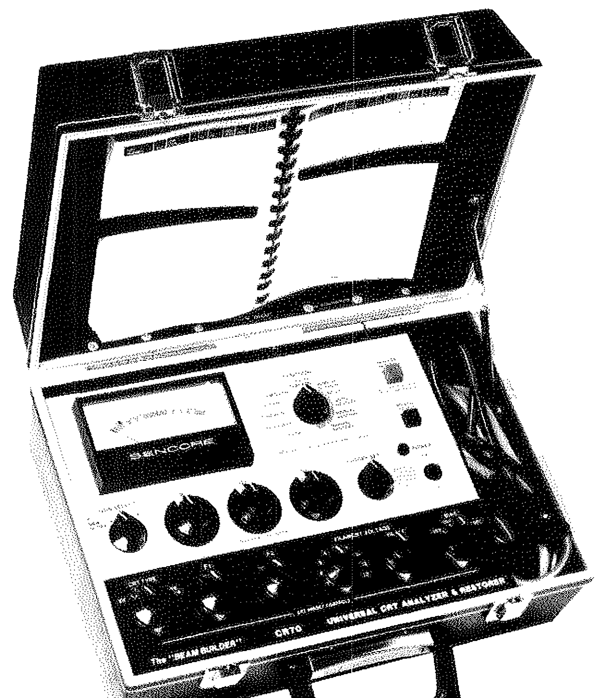
CR70

BEAM BUILDER™

Universal CRT Analyzer and Restorer
Operation and Application Manual



SENCORE

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DESCRIPTION

Introduction

The Sencore CR70 "Beam Builder"™ Universal CRT Analyzer and Restorer is designed to test and restore any type of CRT (cathode ray tube). The tests analyze each type of possible electron gun failure to provide accurate information about the ability of the gun assembly to produce an electron beam with the correct specifications. This information helps you decide whether the CRT will continue to operate in the circuit, whether you should attempt to improve its condition with the CR70 "Beam Builder" functions, or whether it should be replaced.

The beam building functions provide five different levels of cathode improvement, providing the correct type of restoration or rejuvenation needed to improve most defective CRTs with the safest cathode recovery methods possible. You use the test results to guide you through the beam building steps.

Features

The CR70 tests each gun and each element individually, using dynamic tests which simulate the CRT in actual operation. The tests confirm that there are no inter-element shorts, that each gun has the correct dynamic range (range of cathode current between darkest and brightest display) and that each gun has enough emission level to produce an acceptable image on the CRT screen. Color reproduction problems are readily identified with a patented color tracking test, which compares the emission levels of all three electron guns of a color CRT, or the three individual CRTs of a three-tube projection system, to confirm the three colors can be properly balanced against each other.

The CR70 provides five types of cathode recovery to allow you to use enough current to do the job effectively, without applying more than would be safe for a particular type of CRT failure. The CR70 meter monitors the amount of restoring current, allowing you to control the results. The CR70 operates on only one gun of a color CRT at a time allowing the beam building action for each gun.

The design of the CR70 allows the use of the fewest number of adapter sockets possible. Because of its unique design, the CR70 is virtually obsolete proof. Unlike other CRT testers, the CR70 requires only one adapter socket for each type of CRT base. Setup switches let you compensate for different wiring configurations for a single style of socket. The setup switches relate directly to the pins of the CRT, allowing a schematic to be used to determine the testing information for a CRT that is not listed in the CR70 setup book.

CR70 Specifications

CRT Tests

Shorts Tests:
H-K Shorts: 2 megohm good/bad calibration, ±10%.
G1 Shorts: 20 megohm good/bad calibration, ±10%.

TM: "Beam Builder" is a trademark of Sencore, Inc.

Cutoff Test:
G1 Bias: Switch selectable; −20, −36, −52, or −68 VDC.
Calibration Current: Video CRTs, 10 uA to 20 uA ±5%; Projection CRTs, 26 uA to 53 uA ±5%; Scope CRTs, .33 uA to .66 uA ±5%.

Emission Test:
G1 Bias: Zero volts.
Good/Bad Emission Level: Video CRTs, 300 uA ±5%; Projection CRTs, 800 uA ±5%; Scope CRTs, 10 uA ±5%.

Tracking:
Method, (patent number 3,588,184, additional patents pending): Stored emission current levels compared between highest and lowest guns, ratio indicated on meter.
Good/Bad Calibration: 1.55:1.
Minimum memory time: 15 minutes.

Beam Builder

Remove G1 Shorts:
Method, capacitive-discharge; Applied voltage, 450 VDC; Discharge Time, automatically determined by CRT under test. Filament voltage removed to prevent damage to filament.

Rejuvenation:
Method, capacitive-discharge; Applied voltage, 450 VDC; Discharge Time, automatically determined by CRT under test.

Restoration:
Method: Cathode super-heating using elevated filament voltage and increased beam current.
Current Levels: Video and Projection CRTs, 100 mA for auto and Manual 1, 150 mA for Manual 2; Scope CRTs, 75 mA for auto and Manual 1, 100 mA for Manual 2.
Auto restore time: Nominal 4 seconds on and 2 seconds off for 3 cycles.
Manual 1 and Manual 2 times: Determined by user.

Filament Voltage:
Continously variable from 1-14 volts.
Meter accuracy ±5%, calibrated at 6.3 volts at 900 mA.
Life Test: Lowers filament voltage 25%, ±10%.
Restore: Increases filament voltage by 50%, ±10%.

General:
Meter: 4", 100 uA, 2%, 4000 ohms.
Size: 7½" x 14" x 9¾".
Weight: 12 lbs., including sockets and setup book.
Power requirements: 105-130 VAC, 50/60 Hz.

Accessories:
Supplied: 5 dual-sided adapter sockets to fit EIA standard CRT bases.
Optional: 39G170 Universal Test Clip Adapter.

Controls

Fold out for description

Fold back

3. **REJUV OR RESTORE BUTTON** — Used with "Beam Builder" functions (2g-k) to activate rebuilding process.

4. **EMISSION LIFE TEST BUTTON** — Used in conjuction with EMISSION test (2e) to approximate the amount of life remaining.

5. **POWER INDICATOR.**

6. **POWER SWITCH** — Applies power to the CR70 and CRT.

7. **CRT PRESET CONTROLS** — These controls, set from the information in the setup book or from the information on a schematic showing the CRT in operation; generally need to be only set one time to test a CRT, even a color tube. These controls match the CR70 circuits to the CRT under test.

7a. **CRT TYPE SWITCH** — Establishes the correct CR70 internal calibration for the various test and beam building functions for the three basic types of CRTs.

7b. **F1 SELECTOR SWITCH** — Determines which CRT pin is connected to the first CRT filament power supply connection.

7c. **F2 SELECTOR SWITCH** — Determines which CRT pin is connected to the second CRT filament power supply connection.

7d. **FILAMENT RANGE SWITCH** — This 9-position switch determines the range of filament voltage supplied by the CR70 to properly match the CRT under test.

7e. **FIL SET CONTROL** — This control adjusts the filament power supply to exactly match the specifications of the CRT under test by selecting the FIL SET FUNCTION (2a) and monitoring the results on the FILAMENT VOLTAGE meter scale (1a).

7f. **BIAS SWITCH** — This switch determines how much negative bias will be applied to G1 (control grid) when the FUNCTION switch is in the CUTOFF (2d) position in order to provide a dynamic test of the CRT.

8. **INDIVIDUAL GUN SETUP CONTROLS** — These controls select the individual CRT elements that must be tested. In a monochrome CRT, these controls will only be set one time. In a color CRT, they will be changed for each color gun.

8a. **GUN SELECT SWITCH** — This switch tells the CR70 tracking test circuits which color gun is being tested. During the Emission test, the CR70 stores the emission value into memory. During the Color Tracking test, the CR70 calculates the ratio of the three stored emission currents and shows the results on the Good/Bad meter scale (1c).

8b. **K (CATHODE) SELECTOR SWITCH** — Determines which pin of the CRT under test is connected to the cathode test circuits.

8c. **G1 (CONTROL GRID) SELECTOR SWITCH** — Determines which pin of the CRT under test is connected to the G1 test circuits.

8d. **G2 (SCREEN GRID) SELECTOR SWITCH** — Determines which pin of the CRT under test is connected to the G2 test circuits.

8e. **CUTOFF SET CONTROL** — Adjusts the amount of G2 (screen grid) bias during the CUTOFF FUNCTION (2d) to establish the cutoff level for comparison to the maximum beam current during the EMISSION function (2e).

OPERATION

Introduction

This section of the manual explains how to operate the CR70. Each item covered includes a brief explanation of the test and how to use the test in typical applications. The Application section of this manual covers each point in greater detail.

AC Power Connection

WARNING

The CR70 must be connected to a properly grounded 3-wire AC system for safe operation. Failure to do so may result in a shock hazard to the operator. If the CR70 must be used where no third wire ground is available, be absolutely certain to discharge the CRT high voltage before connecting the CR70. Disabling the third wire ground connection voids the warranty.

Setup Book Information

Figure 2 shows a portion of the CR70 setup book. All information required to test a CRT appears next to the tube number. The following descriptions explain each part of the listed information

CRT NUMBER	SKT	CRT TYPE	F1	F2	FIL	NEG BIAS	GUN	K	G1	G2
M31-334	6	VIDEO	3	4	11	36V	B/W	2	5	6
M38-312	4	VIDEO	1	8	6.3	52V	B/W	7	2	3
M38-313	4	VIDEO	1	8	6.3	52V	B/W	7	2	3
M38-314	4	VIDEO	1	8	6.3	52V	B/W	7	2	3
M38-315	4	VIDEO	1	8	6.3	52V	B/W	7	2	3
M38-327	4	VIDEO	1	8	6.3	52V	B/W	7	2	3

Fig. 2 — A portion of the CR70 Setup Book.

CRT Number

The setup book lists standard American listings in the front section and foreign and special tubes in the back section. The book lists the CRTs in numerical/alphabetic order, grouped by size, designation code, and phosphor code. For example, all 5 inch CRTs are grouped together, with five-inch color and five-inch black and white CRTs in alphabetic order within the size group. A full explanation of what each part of the CRT number means is found in the Application section of this manual under the title, "Understanding CRT Numbers".

NOTE: CRTs ending with "TC01", "TC02", etc. are the same as a CRT with a "P22" or a "B22" ending. The "TC" endings are not listed in the CR70 Setup Book. For example, a 15VAETC01 CRT is listed as a 15VAEP22.

SKT
You will find the proper CR70 adapter socket number needed to connect the CR70 to the CRT in this column. A "UA" in this column means that the optional 39G170 Universal Adapter is used to test the CRT as none of the standard sockets supplied with the CR70 fit the CRT. Details on using the Universal Adapter are covered in the section entitled "Using the 39G170 Universal Adapter" later in this manual.

CRT Type
This column tells you what type of CRT you are going to test. The three types, video, projection and scope, differ in three ways. First, they require different amounts of bias applied to G1 to simulate beam cutoff during the Cutoff test. Second, each requires a different amount of beam current for proper Cutoff and Emission tests. Finally, each requires a different amount of restoration current when attempting to improve the performance of a weak electron gun. The CRT TYPE switch automatically scales all the CR70 circuits associated with these parameters.

F1, F2
These columns list the two CRT filament pin numbers. Simply set the F1 and F2 setup switches to the listed numbers to match the filament connection of the CRT under test.

FIL
This column shows the rated filament voltage of the CRT under test. Adjust the CR70 FILAMENT VOLTAGE controls to this value at the beginning of the test procedure to insure accurate test results.

Neg Bias
This column indicates how much bias must be applied to the CRT to test its normal dynamic operating range. The numbers always correspond to one of the four voltages selected by the BIAS switch. The voltage is negative with respect to the cathode (which is always at the zero volt reference point), so the column is labeled accordingly.

Gun
This column reminds you where to set the GUN SELECT switch when testing a color CRT. The GUN SELECT switch must be changed after each gun is tested to store the Emission values into the automatic tracking test circuits.

NOTE: The last three columns show one listing for a black and white CRT or three listings for a color CRT. The three color listings allow the CR70 to test each color gun individually.

K
This column lists the cathode pin number of the CRT. Simply set the "K" Individual Gun Setup switch to the listed number to match the cathode connection of the CRT under test.

G1
This column lists the control grid pin number of the CRT. Simply set the "G1" Individual Gun Setup switch to the listed number to match the first grid of the CRT under test.

G2
This column lists the CRT pin for the screen grid. Set the "G2" Individual Gun Setup switch to the indicated number.

Notice how the columns follow the CR70 panel layout. The first control listings correspond to the lower bank of controls marked "CRT PRESET CONTROLS". For most CRTs, these switches are only set one time. The "INDIVIDUAL GUN SETUP" controls are listed in the last four columns. These controls are set one time for a black and white CRT or three times for a color CRT.

NOTE: New setup books are printed yearly. The updated books contain new listings and will be sent to you ONLY if you return the warranty card sent with the CR70.

Connecting To The CRT

The main difference between the CR70 and other CRT testers is that only one CRT socket adapter is needed for each mechanical socket design. All of the pins in each adapter socket connect to the CR70 setup switches, so you use the setup switches to form different electrical connections for a particular type of CRT basing. This vastly reduces the number of adapters needed to keep the CR70 up to date, and offers the advantage of being able to determine the setup information for a CRT directly from a schematic of the video receiver, monitor, or oscilloscope if the CRT is not listed in the CR70 Setup Book.

Each CR70 adapter connects to the CR70 using a special 14-conductor connector. Since this connector is polarized, the sockets and cable fit together only one way. White dots on the cable connector and CRT adapters aid in connecting the two. Therefore, make sure the dot on the cable aligns with the dot on the adapter before connecting them.

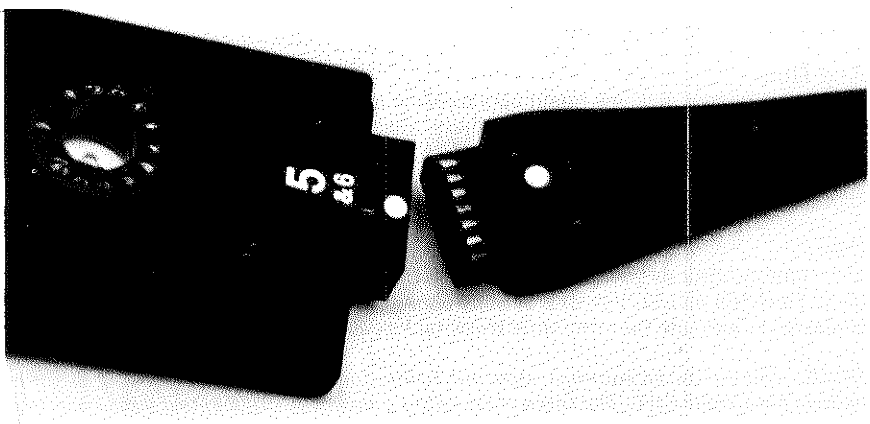


Fig. 3 — Align the dot on the test cable with the dot on the socket.

Most of the adapters fit onto the neck of the CRT exactly the same as the CRT socket in the video receiver, monitor, or oscilloscope. Be sure to observe polarization keyways before attempting to connect the socket to the CRT, thus preventing bent or damaged pins on the CRT or in the adapter socket.

