current drawn by the CRT gun selected by the RESTORE CRT GUN switch (6) when using the Restore functions (3f-i).

h. CENTER SCALE - ***Test Functions:*** G1 SHORT (3b), H-K SHORT (3c), and EMISSION & HI TRACKING (3d) test results that are to the right of this line (Red and Green LEDs illuminated) are considered "good". Test results left of this line (only Red LEDs illuminated) are considered "bad". ***Restore Functions:*** This line indicates the maximum current limit when using one of the Restore functions (3f-i). Only the red LEDs to the left of the line will illuminate.

i. "GOOD" GUN TRACKING - LED Illuminates to indicate a good LO TRACKING (3d) or HI TRACKING (3e) test result when a color CRT is under test.

j. "BAD" GUN TRACKING LED - LED Illuminates to indicate a bad LO TRACKING (3d) or HI TRACKING (3e) test result when a color CRT is under test.

2. CUTOFF LEVEL

Sets amount of G2 (screen) voltage applied to each gun during the CUTOFF & LO TRACKING (3d) and EMISSION & HI TRACKING (3e) tests. Adjust for a reading within the CUTOFF SET BOX (1d) when the CUTOFF TEST (3d) is selected.

a. R - Adjusts red gun G2 voltage when the TEST GUN SELECT (12) switch is set to "Simultaneous" or "Red".

b. G - Adjusts green gun G2 voltage when the TEST GUN SELECT (12) switch is set to "Simultaneous" or "Green".

c. B - Adjusts blue gun G2 voltage when the TEST GUN SELECT (12) switch is set to "Simultaneous" or "Blue".

3. FUNCTION SWITCH

Test Functions - Use the TEST GUN SELECT control (12) to select which gun of a color CRT or project system is tested. View the test results in the DISPLAY (1).

a. FIL VOLTS - Set the display to indicate filament voltage on the bar graph (1a,b,c).

b. G1 SHORT - Determines if gun contains a short between either G1 and K, or between G1 and G2.

c. H-K SHORT - Determines if the CRT gun contains a short between the heater (H) and cathode (K).

d. CUTOFF & LO TRACKING - ***Cutoff Test:*** determines if CRT gun begins to conduct at normal bias as the CUTOFF LEVEL controls (2a,b,c) are adjusted until the corresponding BAR GRAPH for each gun reads in the CUTOFF SET BOX (1d). A CRT gun that will not adjust into this area at specified bias is bad. ***Lo Tracking test:*** compares all three G2 voltages that produce cutoff. If their ratio is within 1.25:1 the GOOD GUN TRACKING LED (1i) illuminates; if their ratio is greater than 1.25:1 the BAD GUN TRACKING LED (1j) illuminates.

e. EMISSION & HI TRACKING - ***Emission Test:*** measures the amount of beam current of each CRT gun. The Hi Tracking test compares the emission currents of all three guns. If their ratio is within 1.55:1 the GOOD GUN TRACKING LED (1i) illuminates; if their ratio is greater than 1.55:1 the BAD GUN TRACKING LED (1j) illuminates.

Restore Functions - The following Restore functions are used with the RESTORE GUN SELECT switch (6) RESTORE button (5), and READY LED (4).

f. RE-ACTIVATE - Applies the lowest level of restoration current.

g. LOW - Applies 1 cycle of restoration at a higher current level than RE-ACTIVATE.

h. NORMAL - Applies 2 cycles of restoration at a higher current level than LOW.

i. HIGH - Applies 3 cycles of restoration at a higher current level than NORMAL.

j. EXTENDED - Applies the same level of restoration as HIGH, but for a longer time.

k. REMOVE G1 SHORT - Use when the G1 SHORT test (3b) indicates a short.

l. REJUV - Use to start a gun that will not draw restore current in any of the other RESTORE functions (f-j).

4. READY LED - Use with the RESTORE functions (3f-k) and RESTORE button (5) to control restoration time. Illuminates when restore circuits are ready and turns off when restoration cycle is complete.

5. RESTORE Button - Push with RESTORE functions (3f-k) selected to begin restoration. Release when READY LED (4) turns off.

6. RESTORE GUN SELECT Switch - Determines which gun of a color CRT will be restored. Use "RED/B&W" for single gun CRTs.

7. FILAMENT VOLTS - Use with FILAMENT VOLTS scales (1a,b,c) to adjust the filament voltage supplied to the CRT under test.

a. Range - Provides a coarse setting of the filament voltage. "0-4 V": use FILAMENT VOLT scale (1a); "4-8 V": use FILAMENT VOLT scale (1b); "8-16 V": use FILAMENT VOLT scale (1c).

b. ADJUST - Provides fine adjustment of the filament power supply to match the CRT under test.

8. BIAS - Determines how much negative bias voltage is applied to the control grid (G1) during the CUTOFF & LO TRACKING Tests (3d). Also determines sliding scale for EMISSION & HI TRACKING tests (3e).

9. POWER - Applies power to the CR7000 and CRT. Switch lights when power is applied.

10. CRT TYPE - Establishes the correct internal calibration to match the selected CRT Type.

11. PRESS FOR EMISSION LIFE - Push button in EMISSION & HI TRACKING test (3e) to test cathode reserve current.

12. TEST GUN SELECT - Determines which gun of a color CRT is tested. Also allows the separate CRTs of a projection system to be tested and compared to each other

a. SIMULTANEOUS - Use this position to test most color CRTs using one of the supplied socket adapters. Test results for all three guns will be displayed simultaneously on the BAR GRAPHs (1e, f, g).

b. RED - Use to test monochrome CRTs, the red gun of a color CRT, or the red CRT in a projection system. Read the test results on the RED or B&W GUN BAR GRAPH (1f).

c. GREEN - Use to test the green gun of a color CRT, or the green CRT in a projection system. Read the test results on the GREEN GUN BAR GRAPH (1g).

d. BLUE - Use to test the blue gun of a color CRT, or the blue CRT in a projection system. Read the test results on the BLUE GUN BAR GRAPH (1h).

e. PRESS TO STORE EMISSION - Use with "Red", "Green"and "Blue" position of the TEST GUN SELECT switch (12b,c,d) to store the CUTOFF (3d) and EMISSION (3e) test results so that all three guns or CRTs can be compared.

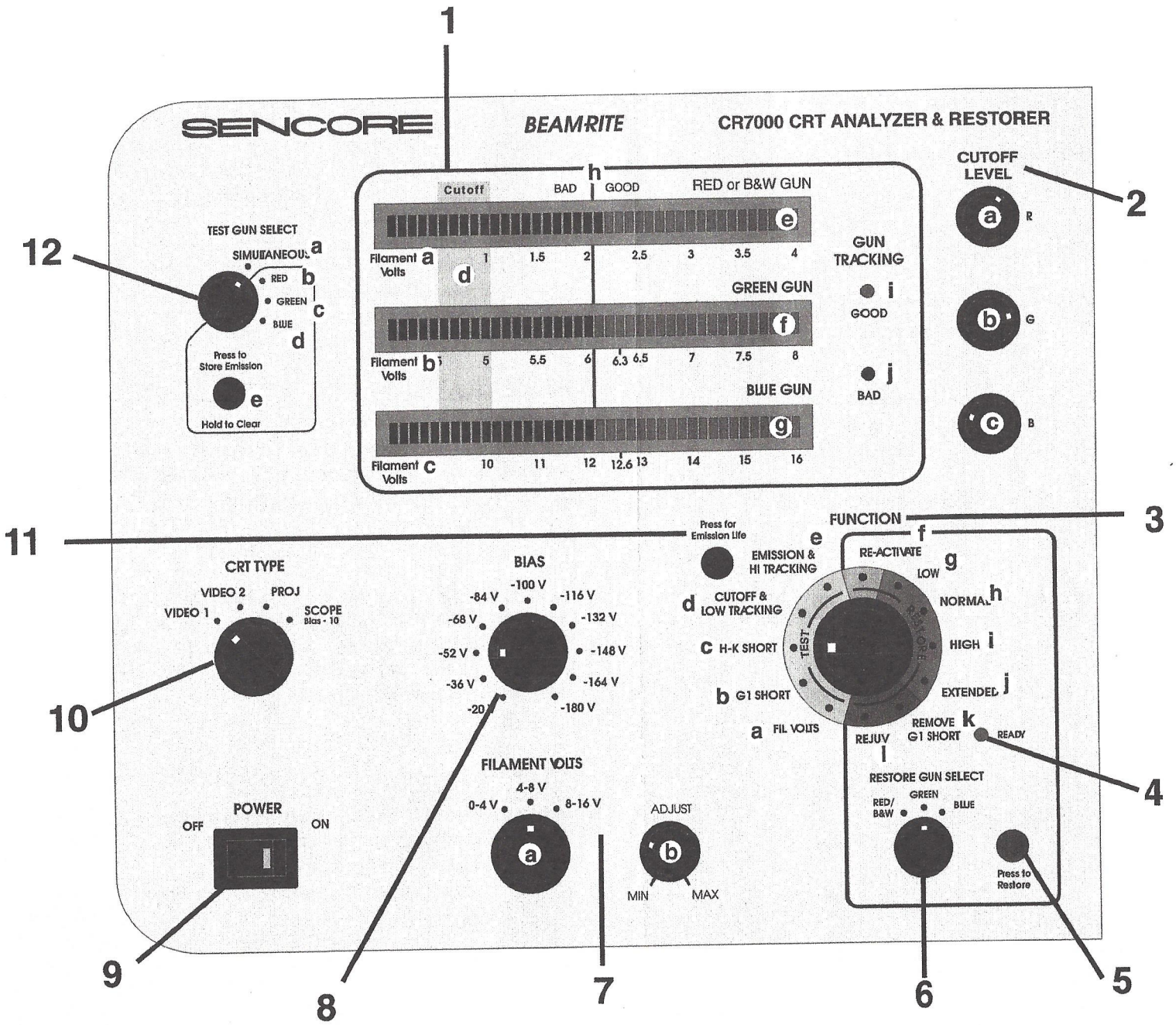


Figure 1- Location of controls and features.

OPERATION

INTRODUCTION

This section of the manual explains how to prepare your CR7000 for operation and describes how to use its controls and features. The material is presented in the sequence you need to follow to test and restore a CRT. It contains the following sections:

1) Preparation For Use
2) Setup Book Information
3) Using The Adapter Sockets
4) Beam Test Functions
5) Restore Functions
6) Using The Test Gun Select Switch

PREPARATION FOR USE

The CR7000 is ready to use when it is removed from its packing material and connected to a proper source of AC power. All of the Supplied Accessories are in the same box as the CR7000. The socket adapters are located inside the lid, behind the door that has the Simplified Instructions. Pull on the latch to open the door.

The CR7000 is wired for use on a 105-125 VAC 50/60 Hz AC line. It is very important that the CR7000 be connected to a properly grounded AC outlet. This third wire safety ground connection is necessary for the safety of the user, and to protect the CR7000 from a CRT that still has a high voltage charge on it.

CAUTION

Defeating the third wire safety earth ground connection may cause the CR7000 to operate incorrectly, may damage the CR7000, or create a safety hazard.

ATTENTION

La suppression du troisiéme cable de l'alimentation (la terre) peut avoir pour concéquences une malfonction du CR7000 ou bien peut endomager l'appareil.

220 VAC Operation

The CR7000 may be wired to operate at 220 VAC 50 Hz. This conversion can be made by the Sencore Service department. You can contact the Sencore Service Department at the address and phone number on the inside back cover of this manual. The label next to the power cord, shown in Figure 2, indicates if the unit is wired for 220 VAC or 110 VAC operation.

AC Line Fuse

The CR7000 is protected from excessive damage caused by internal failures of an AC line fuse. The fuse is located on the right side of the unit, next to the AC power cord, as shown in Figure 2. The proper fuse value is 1 amp, 250 volt, Slo-Blow, type 3AG.

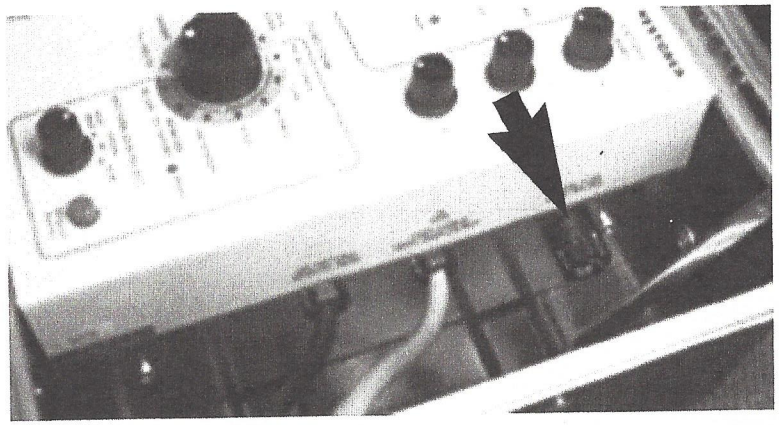


Fig. 2 - Location of the AC line fuse.

CAUTION

The wrong fuse value may damage the CR7000. Replace the AC line fuse only with a 1 amp, 250 volt, Slo-Blow, type 3AG.

ATTENTION

Un mauvais fusible peut endomager le CR7000. Remplacer le fusible de la ligne secteur par un fusible 1 amp, 250 volt, rapide de type 3AG.

SETUP BOOK INFORMATION

Before you can test or restore a CRT you must connect the CR7000's circuits to the pins of the CRT and apply proper bias and filament voltages. The information for most of the CRTs you will test or restore is provided in the Setup Book supplied with the CR7000. The Setup Book is updated regularly and the latest update can be obtained from the Sencore Service Department at the address and phone number listed on the inside back cover of this manual. The APPLICATIONS section of this manual explains how to get the setup information for a CRT that is not listed in the Setup Book.

Figure 3 shows a portion of the CR7000's Setup Book. All of the information required to test a CRT is listed following the CRT number. This information corresponds to the settings of the CR7000's controls. Following is a brief description of the Setup Book information.

CRT NUMBER	SKT	CRT TYPE	BIAS	FIL VOLT	F1	F2	GUN	K	G1	G2
A68AVZ32X	1	Video 1	68V	6.3						
A68EAU00X	UA	Video 1	68V	6.3	9	10	R	8	5	7
							G	6	5	7
							B	11	5	7

Fig. 3 - The Setup Book provides the information needed for connecting the CR7000 to a CRT.

CRT Number
The Setup Book lists the CRTs in alpha-numeric order, grouped by size, designation code, and phosphor code. Here are a few things to keep in mind when looking for a listing in the Setup Book:

1) Some CRT numbers end with suffixes such as TC01, TC02, X01, X02, WW01, WW02 etc. These suffixes refer to special convergence characteristics, such as a bonded yoke or internal magnetic compensation. These CRTs have the same electron gun and are tested the same as an identical CRT number without the ending characters. The Setup Books lists these CRT numbers without the special suffix ending. For example, the CRT number 25VAETC01 is listed as 25VAEP22, and a M63AAX03X01 is listed as M63AAX03X.

