

Cathode Ray Tubes (CRT)

A variation of the vacuum tube that is widely used in oscilloscopes and television monitors is the *cathode ray tube (CRT)*, diagrammed in **Fig 1**. The CRT has a cathode and grid much like a triode tube. The plate, usually referred to as the *anode* in this device, is designed to accelerate the electrons to very high velocities, with anode voltages that can be as high as tens of thousands of volts. The anode of the CRT differs from the plates of other vacuum tubes, since it is designed as a set of plates that are parallel to the electron beam. The anode voltage accelerates the electrons but does not absorb them. The electron beam passes by the anode and continues to the face of the tube. The cathode, grid and anode are all located in the neck of the CRT and are collectively referred to as the *electron gun*.

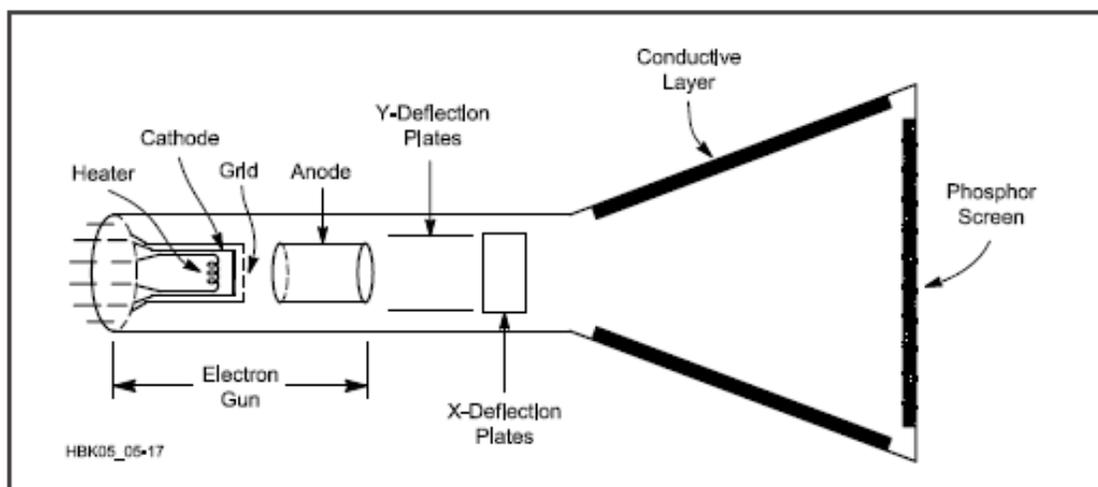


Fig 1 — Cross section of CRT. The electron gun generates a stream of electrons and is made up of a heater, cathode, grid and anode (plate). The electron beam passes by two pairs of deflection plates that deviate the path of the beam in the vertical (y) direction and then the horizontal (x) direction. The deflected electron beam strikes a phosphor screen and causes it to glow at that spot. Any electrons that bounce off the screen are absorbed by the conductive layer along the sides of the tube, preventing spurious luminescence.

The electron beam is deflected from its path by either magnetic deflectors that surround the yoke of the tube or by electrostatic deflection plates that are built into the tube neck just beyond the electron gun. A CRT typically has two sets of deflectors: vertical and horizontal. When a potential is applied to a set of deflectors, the passing electron beam is bent, altering its path. In an oscilloscope, the time base typically drives the horizontal deflectors and the input signal drives the vertical deflectors, although in many oscilloscopes it is possible to connect another input signal to the horizontal deflectors to obtain an X-Y, or vector, display. In televisions and some computer monitors the deflectors typically are driven by a raster generator. The horizontal deflectors are driven by a sawtooth pattern that causes the beam to move repeatedly from left to right and then retrace quickly to the left. The vertical deflectors are driven by a slower sawtooth pattern that causes the beam to move repeatedly from top to bottom and then retrace quickly to the top. The relative timing of the two sawtooth patterns is such that the beam scans from left to right, retraces to the left and then begins the next horizontal trace just below the previous one.

Beyond the deflectors, the CRT flares out. The front face is coated with a phosphorescent material that glows when struck by the electron beam. To prevent spurious phosphorescence, a conductive layer along the sides of the tube absorbs any electrons that reflect off the glass.

Vector displays have better resolution than raster scanning. The trace lines are clearer, which is the reason oscilloscope displays use this technique. It is faster to fill the screen using raster scanning, however. This is why TVs use raster scanning.

Some CRT tubes are designed with multiple electron beams. The beams are sometimes generated by different electron guns that are placed next to each other in the neck of the tube. They can also be generated by splitting the output of a single electron gun into two or more beams. Very high quality oscilloscopes use two electron beams to trace two input channels rather than the more common method of alternating a single beam between the two inputs. Color television tubes use three electron beams for the three primary colors (red, green and blue). Each beam is focused on only one of these colored phosphors, which are interleaved on the face of the tube. A metal shadow mask keeps the colors separate as the beams scan across the tube.