Two of the CR70 adapters, number 7 and number 9, have been specially modified to allow one adapter to fit several different brands of CRTs which use connectors that are similar but not identical. Use special care when connecting these modified sockets, being sure you connect them to the CRT properly. Each socket has been modified in the area occupied by the focus grid connector, as the focus connector is the only difference between brands of CRTs. This can lead to questions, however, when making connections because it is possible to install the adapter upside down on some CRTs. Socket 7 is especially prone to this type of connection error. Such a connection error results in erroneous test results and may damage the pins of the CR70 adapter socket.

Fig. 4 — Match the connector pins of the CRT socket to the pins of the CRT.

As shown in Fig. 4, always match the connector pins of the CRT adapter socket to the corresponding pins on the CRT before attempting to slide the socket onto the CRT. Then, line up the keyway on the socket with the key on the CRT connector. Notice that there are usually two or three keys on the CRTs using this adapter. You know you have the correct key lined up with the keyway if you lined up the connector pins with the CRT conductors before sliding the adapter onto the CRT.

Also note that the focus electrode should be completely covered by the adapter socket. If part of the focus connector shows, the adapter must be pushed farther forward to insure good electrical contact. Use a slight twisting action as you push the adapter forward to allow it to be fully seated.

Using the 39G170 Universal Adapter

The CRT adapter sockets supplied with the CR70 allow you to test most CRTs using the same type of socket found in the video receiver, monitor, or scope using the CRT under test. A few CRTs, however, use connectors that do not match the supplied sockets. The optional 39G170 Universal Adapter allows you to connect to these special CRT bases. CRTs requiring the Universal Adapter are shown as using socket "UA" in the CR70 Setup Book.

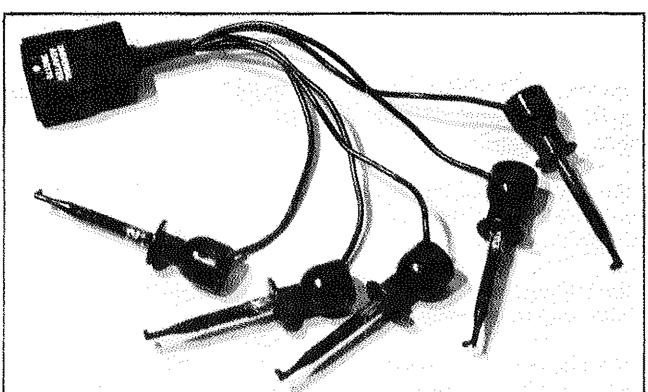


Fig. 5 — The Universal Adaptor.

NOTE: If new adapters are introduced in the future with the "spline" type of connector (where the CRT pins are nestled in ceramic or plastic grooves), you can use the Universal Adapter with a standard replacement socket that fits the CRT. Connect to the wires of the replacement socket and then connect the socket to the CRT. Connect directly to the CRT pins when they are accessible.

Fig. 6 shows how to determine pin numbers on a CRT. Note that the pins are numbered clockwise when looking at the CRT base. Most connectors have a keyway molded into the CRT connector. If so, always start counting from the first pin clockwise from the keyway. If the socket is a special type without a keyway, the CRT socket will often have the pins numbered on the socket in the device using the CRT, on the CRT itself or on the printed circuit board to which the CRT socket is connected.

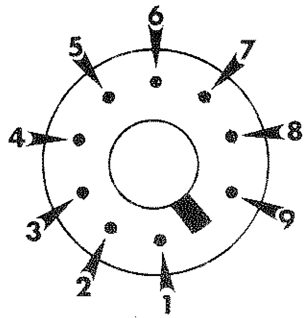


Fig. 6 — CRT pins are numbered clockwise from the keyway when viewed from the base.

Most CRT pin numbers correspond the spaces around the perimeter of the socket, rather than corresponding only to conductor pins. This is important as there are often numbered positions that do not have connectors, especially near the focus connectors. The skipped positions are usually counted as pin numbers, and must be taken into consideration when making connections to the CRT pins with the Universal Adapter. Also note that the skipped positions around the focus connectors *are not* the keyway that references pin number 1. This keyway is on the plastic or ceramic assembly in the center of the pins.

To use the 39G170 Universal Adapter:

1. Connect the UA to the CR70 cable as you would a regular socket, making sure the dots align.

2. Connect the clip lead of the UA labeled "1/F1" to the CRT pin number listed under "F1" in the setup book, or to either of the filament pins if you are determining the setup from a schematic.

3. Connect the UA clip lead labeled "2F/2" to the CRT pin number shown in the setup book under "F2" or to the second filament pin if you are determining the setup from a schematic.

4. Connect the UA clip lead labeled "3/K" to the CRT pin number listed under "K" in the setup book or to the cathode if using a schematic.

5. Connect the UA clip lead labeled "4/G1" to the CRT pin number listed under "G1" in the setup book or to the pin connecting to the grid closest to the cathode on the schematic (the control grid).

6. Connect the UA clip lead labeled "5/G2" to the CRT pin number listed under "G2" in the setup book or to the second grid shown on the schematic (the "screen" or first accelerating grid after the control grid).

7. The Universal Adapter always requires the same setting of the F1, F2, K, G1, and G2 CR70 switches for all CRTs. **The setup switches are not changed to test individual guns of a color CRT because you have compensated for different electrical connections as you connected the UA test clips to the individual CRT elements.**

Switch	Setting
F1	1
F2	2
K	3
G1	4
G2	5

NOTE: The number on each UA connector corresponds to the setup switch positions used so that you do not need to refer to this table or any other setup information. For example, the label "1/F1" indicates that this connector is the first filament connector and that the F1 switch on the CR70 must be set to position 1.

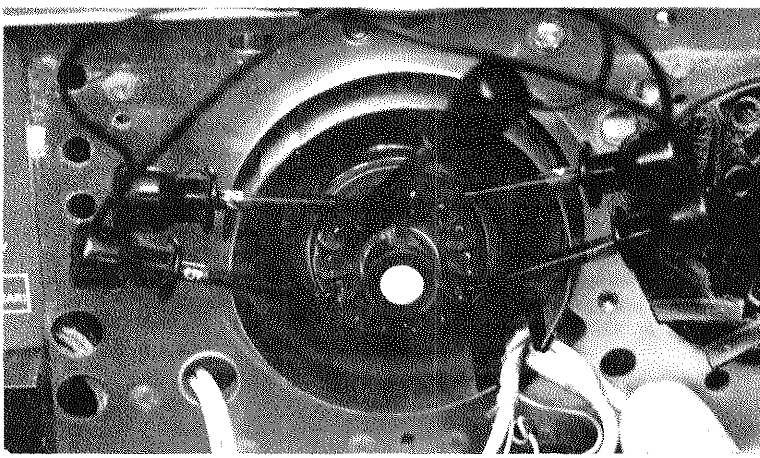


Fig. 7 — The UA allows you to connect to special CRT bases.

If you are testing a color CRT, you will change the CRT pins to which the UA clip leads are connected for each color gun. This takes the place of resetting the Individual Gun Setup controls when using a regular adapter. Be sure to set the GUN SELECT switch to the correct color gun you are testing to store the emission levels needed to calculate the results of the Color Tracking test.

NOTE: New adapter sockets may be introduced in the future to fit tubes that presently require the Universal Adapter. The latest version of the setup book will inform you of these optional adapters.

The CRT Preset Controls

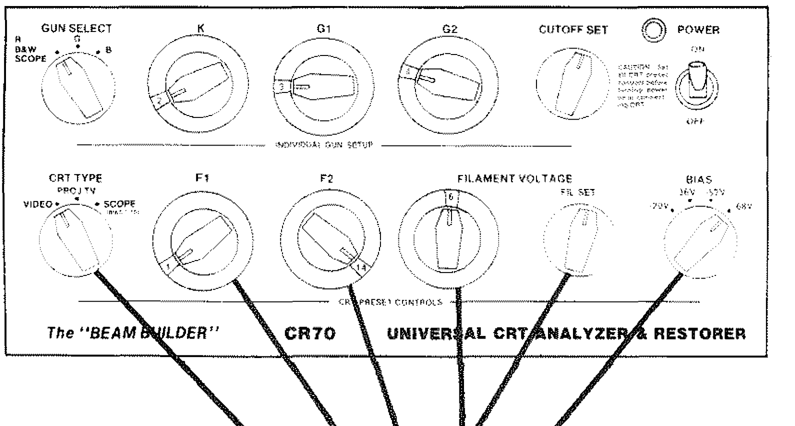
These setup controls are usually only set one time for a particular CRT. A color CRT with three separate filaments, as found in some CRTs used in DC operated receivers, may require the F1 and F2 switches to be changed for each color gun. Observe the following notes for best test results:

1. Set the CRT Preset Controls before applying power to the CR70. This prevents the possibility of damaging the CRT with too much filament voltage applied, and also prevents the CR70 circuit breaker from tripping as the F1 and F2 controls are being set to the correct positions.

2. Be sure the CRT TYPE switch is set to the correct position. The CR70 will give false indications of the Cutoff test and the Emission test if the wrong position is used.

3. See the section of this manual entitled "Testing Tubes Not Listed In The Setup Book" for information on testing CRTs that are not listed in the CR70 Setup Book.

Fig. 8 shows how the CRT setup information relates to the CRT Preset Controls. Notice that each control is called out in the setup instructions.



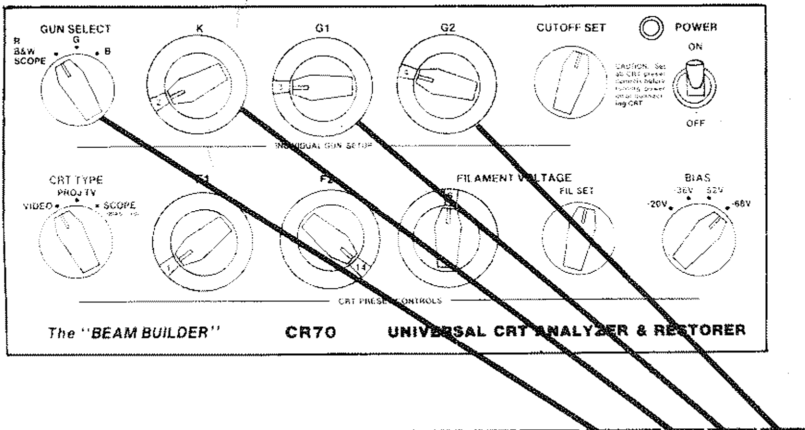
CRT NUMBER	SKT	CRT TYPE	F1	F2	FIL	NEG BIAS	GUN	K	G1	G2
M31-334	6	VIDEO	3	4	11	36V	B/W	2	5	6
M38-312	4	VIDEO	1	8	6.3	52V	B/W	7	2	3
M38-313	4	VIDEO	1	8	6.3	52V	B/W	7	2	3

Fig. 8 — The Setup Book lists the proper Preset switch settings.

The Individual Gun Setup Controls

These controls need to be set only once for a black and white CRT, or three times for a color tri-gun CRT. They must be set to the correct positions for a color gun for either testing or beam building. The GUN SELECT switch is part of the Color Tracking test. Do not switch between the red, green and blue guns, unless the K, G1, and G2 switches are also set to the positions shown in the CR70 Setup Book for the red, green and blue guns. Observe the following notes in reference to these controls:

1. The GUN SELECT switch must be switched during the gun tests of a color CRT. You may switch the GUN SELECT switch before or after moving the FUNCTION switch from the EMISSION position without affecting the test results. However, the switch must be in the correct position before making a second Emission test or the results stored from the first gun will be replaced with the results from the second gun.



CRT NUMBER	SKT	CRT TYPE	F1	F2	FIL	NEG BIAS	GUN	K	G1	G2
E2582	UA	VIDEO	6	7	6.3	68V	R	5	8	4
							G	9	8	4
							B	10	8	4
E2588	10	VIDEO	6	7	6.3	68V	R	8	9	10

Fig. 9 — The Setup Book lists the proper INDIVIDUAL GUN SETUP switch settings.

2. Some color CRTs will require the K, G1, and G2 switches to be changed for each gun while others may only require one or two of the switches to be changed. See the Setup Book for proper switch setting.

3. The CUTOFF SET control must be readjusted for each of the guns of a color CRT.

4. See the section of this manual entitled "Determining Special Setups" for information on testing CRTs that are not listed in the CR70 Setup Book.

Beam Tests

This section will tell you how to test any CRT with the CR70. When testing a color CRT, you will find it faster and simpler to do all the tests on the red gun before proceeding on to the green and blue guns. The tests should be performed in the order listed below, which is also the order in which they appear on the FUNCTION switch.

NOTE: The CRT Preset Controls and Individual Gun Setup controls must be properly set from the information in the CR70 Setup Book or from a schematic showing the CRT under test before making any of the following tests.

Filament Set

The FIL SET function monitors the voltage applied to the CRT under test to allow setting the filament voltage to the normal value specified by the CRT manufacturer. You will notice that some CRTs will show a change in the filament voltage reading from the time power is first applied to the CRT until the filaments are fully lit. This is normal and caused by the change in electrical resistance of the filaments as they heat.

To use the FIL SET function:

1. Make sure the CRT Preset Controls are properly set and that the Individual Gun Setup controls are set up for the first gun to be tested.

2. Move the FUNCTION switch to the FIL SET position.

3. Apply power to the CR70 and the CRT under test by moving the POWER switch to the "on" position. Notice that the POWER INDICATOR light should come on, indicating the CR70 is connected to a properly operating AC outlet.

4. Watch the top meter scale as the CRT filament heats. Adjust the FIL SET control until the meter reads the voltage shown in the CR70 Setup Book after the meter stabilizes.

1. Set CRT Preset and Individual Gun Setup controls to proper gun.
2. Select the FIL SET FUNCTION.
3. Apply power.
4. Adjust the FIL SET control to the proper voltage as shown on the top meter scale.

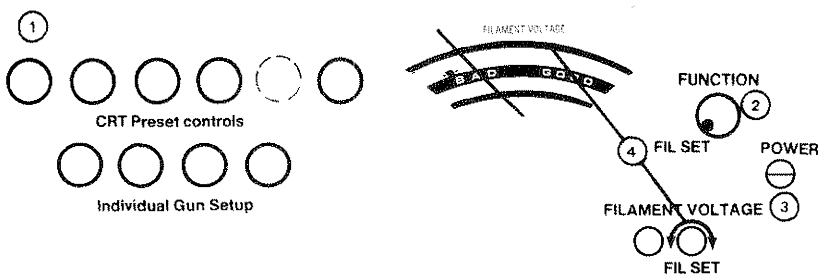


Fig. 10 — Use the FIL SET to apply the correct filament voltage.

It is not necessary to readjust the FIL SET control for each gun of a color CRT unless the CRT is one that uses three separate filaments.

H-K Shorts

This test determines if a leakage path exists between the filament (heater) and the cathode. A short or leakage between the heater and cathode cannot be removed with the remove-shorts function of the CR70 or any other CRT restoring system because the current needed to remove a short of this type would also open the filament, resulting in a completely dead CRT. An isolation-type CRT booster will isolate these shorts in circuits using 60 Hz filament power. Isolation transformers are not available for CRTs powered from the horizontal output transformer (scan-derived power) because the power signal has an operating frequency of 15 KHz. In such cases, the CRT will have to be replaced if the H-K short causes unacceptable results.

To test for H-K Shorts:

1. Move the FUNCTION switch to the H-K SHORTS position.

2. Read the results on the GOOD/BAD meter scale.

3. If there is an H-K short, you may continue with the rest of the tests, but they may not have meaning if the short is responsible for the poor image on the CRT.

Fig. 11 — A short between the heater and cathode is indicated by a BAD reading.