2) Many monochrome CRTs are identical except for phosphor color, which is indicated by the last two or three characters of the CRT number. For example, CRTs numbers 12VAEP4 and 12VAEP31, or M35JJA4GR and M35JJA4WH are identical except for phosphor. These tubes will only be listed once in the Setup Book.

3) Some CRT numbers begin with extra characters that are not part of the numbering standard. A common example is the prefix "MV". The CRT number MVA48ACB41X is listed in the CR7000 setup book as A48ACB41X.

For more information on CRT numbering and what each part of the CRT number means, refer to the "Understanding CRT Numbers" section of the APPLICATION portion of this manual.

SKT
This column lists the number of the adapter socket that is needed to connect the CR7000 to the CRT. The CR7000's adapter sockets provide both the proper mechanical fit and electrical wiring. A few of the CRTs listed in the Setup Book have a "UA" in the SKT column. This means that you will need to use the supplied Universal Adapter to make connections to this CRT base. When UA appears in the SKT column, the pin numbers of the tube's filaments, cathode, G1 and G2 are also listed. Refer to the section "Using The Universal Adapter" on page 42 for details on how to use the Universal Adapter.

Several optional socket adapters are available for the CR7000 to fit less common CRT bases. Optional sockets are listed in the Setup Book with a number following "UA" under the socket heading. The listing "UA/7", for example, means that optional socket #7 is available for connecting to the CRT. If you do not have the optional socket, simply use the Universal Adapter to make connection following the pin numbers in the Setup Book.

CRT Type
Set the CR7000's CRT TYPE switch to the position listed in this column. This sets the CR7000's G2 voltage range, bias range, and measurement mode to match the type of CRT that is being tested.

NOTE: The CRT type listed in the Setup Book may not always match the CRT's application.

BIAS
This voltage represents the G1 bias needed to test the CRT at its normal operating range. Since the cathode is used as the reference, the voltages are negative. Set the CR7000's BIAS switch to the number listed in this column.

FIL VOLT
This column lists the filament (heater) voltage needed to properly test the CRT. Set the FILAMENT VOLTS course control to the closest range (0-4, 4-8 or 8-16), then use the FILAMENT VOLTS ADJUST control to set the voltage to the exact amount listed.

The remaining columns will only contain information if the Universal Adapter ("UA" listed in the SKT column) is needed to make

connections to the CRT. These columns will be blank if an adapter number is listed in the SKT column.

GUN
The letter in this column corresponds to the gun of a color CRT that is being tested that requires the use of the Universal Adapter. Use the TEST GUN SELECT controls to store the individual gun emission readings in to memory. *This column will only contain a letter if "UA" is listed in the SKT column.*

F1, F2
The numbers in these two columns are the pin numbers of the CRT's filament connections. Connect the "F1" and "F2" leads of the Universal Adapter to these pin numbers. *These columns will only contain numbers if "UA" is listed in the SKT column.*

K
The number in this column is the pin number of the CRT's cathode connection. Connect the "K" lead of the Universal Adapter to this pin number. A color CRT will have 3 different cathode connections. Connect each UA "K" lead to its corresponding pin. *This column will only contain a number if "UA" is listed in the SKT column.*

G1
This is the pin number of the CRT's control grid connection. Connect the "G1" lead of the Universal Adapter to this pin number. *This column will only contain a number if "UA" is listed in the SKT column.*

G2
This is the pin number of the CRT's screen grid connection. Connect the "G2" lead of the Universal Adapter to this pin number. *This column will only contain a number if "UA" is listed in the SKT column.*

USING THE ADAPTER SOCKETS

The six, double-sided socket adapters that, supplied with the CR7000, provide the best combination of ease-of-use and flexibility to test a wide number of CRTs. They match both the mechanical and electrical characteristics of the CRT base. Although several adapter sockets have the same mechanical characteristics and appear to be interchangeable, they are not. Be sure to use the socket adapter that is called for in the Setup Book when connecting to a CRT. Using the wrong adapter will cause the CR7000's test circuits to be connected to the wrong electron gun elements inside the CRT, and may cause incorrect test results and possible CRT damage.

⚠ WARNING

The Test Cable may have up to 600 volts and 2.5 amps applied. Do not connect or disconnect the test cable to the adapter sockets, or connect or disconnect the adapter socket to the CRT with the CR7000's AC power switch turned on.

⚠ ATTENTION

Le cable de test peut supporter jusqu'à 600V et 2.5 ampéres. Ne pas connecter ou deconnecter le cable de test de l'adaptateur, ou connecter ou deconnecter l'adaptateur du tube ecran, avec le CR7000 en marche.

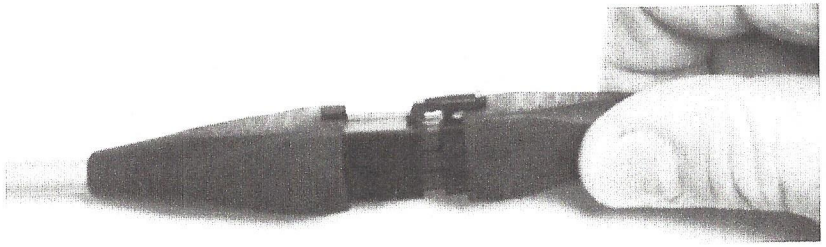


Fig. 4 - Align the test cable with the adapter socket.

The connectors on the adapter socket and test cable are polarized, allowing the socket and cable to only fit together one way. Align the cable with the adapter socket (as shown in Figure 4) to connect them. The adapter socket has a latch that must be released before disconnecting it from the test cable.

A few CRTs do not have a CR7000 adapter socket that matches their electrical wiring, or mechanical base. These CRTs are identified by "UA" in the SKT column of the Setup Book. The supplied Universal Adapter allows you to make connections to these CRTs. For more information on using the Universal Adapter, refer the section entitled "Using The Universal Adapter" in the APPLICATIONS portion of this manual. Several optional socket adapters are available for the CR7000. These optional socket adapters are identified in the Setup Book with a "UA/#", such as "UA/7". If you do not have the optional adapter, simply connect the Universal Adapter to the pin numbers listed in the Setup Book.

Connecting To The CRT

The CR7000 socket adapters connect to the base of the CRT in place of the chassis CRT socket. You will need to disconnect the chassis CRT socket before you can connect the CR7000. **Before you remove the chassis socket connector from the CRT be sure to:** *1) Remove AC power from the CRT chassis by unplugging the AC line cord, if possible, and 2) Discharge the high voltage.*

All of the power needed to test and restore the CRT is supplied by the CR7000 through the adapter socket. Unplugging the chassis AC line cord ensures that the chassis will not unexpectedly start up and produce potentially dangerous voltages. The focus voltage for the CRT is applied through the CRT base. Although the CR7000 does not connect to the focus pin, unexpected high voltage may be present on the pins of the CRT base if the CRT contains a focus short or leakage to high voltage. Most chassis contain circuits that bleed off the high voltage from the CRT when the chassis is turned off. Do not depend on these circuits. **Always discharge the CRT high voltage before removing the socket.** This will protect you from a potentially dangerous shock, and will protect your CR7000 from possible damage should the CRT have a focus short or leakage.

CAUTION

Remove AC power from the chassis and discharge the high voltage before removing the CRT socket from the CRT. Do not apply power to the chassis while the CR7000 is connected.

CAUTION

Debrancher le chassis de l'appareil et décharger la haute tension avant de retirer le socket du tube ecran. Ne pas allumer le chassis de l'appareil tant que le CR7000 est connecté.

Follow these guidelines when discharging CRT high voltage:

1) **Remove AC power from the chassis.** If possible, unplug the AC power cord.

2) **Do not discharge high voltage through a direct short.** The resulting spark will produce EMI that could damage circuits inside the chassis.

3) **Always discharge the high voltage through a resistance**, such as a DVM lead with a 10X multiplier probe attached. Use the Sencore TP212 or TP222, for example.

4) **Connect the ground side of the shorting wire to the spring or wire that goes around the CRT,** as shown in Figure 5.

5) **Connect the shorting wire to ground,** then carefully slip the other end under the 2nd anode cap of the CRT.

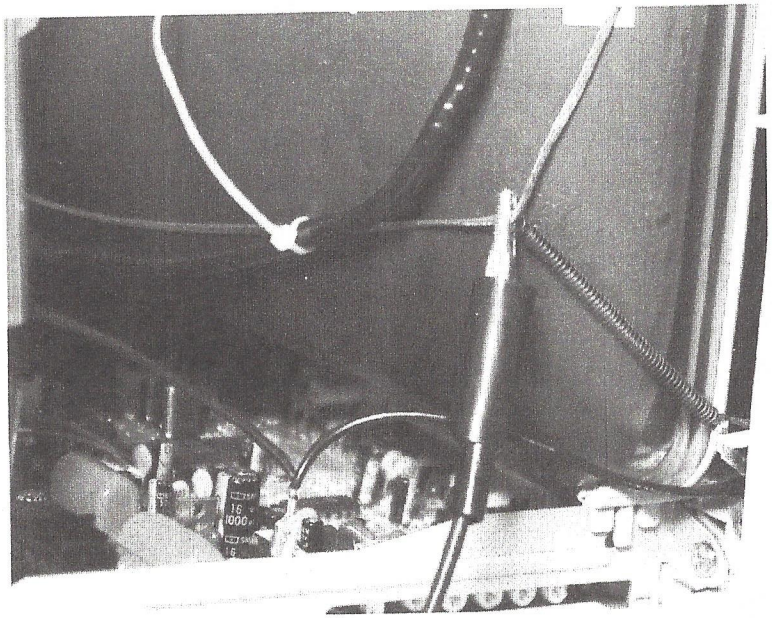


Fig. 5 - Discharge the high voltage through a resistance connected to the high voltage ground.

BEAM TEST FUNCTIONS

This section explains how to test a CRT with the CR7000. The design of the CR7000 allows you to test all three guns of most color CRTs simultaneously. Perform the tests in the sequence listed here and on the FUNCTION switch. Refer to the APPLICATIONS portion of this manual for more information on the tests.

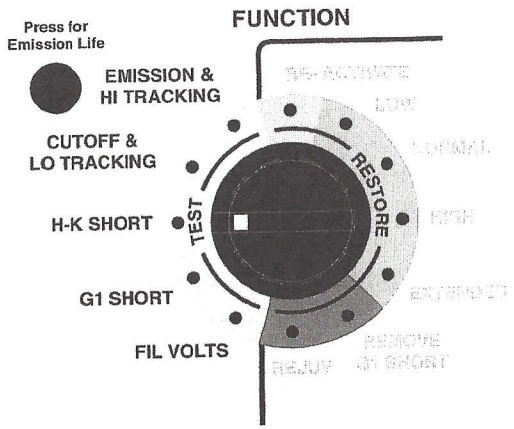


Fig. 6 - Beam Test functions.

Remove AC power from the chassis before beginning the tests. Then set the CR7000 according to the following information in the Setup Book:

1) Connect the CR7000 to the CRT using the socket adapter listed under "SKT".

2) Set the CRT TYPE switch to match the "CRT TYPE" listing.

3) Set the BIAS switch to match the "BIAS" listing.

4) Set the FILAMENT VOLTAGE controls to match the "Fil Volt" listing.

5) Set the TEST GUN SELECT switch to match the CRT you are testing:
   - color CRTs = "Simultaneous"
   - non-projection monochrome CRTs = "Red"
   - projection CRT = set to "Red", "Green" or "Blue", depending on the CRT you are testing.

NOTE: A few older color CRTs have different G1 and/or G2 connections for each electron gun. To test these CRTs with the supplied 7 lead Universal Adapter you will need to change the G1 and/or G2 connection for each gun, and change the setting of the TEST GUN SELECT switch as you test each gun. Refer to the section, "Using The Test Gun Select" in the OPERATION section of this manual.

FIL Volts

The FIL VOLTS function monitors the voltage that is applied to the CRT filament, and allows you to adjust the voltage to the amount specified by the CRT manufacturer. The filament voltage is displayed on one of the three bar graphs, depending on which range is selected by the FILAMENT VOLTS range control. ("0-4" = top bar graph; "4-8" = middle bar graph; "8-16" = bottom bar graph). Read the voltage on the "Filament Volts" scale located directly below the active bar graph. Set the filament voltage to the amount shown in the Setup Book.

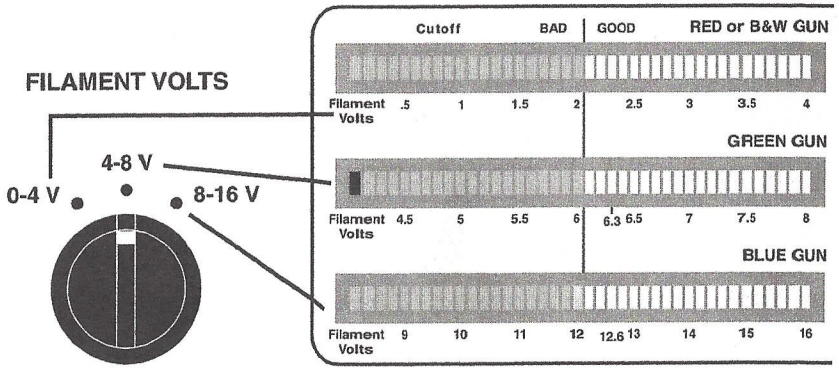


Fig. 7 - The filament voltage is displayed on the three bar graphs

To set filament voltage:

1. Locate the proper filament voltage under the "FIL VOLT" column in the Setup Book.

2. Set the FUNCTION switch to FIL VOLTS.

3. Set the FILAMENT VOLTS range control to the range closest to the voltage shown in the Setup Book. (Use "4-8 V" for CRTs that require 6.3 volts).

4. Set the FILAMENT VOLTS ADJUST control to "MIN".

5. Turn the POWER switch to "ON". The power indicator light on the switch will light.

6. The left segment of one of the bar graphs will light, indicating which voltage scale to read. Adjust the FILAMENT VOLTS ADJUST control so the bar graph reads the filament voltage specified in the Setup Book.

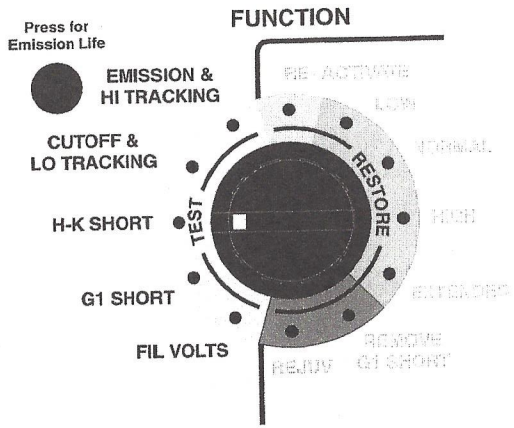


Fig. 6 - Beam Test functions.

Remove AC power from the chassis before beginning the tests. Then set the CR7000 according to the following information in the Setup Book:

1) Connect the CR7000 to the CRT using the socket adapter listed under "SKT".

