Tube Analysis

More Accurate Method of Locating Defective Picture Tubes.

Open G_1 circuit from CRT socket to set. Leave G_2 circuit alone. (It may be assumed that regular B+ is being applied to G_2 terminal.) 4—Lift off the anode lead from the CRT. Leave it hanging, where it cannot arc to chassis. 5—Open CRT cathode return to chassis. Connect the *chassis* side of the cathode lead to negative terminal of VTVM. 6—Hook up a 1,000 ohm resistor across VTVM terminals. 7—Turn the set on.

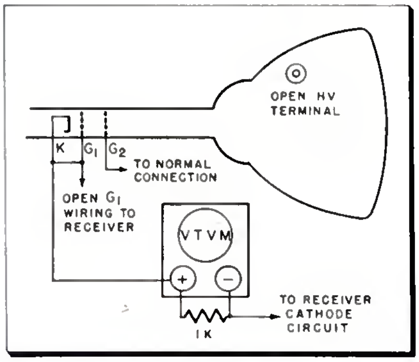

Fig. 2—Connections for CRT emission test.

Using the lowest DC voltage scale on the VTVM, read the voltage developed, but call it *milliamperes.* Thus, if the scale shows 0.76 volts, call it 0.76 mils (760 microamps). In this case, the tube would show 0.76 milliamperes of cathode emission under test.

Experimental CRT Checker

Considering this in further detail: By removing the anode lead, we've eliminated that element from the circuit. Tying the control grid to the cathode eliminates this grid's action—which leaves in the test circuit only the cathode and G_2.

The VTVM measures the voltage drop across the 1000 ohm resistor. By Ohm's Law, $E = IR$. When the resistor is 1000 ohms, the formula is $E = 1000 \times I$. Now, since I is in amperes, $1000 \times I =$ milliamperes. Therefore E (in volts) = I (in MA). For every volt, then, there will be 1 MA flowing in the CRT circuit. Thus we get the true *current* reading with a *voltmeter.*

We now have an experimental CRT checker, with which we can measure picture tube emission between cathode and G_2. Of course that emission reading is meaningless unless we have standards to compare it with. The chart in fig. 3 provides such standards.

To make a dynamic check of a cathode-ray tube, its emission should first be determined, as described above. Its cut-off bias should next be measured. To do so, proceed as follows:

With the picture tube operating normally, lower the blinds and turn off all room lights. Now, watching the raster (without signal) vary the brightness control until the screen goes completely dark. The control setting is now at cut-off. With the VTVM, measure the voltage between G_1 and cathode. Mark this down as *cut-off voltage.* It will, of course, be negative.

By inspecting the chart, it can now be readily determined in which category the tube falls. Let's consider some sample cases. Suppose a tube has an emission of .3 MA, and a cut-off voltage of —30. These two ratings intersect in a box labeled GOOD. If a tube with the same emission had a cut-off of —80 V, it would fall into the box labeled POOR.

G_1 Correlation Factor

If it is desired to avoid cutting into the circuits of the receiver to get the required readings, a simple inexpensive adaptor can be made up, much like the analyzer adaptors used in old-time radio testers, in using which a tube was removed from the set, the adaptor inserted in its place, and the tube plugged into the adaptor.

The need for making the measurements described, as well as adaptor rig-up, can be dispensed with by using one of the commercial CRT checkers available that is capable of making such a dynamic CRT analysis.

The table shown in fig. 3 was set up for tubes with a G_2 voltage of 300. If the G_2 voltage of the CRT under test is other than 300 V, the table in fig. 4 will have to be consulted. Find the G_2 voltage closest to the one actually present in the left-hand column of the table and note the *Correction Factor K* inserted next to this voltage. *The cut-off voltage and emission current of the CRT under test should both be multiplied by the K value.* The table in fig. 3 is then used, as before, to evaluate the condition of the CRT.

Sample Analysis

Let's illustrate the procedure, assuming a tube with a G_2 voltage of 335 V. Inspecting Table B, we find that the listed G_2 voltage closest to 335 V is 325 V. The Correction Factor K for this voltage value is .95. Now, suppose that the measured CRT emission averages .4 MA, and the cut-off voltage is 60 V. Multiplying each of these two values by the .95 Correction Factor changes them to .38 MA and 57 V, respectively. Since .38 MA is much closer to .4 than it is to .3, we start at the top of the .4 MA column (Table C) and move down vertically. 57 V falls between 50 and 60 V—the tube is therefore between *fair* and *poor,* and nearer to *poor* than to *fair.* If the final current value had been .35 MA, we would have determined the tube's "dynamic merit" at .3 MA, then found what it was at .4 MA. Its actual "dynamic merit" would have been about midway between the two.

(EDITOR'S NOTE: Several cathode-ray tube engineers have added some ifs, ands, and buts to the writer's basic thesis that "if two tubes have the same cathode emission, the one with the lower cut-off bias is the better tube."

The engineers say: "Of two picture tubes having the same emission, the one with low cut-off bias has higher modulation sensitivity and is therefore better on weak signals, but is limited in light output capability; the one with the high cutoff bias requires more grid drive, but when adequate signal is available, greater light output will be obtained. Any appreciable drop in emission and consequent reduction in brightness will be more noticeable in a high cutoff tube than in a low cutoff tube.")

Table B
CUT-OFF VOLTAGE
Correction Factor K

G_2 voltage	K
150	2.0
175	1.6
200	1.5
225	1.3
250	1.2
275	1.1
300	1.0
325	0.95
350	0.85
375	0.80
400	0.75
425	0.70
450	0.65

(COURTESY OF ELECTRONIC BEAM CORP.)

Fig. 4—Correcting for different G_2 voltages.