G1 Shorts

This test checks for shorts or leakage between the first grid (control grid) and cathode or screen grid (G2). There are two important differences between this test and the H-K Shorts test. First, the CR70 provides ten times better sensitivity on the G1 Shorts function to isolate leakage problems that will affect the picture. Second, the REMOVE G1 SHORT function will remove most shorts involving the control grid.

The CR70 G1 Shorts test provides more information than other CRT testers to make shorts removal with the beam building function more effective. A dead short reads at the far left of the GOOD/BAD meter scale, indicating a hard mechanical short, such as two pieces of metal touching each other. These shorts are the most difficult to remove with the REMOVE G1 SHORT function. Shorts that read in the BAD area of the meter scale, but somewhere between the left edge of the meter scale and the GOOD/BAD dividing line, have some amount of resistance. The REMOVE G1 SHORT function removes resistive shorts with a high degree of success. Knowing whether the short is resistive increases the chances of repairing more CRTs.

To test for G1 shorts:

1. Move the FUNCTION switch to the G1 SHORTS position.

2. Read the results on the GOOD/BAD meter scale.

Fig. 12 — Remove a G1 short before continuing with the remaining tests.

3. If the meter reads in the BAD zone, move to the REMOVE G1 SHORT function to attempt to remove the short.

NOTE: Do not continue with the other tests if the CRT shows a G1 short. All other tests are totally meaningless if there is a G1 short present. The CRT is unusable with the short.

Cutoff Test

The Cutoff test determines if the CRT under test has the correct dynamic range to produce normal contrast when properly biased and driven with a typical drive signal. The Cutoff test applies a negative bias (with respect to the cathode) to the control grid while the amount of positive DC on the screen grid is adjusted with the CUTOFF SET control. This test duplicates the bias on the CRT needed to blank (cut off) the electron beam and produce a black level. In addition to testing the dynamic range of the CRT, the Cutoff test establishes a standard bias condition to compare during the Emission test. The CRT is defective if you cannot set the meter to the CUTOFF SET area during this test.

The Cutoff test isolates two types of CRT problems: 1. If the meter **cannot be brought up to the designated area on the meter**, the CRT has poor contrast, even if the Emission test shows normal beam current. CRTs with poor contrast can often be improved with the CR70 beam building functions. 2. If the meter needle remains **above the CUTOFF SET area for any setting of the CUTOFF SET control**, the control grid is open. There is no way to correct an open control grid.

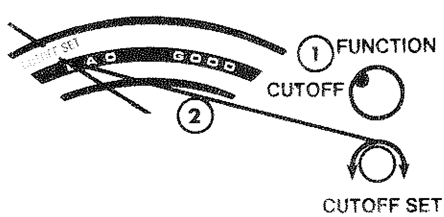
To test for normal beam cutoff:

1. Move the FUNCTION switch to the CUTOFF position.

2. Adjust the CUTOFF SET control until the meter reads in the "CUTOFF SET" area (the meter can be anywhere in the black bar without affecting any other results).

The CRT is defective if the needle cannot be adjusted into the CUTOFF SET area.

1. Set to CUTOFF FUNCTION.
2. Adjust CUTOFF SET control for meter reading in CUTOFF SET area of meter.



CUTOFF test results:

Meter Indication	Tube Condition
Adjusts into box	Tube has good contrast
Stays below box	(Poor tube) Tube has poor contrast
Stays above box	(Bad tube) Tube has open control grid (G1)

Fig. 13 — Adjust the CUTOFF SET control for a reading in the CUTOFF SET area.

Emission Test

The CR70 Emission test completes the test of the full dynamic operating range of the CRT under test. The CRT must have both proper beam current and dynamic range between the darkest and brightest image elements in order to pass both the Cutoff and Emission tests. Some bad CRTs will pass the Cutoff test, but fail the Emission test. Others will pass the Cutoff test but read "BAD" on the Emission test, while still others will fail both tests. Knowing the specific type of defect helps determine the correct beam building function if you want to restore or rejuvenate a weak CRT.

The CR70 measures true beam current (the amount of cathode current passing through the control grid and picked up at the second grid) when the FUNCTION switch is in the EMISSION position. The CR70 removes the negative bias from the first grid (applied during the Cutoff tests) to simulate the beam current produced by the CRT with maximum drive, this being the white level.

1. Set to EMISSION FUNCTION.
2. Read GOOD/BAD meter scale.

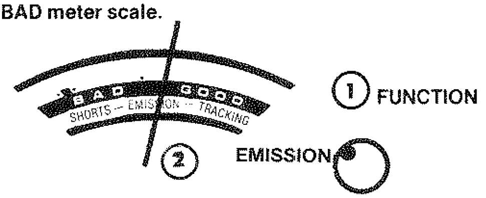


Fig. 14 — A CRT that reads good in the Emission test has sufficient true beam current.

To test Emission.

1. Move the FUNCTION switch to the EMISSION position.
2. Read the results on the GOOD/BAD meter scale.

A CRT that measures anywhere in the GOOD area meets the minimum beam current requirements established by the CRT manufacturer for the bias conditions established.

Emission Life Test

The Emission Life Test shows about how much life remains in the CRT. You should perform the Life Test on every CRT tested as some CRTs will test normally on all other tests but produce an image that is less than satisfactory because the receiver, monitor, or oscilloscope provides operating voltages that are lower than needed for the particular CRT.

While there is no test that can predict the future life of a CRT with 100% accuracy, the CR70 Life Test gives a good approximation of the expected life. The test incorporated into the CR70 reduces the filament voltage by 25%, allowing the cathodes to cool slightly. A cathode with a long life expectancy will continue to emit the same amount of beam current at reduced temperature. A Cathode with little remaining emitting material drops emission current quickly with this lowered filament voltage.

To perform the Emission Life Test:

1. After testing Emission, leave the FUNCTION switch in the EMISSION position.

2. Press the EMISSION LIFE TEST button and watch the meter reading. The reading will drop unless the cathode under test is very good. Hold the EMISSION LIFE TEST button until the needle reaches its lowest point.

3. Note the final meter reading after the lowest reading is reached. Compare the final reading to the table below to learn the approximate remaining life.

EMISSION LIFE test results:

Meter Indication	Expected Life
Doesn't move	12 months or more
Drops ¼ inch, but remains in Good Area	Between 8 & 12 months
Bottom of Good Area	Between 4 & 8 months
Into Bad Area	Less than 4 months

Fig. 15 — Determining the remaining life in a CRT.

Color Tracking Test

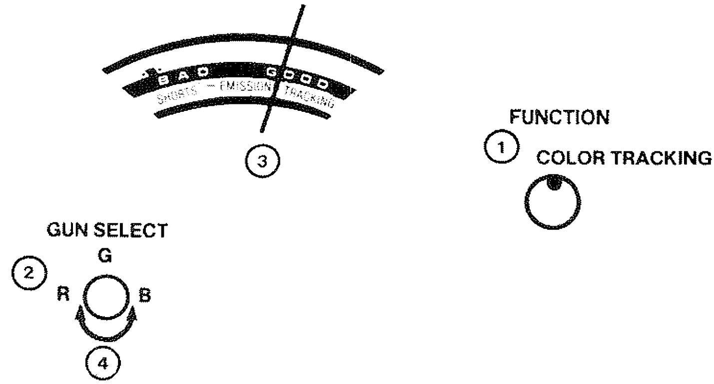
The Color Tracking test automatically compares the emission level of each gun of a color CRT against the other two guns to confirm that the three guns can be balanced to produce a good color picture. A CRT may not track properly even though all three guns produce good Cutoff and Emission test results. If, for example, the red gun produces much more current than the green and blue guns, the picture will be too red. Color receivers and monitors have adjustments that balance the levels of the three guns, but these adjustments have a limited range of control. The CRT produces the wrong colors when the ratio between the strongest and weakest gun is outside the range of these adjustment controls.

The same condition that exists in a three-color CRT also exists in a projection system which uses a separate CRT for each of the three primary colors. The CR70 is the only CRT tester that allows either a conventional three-color CRT or the three separate CRTs of the projection system to be tested with the some Color Tracking test.

The CRT manufacturing industry has established a ratio of 1.55:1 as the greatest variance between the strongest and weakest CRT gun. This simply means the strongest gun cannot produce more than 55% more current than the weakest gun when all three guns have been biased to the same cutoff (black) level. This ratio allows the designer of a receiver or monitor to provide enough range for the color balance controls.

The CR70 calculates the color tracking ratio automatically. Memory circuits store the current levels as you test the red, blue, and green guns of the CRT for emission. You then "ask" the CR70 to calculate the ratio of each gun against the other two by switching to the COLOR TRACKING function and switching the GUN SELECT switch to the red, green and blue positions. A bad meter reading tells you the selected gun is providing an emission current that is at least 55% lower than the stronger of the other two guns. If, for example, you find the red gun reads Bad, you know that either the green or blue gun has at least 55% more emission current. The CR70 indicates the weakest gun or guns because they are the ones that need to be improved with the CR70 beam building functions.

1. Set to COLOR TRACKING FUNCTION.
2. Set GUN SELECT to "R".
3. Read GOOD/BAD meter scale.
4. Repeat for G and B guns.



COLOR TRACKING test results:
"Bad" gun or guns more than 55% lower than strongest gun.

Fig. 16 — Rotate the GUN SELECT switch when in the COLOR TRACKING function to check each gun.

Before doing the Color Tracking test, you must complete the H-K Shorts, G1 Shorts, Cutoff and Emission tests. Also, you must have stored the three emission values into the Tracking memory when performing the Emission tests on the three color guns. In order to do this you must switch the GUN SELECT switch **before** testing each gun for Emission.

NOTES:

1. Since a black and white tube has only one gun, the tracking test serves no useful purpose and should not be performed on these tubes.

2. When testing a projection system, you must test each CRT separately. Each tube will use the same setup switch positions. Remember to switch the GUN SELECT switch between each CRT test so the emission values are properly stored in the memory circuits.

To test for Color Tracking:

1. Test all three color guns (or each tube of a color projection system) for Shorts, Cutoff and Emission.

NOTE: The Color Tracking test is meaningless if the CRT has not passed all other tests. Reject the CRT if it fails an earlier test, or use the Beam Builder functions to improve the tube before testing for Color Tracking.

2. Move the FUNCTION switch to the COLOR TRACKING position.

3. Switch the GUN SELECT switch to the "R" position and read on the Good/Bad meter scale.

4. Repeat step 3 with the GUN SELECT in the green and then the blue positions.

The CRT tracks properly if all three positions of the GUN SELECT switch produce a Good meter reading. If one, or two, of the positions read Bad, that gun (or those guns) are outside the industry-standard limits for tracking. You may wish to improve the emission of these guns with the beam building functions.

Beam Restoration

Introduction

This section of the CR70 manual explains how to use the beam building functions of the CR70. These functions provide five different methods of improving the operation of a weak or shorted CRT. In most cases, they produce a noticeable improvement in the image quality of the CRT. Often the beam building process returns a CRT image close to that provided by a new CRT.

This section of the manual explains how to use each type of beam building function. Additional details concerning cathode recovery processes are found in the Application section of the manual.

Remove G1 Short

The first beam building function allows most control grid (G1) shorts to be removed. Pressing the REJUV OR RESTORE button discharges a large capacitor through the short, causing it to burn away. The REMOVE G1 SHORT function will not damage the electron gun because the capacitive discharge method is self-limiting; the CRT does not draw current once the shorted path opens. In addition, the CR70 removes the filament voltage before applying the capacitor charge to 1.) prevent damage to the filament, and 2.) prevent damage to the cathode from the high current spike.

1. Select REMOVE G1 SHORT FUNCTION.
2. Set INDIVIDUAL GUN setup switches to the bad gun from G1 SHORTS test.
3. Push the REJUV OR RESTORE button and watch for a flash in the CRT neck.
4. Repeat the G1 SHORTS test.

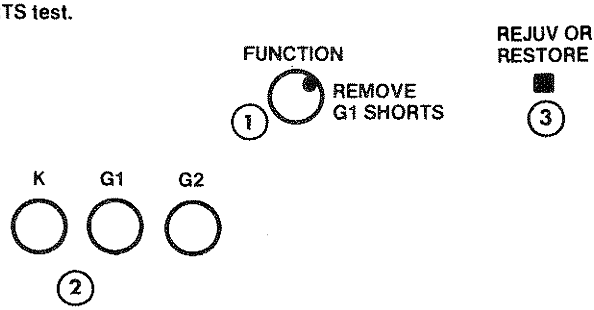


Fig. 17 — Steps involved in removing a G1 Short.

To remove a G1 short:

1. Move the FUNCTION switch to the REMOVE G1 SHORT position.

2. Set the INDIVIDUAL GUN SETUP switches for the gun which indicated a short during the G1 Short test.

NOTE: It is not necessary to adjust the CUTOFF SET control.

3. Allow the CRT to sit for about 30 seconds until the filaments cool to prevent possible filament or cathode damage.

4. Press the REJUV OR RESTORE button while watching for a flash in the CRT neck surrounding the gun elements. The CR70 applies only a momentary pulse of energy regardless of how long you hold down the button. The flash indicates that the particle causing the short has been "blown away".

5. Move the FUNCTION switch to the G1 SHORTS test to confirm the short is gone.

6. Repeat steps 3 through 5 up to three times or until the G1 Shorts test indicates the short has cleared. If the short remains after three attempts of removal, pay close attention to the meter reading during the G1 shorts test. If the meter reads all the way to the left side, the short is a dead (zero resistance) short and probably cannot be removed because two pieces of metal are in direct contact with each other. If, on the other hand, the meter reads at some point in the Bad area, but not at the left-hand edge, the short has some resistance, and can probably be removed with the "Extended G1 Shorts Removal" procedure below.

Extended G1 Shorts Removal

Some G1 shorts cannot be removed with multiple applications of the Remove G1 Shorts function, yet are not direct metal-to-metal shorts. Projection CRTs, for example, often develop this type of stubborn G1 short. Two CR70 features aid in removal of these stubborn shorts: 1.) The CR70 G1 Shorts test tells you whether you have a direct metal-to-metal short or a resistive short so you know whether to attempt the extended procedure, and 2.) The Individual Gun Setup switches allow you to selectively remove some of the elements from the test.

This special procedure involves heating the shorting material (which is usually a flake of oxide material from the cathode) before applying the current surge from the Remove G1 Shorts function. Remember that this procedure is a last-ditch effort. The CRT cannot be used with the G1 short, so there is nothing to lose if additional damage occurs. Therefore, the procedure bypasses some of the safety features designed into the CR70. The gun structure, for example, is not allowed to cool before the short removal pulse is applied. Similarily, the Manual 2 Restore current is applied for a longer time than normal in order to super-heat the shorting material.

To remove stubborn shorts:

1. Disconnect the G2 element from the circuit by moving the G2 switch to an unused number. This is necessary to keep the heating current flowing through the shorting material.

2. Switch the FUNCTION switch to the MANUAL 2 RESTORE position.

3. Press and hold the REJUV OR RESTORE button for 20 seconds.

4. Release the REJUV OR RESTORE button and quickly move the FUNCTION switch to the REMOVE G1 SHORT position. Unlike normal shorts removal, **do not allow the gun structure to cool.**

5. Press the REJUV OR RESTORE button. If you see no flash, release the button and press it again while the gun elements are still hot.

6. Move the FUNCTION switch to the G1 SHORTS test to see if the short is still

present. If so, repeat steps 2 through 5. If the short remains after three attempts to remove it, the CRT must be replaced.

7. Remember to move the G2 switch back to the correct position if the short removal is successful in order to move on to other tests.