2) Set the CRT TYPE switch to match the "CRT TYPE" listing.

3) Set the BIAS switch to match the "BIAS" listing.

4) Set the FILAMENT VOLTAGE controls to match the "Fil Volt" listing.

5) Set the TEST GUN SELECT switch to match the CRT you are testing:
   - color CRTs = "Simultaneous"
   - non-projection monochrome CRTs = "Red"
   - projection CRT = set to "Red", "Green" or "Blue", depending on the CRT you are testing.

NOTE: A few older color CRTs have different G1 and / or G2 connections for each electron gun. To test these CRTs with the supplied 7 lead Universal Adapter you will need to change the G1 and / or G2 connection for each gun, and change the setting of the TEST GUN SELECT switch as you test each gun. Refer to the section, "Using The Test Gun Select" in the OPERATION section of this manual.

FIL Volts

The FIL VOLTS function monitors the voltage that is applied to the CRT filament, and allows you to adjust the voltage to the amount specified by the CRT manufacturer. The filament voltage is displayed on one of the three bar graphs, depending on which range is selected by the FILAMENT VOLTS range control. ("0-4" = top bar graph; "4-8" = middle bar graph; "8-16" = bottom bar graph). Read the voltage on the "Filament Volts" scale located directly below the active bar graph. Set the filament voltage to the amount shown in the Setup Book.

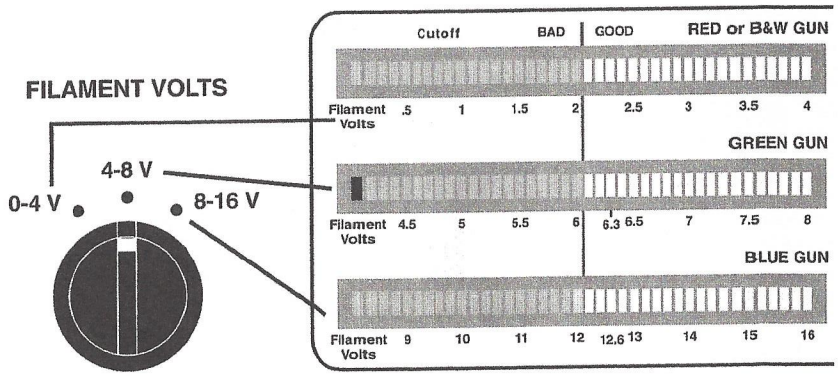


Fig. 7 - The filament voltage is displayed on the three bar graphs

To set filament voltage:

1. Locate the proper filament voltage under the "FIL VOLT" column in the Setup Book.

2. Set the FUNCTION switch to FIL VOLTS.

3. Set the FILAMENT VOLTS range control to the range closest to the voltage shown in the Setup Book. (Use "4-8 V" for CRTs that require 6.3 volts).

4. Set the FILAMENT VOLTS ADJUST control to "MIN".

5. Turn the POWER switch to "ON". The power indicator light on the switch will light.

6. The left segment of one of the bar graphs will light, indicating which voltage scale to read. Adjust the FILAMENT VOLTS ADJUST control so the bar graph reads the filament voltage specified in the Setup Book.

G1 Short

The G1 SHORT function checks for shorts and leakage between the first grid (G1, or control grid) and the cathode, and between G1 and the second grid (G2 or screen grid). The test results are displayed on the bar graphs simultaneously for each gun of a color CRT. In the G1 SHORT function the bar graphs function as an ohmmeter display, with low or 0 resistance readings being to the left (only red LEDs lit) and high resistance readings being full scale (red and green LEDs lit).

A good gun will light all, or nearly all of the green LEDs. A dead short reads at the far left of the bar graph. Such a short usually indicates a mechanical short, such as two elements touching. This type of a short is the most difficult to remove. Leakage produces readings in the bad area of the bar graph, between the left edge and the BAD / GOOD dividing line (only red LEDs lit). These higher resistance shorts can usually be removed with the REMOVE G1 SHORTS function.

If you encounter a G1 short on any of the guns, remove it using the REMOVE G1 SHORTS function before continuing on with the remainder of the test functions. All other tests for that gun are meaningless if a gun has a G1 short.

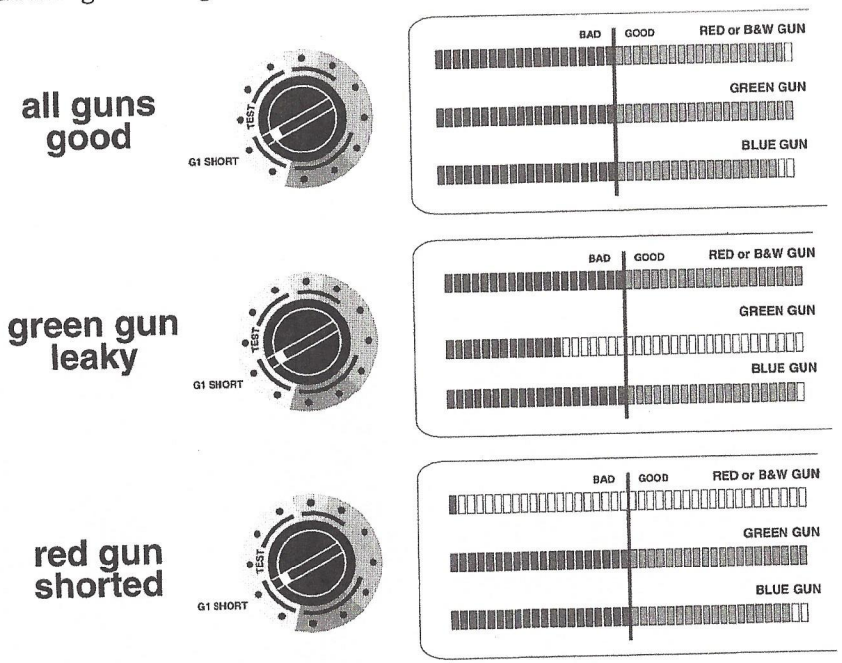


Fig. 8 - Examples of G1 SHORT test results.

To check for G1 shorts:

1. After adjusting the filament voltage, set the FUNCTION switch to G1 SHORT.

2. Read the results on the bar graph for each gun. Only one bar graph will be active when testing a monochrome CRT, or if TEST GUN SELECT switch is not set to "Simultaneous".

A good CRT gun will produce readings in the "Good" area of the Bar Graph display. If any gun shows a short or leakage, use the REMOVE G1 SHORT function on that gun to attempt to remove the short.

H-K Short

The H-K SHORT test determines if a leakage path exists between the filament or heater (H) and cathode (K). The test results are displayed on the bar graphs simultaneously for each gun of a color CRT. In the H-K SHORT function the bar graphs function as an ohmmeter display, with low or 0 resistance "Bad" readings being to the left (only red LEDs lit) and high resistance "Good" readings being full scale (red and green LEDs lit).

A good gun will light all or nearly all of the green LEDs. A dead short reads at the far left of the bar graph. Leakage produces readings in the bad area of the bar graph, between the left edge and the BAD / GOOD dividing line (only red LEDs lit). A short or leakage between heater and cathode cannot be safely removed with any of the CR7000's restore functions, or with any other CRT restoring system. This is because the current needed to remove the short or leakage could just as likely open the filament instead.

A few CRTs use a "directly heated cathode". In a directly heated cathode design the cathode emitting material is deposited directly onto the filament, meaning the filament and cathode are the same element. These CRTs will have a normal H-K short. You will know when you are testing a directly heated cathode CRT because: 1) they will be listed as UA in the Setup Book, and 2) the cathode pin number will be the same as one of the filament pins. For more information on testing CRTs with a directly heated cathode, refer to the section entitled "Testing CRTs With Directly Heated Cathodes" on page 61

In some situations an H-K short, even though abnormal, may not cause a problem if it does not affect the gun's DC bias. Symptoms of an H-K short are a bright white or colored raster with no brightness control, or a raster with visible retrace lines. If the H-K short does cause a picture problem, an isolation device can usually be used to

isolate the DC current path and allow the CRT to produce a normal picture. Because other defects in the chassis may cause the same symptoms as an H-K short, the H-K SHORT test provides an important means of isolating the defect to the chassis or to the CRT.

To check for H-K shorts:

1. After confirming there are no G1 shorts, set the FUNCTION switch to H-K SHORT.

2. Read the results on the bar graph for each gun. Only one bar graph will be active when testing a monochrome CRT, or if the TEST GUN SELECT switch is not set to "Simultaneous".

If the bar graph for any gun reads in the bad area, you may continue with the remaining tests, keeping in mind that they will have little meaning if the H-K short is responsible for the poor picture.

Cutoff Test & Lo Tracking

The CUTOFF & LO TRACKING position of the FUNCTION switch performs two tests: 1) Cutoff test, and 2) Lo Tracking test. Both tests check important performance parameters of a color CRTs electron guns.

Cutoff test
Together, the Cutoff and Emission tests thoroughly test the dynamic range of the electron gun. The cutoff test dynamically reproduces the point where the electron gun just comes out of cutoff and begins to conduct current. This is the normal "black" picture level. The Cutoff test applies a negative bias (respect to cathode) to the control grid (G1), while the amount of positive G2 voltage is adjusted with the CUTOFF LEVEL control. The minimum cutoff point is specified by the CRT's manufacturer to be within a certain range of bias and G2 voltage. A good gun can be adjusted into or above the gray "Cutoff" area of the display as the CUTOFF LEVEL control is adjusted. (You'll need to adjust the corresponding CUTOFF LEVEL controls for each gun of a color CRT.)

A CRT gun can fail the Cutoff test two ways: 1) The gun cannot be brought up to the "Cutoff" area, or 2) The reading is uncontrollable, and quickly pegs full scale, or drifts drastically. A gun that cannot be brought up to the "Cutoff" area has a worn or contaminated cathode. The CRT will have poor contrast (too dark black & grays) if all three guns are weak, or a bad gray scale if just one or two guns are weak. Either problem may occur even if the Emission test shows normal beam current. Weak cutoff can often be improved with the CR7000's

restore functions. The second cutoff test failure (uncontrollable reading that pegs full scale or drifts drastically) is caused by either an open G1 grid, or by air that has leaked into the CRT. An air leak causes a faint blue haze inside the CRT as you increase the CUTOFF LEVEL control. There is no way to correct an open G1 or an air contaminated CRT.

Lo Tracking test
In addition to specifying that each gun reach cutoff within a certain Bias and G2 voltage range, color CRT manufacturers specify the ratio of the highest to lowest G2 voltage needed to produce cutoff. The Lo Tracking test compares the ratio of the G2 voltages as you adjust each CUTOFF LEVEL for gun "Cutoff". The "Good" GUN TRACKING LED lights if all three guns are within the "Cutoff" area and the G2 voltages are within 1.25:1. The "BAD" GUN TRACKING LED will stay lit if any gun is outside the "Cutoff" area, or if the G2 voltage ratio is too great. A weaker gun requires more G2 voltage to reach cutoff. You can determine which is the weaker electron gun by looking at the rotation of the CUTOFF LEVEL controls. The CUTOFF LEVEL control that is rotated most clockwise is the highest G2 voltage, and is the weakest gun.

A color CRT that fails the Cutoff test, will also fail the Low Tracking test. Color CRTs that pass the Cutoff test but fail the Low Tracking test may not be able to be adjusted for a good gray scale, depending on the adjustment range of the chassis setup controls. This condition can often be improved with the CR7000's restore functions. The Cutoff and Lo Tracking results are summarized in Table 1.

Bar Graph Indication	Gun Tracking LED	CRT Condition	Likely Picture Symptom
All guns set to Cutoff area	Good	Good	Good low level contrast
All guns set to Cutoff area	Bad	Bad Lo Tracking	Color shading in grays
1 or more guns stay below Cutoff area	NA	Bad Cutoff	Poor contrast, color shading in gray picture areas
1 or more guns above Cutoff area and won't adjust down or drift slowly upward	NA	Open G1	Uncontrollable bright white or color, chassis may shut down

Table 1 - Summary of Cutoff and Lo Tracking test results.

To perform the Cutoff & Lo Tracking tests:

NOTE: Be sure you have set the CRT TYPE and BIAS controls according to the information in the Setup Book.

1. Confirm there are no G1 or H-K shorts. Then set the FUNCTION switch to CUTOFF & LO TRACKING.

2. Adjust the "R" CUTOFF LEVEL control until the "RED" bar graph reads within the "Cutoff" area.

NOTE: Some CRTs are extremely sensitive to outside electromagnetic and electrostatic fields. Placing your hand in close proximity to the CRT yoke or neck, may cause the cutoff readings to jump erratically. If this occurs, move your hand away from the CRT.

3. Repeat for the "G" and "B" CUTOFF LEVEL controls when testing a color CRT with the TEST GUN SELECT switch set to "Simultaneous". (Only one bar graph is active when you test a monochrome CRT, or if the TEST GUN SELECT switch is not set to "Simultaneous").

4. The "Good" Gun TRACKING LED will light if the G2 voltages are within the good ratio.

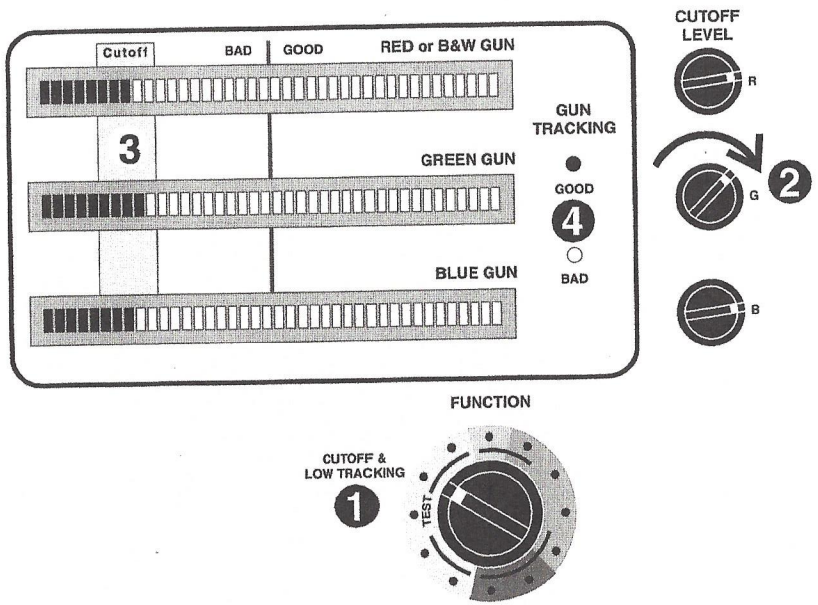


Fig. 9 - Follow these steps to test Cutoff and Lo Tracking.

If you are testing the 3 CRTs of a projection system, or using the Universal Adapter to test a CRT with separate G1 and/or G2 connections, you will want to store the Cutoff test readings for each gun. Refer to the section, "Using The Test Gun Select Switch" on page 40 for more information.

