Quality Testing of Cathode Ray and TV Tubes

A Cathode Ray Tube Gun consists of a heater or filament (F), used to heat and activate the cathode (K), which releases electrons from the cathode coating material. These negative electrons are accelerated and formed into a beam or stream by the G 2 and A 2 electrodes, focussed by either an external magnetic focussing coil or the electrostatic focussing of the A1 electrode. The testing of a cathode ray tube consists of measuring the effectiveness and control of this electron stream, the measurement of leakages between elements, and the testing of the roundness, size and intensity of the focussed spot on the tube face.

In normal tube operation the electron stream emission from the cathode is limited and controlled by a negative voltage (bias) on the first grid, or G 1, which has a small aperture thru which the electron stream must pass. Without voltage on A 2, the side button HV anode connection, this emission is collected by the Grid 2, and thus emission can be read by a meter placed in the lead to G 2, connected to a voltage of from 75 to 500 volts, depending on normal grid 2 voltage for the particular tube type. Emission currents will run up to 2.5 milliamperes, but the criterion of quality here is emission versus cut-off. Cut-off is defined as the negative voltage on G 1 necessary to cut off, or extinguish, all light trace on the tube face- or more accurately to extinguish a focussed spot. In testing without lighting up the tube, cut-off is determined by varying the cut off or bias control volts on G 1, so that emission as read on the emission meter drops to zero, or no emission- and at this point the bias volts is read on the cut-off meter, AND 10 VOLTS IS ADDED to this bias voltage to make it equal to visual cut-off.

Charts are available which show the minimum acceptable emission for any specific cut off voltage- or vice versa, for any specific emission, the highest acceptable cut-off voltage.

General quality of a cathode can be determined by the fact that the emission, at zero bias, will rise fast- the meter will move relatively quickly- and to a point well above the minimum passing limits.

"Slow warm-up" defines the time it takes for the cathode to reach a specified emission point, usually .5 MA. This is a measure of cathode efficiency, or cathode quality factor. A good tube warms up to .5 MA in less than 30 seconds and this is frequently used as a time standard.

If Grid 1, normally negative, is made positive with respect to the cathode, large currents will flow to it, instead of to G 2 or A 2. These very heavy currents "age" or boil out or activate the cathode surface coating very rapidly, and this is sometimes used in processing a tube. It must be remembered however, that only the small area under the Grid 1 aperture is useful in creating the electron beam- and all the emission to Grid 1 is not necessarily relevant. Low voltages of 5 to 15 volts positive are safely used, but only for limited periods of time, or the cathode coating can be harmed. Higher voltages for "sparking" activating are not approved by most manufacturers.

Leakages or resistance paths between the different gun elements are necessary measurement items. There are many causes for such leakages, including foreign materials and dirt, dag, phosphor and getter materials, on the insulating pillars of the gun commonly, sometimes in the base or around the stem leads.

These leakages are measured by using a source of 150 volts approx. in series with a sensitive meter, and measuring the leakage current that results if there is leakage between the two elements measured. G1 leakage is measured to the cathode, with G 1 always negative. Leakage between the heater and the cathode is measured first with cathode negative, then with cathode positive with respect

to the heater. The meter here is 100 or 120 microamps DC (.0001 A full scale), and leakage limits are frequently 15 or 30 microamps. G 2 leakage is unusual, but will be indicated by the fact that the G 2 emission meter will not go to zero, even when the tube has high negative bias (is cut-off).

Under normal conditions the VTVM (vacuum tube voltmeter) which represents the gas ratio and 100 microamp leakage meter, will be zero at all positions of the selector switch. However, high humidity will affect wiring and components of these sensitive circuits, and under these conditions, if you wish to establish exact limits of a particular measurement, zero can be re-set at any position of the selector switch before testing the tube for that particular measurement, and then readings will be exact.

The quick neon lamp check is used for preliminary indications of high leakages or shorts between elements, cathode, grid 1, and heater. A good tube will rectify, (change to DC) the 150 volts AC impressed on the cathode, while grid 1 and heater are grounded. A neon lamp in series with this cathode will show ONE SIDE of the two elements lit cleanly, showing only DC, and likewise a neon lamp in the grid 1 lead will also show only one half of the lamp clearly lit, and the other side dark. However, a short or leakage will allow the AC to leak past the rectifying action of the electron stream, and lite the other side of the G 1 lamp, or various combinations of leakages may make lamps go out. ANYTHING DIFFERENT than one side of each lamp lit indicates trouble.

When Hi voltage, 15,000 V nominal, is impressed on the anode 2 button, there is no electron flow to G 2, and emission can only be read by a meter in the A 2 lead, or in the cathode return lead.

Gas Ratio is an arbitrary formula for measuring the degree of vacuum in a tube. The exact formula is

$$\text{GAS RATIO} = \frac{\text{Gas Current in microamps}}{\text{Beam current in milliamps}}$$

To make it unnecessary to divide one number by another, the Gas Ratio meter has been calibrated WITH the beam current (or emission current) set at .5 Milliamp. Therefore, if the emission is set at .5 on the scale, the gas ratio can be read directly as per the scale, 0 to .5 etc. Leakage will also be read on the gas current VTVM meter, but a simple check is to set the cut-off voltage to some high point where there is no emission or beam current. Then if the gas meter still has a reading, this is not caused by ions from the electron beam, and is therefore not gas. Any reading now is leakage, usually on the outside of the glass envelope, around the button. Sometimes hard rubbing with carbon tetrachoride is necessary to remove such leakage.

A perfectly made and aligned electron gun will focus, bring to a point, the electron stream at the phosphor coating, not only in the center of the tube, but equally perfect at all points of the tube face when deflected by the yoke. Average guns normally do not reach this degree of perfection, the spot can suffer from distortion and astigmatism (the focussing in one plane differing from another another), may be oval, diamond shaped, etc., instead of round.

Models 103 and 1021 Dot Generators are used for quality focussing and gun design problems.

Write for further information on any cathode ray tube test problem, and for complete lists of testing and automatic processing equipment to

RESEARCH INDUSTRIAL LABS. Roslyn, Pa.