Rejuvenation

Rejuvenation improves the cathode emission of some CRTs. The Application section of this manual gives a detailed description of the rejuvenation and restoration process. Here, we will simplify the description by stating that rejuvenation affects a much smaller area of the cathode surface than restoration. Generally rejuvenation is used to start a gun that does not have enough emission capability to draw restoration current.

CR70 rejuvenation discharges a series resistor-capacitor network between the cathode and first grid. This provides a self-timing process because the CRT that draws high current will discharge the capacitor faster than a weaker one that draws less current. The series resistor limits the current to a much lower level than older CRT rejuvenators that only have capacitive-discharge rejuvenation. This lower current offers increased safety and a lesser chance of stripping a cathode than the higher levels of rejuvenation in other testers.

1. Select the REJUV FUNCTION.
2. Set INDIVIDUAL GUN SETUP switches to the bad gun from the EMISSION or TRACKING test.
3. Push the REJUV OR RESTORE button and watch for a flash in the CRT.
4. Repeat the EMISSION and TRACKING tests.

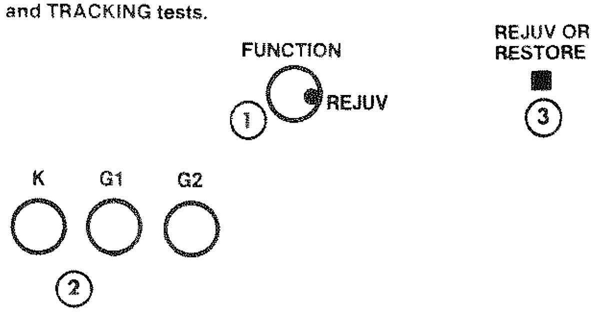


Fig. 18 — Steps involved in rejuvenating a CRT.

To Rejuvenate a CRT gun:

1. Set the INDIVIDUAL GUN SETUP controls to the correct position for the gun to be rejuvenated. It is not necessary to adjust the CUTOFF SET control.

2. Move the FUNCTION switch to the REJUV position.

3. Depress the REJUV OR RESTORE button.

NOTE: Rejuvenating current is only applied to the CRT for a short time, so holding the button down for a couple of seconds is all that is needed.

4. Repeat the Cutoff and Emission tests to determine if the original defect has been corrected.

Auto Restoration

Restoration differs from rejuvenation in two ways. First, restoration applies current for a much longer time (seconds versus milliseconds). Second, the longer restoration current is at a much lower level than the brief pulse from the rejuvenation. The result is that restoration affects a much larger area of the cathode than rejuvenation does.

The CR70 Auto Restore function offers the safest form of restoration. The CR70 limits the current while automatically timing the application of the current. Most CRTs respond effectively to the Auto Cycle current levels and times. You only need to increase the time or current level for some CRTs, meaning you are always using the least amount of energy to do the job effectively. The Application section of this manual explains restoration in more detail.

1. Select the AUTO RESTORE FUNCTION.
2. Set INDIVIDUAL GUN SETUP switches to the weak gun from emission test.
3. Hold the REJUV OR RESTORE button until the current cycles three times as indicated on the meter.
4. Repeat the EMISSION and TRACKING test.

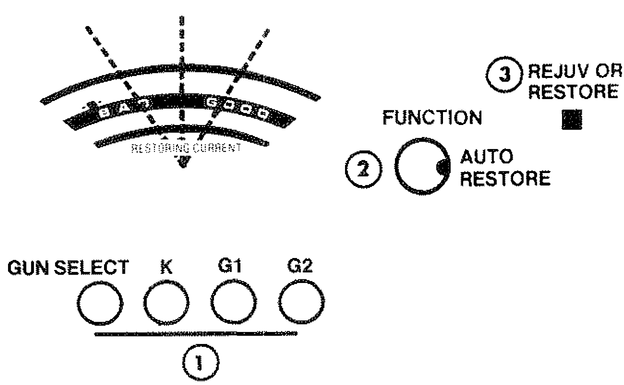


Fig. 19 — Steps involved in using the AUTO RESTORE function.

To use the AUTO RESTORE function:

1. Set the INDIVIDUAL GUN SETUP controls to the correct positions for the gun to be restored. NOTE: It is not necessary to adjust the CUTOFF SET control.

2. Move the FUNCTION switch to the AUTO RESTORE position.

3. The CR70 increases the filament voltage in the restoration functions. Allow the CRT to sit for 30 seconds as the filaments increase their heat output.

4. Depress and hold the REJUV OR RESTORE button. The CR70 automatically cycles through three cycles consisting of four seconds of applied restoration current and 2 seconds of no current, during which time the cathode cools. Do not release the REJUV OR RESTORE button until the CR70 has cycled through all three cycles unless you want to manually interrupt the automatic cycle.

5. Retest the gun for Shorts, Cutoff and Emission to confirm it is satisfactorily improved.

NOTE: If you are correcting a color tracking condition, it is not necessary to repeat the tests on the other two guns **as long as you have the GUN SELECT switch set to the gun you are restoring before switching out of the COLOR TRACKING position.** *The tracking memory circuits will remember the emission levels of the other two guns for comparison after you have restored the weak gun.*

MANUAL 1, MANUAL 2 RESTORE

The Manual 1 and Manual 2 functions differ from Auto Restore only in that you now have complete control over the amount of time that current is applied to the tube. The current doesn't cycle, but stays as long as you press the RESTORE OR REJUV button.

These two functions are similar to each other except for the amount of beam current limiting they provide. The Manual 1 Function limits the maximum beam current to 100 mA (75 mA for scope tubes) while the Manual 2 position allows 150 mA of beam current (100 mA for scope tubes). Always use the Manual 1 Function first. Use the Manual 2 function only if the Manual 1 function fails to restore the tube.

1. Select the MANUAL 1 RESTORE FUNCTION.
2. Set INDIVIDUAL GUN SETUP switches to the weak gun from EMISSION or TRACKING test.
3. Hold the REJUV OR RESTORE button in only as long as the metered current (bottom scale) increases, not to exceed 15 seconds.
4. If, after 15 seconds, the RESTORING CURRENT is still increasing, release button and wait 10 seconds before continuing.
5. Repeat the EMISSION and TRACKING tests.
6. Use MANUAL 2 RESTORE only if MANUAL 1 or REJUV fail to restore emission.

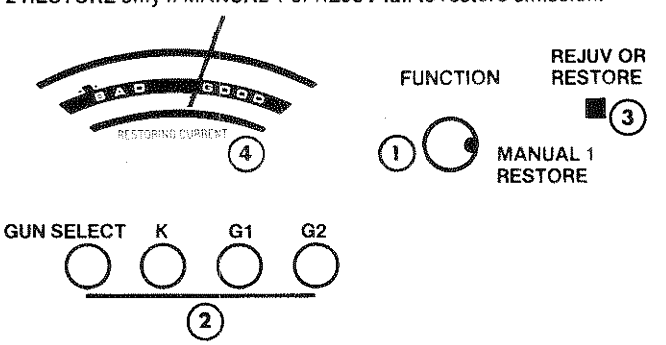


Fig. 20 — Basic steps in using Manual Restore.

To use the Manual 1 or Manual 2 Functions:

1. Set the INDIVIDUAL GUN SETUP controls to the correct position for the gun to be restored. It is not necessary to adjust the CUTOFF SET control.

2. Move the FUNCTION switch to the MANUAL 1 or MANUAL 2 RESTORE position.

3. The CR70 increases the filament voltage in the restoration functions. Allow the CRT to sit for 30 seconds as the filaments increase their heat output.

4. Depress and hold the REJUV OR RESTORE button while monitoring the restoration current on the bottom meter scale.

NOTE: See "Answers to common questions on beam building" in the Applications section of this manual for more details.

5. Retest the gun for Shorts, Cutoff, and Emission to confirm it is satisfactorily improved.

Interpreting the meter indication

Sometimes the restoring current dips suddenly during Manual 1 or Manual 2 Restore. The sudden dip is followed by a continued increase in the current. This usually happens on CRTs that had quite low emission or low life readings before applying the restoring current. The dip occurs as the restoration current activates larger and larger areas of the cathode surface.

Maximum restoration is attained when the restoring current stops its increase. Not all tubes will reach the same maximum level of restoring current. This is because not all tubes have had the same amount of use, nor do all tubes age at the same rate. All tubes will eventually reach a point at which they no longer contain enough emitting material to supply beam current. These are tubes which have provided many hours of service and have been restored several times.

APPLICATIONS

Introduction

The Operation section of this manual described how to use each CR70 feature individually. Understanding how to interpret the results of the CR70 in special situations or how to use different functions of the CR70 with each other helps you use the CR70 more effectively. This section gives you these details. Some applications are extensions of the basic CR70 tests, while others relate the results of one test to another.

Testing Tubes Not Listed In The Setup Book

You may encounter CRTs that are not listed because they have been introduced since the last setup book revision or because they do not use standard CRT designation numbers. The CR70 allows you to use a schematic to determine setup data for such unlisted CRTs. Some schematics may not show the bias or filament voltages. If that is the case, you can measure the voltages in the circuit before testing the CRT, if you are certain that the circuits are operating properly.

The CR70 setup controls relate directly to the CRT as shown on most schematics. The switches that connect the CRT elements to the internal test circuits relate pin-by-pin to the numbers shown on the schematic. The filament voltage and G1 bias voltage relate to the values on the schematic or, if these voltages are not shown on the schematic, directly to circuit measurements.

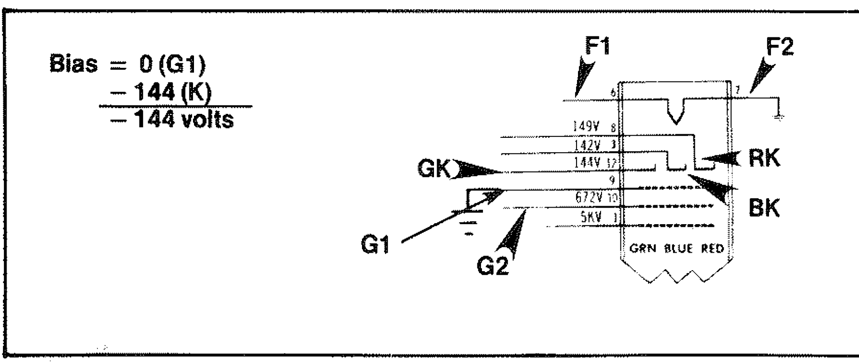


Fig. 21 — The setup information can be obtained from a schematic.

To determine the setup information from a schematic:

1. Determine which adapter socket fits by physical inspection. If none of the standard adapters fit, use the Universal Adapter as explained on page 11.

2. Set the CRT TYPE switch according to the application of the CRT being tested.

3. Locate the two filament pins on the schematic. Set the "F1" and "F2" CRT Preset Controls to the corresponding numbers.

NOTE: A few CRTs use separate filaments for each gun. If so, the "F1" and "F2" switches must be changed as you move from gun to gun.

4. Locate the filament voltage on the schematic. Set the FILAMENT VOLTAGE switch to the nearest value.

NOTE: Schematics generally show scan-derived filament voltages as a peak-to-peak measurement. Most scan-derived filaments operate at 6.3 volts RMS. To measure the filament voltage, YOU MUST USE A TRUE RMS METER.

5. Set the G1 BIAS switch. The G1 bias is equal to the **difference** between the DC cathode voltage and the DC G1 voltage. Set the CR70 to the nearest voltage or to −68 volts if the bias is more than −68 volts.

NOTES: Scope Tubes: When testing scope CRTs always set the BIAS switch to -68V.
Tri-Potential Tubes: Some Zenith, Tri-Potential (dual focus voltage) tubes must be tested at -52V bias to obtain proper results. Only tubes with two focus voltages require this lower G1 bias.

6. Set the GUN SELECT control to the first gun to be tested. Always start with the RED gun and do all the tests before continuing on to the GREEN and BLUE guns.

7. Locate the pin number of the cathode on the schematic. Set the "K" Individual Gun Setup switch to the corresponding number.

NOTE: Some CRTs use the filament as the cathode or have a common connection between the filament and cathode. If so, set the "K" switch to the same number as the "F1" or the "F2" switch. If the cathode is separate from the filament, but connected to a common pin, set the "K" switch to the common connection.

8. Locate the pin number of the first grid (G1). Set the "G1" Individual Gun Setup switch to the corresponding number.

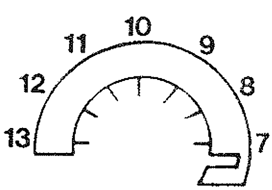
9. Locate the pin number of the second grid (G2). Set the "G2" Individual Gun Setup switch to the corresponding number.

NOTE: If the CRT has a single cathode, G1, and/or G2 for all three guns, leave the corresponding setup switches set to the same position for all three guns.

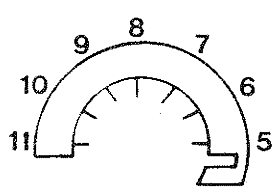
10. Perform the normal Shorts, Cutoff and Emission tests. If you are testing a color CRT, repeat steps 6 through 9 for the remaining two guns.

Pin Numbering Of Sockets

Some imported televisions may have their CRT pins numbered from a starting point other than the keyway. If you are using a schematic to determine a setup, be sure that the pin numbers correspond to the CR70 socket numbers. All CR70 sockets are numbered starting at the keyway. Sockets 7 and 9 are somewhat unique and their numbering is shown below.



Socket 7



Socket 9

Extended Cutoff Test

The standard Cutoff test indicates whether the CRT under test will produce an image with normal contrast, the test being essentially a good/bad test. You know the CRT will not produce proper contrast if you cannot bring the meter reading up to the CUTOFF SET, but you do not know how far the contrast varies from a good CRT. This good/bad information is sufficient to explain the test results to a non-technical person, or if you are not interested in attempting to improve the contrast with the beam building functions.

Many old CRTs can be improved with the CR70 beam building functions, even though they may not return to a "like-new" condition. In these cases, you may wish to see how much improvement takes place in the Cutoff test. This section explains how to use the BIAS switch to determine the extent of the contrast problem identified by the Cutoff test. This procedure is only meaningful if the Emission test reads good. **The extended Cutoff test provides no meaningful data on a tube with poor emission.**

1. Perform H-K Shorts, G1 Shorts and Cutoff tests.
2. Failure of the CUTOFF SET control to set meter into Cutoff area indicates bad contrast.
3. If the tube has bad emission do not continue.
4. Reset FUNCTION to CUTOFF.
5. Set CUTOFF SET fully clock-wise.
6. Reduce Bias until Cutoff reads in or about CUTOFF SET area.
7. A higher G1 Bias setting indicates that restoring improved contrast.

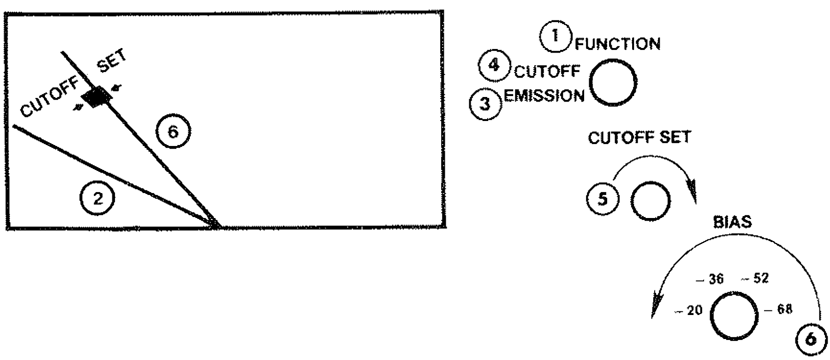


Fig. 22 — Steps involved in performing the Extended Cutoff test.