A gun has bad cutoff if it cannot be adjusted into the "Cutoff" area. Use the CR7000's Restore functions to attempt to improve the gun's cutoff.

If the "Bad" GUN TRACKING LED stays lit when all three guns are set to "Cutoff", one gun is weaker and requires 25% more G2 voltage than the others to produce cutoff. Look at the settings of the CUTOFF LEVEL controls to determine which gun needs the higher G2 voltage. The control that is set more clockwise is the weaker gun. Use the CR7000's Restore functions to attempt to improve this gun's cutoff.

Emission & Hi Tracking

The EMISSION & HI TRACKING position of the FUNCTION switch performs two tests: 1) Emission, and 2) Hi Tracking. Together with the Cutoff and Lo Tracking tests, the Emission & Hi Tracking tests thoroughly check the dynamic operating condition of color and monochrome CRTs.

Emission test

The Emission test measures how much current the electron gun produces at zero bias. During the Emission test the negative bias is removed from the control grid. This allows the G2 voltage that was set during the Cutoff test to pull electrons from the cathode and simulate maximum video drive (white picture levels).

The CR7000's emission test uses an exclusive "sliding Good/Bad" scale which is based on the manufacturer's specified operating bias. The test compares the gun's actual output to the normal expected output. The results for all three guns are displayed simultaneously on the bar graphs, with the center scale "Bad/Good" dividing line representing about 50% of normal emission. Good CRT guns will produce readings to the right of the "Bad/Good" dividing line (green LEDs lit). One, two, or all three guns of a color CRT can have bad emission. Low emission can often be improved with the CR7000's restore functions. For more details on how the Emission test works or how to interpret the test results, refer to the section entitled " The Emission Test" on page 55.

Hi Tracking test

All three guns in a color CRT must be properly balanced to produce a proper gray scale. Computer monitors and color television receivers have setup adjustments to balance the three guns, but these adjustments have a limited range. If the emission from one gun is too much higher or lower than the others, the chassis adjustments will

not have enough range to properly balance the guns. The result is a picture with wrong colors and colored grays and whites. This is called poor gray scale or color tracking. CRT manufacturers have established a ratio of 1.55:1 as the greatest variance between the strongest and weakest guns. This simply means that the strongest gun cannot produce more than 55% more current than the weakest gun when all three guns are set to the same cutoff point.

The CR7000 High 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 "good" emission and the ratio of emission currents is within 1.55:1. If one or two guns have weak emission, or if the ratio of emission currents is greater than 1.55:1, the "Bad" GUN TRACKING LED stays lit. A color CRT that fails the Emission test will also fail the High Tracking test. Weak emission and poor tracking problems can often be improved with the CR7000's restore functions.

The Hi Tracking test is very similar to the Lo Tracking test in that both compare the conduction ratio of all three guns and the ability of the CRT to produce good gray scale (color) tracking. The Lo Tracking test however, checks the guns at the point where they just begin to conduct. A CRT that fails this test will have gray scale problems in the darker (gray) levels. The Hi Tracking test on the other hand, checks the guns at full output. A CRT that fails this test will have gray scale problems in the brighter (white) levels.

Time-Out

The CR7000's Emission test times out after approximately 12 seconds to protect the CRT from any potential damage that could occur if the electron guns were left in the zero bias condition too long. A blinking GUN TRACKING LED indicates the test has timed out. Whichever LED that was on when time-out occurred will blink. The bar graphs hold the last emission readings after time-out and do not update. To reset the time-out and return to an active emission test simply switch out of and back into the Emission function. The time-out is defeated when the Emission Life button is pressed.

Table 2 summarizes the results of the Emission and Hi Tracking tests.

Bar Graph Indication	Gun Tracking LED	CRT Condition	Likely Picture Symptom
All guns good	Good	Good	Good brightness and contrast
All guns good	Bad	Bad Hi Tracking	Good brightness, color shading
1 or more guns bad	NA	Bad Emission	Dim picture, may have color shading

Table 2 - Summary of Emission and Hi Tracking tests.

To perform the Emission & High Tracking tests:

1. After confirming the CRT passes the Cutoff and Lo Tracking tests, set the FUNCTION switch to EMISSION & HI TRACKING.

2. Read the emission levels of all three guns simultaneously on the bar graphs. Only one bar graph is active when you test a monochrome CRT, or if the TEST GUN SELECT switch is not set to "Simultaneous".

NOTE: If you are testing the 3 CRTs of a projection system, or if you are using the Universal Adapter to test a CRT with separate G1 and/or G2 connections, you will want to store the Emission test readings for each gun. If you are not familiar with how to do this Refer to the section, "Using The Test Gun Select Switch" on page 40

3. The "Good" GUN TRACKING LED lights if all emission levels are within a good ratio.

Any gun that reads in the bad area to the left of the "Bad/Good" dividing line (red LEDs only), has bad emission. Use the CR7000's Restore functions to attempt to improve the gun's performance. If the "Bad" GUN TRACKING LED stays lit, the ratio of the emission currents is outside the industry standard limits. Use the CR7000's Restore functions to attempt to improve the emission of the gun(s) that has the lowest emission.

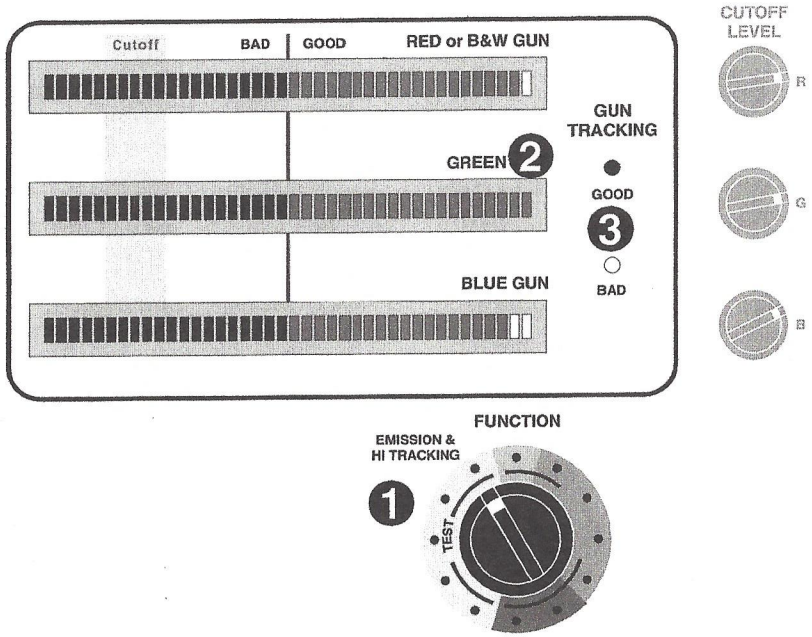


Fig. 10 - Checking Emission and High Tracking.

Emission Life

The Emission Life test provides an indication of the cathode's approximate remaining useful emission. To perform the Emission Life test press and hold the "Press For Emission Life" button for 10 seconds while watching how far the emission readings drop.

The Life test cools the cathodes slightly by decreasing the filament voltage by 25%. A cooler cathode produces less emission, but most good cathodes produce more current than is needed for full beam current (white picture level). Decreased filament voltage produces little or no reduction in the emission of good cathodes. Cathodes that have lost emitting material and contaminated cathodes have little or no reserve, causing the emission current to drop off rapidly with reduced filament voltage. A small amount of restoration often helps cathodes that drop into the "Bad" area during the Life Test.

Many new and rebuilt CRTs normally show poor Emission Life if they are tested right out of the box. This does not mean the CRT is bad - it simply means that the cathodes need time to fully activate. Refer to page 57 of the APPLICATIONS portion of this manual for more information on the Emission Life test.

NOTE: Only one bar graph is active when testing a monochrome CRT, or if the TEST GUN SELECT switch is not set to "Simultaneous". Set the Test Gun Select switch to test each gun if you are testing the 3 CRTs of a projection system, or if you are using the Universal Adapter to test a CRT with separate G1 and/or G2 connections.

To perform the Emission Life test:

1. After testing Emission, press and hold the "PRESS FOR EMISSION LIFE" button.

2. Watch the bar graphs. The readings will drop, unless the cathode is very good. Hold the test button until the readings stop dropping. If the readings are still dropping after 10 seconds release the button.

3. Note how far and how fast the emission drops for each gun.

Refer to page 57 of the APPLICATIONS portion of this manual for more information on how to interpret the Emission Life test results.

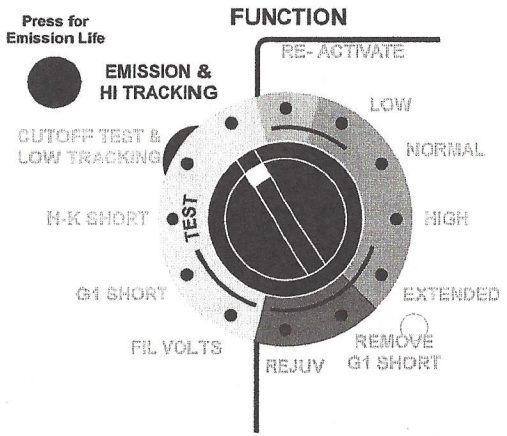


Fig. 11 - Press the Life test button to check a CRT gun's reserve capability.

RESTORE FUNCTIONS

This section describes how to use the CR7000's beam Restore functions. The CR7000 provides 6 levels of progressive beam restoration, plus a remove G1 Short function. Proper restoration produces a noticeable improvement in the picture quality of most weak or shorted CRTs. Often, restoration returns CRTs to like-new performance.

Unlike the CR7000's Test functions which test all three guns of a color CRT simultaneously, the Restore functions act on only one CRT gun at a time. This is important because all three guns of a color CRT don't always need restoration, or the same amount of restoration. You must use the RESTORE GUN SELECT switch to tell the CR7000's circuits which gun

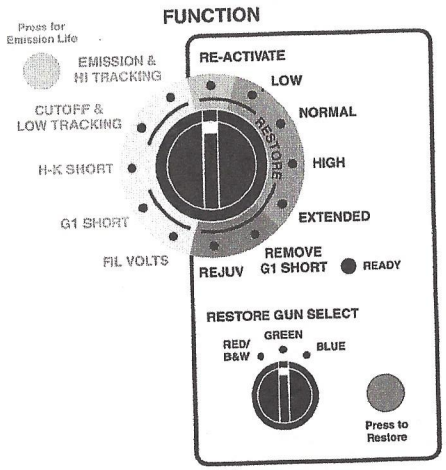


Fig. 12 - The Restore functions are arranged from lowest to highest current level.

to restore. Start with the gun that needs the most restoration (the gun that has the lowest Cutoff or Emission reading). Use the "Red/B&W" position for monochrome CRTs and the single color tubes of a projection system. The best way to use restoration is to start low and work up. Always re-test the CRT after using an application of restoration. If the gun has not been adequately restored, either re-apply that level of restoration, or step-up to the next level. The restore functions are arranged around the FUNCTION switch in order from lowest to highest. Always start with "Re-Activate". If this level does not adequately restore the gun, step up to "Low". If necessary, continue to increase restoration levels. You will find that most CRTs restore sufficiently using just Re-Activate and Low.

Test Result	Restore Function
G1 Short	Remove G1 Short
H-K Short	Do not attempt to remove
Bad Cutoff	Re-Activate, step to next level as needed
Bad Lo Tracking (all guns adjust to Cutoff)	Re-Activate gun with highest Cutoff Level control setting
Bad Emission (Good or Bad Hi Tracking)	Re-Activate, step to next level as needed
Good Emission all guns; Bad Hi Tracking	Re-Activate gun with lowest emission
Bad Emission Life (Emission drops to Bad)	Re-Activate
No current in any Restore function	REJUV

Table 3 - Test result and recommended Restore function.

Keep in mind that you are much better off applying two applications of restoration, rather than over restoring the gun the first time. Table 3 summarizes which restoration to use based on the gun test results.

The CR7000's progressive restoration levels differ in three ways: 1) applied filament voltage, 2) current limit, and 3) duration. Several Restore functions increase the filament voltage. Increasing the filament voltage helps to superheat the cathode and bring new emitting material to the surface. Each progressive restoration step allows more restore current to flow. Some cathodes require higher current levels in order to clear the contamination.

Lastly, the duration of the restoration period is controlled. Allowing too much current to flow too long could strip the cathode of its emitting material, or cause one of the gun elements to warp. The CR7000's Restore functions are automatically current limited and timed to help prevent you from over-restoring a CRT. The READY LED turns on when the restore function is ready to begin, and turns off when the restore function is complete. However, the Restoration process does not begin until you press the PRESS TO RESTORE button. Continue to hold the PRESS TO RESTORE button until the LED turns off. You can release the button before the LED turns off if you don't want to apply the full restoration cycle. No restoration will occur if you press the PRESS TO RESTORE button when the READY LED is not lit, or if you continue to hold the button after the LED turns off. The Restore functions are summarized in Table 4.

FUNCTION	FILAMENT VOLTAGE	CURRENT LIMIT	TIME DURATION
Re-activate	50% boost	1mA	30 sec.
Low	normal	40 mA	2 sec.
Normal	normal	80 mA	2 cycles (3 sec. on/3 sec. off)
High	50% boost	100 mA	3 cycles (4 sec. on/2 sec. off)
Extended	50% boost	100 mA	15 sec.
Remove G1 Short	removed	self-limited surge	20 sec. cool-down before active; self-limiting
Rejuv	normal	self-limited surge	self-limiting

Table 4 - Summary of Restore filament voltages, currents and durations.

Remove G1 Short

This special Restore function provides an effective method for removing most G1 shorts. The Remove G1 Short function discharges a large capacitor through the short, causing it to burn away. This method will not damage an otherwise good electron gun because the capacitive discharge is self limiting; the CRT does not draw current once the short opens. For added safety the capacitor will not discharge until the cathode has had time to cool. When you switch to the Remove G1 Short function, the READY LED will not light until the filament voltage has been removed from the CRT for approximately 20 seconds. When the LED comes on press the PRESS TO RESTORE button to discharge the capacitor through the short. You will often see a flash inside the gun as the short is burned away. After removing the short, re-test the gun. If necessary, repeat the Remove G1 Short procedure.

Rejuv

Rejuvenation is the most severe form of cathode restoration. **Use Rejuv only if none of the other progressive restoration steps produce restore current.** Rejuvenation works by discharging an RC network between the cathode and G1 with normal filament voltage applied. This produces momentary, high positive bias. Rejuvenation often successfully breaks the contamination layer on severely contaminated cathodes to allow normal restore currents to occur. However, if you apply rejuvenation to a cathode that is able to produce restore current, the sudden, high positive bias surge can easily strip emitting material from the warm cathode.

Here are some important points to remember about restoration:

1) **Restoration is a subtractive process.** It does not add "new" emitting material to the cathode. Removing the contaminating layer exposes fresh emitting material on the surface, allowing normal emission.

