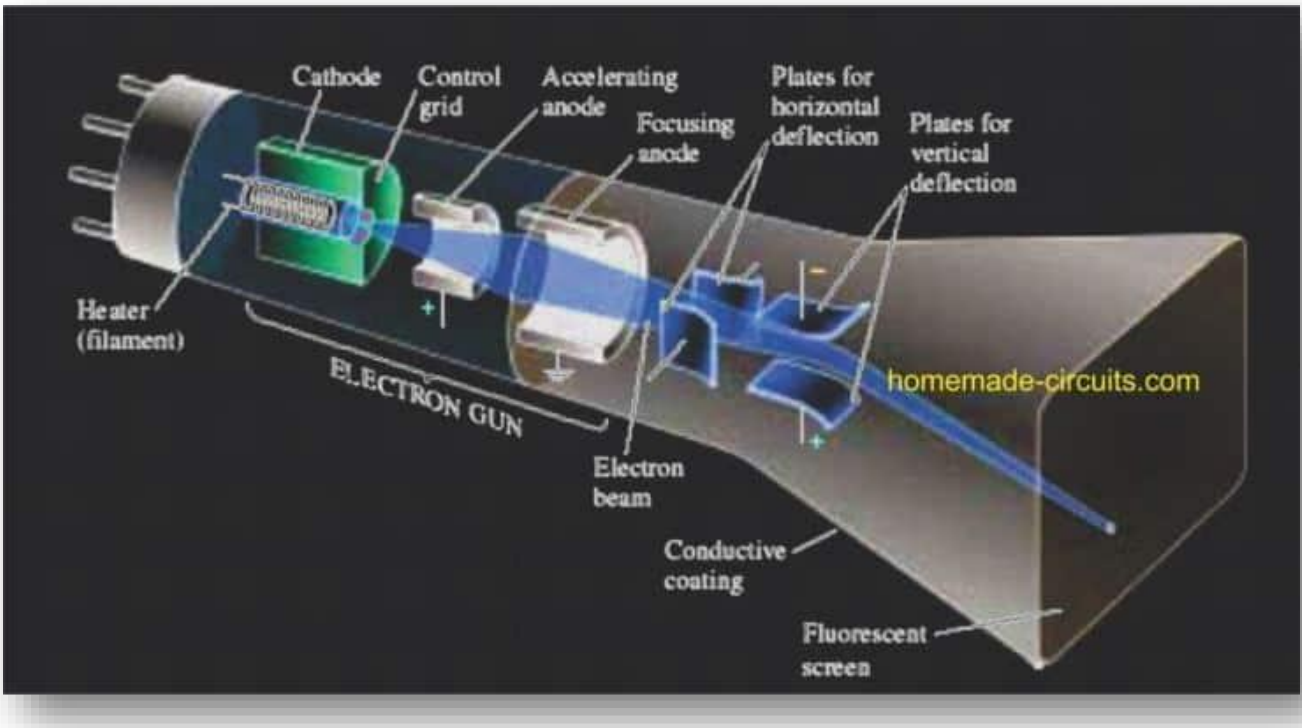
CATHODE RAY OSCILLOSCOPE



INDEX

INTRODUCTION

An **oscilloscope** (informally a **scope**) is an electronic test equipment that graphically displays varying electrical voltages as a two-dimensional plot of one or more signals as a function of time. The primary purposes are to display repetitive or single waveforms on the screen that would otherwise occur too briefly to be perceived by the human eye. The displayed waveform can then be analyzed for properties such as amplitude, frequency, rise time, time interval, distortion, and others. Originally, calculating these values required manually measuring the waveform against the scales built into the instrument's screen. Modern digital instruments may calculate and display these properties directly.

Early high-speed visualizations of electrical voltages were made with an electro-mechanical **oscillograph**. These were superseded by the oscilloscope, which used a cathode ray tube (CRT) as its display element, often referred to as Cathode Ray Oscilloscopes - CROs. CROs were later largely superseded by the digital storage oscilloscope (DSO) with thin panel displays, fast analog-to-digital converters, and digital signal processors. These can have integrated displays or an electronic module, sometimes known as a digitizer, which feeds into a general-purpose computer to process, display, and record waveforms.