To perform the Extended Cutoff test:

1. Perform the H-K Shorts, G1 Shorts and Cutoff tests as explained in the Operation section of this manual.

2. If the needle does not reach the CUTOFF SET area of the meter with the BIAS listed in the setup book, you know the CRT does not have normal contrast range. Leave the CUTOFF SET control turned fully clockwise.

3. Move the FUNCTION switch to the EMISSION position. If the meter reads in the BAD area, there is no point in continuing the test.

4. Move the FUNCTION switch back to the CUTOFF position.

5. Set the CUTOFF SET control to the full clockwise position.

6. Switch the BIAS switch to a lower voltage setting, one step at a time, until the meter reads near or above the CUTOFF SET area.

NOTE: Since this is only a relative test, you do not need to adjust the CUTOFF SET control until the meter reads in the CUTOFF SET area. Simply find the setting of the BIAS switch that brings the needle near or above the CUTOFF SET box.

7. Note the setting of the BIAS switch at the conclusion of step 6. If the needle still remains at the left of the meter with −20 volts bias, the CRT has extremely poor contrast.

Using the bias voltage as your reference, you can determine if attempts to improve the contrast range have helped. For example, a CRT that normally requires a bias setting of −68 volts requires a bias of −20 volts in the Extended Cutoff test. After restoring the cathode with the beam building function, you find the CRT reaches the CUTOFF SET area on the meter with a bias of −52 volts. The CRT has less than normal contrast but is now much better than at the start of the test.

Air Contaminated Tubes

A CRT that has been aired (lost most or all of its vacuum) generally will have open filaments because the filament burns within several seconds when heated in pure air. Some CRTs, however, develop a slow air leak; in which case weeks or even years, may pass before the CRT loses all its vacuum. These CRTs may show one of two conditions when tested with the CR70: 1.) They may test normally after being restored but fail again after several hours or days, or 2.) They may act like a gas filled regulator during the Cutoff test.

Short life after beam building

A small amount of air contamination causes the cathode surface to become covered with non-conductive contamination. You can often bring one of these CRTs back to normal Cutoff, Emission and Life tests with a single application of the Auto Restore or one of the Manual Restore functions. When tested the next day (or several days later) the CRT may test totally bad. This indicates the cathode has totally recontaminated itself because of the air contamination. These tubes must be replaced.

Regulator action

A tube with slightly more air may act like a gas-filled regulator during the Cutoff test. The needle stays at the left edge of the meter when the CUTOFF SET control is turned counter-clockwise. The needle will suddenly lift off the zero position and read full scale as the CUTOFF SET control is turned clockwise. Turning the CUTOFF SET control counter-clockwise in an attempt to bring the needle into the CUTOFF SET area causes the needle to again drop to zero.

If you look inside the neck of the CRT during this condition, you will often notice that a blue haze surrounds the gun assembly when the meter shows a high reading. The glow stops when the G2 voltage is reduced by turning the CUTOFF SET control in the counter-clockwise direction.

The air in the tube is acting like the gas in a gas-filled regulator. It does not conduct until the voltage potential causes the air to ionize. The ionized air offers a low resistance to the applied test voltage, resulting in current flow and a high meter reading. This high current condition continues until the voltage is lowered to a point that allows the ionization to stop, causing the current to drop to zero.

You may not see this condition until after you have restored or rejuvenated the CRT, making you think the condition is somehow related to the restoration or rejuvenation. This is not the case. The air in the CRT caused the original low emission and the restoration or rejuvenation simply cleared enough of the contamination from the cathode surface to allow the ionization to take place.

Dynamic Shorts

The spacing between CRT elements is smaller in new compact CRT designs compared to older designs. CRTs will occasionally check good, yet they will not work when operating in the circuit. The chassis symptom indicates a CRT-related problem, such as loss of control of one color, poor focus, retrace lines, or loaded high voltage power supplies. These problems are often caused by dynamic CRT shorts; a short that occurs only when the CRT has full operating voltage applied or only when the CRT is hot. Dynamic shorts may appear as soon as the CRT is turned on or after it operates for several minutes.

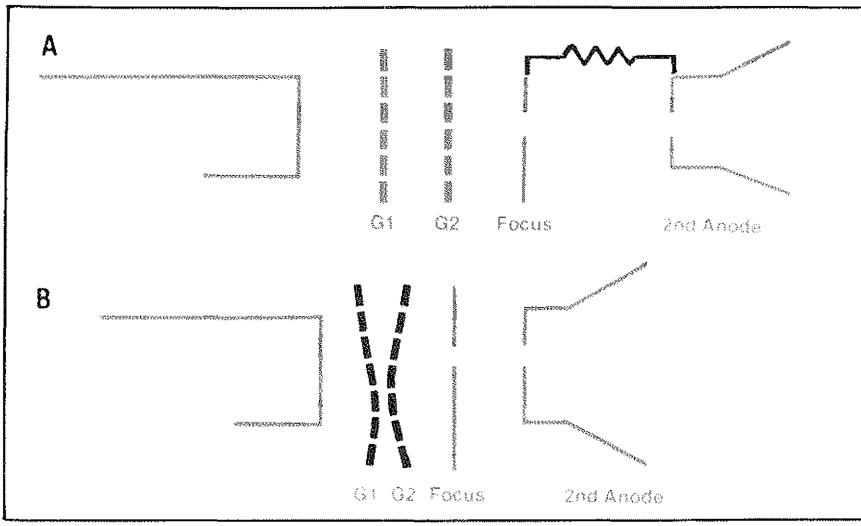


Fig. 23 — Dynamic shorts can be caused by leakage between the 2nd anode and focus (A) or by elements warping (B) when warm.

Second anode leakage

A dynamic short or leakage sometimes occurs between the second anode and the focus grid. This leakage path can only be isolated with full high voltage applied to the CRT. You should test for this type of short before using the CR70 to isolate other types of dynamic shorts when the symptoms of the chassis suggest that a dynamic short may be involved. The test for second anode shorts requires the use of a high voltage DC meter.

WARNING

Potentials up to second anode voltage levels may appear at the focus electrode if there is a direct short between the second anode and focus grid. Use a protected, high voltage probe to make this test and take normal high voltage measuring precautions.

To test for second anode shorts:

1. Remove power from the chassis.

2. Disconnect the socket from the CRT.

3. Connect a high voltage probe between the focus pin of the CRT and the CRT ground.

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

A good CRT should show no voltage at the focus connector. If you read a voltage, you know the CRT has a short or leakage path between the second anode and the focus grid. A CRT with this leakage is defective and cannot be repaired with the beam building functions.

Dynamic gun shorts

If the CRT shows no second anode leakage, it may have a dynamic short between some other elements. One cause, for example, is an element of the electron gun that warps as it is heated, causing metal-to-metal contact. The CR70 may not show this short during normal testing because the short may take several minutes or hours to develop at normal operating temperatures. The CR70 helps isolate these problems if you increase the filament voltage to accelerate the heating.

To use the CR70 to isolate dynamic shorts:

1. Increase the filament voltage by 50% over what is listed in the setup book. (For example, use 9 volts if the setup book calls for 6.3 volts.)

2. Repeat the H-K and G2 shorts test at this increased voltage. Both tests should still read in the "good" area of the meter, even after a couple of minutes at this increased voltage.

If the CR70 shows a bad reading, you may try to remove the short by using the Remove G1 Short function. Since the short may be caused by the gun elements distoring in shape, press the REJUV OR RESTORE button immediately after switching to the REMOVE G1 SHORT position of the FUNCTION switch rather than waiting for the gun to cool. The chances of correcing a dynamic short are less than correcting a normal short since actual metal-to-metal contact may be involved after the elements reach a certain temperature.

Since the cathode is forced to emit increased amounts of beam current when the filament voltage is increased, this dynamic short test should only be done to confirm a suspect tube which has failed in the chassis, rather than on every CRT tested. This will prevent stressing a good CRT and possibly reducing its life.

Understanding CRT Numbers

Most CRTs are registered according to some kind of industry standard. These standards define certain characteristics of the tube. Since April 1, 1982, these standards have been combined into one worldwide standard, prior to that date, several non-universal standards were used.

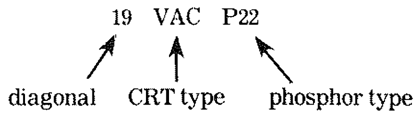


Fig. 24 — The old standard contained meaningful tube size and phosphor type information.

Old Standards

The CRTs which were introduced prior to April 1, 1982, were registered differently in the United States, Japan and Europe. In general, the registration number broke down into three parts. This is the numbering system with which everyone has become at least somewhat familiar.

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, which are listed in the first half of the CR70 Setup Book, this size is in inches. Thus, a 19VACP22 would have a viewing diagonal measure of 19 inches. Japanese tubes, which appear later in the book, have this distance measured in millimeters.

The next part of the CRT number consists of one to four letters which 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 12 VAC listing is not necessarily similar to a 5 VAC CRT), nor is there any correlation between a black and white and a color CRT with the same letter code. The CR70 Setup Book uses these letters as the second level of sequencing. The final letter (P) is not part of the letter sequence, as we will see in just a moment.

The final part of the CRT designation indicates the type of phosphor used. All black and white video CRTs use a P4 designation for American listings or a B4 listing for Japanese listings while all color CRTs use a P22 (American) or B22 (Japanese) listing. Computer CRTs or scope CRTs may use some other type of phosphor, and will have a different number following the "P" or "B". But, as you see, the "P" or "B" is not part of the tube designation.

Listing ending with TC01, 02, etc.

Some CRTs have listings that do not have a "P" or "B" ending. The most common non-standard ending is "TC01" or "TC02". These CRTs always have bonded yokes (or some other component) permanently attached to the CRT neck. The "TC" ending simply indicates the type of yoke plug the CRT uses 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.

WTDS Standard

Since April 1, 1982, a new system for catagorizing and numbering CRTs has been in use. This system is officially called the *Worldwide Type Designation System For TV Picture Tubes And Monitor Tubes*, or simply WTDS. Until the adoption of this system, American, Japanese, and European tube manufacturers have all numbered their tubes differently. This has led to confusion and incomplete or inaccurate information in the past. The new WTDS numbering is an effort to simplify and unify CRT designations.

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; either an A for picture tubes or an M for monitor tubes.

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. These letters designate a family code for the CRT. 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 CR70 is concerned.*

One, or two digits follow the family code. These digits indicate a specific member within a particular family. A different member number would be 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 2 letter code to designate the phosphor type.

Some tubes contain integral neck components, such as bonded yokes. These tubes have a sixth group of symbols assigned to them. A two digit number is used to define the characteristics of these integral neck components.

A62AAA00X

A	62	AAA	00	X
Application (picture)	Diagonal (in CM)	Family	Member	Phosphor (color)

Fig. 25 — A WTDS CRT designation.

Tubes which follow the WTDS number format are listed in the CR70 Setup Book. The whole WTDS number is included in the setup book, (even though the three letter family code is the only part of the designation which is required for proper setup), to avoid the possibility of confusion with some other number that may appear on the CRT, such as a manufacturer's part number. Tubes having the sixth symbol (designating an integral neck component) are listed without this sixth symbol just as "TC01" endings are deleted from the conventional CRT numbers.

NOTE: Some CRTs have completely non-standard listings. CRT manufacturers, or the manufacturers of equipment using the CRT, often assign a part number that *differs from standard listings. The CR70 Setup Book lists these special CRTs at the end of the standard listings.*

Answers To Common Questions On Beam Building

General guidelines for using the beam building functions are covered in the Operation section of this manual and in the Simplified Beam Building Instructions in the beginning of the CR70 Setup Book. Cathode recovery procedures vary, depending on the CRT. The following section covers the most common questions asked about cathode recovery processes. You may wish to use your CR70 on a number of known-bad CRTs (duds) to become more familiar with the tests and beam building procedures.

1. What Is The Difference Between Rejuvenation And Restoration?

The best way to remember the difference is to remember how the functions operate. **Rejuvenation** applies a large current pulse for a very short period of time, as indicated by the sudden flash in the neck of the CRT when you press the REJUV OR RESTORE button. Because of the short time, only a small area of the cathode is affected. **Restoration** applies beam current that is much higher than the CRT produces during normal operation, but much lower than the rejuvenation pulse. The meter shows that the current is applied for several seconds at a time, compared to milliseconds for rejuvenation. Because of the longer time, a much larger area of the cathode is affected.

2. When Should I Use Rejuvenation And When Should I Use Restoration?

First, remember the general rule for cathode recovery: **Always use just enough current to improve the CRT, and then stop.**

The meter readings during restoration or the results of the Shorts, Cutoff and Emission tests indicate when the CRT has reached its peak output. Continuing beyond that point will do no good and, in some cases, risks degrading the CRT performance.

Restoration is used most of the time. Always start with the AUTO RESTORE function, as this is the mildest form of cathode recovery. Let the Auto mode run through all three cycles for best effectiveness, even if the meter readings indicate the current has reached its peak. Step up to the Manual 1 or Manual 2 levels only if the automatic mode was not effective.

Rejuventation has two applications that can help you save some CRTs that do not respond to restoring alone. First, the increased voltages and currents available during rejuvenation allow you to get a small area of the cathode surface activated when the tube draws no restoring current in the AUTO RESTORE mode. After using REJUV to start the cathode current, move to the AUTO RESTORE mode to complete the restoration process. The second use of rejuventation involves a CRT that responded to restoration but then shows poor results on the Life test. You can often improve the Life test results by applying one shot of rejuvenation after restoration. This application is not always 100% effective, but does help improve the life of some CRTs. You will not damage CRTs as long as you apply only one shot of rejuvenation.

3. Can The CR70 Improve Every CRT I Test?

The CR70 "Beam Builder" will improve most CRTs, but there will be a few that cannot be restored with any system. You must remember that beam building does not add any new emitting material to the cathodes; it only re-activates the material that is already there. Some CRT cathodes may be completely stripped by repeated attempts at rejuvenation, especially with old-style CRT testers whose lowest levels of rejuvenation were several times more powerful than the CR70 rejuvenation function. Other CRTs simply have been used to the point that the emitting material is gone. On the average, however, the CR70 will improve the performance of nearly 90 percent of the CRTs you find with shorts or weak emission.

4. Should I Use The Beam Building Functions On A Tube That Is Extremely Old But Still Tests Properly On All Tests?

No. Even the mildest cathode recovery process puts the CRT under a certain amount of stress. If the tube tests properly on all tests, including the Life test, leave it alone. A weak picture on a receiver or monitor or a dim trace on an oscilloscope is caused by circuit problems if the CRT tests properly.

5. Are All Three Guns Of A Color CRT All Recovered At The Same Time When I Rejuvenate Or Restore?

No. The CR70 INDIVIDUAL GUN SETUP controls allow you to connect to only one electron gun at a time. Remember to set the switches to the correct gun before performing any beam building processes.

6. I Have Been Told That A CRT That Has Been Used With A Brightener Cannot Be Restored. Is This Always The Case?

A brightener tends to reduce the chances of improving the CRT cathodes but in no way makes cathode recovery impossible. The CR70 often improves a CRT to the point that the brightener can be removed. If the CRT tests weak after performing the beam building processes, increase the filament voltage by the amount that the brightener increases the filament voltage and repeat the Cutoff and Emission tests. If the CRT then tests good, put the brightener back into the circuit.