2) **Always test a CRT before restoring it - never restore a CRT that tests good.** A poor picture can be caused by a bad CRT or by a chassis defect. Needlessly restoring a CRT wastes time and may shorten the CRT's life. Do not clean a CRT just because it has been in use for awhile.

3) **More is NOT better.** A CRT will be damaged by too much restoration. Only use enough restoration to bring the CRT back to an acceptable level of performance.

4) **Do not restore a brand new or newly re-built CRT.** If a new or rebuilt CRT tests poorly, let it operate for an hour with normal filament voltage applied. Contact the manufacturer before restoring it.

To use the Restore functions:

1. Test the CRT to determine which if any guns need restoring.
2. Select the desired Restore function.
3. Set the RESTORE GUN SELECT switch the gun to be restored.
4. When the READY LED turns on, press the PRESS TO RESTORE button to begin the restoration process.
5. Continue to hold the PRESS TO RESTORE button until the READY LED turns off.
6. Re-test the CRT to see if restoration improved its performance.

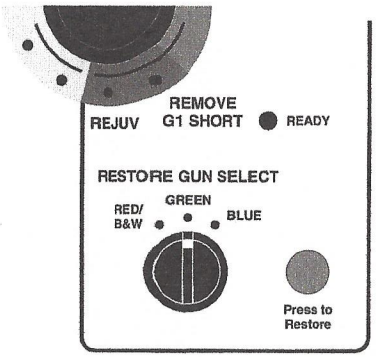


Fig. 13 - Set the RESTORE GUN SELECT switch to the gun to be restored.

USING THE TEST GUN SELECT SWITCH

The TEST GUN SELECT switch allows you to store cutoff and emission test results when testing separate projection CRTs, or color CRTs with separate G1/G2 grids. This lets you compare all three guns simultaneously and enables the CR7000 to display Lo and Hi Tracking test results. The TEST GUN SELECT switch selects which CRT gun is tested. It basically has two settings: "Simultaneous" and "Individua"l (Red, Green or Blue) guns.

NOTE: The TEST GUN SELECT switch does not effect the Restore functions.

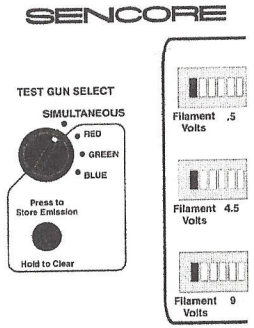


Fig. 14 - The TEST GUN SELECT switch.

Simultaneous

You will use this position for most color CRTs (including color CRTs requiring the Universal adapter). In this position the CR7000's test functions sequence through all three guns and display the test results in "real time" on the three bar graphs. The "PRESS TO STORE" button does not function in this position. Use the "Simultaneous" position to test:

- all color CRTs that use a numbered (non-UA) socket
- color CRTs with a common G1 and common G2 for all three guns

Individual (Red, Green, Blue)

These TEST GUN SELECT switch positions allow you to store the Cutoff and Emission test results for the red, green and blue guns of a color CRT or projection system. Storing the readings allows you to compare them side-by-side and make Lo and High Tracking tests even though you are unable to compare the guns in real time. Use the Individual Red, Green, Blue positions when:

- testing the individual CRTs of a 3-tube projection system
- using the 7-lead Universal Adapter to test color CRTs that have different G1 and G2 grids for all 3 guns. (You also need to move the G1 and G2 connection for each gun, as explained in the section entitled "Using the Universal Adapter", on page 42).
- Use the "Red" position to test non-projection monochrome CRTs.

As you switch to "Red", "Green" and "Blue" the corresponding bar graph becomes active. When you are in the CUTOFF & LO TRACKING or the EMISSION & HI TRACKING functions, the bar graph remains active until you press the HOLD TO CLEAR button. This button stores the Cutoff or Emission test reading. (G1 and H-K Short readings cannot be stored since there is no need to compare the shorts results). After you store the Cutoff or Emission for the third gun, the GUN TRACKING LED shows the result of the selected Tracking test.

Pressing the PRESS TO STORE EMISSION/HOLD TO CLEAR button replaces any stored reading with the new reading, and updates the Gun Tracking test. Stored readings remain in memory until they are changed, until you turn off the POWER switch, or until cleared.

To Store Cutoff & Emission Readings:

1. Connect the CR7000 to the red CR, or red gun following the Setup Book information.
2. Set the CRT TYPE, BIAS and filament voltage according to the Setup Book information.
3. Set the TEST GUN SELECT switch to "Red".
4. Perform the G1 and H-K Shorts tests.
5. Perform the CUTOFF & LO TRACKING test.
6. Press and hold the PRESS TO STORE EMISSION button until the display blinks.
7. Set the FUNCTION switch to EMISSION & HI TRACKING.
8. Press and hold the PRESS TO STORE EMISSION button until the display blinks.
9. Repeat steps 3 - 8 for the "Green" and "Blue" guns or CRTs.

To Clear The Stored Readings:

1. Set the FUNCTION switch to "CUTOFF & LO TRACKING".
2. Press and hold the HOLD TO CLEAR button until all three bar graphs blink.
3. Repeat to clear the EMISSION & HI TRACKING tests.

APPLICATIONS

INTRODUCTION

This APPLICATIONS section provides you with more information on how to use the CR7000's tests and features in special applications. It also contains information on how each of the CR7000 tests work, plus a review of CRT operation and numbering.

USING THE UNIVERSAL ADAPTER

To test a CRT, the CR7000 must connect to four elements for each electron gun: heater (2 connections) cathode (K), control grid (G1), and screen grid (G2). Color CRTs have three electron guns, but usually share the heater, G1 and G2 connections. The Universal Adapter allows you to connect to these gun elements when none of the CR7000's adapter sockets match the CRT's electrical wiring or mechanical base. CRTs that are listed with "UA" SKT in the socket column in the Setup Book require you to use the Universal Adapter to make connections to e CRT pins. A number following "UA", such as "UA/8", means that an optional socket is available. You can use either the UA or the optional socket to connect to the CRT.

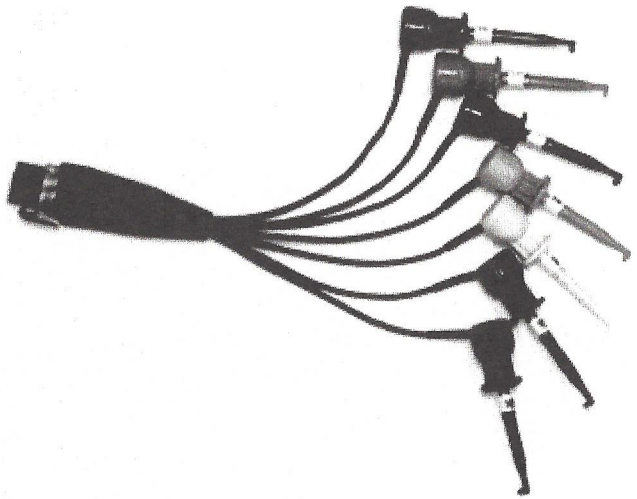


Fig 15 - Use the Universal Adapter to connect to a CRT when none of the adapter sockets match the CRTs wiring or mechanical base.

The seven leads of the Universal Adapter connect to the elements of all three guns in a color CRT at once. This allows you to test all guns of a color CRT simultaneously, just as you would if you were using an adapter socket. The leads of the Universal Adapter are individually labeled as to what pin each connects to, and the corresponding pin numbers are shown in the Setup Book. For quick identification, the UA leads are color coded:

LEAD	COLOR	CRT CONNECTION
F1, F2	black	filaments(F1 & F2 are interchangeable)
Rk	red	cathode of red gun
Bk	blue	cathode of blue gun
Gk	green	cathode of green gun
G1	yellow	G1 - red, green and blue guns
G2	orange	G2 - red, green and blue guns

Connect the Universal Adapter leads to the corresponding CRT pin numbers listed under the "F1", "F2", "K", "G1" and "G2" columns in the Setup Book. (Refer to the next section for information on how to identify the CRT pins). Notice that there are 3 lines listed for each color CRT. The first line contains the pin numbers for the filament pins for the red gun, the second line contains the pin numbers for the green gun, and the last line contains the pin numbers for the blue gun.

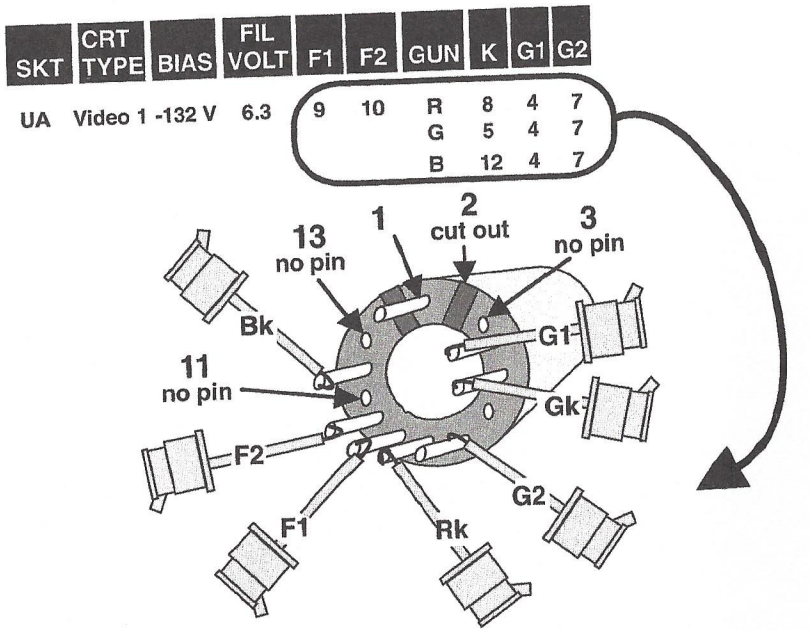


Fig. 16 - Connect the Universal Adapter leads to the CRT pins listed under the "F1", "F2", "K", "G1" and "G2" columns of the Setup Book.

The G1 and G2 pin numbers are the same for all three guns in most color CRTs. If you are testing a color CRT with common G1 and common G2 connections for each gun, set the TEST GUN SELECT switch to "Simultaneous" and proceed with testing and restoring the CRT as normal. However, a few older color CRTs have different G1 and/or G2 connections for each electron gun. To test these CRTs with the 7 lead Universal Adapter you need to change the G1 and/or G2 connection for each gun. In addition, you will want to set the TEST GUN SELECT switch as you test each gun. Refer to the section, "Using The Test Gun Select" on page 40 of the OPERATION section.

IDENTIFYING CRT PIN NUMBERS

To use the Universal Adapter you need to determine the CRT pin numbers or gun element connections. There are two ways to do this. First, check the CRT socket board for pin numbers or gun element labels. If the board is labeled, connect the Universal Adapter leads to the corresponding pins on the CRT. Some manufacturers may use a non-standard pin numbering scheme. If so, go by the numbers that are printed onto the socket board.

The second way to determine the CRT pin numbers is to count them. CRT pins are numbered clockwise when viewed from the rear of the CRT base looking toward the pins. A keyway or focus pin is usually the starting point for the pin numbering. If there is a keyway, count the first pin clockwise from it as pin #1. If there is no keyway, count the focus pin as pin #1. Once you have established pin #1, begin counting the pins in a clockwise direction. Remember to count all blank spaces where a pin could be placed but was omitted. Figure 17 shows several examples of pin numbering.

NOTE: A keyway is a notch in the plastic piece that surrounds the pins and serves as a guide so that the socket can only be placed on to the base one way. A focus pin is set apart from the others by either blank pin positions on either side, by a built- up shield or "silo", or most often by a combination of both.

Some CRT bases have multiple keyways or focus pins. On these bases, pin #1 is located after the first obstruction counter-clockwise from the main body of pins, as shown in Figure17. If in doubt about pin numbering you may wish to check for continuity between the two pins you have identified as "F1" and "F2". Once you have established them, you can confirm the location of the remaining pins.

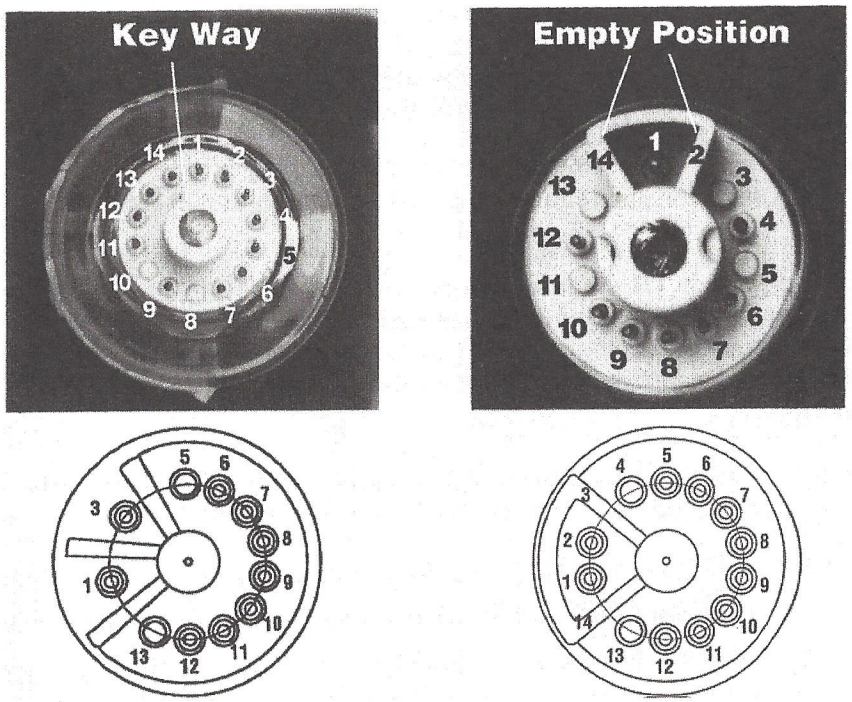


Fig. 17 - Examples of CRT pin numbering.

TESTING CRTS NOT LISTED IN THE SETUP BOOK

The CR70000 Setup Book is updated regularly with information taken from many sources of CRT registration. Occasionally you will still encounter CRTs that are not listed in the Setup Book for several reasons. First, the CRT may be listed with a variation of the base number designation. Here are several things to keep in mind when looking for a listing in the Setup Book:

Extra ending - Numbers with a TC01, TC02, X01, X02, WW01, WW02 etc. ending have the same electron gun and are tested the same as CRTs having an identical number, except for ending in "P22" or "B22". CRT numbers are listed in the Setup Book without the added suffix.

Phosphor designation - Many monochrome CRTs are identical expect for their phosphor color which is indicated by the last 2 or 3 characters of the CRT number. For example, CRTs numbers

12VAEP4, 12VAEP31 and 12VAEP17 are identical except for phosphor. Monochrome CRTs are usually listed with the more common "P4" or "B4" or "X" phosphor designation.

Extra prefix - Some CRT numbers begin with extra characters that are not part of the standard numbering, such as "MV". Look up the tube number omitting the 1 or 2 character prefix.