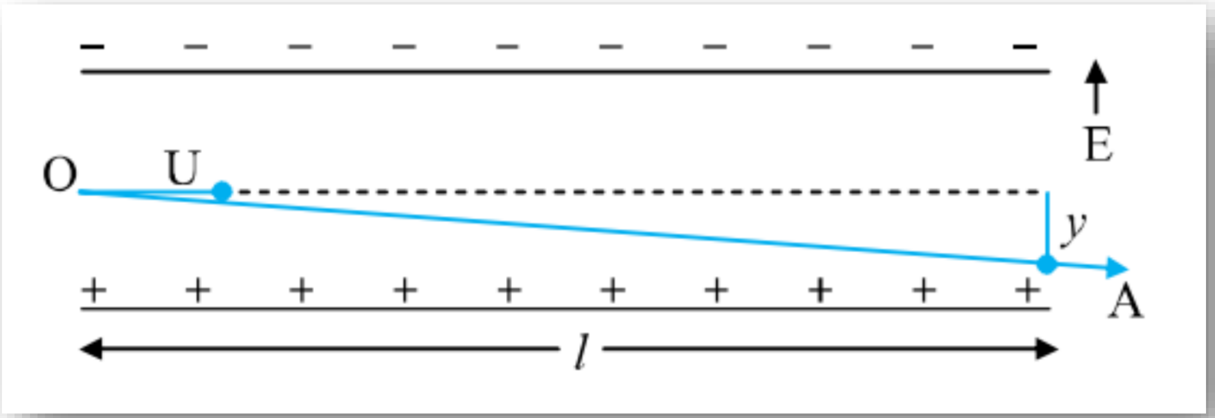
QUESTION

An **oscilloscope** is an electronic test equipment that graphically displays varying electrical voltages as a two-dimensional plot of one or more signals as a function of time. These signals are sometimes created by electrons emitted from a cathode at a high temperature. These electron beams thus made are called cathode rays and achieve a Kinetic Energy, K, till they reach the deflecting plates.

The manipulation of the electrons is done so that after the electron passes through the x and y deflection plates, we get the exact waveform of an unknown function on the phosphorescent screen in front of it.

Design a way to achieve this objective.

<u>SOLUTION</u>



Let the length of the deflection plates be ‘l’. And we set up the model as per the diagram above. As the plates are horizontal, the electric field will be vertical, and as the electron is a charged particle, it will cause deflection in the y-direction.

From Coulomb’s Law, we know that,

$$F=qE$$

The force will act in the downward direction, causing the electron to move in a curved path and get displaced in the y-direction. As no force acts in the x-direction, the electron continues uniform motion.

$$a_x=0 \qquad \text{and,} \qquad a_y=\frac{F}{m}$$

where m is the mass of the electron.

Applying the II equation of motion in the y-direction,

$$s_y=\frac{1}{2}at^2$$

where t is the time taken by the electron to cross the plate. This will depend on its motion in the x-direction, and as it is a uniform motion, then

$$t = \frac{l}{v}$$

So,

$$s_y = \frac{1}{2}\frac{qE}{m}\left(\frac{l}{v}\right)^2$$

For v, it is given that the kinetic energy of the electron just before entering the deflection plates is K

So, $K = qV = \frac{1}{2}mu^2$ (From the work-energy theorem in electrostatics)

$$u^2 = \frac{2qV}{m}$$

where u is the electron's velocity and V is the potential difference between the anode and the cathode from where the electron originated.

So our deflection in the y-direction becomes,

$$y = s_y = \frac{l * l * E}{4V}$$

Similarly, if we do this for the x-deflection plates, then we get a similar result

$$x = s_x = \frac{l * l * E}{4V}$$

But here, the E would be the Electric field applied on the x deflection plates.

If we use the y-deflection plates with an unknown varying Electric Field (whose waveform is to be determined). We take the Electric field from standard equipment in a lab called the Function generator to create a Sawtooth Sweep function.

The Sawtooth Sweep Electric field function will force the electric field to travel from negative to zero to positive, causing the beam to travel from the left side of the screen to the center and the right side of the screen.

Thus according to the above setup, we will get the waveform of the unknown function efficiently on the phosphorescent screen, and it can be studied for its frequency, time period, wavelength, etc.

The above model finds its uses in various fields, like Television and computer industry, radar technology, etc.

s

SOURCES

Introduction- Wikipedia- Oscilloscope - Wikipedia

The picture on the title page- Cathode Ray Oscilloscopes - Working and Operational Details - Homemade Circuit Projects (homemade-circuits.com)