7. Can I Improve CRTs That Draw Absolutely No Restoring Or Emission Current, Even After Rejuvenating?

Some CRTs develop open cathode connections which can, in some cases, be welded with the REMOVE G1 SHORTS function. The success of this procedure depends on the physical spacing of the separated elements inside the CRT.

Use the following procedure to attempt to weld the cathode:

1. Set the INDIVIDUAL GUN SETUP switches to the setup for the gun that needs welding. It is not necessary to adjust the CUTOFF SET control.

2. Set the FUNCTION switch to the AUTO RESTORE position and allow the filaments to warm the cathode for approximately one minute.

3. After the cathode has warmed, set the FUNCTION switch to the REMOVE G1 SHORTS position. **Do not wait for the filament to cool, as in normal shorts removal.**

Immediately press the REJUV OR RESTORE button while tapping the CRT neck. Watch for a flash inside the CRT neck, indicating that welding has taken place.

NOTE: Do not tap the neck too hard as you may break it.

4. Repeat the beam tests for this gun to determine if the cathode has welded.

You may repeat this procedure several times in an attempt to weld the CRT elements. If you are unsuccessful, the CRT must be replaced.

Understanding The Functions

How CRTs Work

There may be times when you need to understand how one of the CR70 functions operates to use it in special applications. Each of the CR70 tests closely duplicates the operation of the CRT in the circuit. This section covers a quick review of CRT operation so you can relate each CR70 function to the operating CRT.

The CRT can be divided into three major groups of elements: the cathode, the control grids, and the phosphor screen.

The concept behind a CRT is very simple: an electron beam from the cathode strikes the screen which gives off light. Circuits external to the CRT deflect this beam so it fills the whole viewing screen of the CRT. Some CRTs, like those used in scopes, contain special internal deflection plates.

The cathode is the source of the electron beam. The cathode is coated with a material (such as barium or thorium) which gives off large numbers of electrons when heated by the filament. The hot cathode emits electrons which form a cloud around the cathode until something attracts them away.

The next group of elements, directly in front of the cathode, consists of several grids. Each grid has a specific function. The grid closest to the cathode (G1) is the control grid. A bias (a negative voltage compared to the cathode) is placed on this grid which repels the electrons back towards the cathode. The amount of negative bias determines how many electrons pass on towards the screen. The control grid is cylindrical in shape, having a hole in the center. The electrons are pulled through this hole by the next grid (G2), called the screen grid, forming a thin stream of electrons.

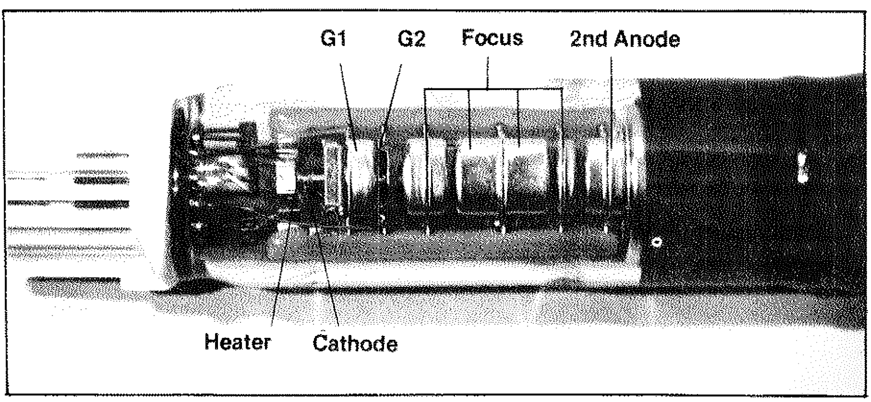


Fig. 26 — The basic elements in a CRT gun.

The screen grid has a positive voltage on it to pull the electrons through the control grid. Only the electrons which pass through the hole in the control grid form the true beam current or the current that eventually strikes the face of the CRT. The screen grid is shaped like the control grid and also has a hole through which the electron beam passes.

One or more accelerating grids follow the screen grid (each of which has increasing levels of positive bias) to increase the speed of the electron beam. In addition, one or more focus grids form the electron beam into a fine hair-like thread which hits the phosphor screen, resulting in a very tiny spot of light.

The final group of CRT elements is responsible for producing the visual image. These elements include the phosphor screen and a structure called the second anode. The second anode is quite similar in shape to the other grids but it has a very high positive potential on it. An aquadag coating lines the inside of the CRT between the second anode and phosphor screen. This is at the same potential as the second anode and keeps the beam from being distracted off coarse. The second anode speeds the electron beam to an extremely high rate. The beam then suddenly collides with the phosphor screen, causing light to be emitted by the phosphor. A color CRT has a phosphor screen with three colors of phosphor (red, blue and green) which are very close to each other. Each one is struck by electrons from the corresponding beam from one of three identical electron gun assemblies.

In order for an image to be produced on the screen, the electron beam must be made to vary in intensity by changing the bias between the cathode and control grid.

The CRT beam is cut off with the normal DC bias which is applied to the control grid. This results in a black level being displayed on the screen, since no beam current reaches the screen. Video information is applied to the cathode, control grid or to both the cathode and control grid, which reduces the amount of G1 bias, enabling more of the electron beam to strike the phosphor screen. Reducing the bias to zero allows maximum beam current and maximum CRT brightness. Varying the bias produces brightness levels between cutoff and full brightness.

What Fails In The CRT

Understanding what goes wrong in a CRT helps you understand the CR70 test results and how the beam building functions help correct various CRT problems. The following section explains how CRTs fail and how each failure is indicated by the CR70 test results.

H-K Short

A heater-to-cathode short occurs when the filament comes into direct contact with the cathode or when a flake of conductive material becomes lodged in the tiny space between these two elements. The symptom of an H-K short on the operating CRT varies, depending on the source of the filament power. An H-K short, in video applications, produces a hum bar running across the screen if the filament is powered from the 60 Hz AC line. The interaction may not be noticeable on a CRT powered from the horizontal output transformer (flyback) because the interference is in sync with the incoming video signal. Flyback powered systems may show a dark line on the left or right edge of the picture.

H-K shorts cannot be removed because the surge current that is needed to remove the short will blow out the filament, resulting in a completely dead CRT. Isolation-type filament transformers (CRT "brightners") are available for 60 Hz systems, but if the filament is powered from a scan-derived supply, there is no alternative except to replace the CRT if the interaction from the filament causes unusable conditions.

G1 Shorts

Most shorts involving the control grid are caused by flakes of cathode material that have become lodged between the cathode and the control grid (G1). Shorts between the control grid and the screen grid (G2) are less common because the space between these elements is so much larger than the spacing between the cathode and G1.

A G1 short can cause loss of control of the CRT beam, resulting in visible retrace lines. G1 shorts also result in CRTs that cannot be controlled by the brightness control or the incoming signal. The CR70 REMOVE G1 SHORT function will vaporize most shorting particles, resulting in normal CRT operation.

Cutoff-related failures

In order to understand the CR70 Cutoff test, we must examine the operation of the cathode more closely. The entire cathode surface does not supply the electrons that make up the electron beam. Rather the amount of cathode area that supplies electrons at any given time depends on the amount of negative bias applied to G1.

The control grid controls the amount of beam current by using a negatively charged field to repel electrons back towards the cathode as they are being attracted by the high positively charged surfaces of the accelerating and focus grids. When the negative G1 bias is strong enough to completely cut off the electron beam, the bias effectively closes the small hole in G1, much like the iris in a camera lens closes the lens opening, to let in less light.

The CRT comes out of cutoff as the bias is reduced by either turning up the intensity control on an oscilloscope or by applying a video signal to a video CRT. Effectively, the hole in the control grid begins to open, allowing some electrons to be pulled from the cathode surface to form the electron beam that strikes the CRT screen. The negative field, from the bias, is equally distributed around the control grid aperture, meaning the hole in the grid is effectively smaller than its physical dimensions. We will call this the "virtual aperture" because, even though the hole is not physically smaller, it is electrically smaller than when full beam current passes from the cathode.

The smaller dimension of the highly biased grid allows only the center of the cathode to supply electrons for the electron beam. Therefore, the cathode emitting material in the center of the cathode wears out before the material at the edges because the center part is contributing electrons almost all the time. The outer areas only supply electrons during peak white periods and so do not wear out as soon. When the center part becomes worn, the CRT screen still lights brightly when the virtual aperture is large, but the beam cuts off long before the virtual aperture is completely closed. Thus, the amount of beam current becomes non-linear in relationship to the G1 bias.

27 A. Only a small area of the cathode emits electrons when a high G1 bias closes the "virtual aperture".

27 B. High beam current results when the G1 bias is reduced, allowing a larger area of the cathode to emit electrons.

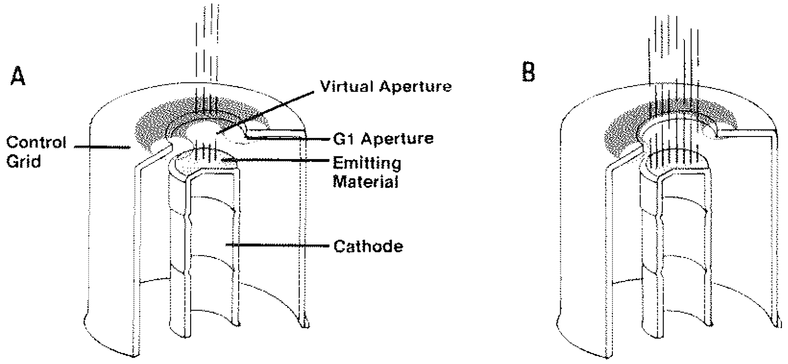


Fig. 27 — A cathode with good Cutoff and Emission.

28 A. The CRT cuts off too soon when the center of the cathode wears, causing grey images to be too dark.

28 B. The CRT with a cathode worn in the center produces bright highlights because the outer edges are still good.

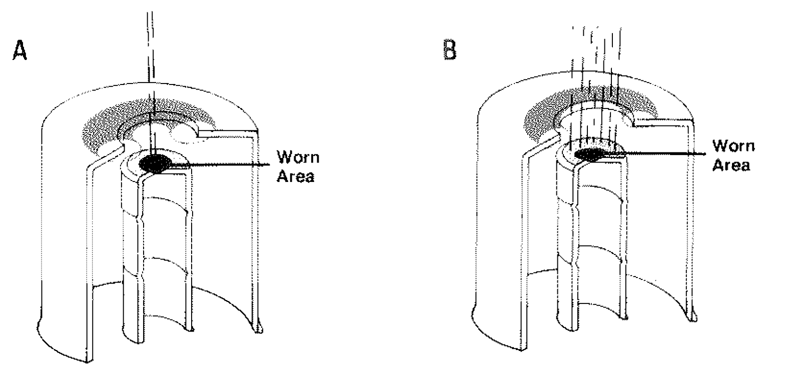


Fig. 28 — A cathode with bad Cutoff and good Emission.

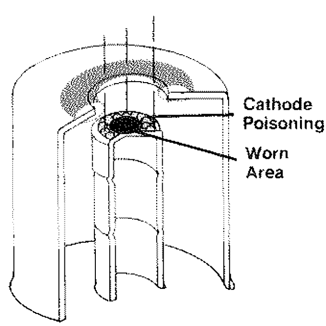


Fig. 29 — Low white-level beam current is usually caused by a poisoning ion layer that prevents electron emission.

For example, consider a CRT designed to reach cutoff with 70 volts of negative bias on G1. As the center of the cathode wears out, the CRT beam can be cut off with only 50 volts of bias on G1. The CRT produces near normal brightness because the emission with a large virtual aperture is still high. Grey areas in the picture, however, will be too dark because the tube reaches cutoff when the applied signal is still at some level between black and white. Thus, instead of a picture made up of whites and many shades of grey, the picture has bright shimmery whites and deep blacks. Many technicians call this a "gassy" tube. The correct term is that the tube has poor "gamma", which is the ability to correctly reproduce different shades of grey.

Fig. 30 — This CRT is often called "gassy".

Interpreting The CR70 Cutoff Test

Now that you better understand what causes a CRT to develop poor contrast, let's see how the test results, as seen on the CR70, relate. A CRT with poor gamma fails to reach the CUTOFF SET area of the meter when the BIAS switch is set to the proper negative voltage, yet these CRTs often read in the good area when you test for emission. The CRT may reach the cutoff area when the bias is reduced (see the section on "Extended Cutoff test" earlier in this section of the manual) because the virtual aperature is larger at a lower bias voltage. The CR70 beam building functions usually improve a tube with poor gamma, even though the worn center area may prevent returning the CRT to its original specifications. The restoring current activates the cathode emitting material around the "dead" center zone, bringing the tube closer to its original cutoff design.

Low Emission Due To Poisoning

A second type of CRT failure affects the brightness more than the contrast. This CRT failure is caused by a coating of positive ions covering the electron emitting material on the cathode. The ions are a result of the tiny amount of air that is left in the CRT during manufacturing. These ions react with the hot cathode surface over a period of time and reduce (or in some cases completely shut off) the number of electrons emitted as the cathode material is heated. This condition is called "cathode poisoning".

Sometimes, the poisoning affects the entire cathode surface, which causes a total reduction in the CRT light output over the entire range of brightness levels. At other times, the peak light output is reduced, but the black and dark grey areas are normal. This is because the CRT can still supply low level beam current. The reason the CRT still supplies low level beam current is that the center of the cathode is almost always drawing some beam current. This constant beam current keeps the positive ions from affecting the center of the cathode as badly as the outside edges. Remember that electrons are only drawn from these outside areas during peak whites or when the intensity control is turned up.

Beam building of a poisoned cathode involves removing the contamination from the cathode surface by increasing the filament temperature (to thermally activate the electron emitting material to a higher than normal state and soften the ion coating), and then drawing much higher than normal current from the cathode surface. This boils off most of the poisoning ions and allows the cathode surface to emit more electrons.

Temperature-Sensitive Cathode

The number of electrons emitted by the cathode surface is dependant on the temperature of the cathode. A new CRT, however, is much less temperature-dependant than one that has operated for a number of years. The beam current becomes severely affected as the amount of the emitting material is reduced with age. Thus, lowering the filament voltage has a minor effect on the beam current in a CRT with long life expectancy, but causes a big change in a CRT that will only continue to operate for a short period of time. A CRT close to the end of its useful life will drop off very quickly with a reduction in filament voltage, giving a general indication of the amount of life remaining.

Stripped Cathode

Another cathode failure involves massive losses of cathode emitting material or a stripped cathode. The most common cause of a stripped cathode is the use of an old-fashioned rejuvenator, which applies current levels many times higher than the rejuvenation supplied by the CR70. At other times, the cathode becomes stripped by repeated use of a restorer over a period of months or years, or by operating the cathode at higher than normal temperatures, such as supplied by a picture tube brightener. A stripped cathode cannot be improved with any type of restoring or rejuvenating because there is effectively no emitting material left to improve.

Interpreting The CR70 Emission Test

The Emission test shows the true beam current (the amount of beam current that passes through the G1 aperture). The Emission test results, when combined with the results of the Cutoff test (explained earlier), and the Emission Life test, give you a true picture of the CRT cathode conditions. Understanding the different CRT failures should also help you understand why different levels of rejuvenation or restoration are needed to effectively activate whatever cathode emitting material remains on the cathode.

The Cutoff test indicates if the center of the cathode is working properly and the Emission test indicates if the edges of the cathode surface are poisoned. If a tube fails both tests, the entire surface (including the center) is poisoned or stripped. The Emission Life test reduces the filament voltage to detect cathodes that are overly temperature dependant, indicating a short life expectancy.