A CRT may not be listed in the Setup Book because it has been introduced since the last revision of the Setup Book, because it has not been registered, or because the number is a non-standard designation, such as a manufacturer's part number. Some manufacturers for example, number their CRTs with a part number.

You can use a schematic to determine the setup data for unlisted CRTs. To test a CRT you will need:

1) the negative bias
2) the G2 voltage
3) the filament voltage
4) the pins numbers of the gun elements (F1, F2, K, G1, G2)
5) a socket that fits the CRT and matches the electrical pinout (the UA will always work)

A CRT may test better than it really is when you use a schematic to obtain the setup bias information because the CR7000's sliding good/bad scale is based on the CRT manufacturer's specified bias - not on circuit bias. The bias voltages listed in a schematic are often the average DC level of the AC video signal, which is lower than the static DC bias specified by the manufacturer. If you test a CRT at a lower than normal bias, the CR7000 expects lower emission. Consequently, a CRT that has lower than normal emission may show better Emission than it really has. (This CRT will test bad when tested at normal bias). To minimize this problem, test the CRT at a higher bias setting than the schematic shows. Use the highest bias setting that produces good Cutoff range in one of the CRT guns. In a good CRT, all three guns will reach cutoff at the same bias.

Figure 18 shows typical schematic information. The filament, G1 bias, and G2 voltage (CRT TYPE) relate to the voltage values on the schematic. Use the following guidelines to determine the setup information from a schematic.

Filament voltage

Many chassis use a scan-derived supply to produce the filament voltage. Schematics often show scan-derived filament voltages as a peak-to-peak measurement, usually around 20-25 VPP. However, most scan-derived CRT filaments operate at 6.3 volts RMS. To measure

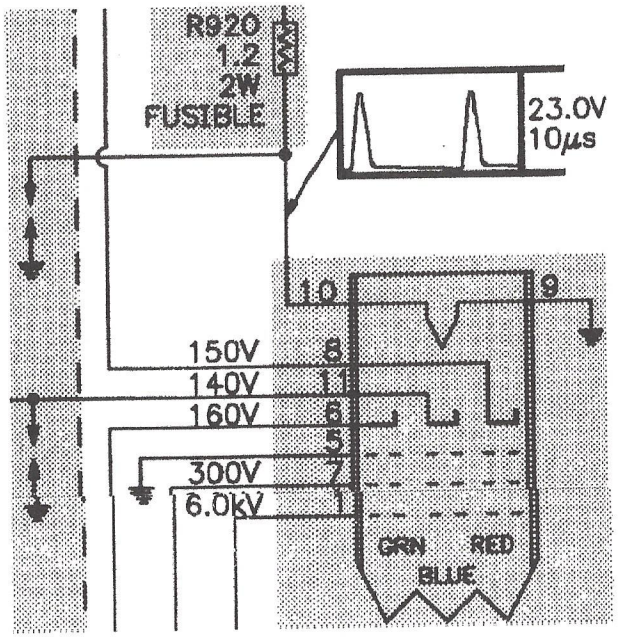


Fig. 18 - Typical schematic information.

scan-derived filament voltages you must use a true RMS meter. The filament voltage in the example in Figure 17 is 6.3 volts.

G2 Voltage

This is the DC voltage on G2 referenced to G2. The amount of G2 voltage applied during the CR7000's tests is determined by the CRT TYPE control; "Video 1" = 400 volts and "Video 2" = 600 volts G2. Set the CRT TYPE control for the closest G2 voltage. Use "Video 1" for the example in Figure 18.

Bias

The bias is the DC voltage difference between the cathode and G1 control grid. Often the schematic shows a slightly different bias for each gun. Set the CR7000's BIAS switch to setting that is closest to the value of the highest guns bias. If this bias produces good Cutoff range, try the next highest BIAS switch setting. Use the highest bias that produces Cutoff on at least one of the guns. Use "-132 V" for the example in Figure 17.

Socket

The wiring of each of the CR7000 sockets adapters is listed in the Setup Book. Use the Universal Adapter if you cannot find a socket that matches the mechanical fit and the electrical wiring of the CRT.

UNDERSTANDING HOW CRTS WORK

A CRT functions by producing a steady flow of electrons from the electron gun at the base of the CRT. These electrons are attracted to and strike the phosphor-coated screen, causing the phosphors to give off light. A deflection yoke outside the CRT produces a changing magnetic field inside the CRT. This magnetic field deflects the electron beam across the entire face of the CRT, lighting up the entire screen.

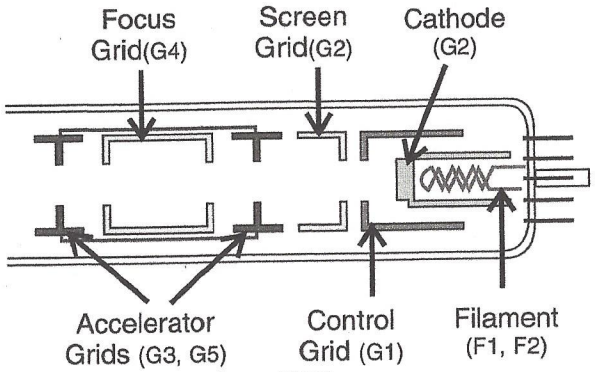


Fig. 19 - The basic elements in a CRT

Cathode (K) - The cathode is the source of the electrons. It is coated with a material (such as barium or thorium) that gives off large numbers of electrons when heated by the electron gun filament. The electrons emitted by the hot cathode form a negatively charged electron cloud that surrounds the cathode until an attracting force pulls them away.

Grids located directly in front of the cathode attract the electrons away from the cathode toward the phosphor screen, control the rate of electron flow, and shape the cloud of electrons into a sharply focused beam (think of a thin beam of light). Each grid plays a specific role in this process.

Control Grid (G1) - The grid closest to the cathode is the control grid, or G1. A negative voltage (compared to the K) called "bias" is applied to the control grid and acts as a repelling force on the electrons. The amount of negative grid-to-cathode bias determines the rate that electrons are allowed to pass through the circular opening in the control grid as they are attracted by later elements on their path to the phosphor screen. In color CRTs the control grids of all three guns may be tied together for a common circuit connection.

Bias - To produce an image on the screen the electron beam's intensity must be made to vary by controlling the rate of the electrons flowing from the cathode to the phosphor screen. This is done by changing the grid/cathode bias voltage difference in step with the brightness level changes in the picture. While the electron beam is being scanned to points on the screen that should be bright areas, the negative bias voltage is reduced, allowing more electrons to leave the cathode and strike the phosphor screen. While the electron beam is being scanned to points on the screen which should be darker areas, the negative bias voltage is increased, allowing fewer electrons to leave the cathode and strike the phosphor screen.

If the negative bias voltage is increased enough (to cutoff), no electrons are allowed to leave the cathode, and the screen remains dark. Note that with a high reverse bias approaching cutoff, the negative voltage on the control grid primarily blocks electrons from the outer edge of the cathode surface. That allows electron flow for darker areas of the image to be only from the center of the cathode surface.

Screen Grid (G2) - The grid just beyond the control grid is the screen grid, or G2. The screen grid has a circular opening and has a moderately-high positive voltage on it (400-1100 volts). This positive voltage is the attracting force that pulls electrons away from the cloud surrounding the cathode, through the control grid, and begins to form them into a thin beam. As the individual electrons accelerate toward the screen grid they feel the attracting force of higher voltage further on, so most of the electrons pass through the screen grid opening. The screen grid is common to all three color guns in most color CRTs.

Accelerating Grids (G3, G5) - The accelerating grids have the high voltage developed by the flyback (5-30 kV) applied to them. The attracting voltage on these grids accelerates the electrons to an extremely high rate as they head toward the phosphor.

Focus Grid (G4) - Between the accelerating grids is a group of cylindrical elements that make up the focus grid. Higher voltage (4-10 kV) applied to the focus grid compared to the accelerating grids creates an electronic lens effect that focuses the stream of electrons into a hair-thin beam at the point where it strikes the phosphor screen. The exact voltage applied to the focus grid is critical in causing the electron beam to achieve its tightest focus (smallest diameter) just as it reaches the phosphor screen. The focus grid is common to all three color guns in color CRTs.

What Fails Inside The CRT

Understanding what goes wrong inside the CRT helps you understand the CR7000 test results and how the Restore functions help correct various CRT failures.

Open Filament - A CRT with an open filament has no emission since a cold cathode cannot emit electrons. The filaments are fairly durable, so open filaments aren't common. An open filament cannot be repaired.

H-K Short - A heater-to-cathode short (H-K) occurs when the two elements physically touch or when a flake of conductive material from inside the tube bridges between them. Depending upon how the filaments are powered and the conductivity of the short, an H-K short may cause loss of contrast, loss of video, hum bars, or excessively bright display with retrace lines. H-K shorts cannot be repaired.

G1 short - Most G1 shorts occur when a conductive flake of material bridges between the cathode and control grid (G1). Shorts between G1 and G2 are possible, but less common. A G1 short usually causes loss of bias control, producing maximum beam current. The result is a bright white, red, green, or blue raster, usually with retrace lines. The resulting excessive beam current may even be enough to cause the chassis to shut down.

Interpreting The Cutoff Test

The entire cathode surface does not always supply the electrons for the electron beam. Instead, the surface area supplying electrons depends on the amount of negative bias. The negative field on G1 controls the beam current by repelling electrons back to the cathode. When the bias is strong enough it effectively closes the G1 opening, cutting off the electron beam. To bring the gun out of cutoff, the bias is decreased. As the gun comes out of cutoff the hole in G1 opens, allowing electrons to be pulled from the cathode's surface. The negative field produced by the bias is evenly distributed around the G1 opening, meaning the electrical opening is smaller than the physical opening. We call this electrical opening the "virtual aperture".

The smaller virtual aperture at high bias means that only the cathode's center supplies electrons. The emitting material at the cathode's center wears out before the material at the edges because the center contributes electrons all of the time, while the edges only contribute electrons during bright white picture periods. This condition is called "poor gamma". Poor gamma means that the CRT cannot produce a linear gray scale from black to white. The result is deep blacks (most of which should be shades of gray)

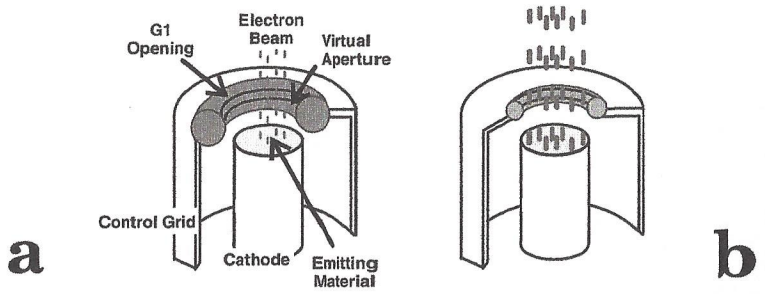
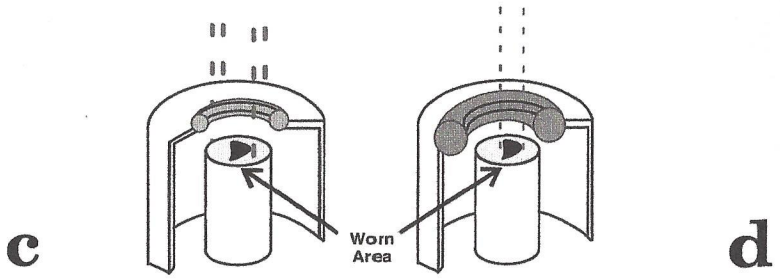


Fig. 20 - Only a small portion of the cathode emits electrons when high G1 Bias closes the virtual aperture (a). Reducing the bias results in more beam current because more of the cathode's surface emits electrons. (b)



Bad Cathode / High Bias **Bad Cathode / Low Bias**

Fig 20 continued - A CRT with a worn cathode center area (c) still produces good light output at low bias, but cuts off far too soon at higher biases (d).

and possibly overly bright whites (because of increased user Brightness and Contrast control settings), but few shades of gray in between. Although these CRTs are often called "gassy", the problem is a partially depleted cathode surface.

A CRT gun that has poor gamma cannot be set up into the "Cutoff" box at the bias and CRT Type listed in the Setup Book (the gun may reach Cutoff at a lower bias), but the gun will often read good on the "Emission" test. Poor cutoff can usually be improved with the CR7000's Restore functions.

Low Emission

Low CRT emission usually occurs when a layer of "contamination" coats the cathode's surface. This coating is really a layer of positively charged ions that are created when the electrons strike stray air molecules inside the CRT. Over time enough positive ions are attracted to the negatively charged cathode to act like a wet blanket that prevents electrons from leaving the cathode. If the contamination covers the entire cathode surface, the CRT has reduced output over its entire brightness range.

Sometimes the contamination develops only around the edges of the cathode, since the center portion is always conducting heavily. This results in normal blacks and grays, but reduced whites (the opposite of poor gamma) and poor contrast. Low emission caused by contamination can usually be improved with the CR7000's Restore functions.

Stripped Cathode

A stripped cathode is usually caused by excessive cathode restoration which removes emitting material along with the harmful contamination, leaving little or no emitting material. An open Cathode occurs when the wire connection inside the CRT between the cathode and the base connection pin breaks. Stripped and open cathodes produce no beam current in either the Cutoff or Emission tests, and cannot be repaired or restored.

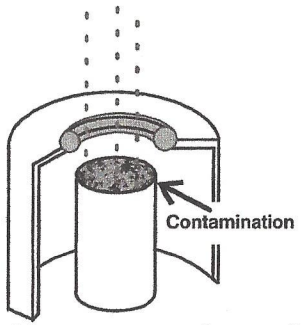


Fig. 21 - Low white level beam current is usually caused by layer of ion contamination on the cathode's surface.

Temperature Sensitive Cathode

All CRT cathodes have lower emission at reduced filament voltage. A normal cathode however, produces more electrons than are needed for the electron beam, so a small drop in filament voltage produces only a small drop in beam current as electrons are pulled from the "reserve." Some CRTs produce good emission under normal operation but drop to very low emission with a small filament voltage drop. Partially depleted emitting material or a thin layer of contamination cause this abnormal current drop. Eventually the emission current will be reduced even at normal filament voltage. Temperature-sensitive cathodes can usually be improved using Re-activate.

Bad Color Tracking

Bad color tracking occurs when the maximum current output of the CRT's three guns are imbalanced enough that the monitor cutoff and tracking controls aren't able to adjust for the imbalance. This prevents the gray scale tracking (white balance) from being properly adjusted. Areas of the image which should be white or gray will have red, green,

or blue coloration. Bad color tracking can occur even though each gun has "good" emission. CRT manufacturers specify that the weakest CRT gun should not produce less than 55% of the beam current of the strongest gun. Any CRT gun outside this limit can prevent the monitor setup controls from being properly balanced.Bad tracking can usually be improved with the CR7000's Restore functions.