Special Consideration Of Color CRTs

The only test that remains is the Color Tracking test. It is possible for a color CRT, or for the three separate monochrome CRTs of a projection system, to have proper cutoff, and emission characteristics but still not produce a good color picture because they do not match each other properly. The CRT manufacturer specifies that one color gun will not be more than 55 percent stronger or weaker than another gun. The receiver or monitor manufacturer then designs the CRT drive circuits around this specification. If a CRT falls outside this limit, the color balance controls may not have enough range to allow the weakest and strongest CRT to be balanced to each other.

The CR70 provides a separate test of Color Tracking because the design of the CR70 compresses the meter readings in the good area of the Emission test. This compression is necessary to eliminate the need for the two or three meter scales that would be needed for a linear current representation. This compression, however, causes CRTs with sizeable differences in current to read close to the same area on the meter.

The CR70 Color Tracking test measures the ratio between the strongest and weakest gun. If the difference is less than 55% the meter reads in the good area, or if it is greater than 55% the meter reads in the bad area. The weakest gun is the one that reads bad. It is possible for two guns to read bad if they are both less than 55% of the emission of the good gun.

How The CR70 Works

This section relates each CR70 function to the way the CRT operates. The explanations are done from the functional level, rather than as a circuit description, so you can understand how the CR70 operates on each function. You may find this information helpful for advanced applications of the tests or beam building functions.

Filament Voltage

The CR70 uses a regulated, DC power supply to provide the proper RMS filament voltage to the CRT. Normal CRT filament voltage must be supplied for valid test indications.

H-K And G1 Shorts

In these two functions, the CR70 functions as a sensitive ohmmeter. Unlike other CRT testers which only provide a Good/Bad indication, the CR70 displays an indication of the severity of the short. In the G1 SHORTS function, shorts between K and G1 or G1 and G2 are detected. In the H-K SHORTS function, any short between the heater and any other element is detected. In the H-K SHORTS function, the center line between BAD and GOOD on the meter indicates 2 megohms of resistance while in the G1 SHORTS function the center line indicates 20 megohms of resistance.

A reading of zero or near zero on the meter scale in either function indicates a short having little or no resistance.

Cutoff

The Cutoff and Emission tests, when used together, check the dynamic range of the CRT. During the Cutoff test, the CRT is biased near beam cutoff, which corresponds to the black level of the tube. This checks the CRT's ability to turn the beam off to a minimum current level.

Normal negative bias is applied to the CRT during the Cutoff test. This negative bias repels the electron beam back to the cathode. A positive voltage (which attracts the electrons) is applied to the screen grid and adjusted with the CUTOFF SET control to a point where the tube just begins to conduct emission current. This is the black level of the tube, which corresponds to the black portion of the video signal. Once the G2 voltage is adjusted with the CUTOFF SET control, it is left at the same level for the Emission and Emission Life tests.

The beam current is developed across one of the CRT type resistors which changes the current into a voltage, which is passed on to the meter. Each type of CRT produces a different amount of black level beam current. The CR70 automatically adjusts for this when the CRT TYPE switch is set to the correct position. The amount of current to which the cutoff area is calibrated is: 10 - 20 uA for video CRTs; .33 uA to .66 uA for scope CRTs; 26 to 53 uA for projection CRTs.

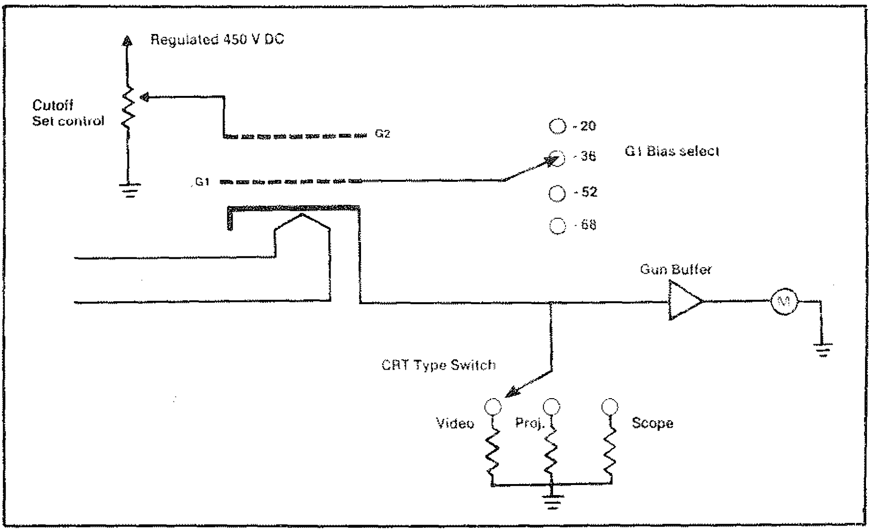


Fig. 31 — A simplified drawing of the CUTOFF function.

Emission

The Emission test completes the dynamic range test of the CRT by checking the ability of the CRT to produce a white level. The CR70 measures the true beam current when in the Emission test, not the cathode current as most CRT testers do. The difference is important. True beam current is the amount of current which is emitted by the cathode and is allowed to pass through G1 to G2 while cathode current is the amount of current that reaches G1. A tube may have ample cathode current but, if G1 is obstructed, no true beam current will reach G2.

The CR70 test of true beam current is a measure of the current which actually hits the phosphor. During the Emission test, no bias is applied to G1. This simulates the condition when a white level video signal is applied to the tube. G1 is tied directly to the cathode so it will not pick up a charge which could repel electrons back to the cathode. The amount of bias applied to G2 remains unchanged from what was set during the Cutoff test. This positive bias attracts the electrons through G1, to G2 where it is measured. The beam current is again developed into a voltage by one of three CRT type resistors. This voltage, representing the true beam current, is applied to a storage capacitor for later use in the Tracking test. The voltage is also applied to the meter, which gives a GOOD/BAD reading of the tube emission. This reading is scaled for the type of tube being tested. The center line between the "Bad" and "Good" scale corresponds to the following: video CRT, 300 uA; scope CRT, 10 uA; projection CRT, 800 uA.

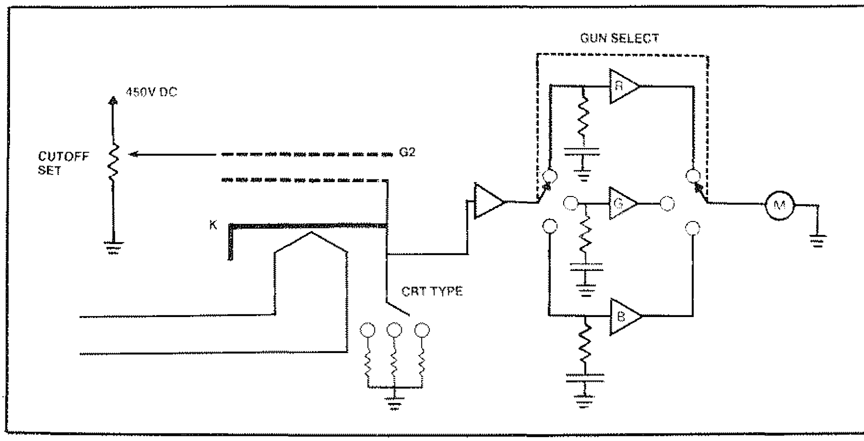


Fig. 32 — A simplified drawing of the EMISSION function.

Relating CR70 Bias To The Circuit

The CRT heater, cathode, control grid (G1) and screen grid (G2) are the elements responsible for controlling the intensity of the beam current. The remaining elements shape the beam and accelerate it as it heads towards the phosphor screen. Since these dangerously high voltages have a minimal effect (if any at all) on the beam current, they are not included in the CR70 tests.

Figure 33 shows a characteristic cutoff curve for a CRT taken from a set of CRT design specifications. For example, the tube whose cutoff curve is shown may be operated with a G2 voltage of 600 volts. With that level of G2 voltage, −160 volts would need to be applied to G1 to cut off the electron beam.

The CR70 Cutoff test duplicates these bias conditions, although the actual operating point may not fall at the same point on the curve as in the circuit. The CR70 G2 power supply is safely limited to a range of voltages from near zero to 450 VDC, while the G1 supply has four fixed values which provide an adequate range of test biases for any CRT. When this particular tube is tested on the CR70, for example, the setup book tells us to set the G1 BIAS to −68 volts. This bias insures the tube will reach the CUTOFF SET area of the meter before the CUTOFF SET control reaches 450 volts. For this particular tube, cutoff will be reached when the CUTOFF SET control applies 220 volts to G2. Notice that both points (normal operation and CR70 cutoff) fall along the same line. The same thing applies to oscilloscope and projection CRTs except the CR70 bias results fall at some other point on the cutoff curve.

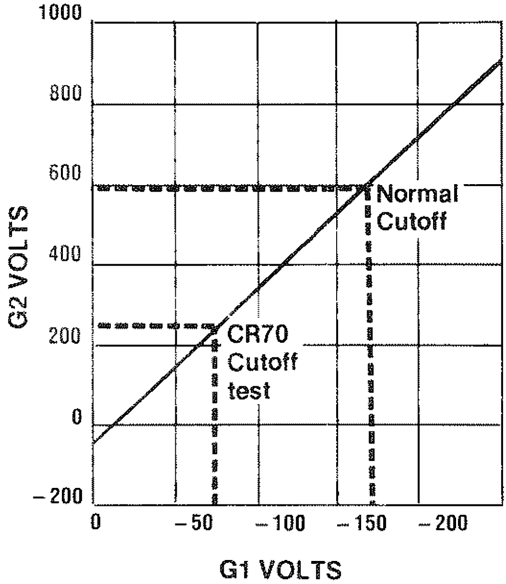


Fig. 33 — A characteristic CRT design curve.

Tracking

During the Emission test, a voltage representing the true beam current is applied to a separate storage capacitor for each color gun. When the Tracking function is selected, the voltage on each capacitor is applied to a buffer, again, one buffer per gun. The buffers feed the voltages to a calculator circuit which compares the three voltages against each other. If the emission of any one gun differs from the others by more than 55%, a bad meter reading is displayed when the GUN SELECT switch is set to the gun with the lowest emission.

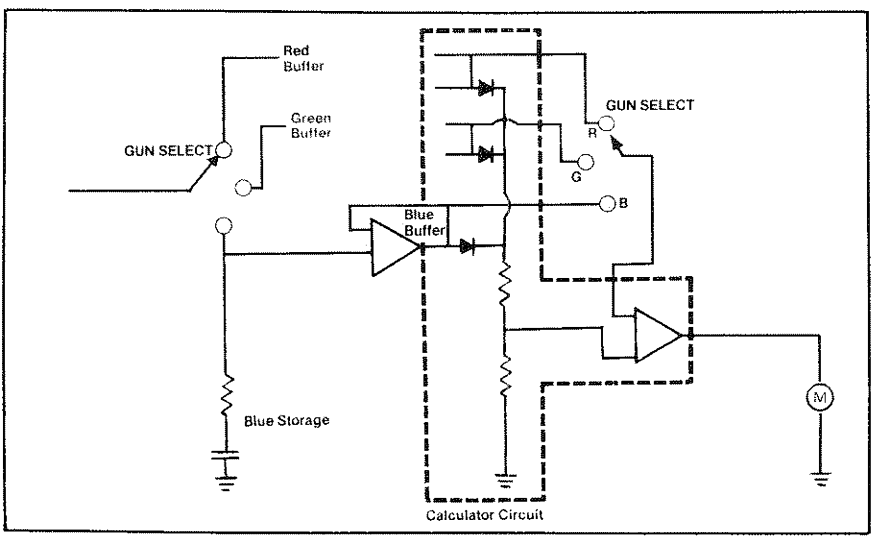


Fig. 34 — Simplified CR70 Tracking test.

Remove G1 Shorts

The REMOVE G1 SHORTS function of the CR70 will remove most of the shorts that lie between the control grid, G1, and either the cathode or screen grid, G2. Most of the shorts will be small particles of foreign material lying between the elements. Shorts caused by the elements physically touching can't be readily removed. Shorts of this nature are indicated by a reading on the far left side of the meter during the G1 Shorts test.

In the REMOVE G1 SHORTS function, the cathode and screen grid are tied together, thus allowing a short between G1 and either element to be removed. No heater voltage is applied to the CRT during this function to minimized the possibility of damage to both the heater and cathode. When the REJUV OR RESTORE button is depressed, the charge from a 450 V capacitor is applied between the cathode/screen grid and control gird. A 10 ohm resistor, in series with this discharging capacitor, limits the maximum current surge in the event that a direct short to G1 exists. The capacitor will discharge through the existing short, effectively "blowing" it away. This method of removing G1 shorts is the safest and most effective method possible since only enough power is supplied by the capacitor to remove the short, and once the short is gone, the discharge stops.

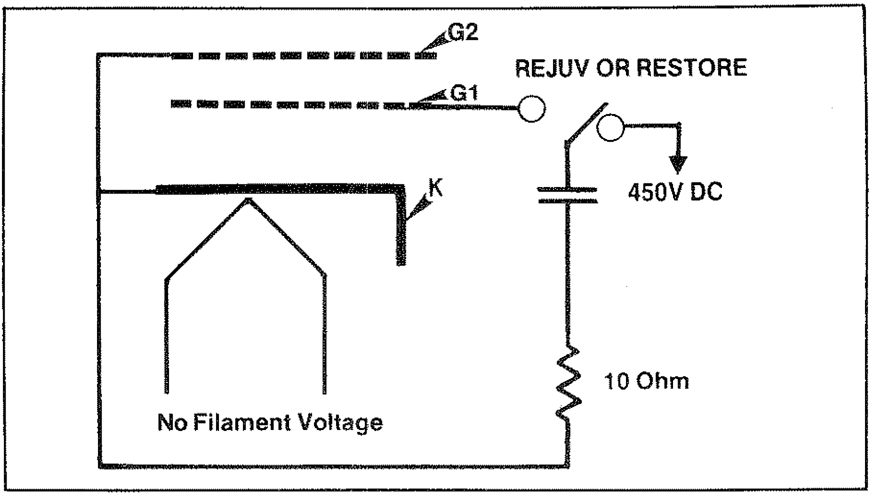


Fig. 35 — Simplified REMOVE G1 SHORT function.

Rejuvenate

Many CRT restorers do not have a function similar to the REJUV function on the CR70, yet this function serves a very important use.

Rejuvenation is needed to start some CRTs that will not draw restore current. These CRTs have such a thick coating, completely surrounding the cathode, that no electrons can escape. The sudden current surge that is produced in the REJUV function effectively cracks this coating, allowing the restoration to take place.

In the REJUV function, the cathode and screen grid are again tied together. Normal filament voltage is supplied to the CRT and, a one kilohm resistor is placed in series with the discharging capacitor to limit the amount of surge current to a safe level. When the REJUV OR RESTORE button is depressed, G1 is positively biased, allowing a sudden surge in current to pass from the cathode to G1. This current quickly drops to zero as the capacitor discharges, removing the bias on G1. This sudden current surge cracks any coating or removes any spot of contamination which is on the cathode. This allows the cathode to once again supply proper emission current.

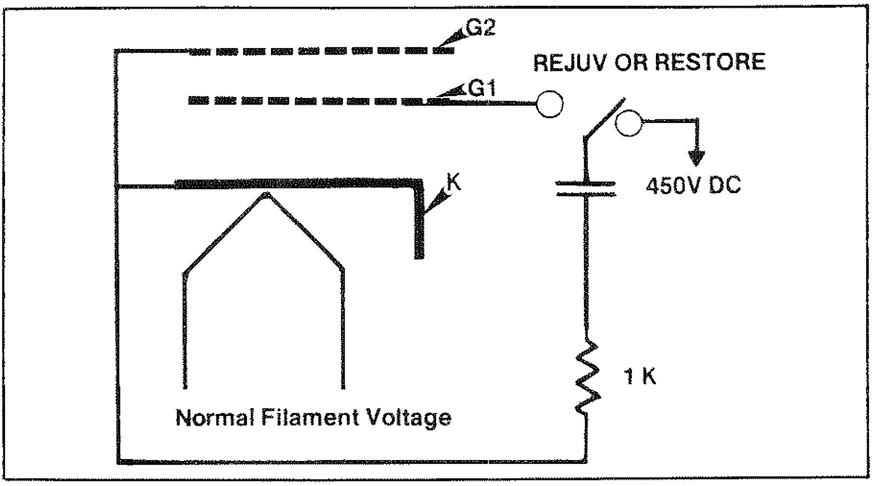


Fig. 36 — Simplified REJUV function.

Restore

The CR70 provides three levels of restoration. These levels of restoration bring new emitting material to the surface of the cathode by removing the old material. Three levels are provided so that unnecessary strain is not applied to the CRT.

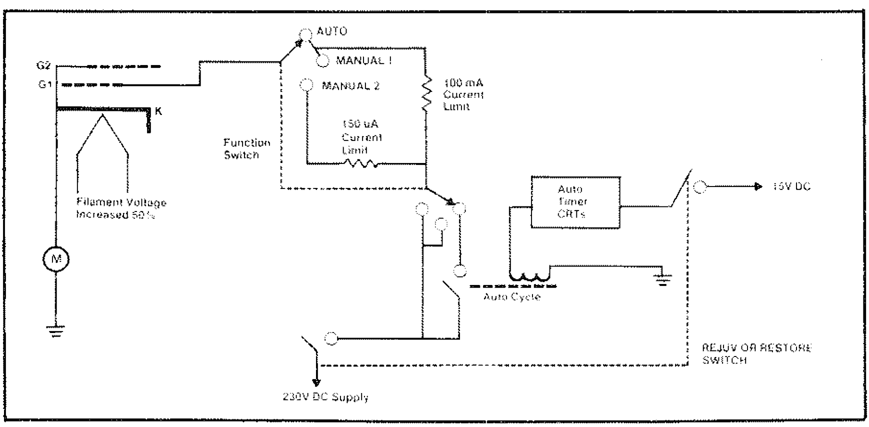


Fig. 37 — Simplified RESTORE functions.

AUTO RESTORE and MANUAL 1 are much the same in their level of restoration. The only difference between them is that during Auto Restore, the CR70 cycles the CRT beam current 3 times, while in Manual 1 the tube will draw beam current as long as the REJUV OR RESTORE button is held down. In both the Auto Restore and Manual 1 Restore functions, the current through the CRT is limited to 100 mA. The Manual 2 Restore function limits the current to 150 mA and is the highest level of restoration offered by the CR70. In each of these three restore functions, the filament voltage is increased by 50%, which superheats the cathode and softens the old material. The cathode (K) and screen grid (G2) are tied together which places zero bias on the tube and allows the maximum amount of beam current. No current flows until 230 volts is applied to the control grid (G1). The CRT now allows maximum current to flow between the cathode and control grid. This current is limited by the CR70 and the magnitude of it is displayed on the restoring current scale of the meter. The large amount of current flowing through the cathode "boils off" the poisoning material, allowing new emitting material to come to the surface. Maximum restoration is reached when all new emitting material is exposed on the surface of the cathode, and is indicated as a peak current reading on the CR70 meter. Since some emitting material may be removed during restoration, three levels are provided so minimum emitting material is removed. When restoring, you should therefore always start with the lowest level and use the higher levels in turn as needed.

CR70 Output Cable Wiring Diagram

You may need to know the wiring pattern of the CR70 output cable. This diagram shows the pin numbers used for both the CR70 output cable connector and the adapter socket's connector.

The connector numbers are not in a sequential order. Sencore uses standard manufacturer's CRT sockets which are wired according to a standard numbering system, 1 through 14. By placing the numbers as shown in Figure 38, we take the simplest path to the socket pins while maintaining the manufacturer's sequence, at the socket itself.

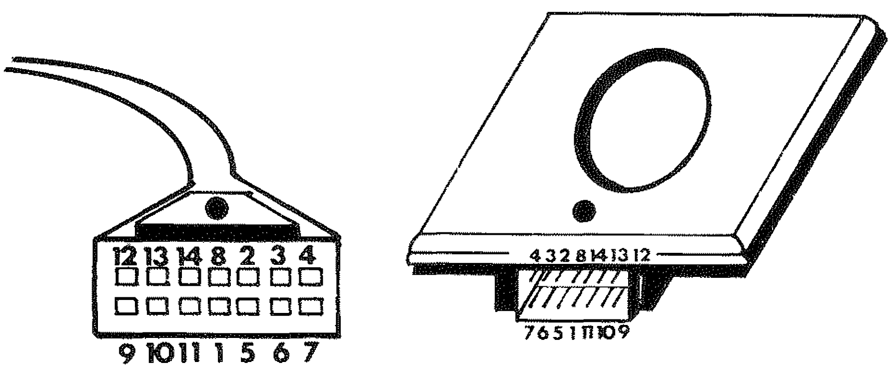


Fig. 38 — Each number on the cable corresponds to the same number shown on the CR70 gun element set-up switches.

Testing The Universal Adapter

The wiring of the Universal Test Adapter can easily be tested using the G1 SHORTS function of the CR70.

To test the adapter.

1. Set the F1, F2, K and G2 switches to position "1".

2. Connect the F1, F2, K, G1 & G2 leads together.

3. Set the FILAMENT VOLTAGE and FIL SET controls to minimum (fully counterclockwise).

NOTE: Make certain both the FILAMENT VOLTAGE and FIL SET controls are fully counterclockwise.

4. Set the CR70 FUNCTION switch to the G1 SHORTS position.

5. Turn the POWER switch to the "On" position.

6. Rotate the G1 control through positions 1 through 5. The CR70 should show a "Bad" reading in all five positions. If any one of the positions reads "Good" in all five settings of the G1 switch, an open F1/1 lead on the UA is indicated.

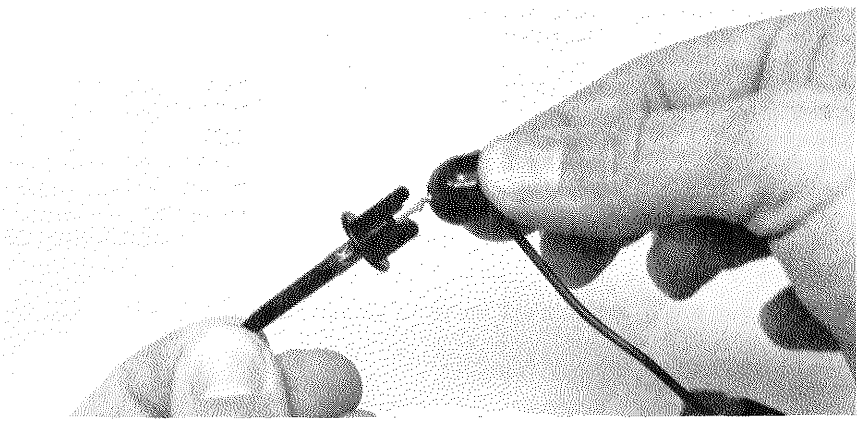


Fig. 39 — A broken UA lead can easily be repaired.

Repairing The Universal Adapter

If the Universal Adapter checks "Bad", it can easily be repaired since the leads usually break within ½" of the E-Z Hook* connector.

To repair a broken lead:

1. Give a sharp tug to the lead that has been determined to be open. If the break is near the connector, the wire will slide out of the insulation.

2. Re-strip the wire, leaving about ½" of the conducting wire exposed.

3. Open the E-Z Hook* by pulling the ball straight off the back of the connector. (See Figure 39.)

4. Resolder the test lead onto the hook, and slide the ball back into place. The ball must be correctly aligned with the clip body in order for the two to go together properly.

5. Retest the adapter to make sure the problem has been corrected.

*E-Z Hook is a registered trademark of Tektest, Inc.

Special CRT Applications

Testing Sony SD59 CRTs

Sony SD59 color picture tubes require special testing and restoring methods because of their unique design. These tubes contain three directly heated cathodes, in which the three separate filaments are covered with emitting material. The filament and cathode are the same element. Another aspect of Sony SD59 CRTs is the fact that they operate at a low filament voltage.

Setup

Since the heater and cathode are the same element, the "F1/1" and "F2/2" leads of the Universal Adapter need to be connected to different pins of the CRT for each gun tested. Also, since the cathode is common to the heater, the "K" switch is set to position 2 and the "K/3" lead of the UA is not connected to the CRT.

To protect the tube's low voltage filament, a 1 ohm resistor must be placed in series between the "F1/1" lead of the UA and the test pin of the tube. The Filament Voltage switch is set to 1 volt and the FIL SET control is turned fully counterclockwise. Because .63 volts is near the very bottom of the scale, it may be difficult to see when the voltage is adjusted for .63. To overcome this resolution problem, simply connect a DC volt meter across the filament pins and adjust the voltage. Be sure to disconnect the meter after you have set the voltage and before you begin testing the tube.

The remaining test procedures are the same for any tube that requires using the Universal Adapter.

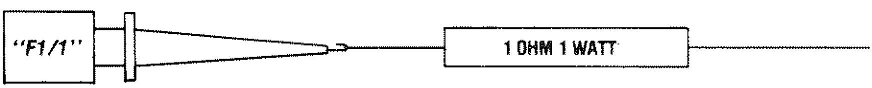


Fig. 40 — Always place a 1 ohm resistor in series with the "F1/1" lead of the UA when testing or restoring SD59 CRTs and adjust the filament voltage using a DVM connected across the filaments.

Test Results

All SD59 tubes will show an H-K short when the CR70 is properly connected because the heater and cathode are the same element. A common failure in SD59 CRTs is a dynamic G1 short. 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 CR70 Function switch to the "G1 Shorts" position 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.

Restoration

Many of the G1 shorts which occur in SD59 CRTs 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 using standard shorts removal procedures.

The construction of an SD59 contains some very delicate elements. Therefore, to avoid unnecessary strain on the gun assembly, use only 1 cycle of Auto Restore on weak tubes, instead of the usual 3 cycles. Be certain that the 1 ohm resistor is in series with the CR70 filament connection when using Auto Restoration.

Tube	Type	SKT	F1	F2	Bias	Gun	K	G1	G2	FIL
SD59	Video	UA	3	4	−68	R	*	2	5	.63**
			1	6	−52	G	*	2	5	.63**
			8	9	−68	B	*	2	5	.63**

*Set the "K" switch to 2, which is the same setting as the "F2" switch. It is not necessary to connect the "K/3" lead of the UA. Set the remaining CR70 switches to the normal setting for using the UA.

**A 1 ohm resistor must be placed in series with the "F1" lead of the UA for all tests. Adjust the filament voltage using a DVM to a reading of .63V.

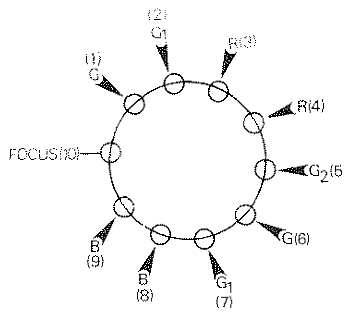


Fig. 41 — The pins on an SD59 are numbered clockwise with the focus pin as the highest number, 10.

Restoring Camera Tubes

In addition to restoring CRTs, the CR70 can also be used to restore many weak camera tubes. Many camera tube failures are caused by weak electron gun emission. Symptoms of weak emission are lag ("sticking" highlights), poor light sensitivity, or low output levels.

Target failures cannot be corrected with restoration. Target failures are permanent and are usually not cured with the increased cathode current that results from restoration. Target flaws include spots, burned-in images, halos around bright objects, and areas of higher or lower light sensitivity in various parts of the picture. The easiest way to note these target problems is to aim the camera at a scene, and then move the camera. If a flaw in the picture stays in the same place on the CRT, the target is damaged.

Other target failures may cause general "sticking" or lag. Restoring the cathode often improves this condition, although it cannot eliminate the condition 100% if the target is part of the problem.

Connecting and Setup

The 39G170 Universal Adapter (UA) is used to connect to most camera tubes. Remember to use the camera's schematic to determine the setup for tubes that are not listed in the setup book. If you are using the Universal adapter:

1. Connect the F1, F2, K, G1, and G2 connectors of the UA to the pins indicated in the setup instructions or on the schematic.

2. Set the CR70 setup switches to match the UA: F1-1, F2-2, K-3, G1-4, G2-5.

Set the remaining switches as follows:
Bias: -36; Type: Video; Fil. Volts: 6.3 (Most camera tubes operate with 6.3 volt filaments. Check the schematic if there are questions.

Testing

Camera tubes test differently than 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. The camera tube uses 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 CR70 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 CR70 Emission test does not directly correlate to the tube's quality. Once you have decided the tube is weak, however, you can use the CR70 Emission Life Test to monitor your progress during restoring.

The shorts tests are used the same as when testing CRTs. Remove any G1 shorts with the REMOVE G1 SHORTS function before making any other tests or attempting restoration.

Then, perform the CUTOFF, EMISSION, and LIFE tests. Hold the LIFE TEST button down until the meter reading stops dropping, and note the meter reading on the FILAMENT or RESTORING CURRENT scales. Then, use these results to note any major improvements in operation during restoration. The Emission Scale of the CR70 is not linear. Therefore a small increase in the LIFE test indication may mean a large increase in beam current. Double-check the results by firing up the camera if you think the cathode current has been improved enough to return an acceptable picture. When restoring camera tubes and CRTs, you are looking for an improvement in the operation of the tube. Do not expect restored tubes to perform exactly like a brand new tube. In most cases, the amount of restoring needed to do so will severely limit the life of the tube or otherwise damage it.

Restoring

Camera tube restoration is identical to CRT restoration. Use the following guidelines for best results:

1. Be sure you have connected to the tube correctly. Remember that the switch setup for the Universal Adapter is *the same for every tube* (F1-1; F2-2; K-3; G1-4; G2-5) and that the numbers in the setup information tell you *which tube pins to connect each UA connector to. If you are not using the UA, set the switches to correspond with the pin numbers.*

2. Start with the lowest level of restoration (AUTO RESTORE). Only move up to higher levels if the tube has not responded to the lower levels.

3. If you don't get a restoring current meter reading using AUTO RESTORE, the cathode is probably very badly poisoned. Try one shot of Rejuvenation to open an area on the cathode surface, followed by the Auto Cycle restoring function.

4. After noting a major improvement in the LIFE TEST results, *double-check the operation of the tube in the camera.* The CR70 does an excellent job of restoration, but the true test of the tube's quality will have to be based on its operation in the circuit. The chances of stripping a cathode with the CR70 are slim compared to many other restorers, but stripping is possible if too much restoring is applied too many times. To reduce the risk of stripping the cathode, don't attempt to further restore the tube if the camera produces an acceptable picture.

5. Remember: *restoration cannot improve a bad target.* Problems like burned images, spots, or variations in picture intensity in particular areas of the picture indicate permanent, and non-repairable target damage. Excessive lag ("sticking") may also be caused by a bad target, although restoring a weak cathode often reduces lag.