UNDERSTANDING HOW THE CR7000 WORKS

This section relates each CR7000 function to the way the CRT operates. The explanations are given from a functional, rather than from a circuit description standpoint.

Filament Voltage

Normal filament voltage must be supplied to the CRT for all tests. The CR7000 uses a regulated DC power supply to provide the proper RMS filament voltage for the CRT. The voltage at the CRT connection is sensed to compensate for power losses in the test cable.

G1 & H-K Short

In these functions the CR7000 operates as a sensitive ohmmeter. The CR7000 bar graph shows the severity of the short or leakage. The G1 SHORT function detects shorts between K and G1, or between G1 and G2.

Cutoff Test

Together, the Cutoff and Emission tests check the dynamic range of the CRT. During the Cutoff test the CRT is biased near electron beam cutoff which corresponds to the CRT's black level. The manufacturer's specified bias is applied to the CRT which repels the electron beam back towards the cathode. A positive voltage which attracts the electrons is applied to G2 and adjusted with the CUTOFF LEVEL control until the gun just begins to conduct, as indicated by a bar graph reading within the "Cutoff" area. The G2 voltage can be varied from 0 to 600 in the "Video 2" position of the CRT TYPE control, and 0-400 in the other positions. Once the G2 voltage is adjusted for Cutoff it remains set at the same level for the Emission and Emission Life tests.

Bias

The point where an electron gun just begins to conduct (cutoff point) is affected by the G1 and G2 voltages applied to it. CRT manufacturers specify the range of G1 "bias" and G2 voltages that produce cutoff . Figure 22 shows a typical cutoff design chart for a particular color CRT design. (Different CRT designs have a different cutoff characteristics). The area between the "Minimum Spot Cutoff" and "Maximum Spot Cutoff" lines is the range over which all good CRT

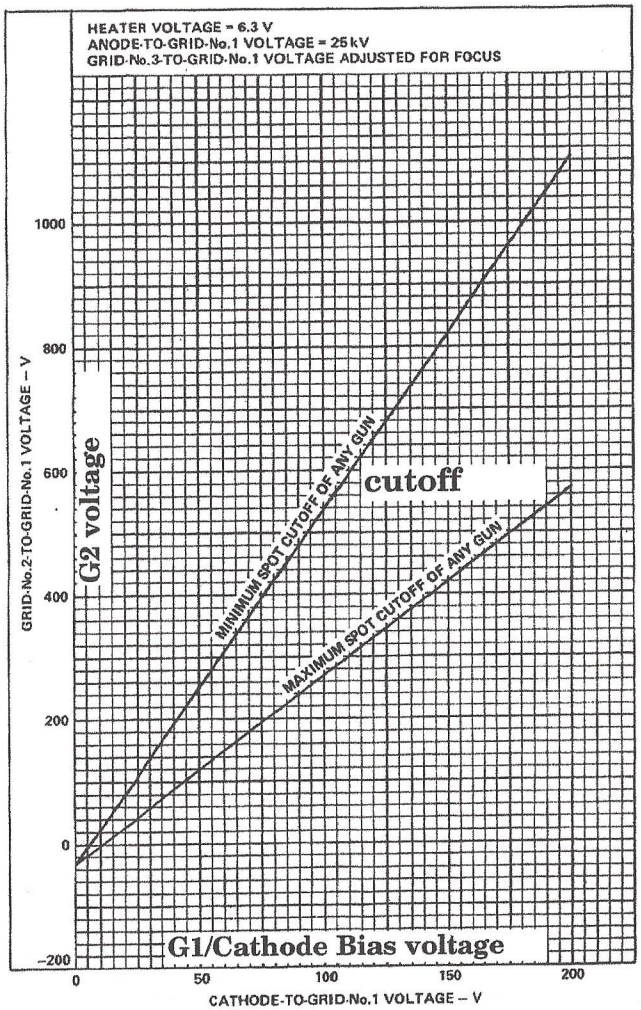


Fig. 22 - An example of a manufacturer's cutoff chart.

guns of this design should reach cutoff. For example, with -100 volt bias (CATHODE-TO-GRID-NO.1 VOLTAGE scale along the bottom of the graph) all good guns should produce cutoff current with at most 540 volts G2 applied (GRID-NO. 2-TO-GRID-NO. 1 VOLTAGE scale along the side of the graph , and some guns may reach cutoff with as little as 260 volts G2.

You can also use this chart by first fixing the G2 voltage amount and then determining the greatest negative bias level at which the CRT should reach cutoff. For example, with a G2 voltage of 600 volts the CRT in Figure 22 meets the "Maximum Spot Cutoff" point at a bias of 110 volts. (All good CRTs of this type will reach cutoff at this point). Notice that some CRT guns of this design can have as much as -200

volts of bias and still reach cutoff at 600 volts G2.
The CR7000 setup information is developed by picking the G2 voltage and then deciding the maximum cutoff bais. First, a maximum G2 voltage point is selected on the graph - either 400 or 600 volts. This is the G2 voltage applied by the CR7000 when the CUTOFF LEVEL controls are set fully clockwise (400 V = "Video 1", 600 V = "Video 2"). Next, the maximum bias at which all good CRT guns will produce cutoff current is determined from the chart. For accurate testing, we use the highest combination of G2 and negative bias voltage that produces cutoff.

Notice that both the G2 voltage scale and the Cathode bias voltage scale in Figure 22 are referenced to G1 (G1 = 0 volts). Some manufactures use a G1 reference as shown here, while other data sheets reference the G1 and G2 voltages to the cathode (K = 0 volts). The CR7000 circuits are referenced to cathode, so the scales on the Cutoff chart in Figure 22 need to be shifted. This particular tube is tested with the CR7000 using a BIAS setting of "-132V and CRT TYPE of "Video 2" (600 volts G2).

Low Tracking test

The Low Tracking test compares the G2 voltage ratio as you adjust each CUTOFF LEVEL control for cutoff. The "GOOD" GUN TRACKING LED lights if all three guns are within the "Cutoff" area and the G2 voltages are within a ratio of 1.25:1. The "BAD" GUN TRACKING LED stays lit if any gun is outside the "Cutoff" area, or if the G2 voltage ratio is too great.

Emission Test

The CR7000's Emission test has two important features that provide accurate measurements of the performance capabilities of a CRT electron gun. First, the Emission test measures "true beam" current. True beam current is the electrons that pass from the cathode, through the opening in G1 and on to G2. This provides the best representation of the actual current that produces the electron beam that strikes the phosphor. Some CRT failures are caused by a blocked G1 opening. No cathode current can reach the phosphor to produce light with a blocked G1 opening. Emission tests that measure cathode current (current between the cathode and G1) will not find a blocked G1.

The second CR7000 Emission test feature a sliding "Good/Bad" scale. The sliding Good/Bad scale compares the actual measured emission of a CRT to what the minimum emission should be in a good, new CRT based on the manufacturer's specifications. The amount of emission current produced by a new, good CRT electron gun corresponds to the bias voltage needed to cut the beam off (cutoff voltage). This relationship is: $Ik_{max} = 3 \times (V_{cutoff})^{3/2}$. Note that this is the

minimum amount of current that a gun should produce when it is new; some guns produce higher current. CRT manufacturers use a very similar method of comparing cutoff voltage and emission current to determine if their new or remanufactured CRTs are good.

Of course the current producing capability of all CRT electron guns decreases as the cathode's surface ages or becomes contaminated. These slow changes in performance are compensated for with the "Brightness" and "contrast" User controls, and the Bias, Drive and G2 chassis Setup adjustments. However, at some point a CRTs worsening performance can no longer be compensated for. The picture becomes too dim, won't focus properly, lacks contrast, or lacks gray scale adjustment. For most applications the emission current is too low to produce an acceptable image when the current drops to about 50% of Ik_{max}.

The "Good/Bad" center point of the CR7000's emission scale is calibrated at 50% of Ik_{max} for each of the different bias settings. Full scale is Ik_{max} current, or more. Because the "Good/Bad" current changes with bias, we call it a "sliding" good/bad scale.

The CR7000's emission scale is linear. This allows you to gauge the actual emission level of a CRT. An emission reading that is 3/4 of full scale for example, means the gun is producing 75% of new current. Table 5 shows the relationship between cutoff voltage and the corresponding minimum Ik_{max} cathode current. The CR7000's "Good/Bad" dividing line (50% of Ik_{max}) current is also shown. The Emission test sequences through each gun, taking an emission

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

Table 5 - The emission current produced by a CRT gun corresponds to its cutoff voltage. The CR7000's "Good/Bad" dividing line represents 50% of "new" emission current.

reading on each gun about 3 times per second. During the test, the bias on the gun is momentarily reduced to 0, which forces the gun into full conduction. The bar graph displays the full conduction current for all three guns. After approximately 15 seconds, the test sequence times out and the bar graphs hold and display the last emission current reading.

High Tracking Test

The CR7000 High Tracking test automatically compares the Emission currents of all three guns. The "Good" GUN TRACKING LED will light if all three guns have "good" emission and the ratio of emission currents is within 1.55:1. If one or two guns have weak emission, or if the ratio of emission currents is greater than 1.55:1, the "Bad" GUN TRACKING LED will stay lit.

Emission Life Test

The Emission Life test provides an indication of the reserve electron cloud that normally surrounds a hot cathode. This is can be used as an indication of the cathode's approximate remaining useful emission, or life, and provides another way to qualify the performance of a CRT.

It is difficult to exactly equate the remaining CRT life to the Emission Life test results. Several factors affect CRT life. One factor is the CRTs application. A CRT in a monitor that display black text on white background, for example, will not have the same life as a similar CRT in a monitor that is mostly in a blank power save or screen save mode. Likewise, a television CRT that is used for 2 hours per day will last months longer than a television CRT that is used for 12 hours per day.

Other factors also affect CRT life, such as the amount of "getter" material that is deposited inside the CRT to trap ions. Once the getter material is consumed, the cathodes become contaminated and quickly re-contaminated again after restoration. How hard the CRT is driven by the chassis, the chassis high voltage, and even the filament voltage are factors in CRT life.

Some CRT cathodes are normally sensitive to filament voltage. In these CRTs. even a 5 or 10% change in filament voltage will cause a noticeable and normal change in emission. If in doubt, do not restore a CRT unless the picture is noticeably degraded. The best indication of a weak or contaminated cathode is a CRT in which one or two guns drop off in the Life Test, but the other cathode(s) remains constant or nearly constant. New and rebuilt CRTs will typically check poor for Emission Life if they are tested right out of the box. This does not mean the CRT is bad. It simply means that the cathodes need time to fully activate. Refer to the section "Testing New or Newly Rebuilt CRTs" on page 60 for more information.

RESTORE FUNCTIONS

The CR7000 provides five levels of beams restoration, plus "Remove G1 Short" and "Rejuv" functions. These functions differ in the amount and duration of restore current, as summarized in Table 6.

FUNCTION	FILAMENT VOLTAGE	CURRENT LIMIT	TIME DURATION
Re-activate	50% boost	1mA	30 sec.
Low	normal	40 mA	2 sec.
Normal	normal	80 mA	2 cycles (3 sec. on/3 sec. off)
High	50% boost	100 mA	3 cycles (4 sec. on/2 sec. off)
Extended	50% boost	100 mA	15 sec.
Remove G1 Short	removed	self-limited surge	20 sec. cool-down before active; self-limiting
Rejuv	normal	self-limited surge	self-limiting

Table 6 - Summary of Restore filament voltage, current and duration. Remove G1 Short

Restore

The first five Restore functions (RE-ACTIVATE, LOW, NORMAL, HIGH and EXTENDED) bring fresh emitting material to the cathode's surface by removing old emitting material and contamination from the cathode's surface. Restoration does not add new emitting material. Five levels of restoration are provided so that unnecessary strain is not applied to the CRT. Always begin with the lowest level of Restore (RE-ACTIVATE) and move up to a higher level only if a lower level does not return the CRT to acceptable operation.

During the restore functions the cathode and G2 are tied together and positive bias is applied to G1. This causes current to flow from the cathode to G1. This current is limited to the amounts shown in Table 6, and is displayed on the bar graph for the gun that is being restored. The "Good/Bad" line at the center of the display is the maximum current for each Restore function. The filament voltage is increased by 50% in several of the Restore functions. This helps to superheat the cathode and soften the contamination.

The time that restore current is allowed to flow is also limited by the CR7000, as shown in Table 6. The "Ready" LED guides you when to press and release the "Press To Restore" button. When the LED is on, the CR7000 Restore circuits are charged and ready. When the LED is off, the circuits are either charging up, or the restore cycle is complete.

Remove G1 short

The REMOVE G1 SHORT function removes most shorts between G1 and the cathode, or between G1 and G2. Most shorts are small particles of foreign material that have wedged between the elements. A few shorts are caused by the elements physically touching. These shorts (indicated by a reading near the far left of the scale) cannot be removed.

In the REMOVE G1 SHORT function the cathode and G2 are tied together so that a short between either K and G1, or G1 and G2 will be removed. The filament voltage is removed from the CRT to minimize the possibility of damaging either the heater or cathode. To insure that these elements have cooled, the CR7000 waits 20 seconds before turning on the "Ready" LED. Pressing the "Press To Restore" button after the Ready LED is lit discharges a 450 volt capacitor between G1 and the K/G2 connection. A resistor in series with the capacitor limits the maximum surge current, in case a direct short exists. The capacitor discharge blows the short away. This method of removing G1 shorts is the safest and most effective method, since only enough power is applied to remove the short. Once the short is gone, the discharge stops.

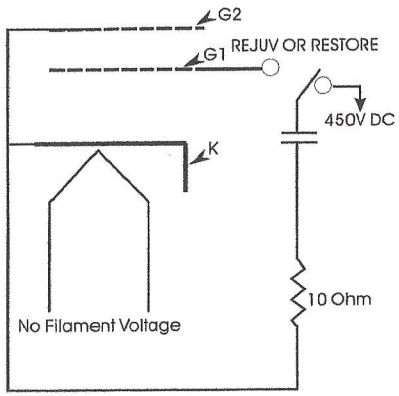


Fig. 22 - Simplified Remove G1 Short function.

Rejuv

The last and most severe of the CR7000 Restore functions is rejuvenate. Rejuvenate should only be used to start CRTs that will not draw restore current in any of the other Restore functions because they have such a thick coating surrounding the cathode. The sudden current surge produce by the REJUV function effectively cracks this coating and allows restoration to begin.

In the REJUV function the cathode and G2 are tied together, normal filament voltage is applied, and a capacitor is supplies a sudden voltage surge. When the "Press To Restore" button is pressed, G1 is instantly driven very positive which causes a sudden current surge in cathode current. This current quickly drops to zero as the capacitor discharges. This sudden current discharge cracks any coating of contamination from the cathode, allowing it to once again supply proper emission. If you use REJUV on a cathode that is able to produce Restore however, you may severely damage the cathode by stripping away good emitting material. For this reason, only use REJUV after all of the Restore functions have failed to produce restore current.

BEAM TESTING APPLICATIONS

Testing New Or Newly Rebuilt CTRs

Many new and rebuilt CRTs normally show poor Emission Life if they are tested right out of the box. This does not mean the CRT is bad - it simply means that the cathodes need time to fully activate. Some new CRTs set in storage for several months before being put into service. During this period of inactivity the emitting material on the cathode's surface normally de-activates slightly. Another reason for low Emission Life readings on new or rebuilt CRTs is that manufacturers do not activate the cathodes to 100%. Instead, they allow the activation process to finish itself as the CRT operates. This is done to prevent over activation which would drastically shorten the CRTs life.

Always allow a new or rebuilt CRT, or a tube that has sat idle for a long period of time, to warm up for 30-60 minutes with filament voltage applied before testing the tube and before performing the chassis setup adjustments. (Set the FUNCTION switch to "Fil Set" and select normal heater voltage). After the CRT has undergone this re-activation period, as good CRT should perform without any problems. Do not restore a new or rebuilt CRT unless directed to do so by the manufacturer. Restoring a new or rebuilt CRT will unnecessarily remove cathode emitting material, shorting the useful life of the CRT.

Testing CRTs With Directly Heated Cathodes

In a directly heated cathode CRT the filament and cathode are the same element. All directly heated cathode CRTs are listed as "UA" in the Setup Book and require you to use the Universal Adapter. To test a directly heated CRT you connect the "F1" and "F2" clips of the UA to the CRT filament pins as you would for a conventional CRT. Then connect the "K" clip the same CRT pin as the "F1" clip. To test each gun of a directly heated color CRT you must change the "F1" and "F2" UA clips as well as the "K", "G1", and "G2" connections to the CRT pins.

All directly heated cathode CRTs normally show an H-K short because the heater and cathode are the same element. A common failure in these CRTs is a dynamic G1 short. This occurs when the filament/cathode assembly physically touches the first grid (G1) as the filament heats. You can confirm the dynamic nature of these shorts by setting the CR7000 FUNCTION switch to "G1 Shorts" before applying power. A tube with a dynamic short will read GOOD when power is first applied and then drop to BAD as the filament heats.

Many of the G1 shorts which occur in CRTs with directly heated cathodes cannot be removed successfully. Attempts at removing these shorts usually result in opening the filament. However, since the tube is useless with the G1 short, nothing is lost in trying to remove the G1 short. Directly heated cathode CRTs contain very delicate elements. Therefore, to avoid unnecessary strain on the gun assembly, only use one RE-ACTIVE on weak tubes.

Camera Tubes

The CR7000 can successfully restore many weak camera pickup tubes. Camera pickup tube failures are often caused by weak electron gun emission. Symptoms of weak emission are lag ("sticking" highlights), poor light sensitivity, or low output levels.

Target failures in camera tubes cannot be corrected with restoration. Target flaws include spots, burned-in images, ghosts around bright objects, and areas of higher or lower light sensitivity in various parts of the picture. The easiest way to detect a target problem is to aim the camera at a scene and then move the camera. If the picture flaw stays in the same place the target is damaged. Some target failures may cause general "sticking" or lag. Restoring the cathode often improves this condition, but will not eliminate the condition 100% if the target is part of the problem.

Use the Universal Adapter to connect to camera tubes. Remember to use the cameras schematic to determine the setup for tubes that are not listed in the Setup Book. Most camera tubes use a Bias "-36", CRT Type: "Video 1", and 6.3 Filament volts.

Camera tubes test differently than other CRTs because of the way the electron beam that reaches the target is formed. The cathode (K), control grid (G1), and screen grid (G2) are virtually identical to the similar elements in a CRT, except for the opening in G2. Camera tubes use a G2 opening that is much smaller than that of a CRT. This restricts much of the electron beam and forms the remaining electrons into an extremely fine beam. The tiny electron beam is then focused and sent to the target.

The CR7000 measures the beam current that reaches G2. Because of this you must **use the operation of the tube in the camera as the main indication of a weak tube** since the Emission test does not directly correlate to the tube's quality. Once you have decided the tube is weak, however, you can use the Emission Life Test to monitor your progress during restoring. After noting a major improvement in the Life test results, check the operation of the tube in the camera. The true test of the tube's quality will have to be based on its operation in the circuit. Don't attempt to further restore the tube if the camera produces an acceptable picture.

Air Contaminated Tubes

A CRT becomes air contaminated when it loses some or all of its vacuum. A tube that has lost all of its vacuum usually has open filaments since the heated filament burns open when it contacts air. Some CRTs, however, develop a slow air leak that occurs over months. These CRTs either 1) test normal after being restored but quickly fail again after several hours or days as the cathode recontaminates itself because of the air leak ; or 2) act like a gas filled regulator during the Cutoff test. The bar graph stays at the left edge as the CUTOFF LEVEL control is adjusted, but suddenly pegs full scale. You will see a blue haze surrounding the electron gun when the bar graph is pegged full scale. The blue haze and pegged bar graph occur when the air inside the tube ionizes and provides a low resistance path for the cathode current to flow to G2.

Dynamic Shorts

The spacing between CRT elements is quite small in today's CRTs. Some CRTs test good but will not work in the circuit, or work for a few minutes and then fail with a symptom of loss of control of one color, poor focus, retrace lines, high voltage loading, or chassis shutdown. These problems are often caused by a dynamic shorts. Dynamic shorts are shorts which occur only when the CRT has full operating voltages applied, or when the CRT is hot. Dynamic shorts may appear as soon as the CRT is turned on, or after the tube has been operating for several minutes.

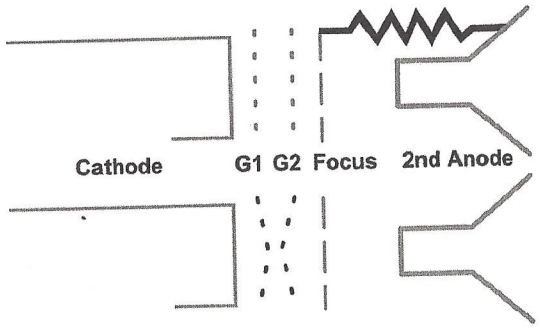


Fig. 24- Dynamic shorts can be caused by leakage between the second anode and the focus grid or by elements warping when they warm up.

Second Anode Leakage

One type of dynamic short occurs between the second anode and the focus grid. This leakage path can only be isolated with full high voltage applied to the CRT. Always test for this type of short first.

⚠ WARNING

Potentials up to second anode voltage levels (15- 35 kV) may appear at the focus pin if there is a short between the 2nd anode and focus grid. Use a protected, high voltage probe to make this test, and follow normal high voltage precautions.

⚠ WARNING

Il est possible d'obtenir à la patte de focalisation des voltages équivalents à ceux trouvés sur la seconde anode (15-35kV) si il y a un court circuit entre la seconde anode te la grille de focalisation. Utiliser une sonde haute tension pour faire ce test, et utiliser les précautions d'usage pour les hautes tensions.

To test for second anode leakage:

1. Remove power from the chassis.

2. Disconnect the socket from the CRT.

3. Connect a high voltage probe from the focus pin of the CRT to CRT ground.

4. Apply power to the chassis while observing the reading on the high voltage probe.

5. If the CRT has two focus pins, repeat the procedure for the other focus pin.

A good CRT should show no voltage at the focus pin. If you read any voltage, the CRT has a leakage path between the second anode and focus grid. This failure cannot be repaired with the CR7000's Restore functions.

Dynamic Gun Shorts

If the CRT has no second anode voltage it may have a dynamic short between some other elements. An electron gun that wraps when it is heated will cause metal-to-metal contact. The CR7000 may not show this short during normal testing because the short may take several minutes or hours to develop at normal operating temperatures. (Likely the symptoms in the chassis won't show up for a period of time either).

To isolate dynamic shorts:

1. Increase the filament voltage by 50% over normal.

2. Repeat the G1 and H-K SHORT tests at this increased filament voltage. Neither test should show readings in the "bad" area of the bar graph.

If the G1 SHORT test shows "bad", try to remove it by using the REMOVE G1 SHORT function.

UNDERSTANDING CRT NUMBERS

Most CRTs are registered according to some kind of industry standard. These standards define certain characteristics of the tube. In 1982 the Worldwide Type Designation System was adopted as the world-wide standard for CRT numbering. The Worldwide Type Designation System for TV Picture Tubes and Monitor Tubes (WTDS) is a numbering

standard used internationally by CRT manufacturers as an effort to simplify and unify CRT designations. Prior to this system, American, Japanese, and European tube manufacturers numbered their tubes differently. This led to confusion and incomplete or inaccurate information.

The WTDS number consists of six groups of symbols. The first symbol defines the application of the tube. This symbol is always a single letter: "A" or "W" = TV picture tubes, "M" = monitor tubes (these differ in the size and pitch of the phosphor dots), P = projection tubes, "D" = electrostatic deflection types.

The second group of symbols is a two-digit number which defines the minimum viewable diagonal. This measurement is always listed in centimeters. (1 inch = 2.54 cm).

The next group of symbols consists of three letters and designates a family code. Tubes within a particular family have specific mechanical and electrical characteristics. These letters are assigned alphabetically beginning with "AAA", followed by "AAB", "AAC", etc. Tubes which contain the same sequence of letters are identical as far as their setup for the CR7000 is concerned. The letter sequences are grouped according to the country they are manufactured in.

One or two digits follow the family code. These digits indicate a specific member within a particular family. A different number is assigned to tubes within the same family that have different neck diameters, for example. A single digit member symbol indicates a monochrome tube, while a two digit number indicates a color tube.

Following the one or two digit member symbol is the phosphor type designation. Color picture tubes are designated by the single letter "X", while color monitor tubes may have some other single letter designation. Monochrome picture tubes are designated by the two letters, 'WW". Other monochrome tubes, such as monitors, have a different, specific two letter code to designate the phosphor type.

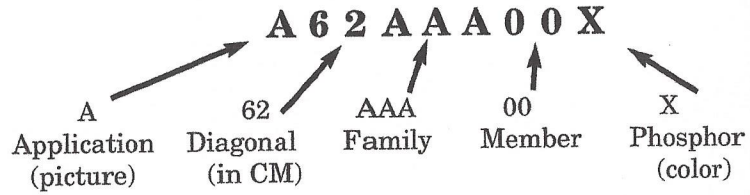


Fig. 25 - A sample WTDS CRT number.

Many CRTs contain integral neck components such as bonded yokes, or internal compensation for the earth's magnetic field. These tubes have a sixth group of symbols. A two digit number defines the characteristics of these integral neck components. This part of the number is not included in the CR7000 Setup Book.

Even though the three letter family code is the only part of the designation which is required for proper setup, the whole WTDS number is included in the Setup Book to avoid the possibility of confusion with some other number that may appear on the CRT, such as a manufacturer's part number.

Old Standards

The CRTs registered prior to the WTDS standard were registered differently in the United States, Japan, and Europe. In general the registration number included three parts.

The first part of the CRT number is a series of digits which signify the minimum diagonal viewing measure of the CRT. For American tubes, this size is in inches. Thus, a 19VACP22 has a viewing diagonal measure of 19 inches. Japanese and European tubes specify this distance in millimeters.

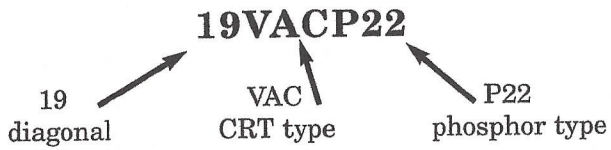


Fig. 26 - The old standard contained tube size and phosphor type information.

The next part of the CRT number consists of one to four letters that designate a particular CRT within a group of CRTs having the same screen size. Unlike receiving tubes, these letters do not cross reference from one size group to another. For example, a CRT with a "12VAC" listing is not necessarily similar to a "5VAC", nor is there any correlation between B&W and color CRTs having the same letter code. The CR7000 Setup Book uses these letters as the second level of sequencing.

The final part of the CRT designation indicates the type of screen phosphor. All B&W video CRTs are designated "P4" for American listings, and "B4" for Japanese listings. Color CRTs are "P22" (American) or "B22" (Japanese). Computer CRTs or scope CRTs may use some other type of phosphor, and will have a different number following the "P" or "B". The "P" or "B" is not part of the tube designation.

Listings ending with TC01, TC02, etc.

Some CRTs numbers do not end with a "P" or "B". The most common non-standard ending is "TC01", "TC02", "TC03" etc. These CRTs always have a bonded yokes or some other component permanently attached to the neck. The "TC" ending simply indicates the type of yoke plug that is used to connect to the chassis. The CRT is identical to one with a "P22" or "B22" ending. For example, a 15VAETC01 is identical to a 15VAEP22. Only the standard (P22 or B22) listings appear in the CR70 Setup Book.

Output Cable Wiring

The wiring of the CR7000's test cable plug and socket connector are shown below. Use this information if you need to check for an open connection in one of the sockets or in the test cable. You can also use this information to wire a special adapter socket to use in place of the Universal Adapter.

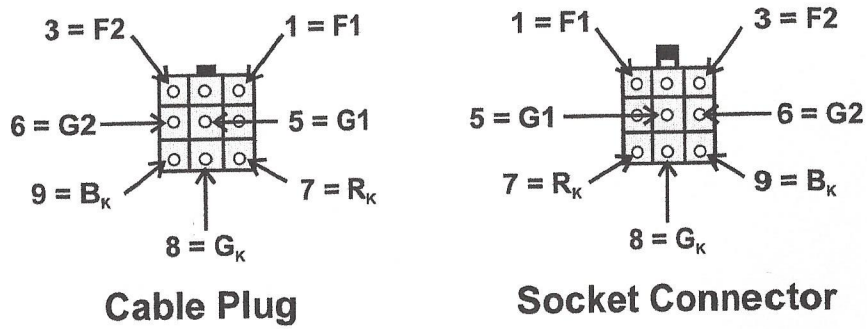


Fig. 27 - Test cable plug and socket connector wiring.

Testing The Universal Adapter

The wiring of the Universal Adapter can be tested using the H-K and G1 SHORT test functions of the CR7000.

1. Set the FUNCTION switch to G1 SHORT.

2. Set the TEST GUN SELECT switch to "Simultaneous".

3. Set the Filament voltage to minimum.

4. Connect the Rk, Gk, Bk and G1 leads together. The Bar Graph for each gun should drop to the far left (1 LED on),indicating a G1 short.

5. If the Bar Graph stays "Good" (no short) for any gun, the Universal Adapter cathode lead for that gun is open.

6. If all three guns continue to show "Good", (no short) either the G1 lead is open, or all three cathode leads are open (not too likely).

7. Connect the G1 and G2 leads together. All three guns should show a short. If the reading stays good, the G2 lead of the Universal Adapter is open.

8. Set the FUNCTION switch to H-K SHORT.

9. Connect the Rk and F1 leads together. The display should show a red gun H-K short.

10. Connect the Rk and F2 leads together. The display should again show a red gun H-K short.

Notes