CRO

Mainly consists of CRT (Cathode Ray tube).

main components of CRT.

(i) Electron Gun.

(ii) Deflecting plates.

(iii) Screen of CRO

Electron Gun consists of

(i) heater element.

(ii) Cathode

(iii) Control grid

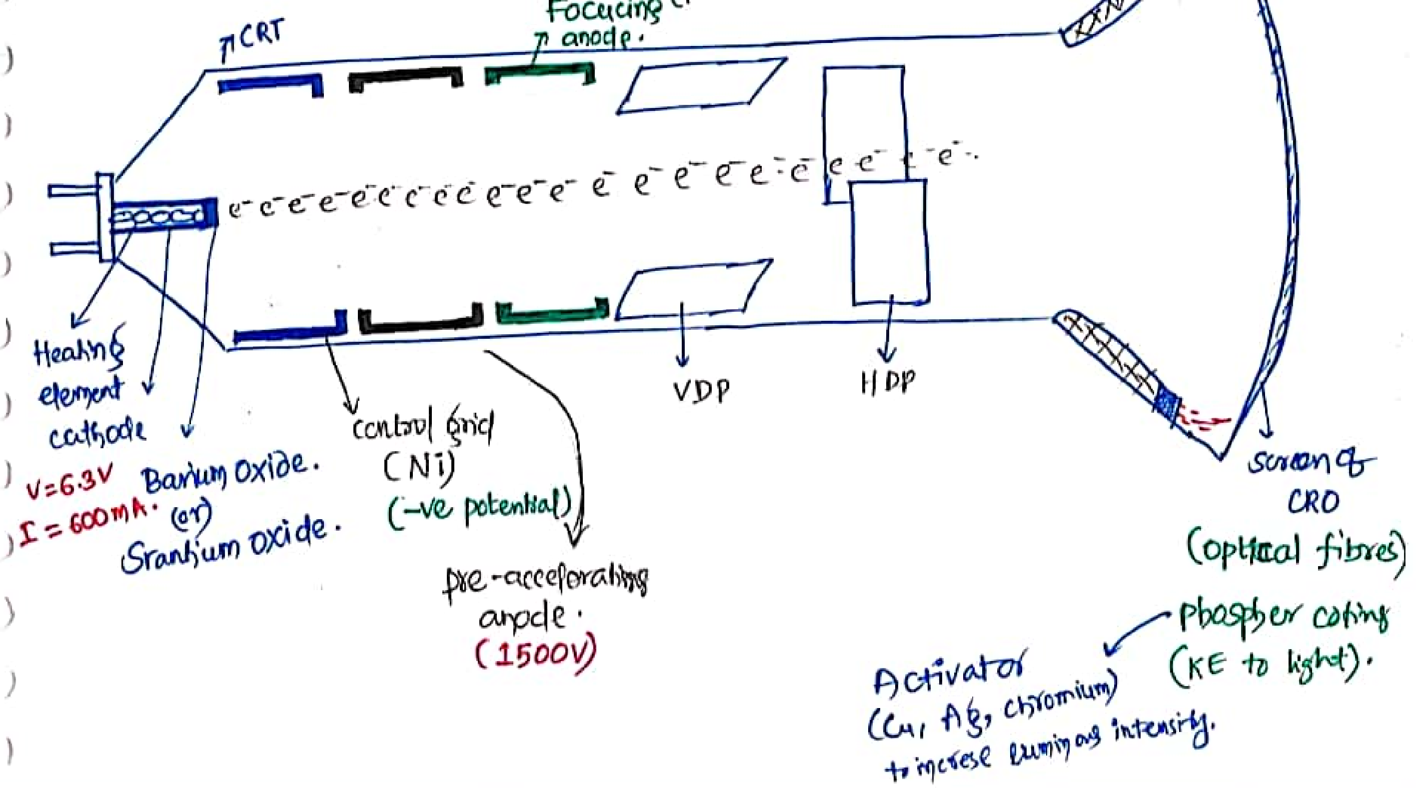
(iv) pre & post accelerating anode.

(v) Focusing anode.

There are two types of deflecting plates

(i) Horizontal deflecting plate.

(ii) Vertical deflecting plate.



$\frac{1}{2}mv^2 = KE$, $v \rightarrow$ velocity of electron.

$KE = W.D = Vq$ $\Rightarrow$ V = applied voltage , $q = e = 1.6 \times 10^{-19}$ C

$\therefore$ $v = \sqrt{\frac{2eV}{m}}$; m = mass of electron = 9.31×10^{-31} kg.

The purpose of heating element, it is used to heat-up the cathode. The required voltage is around 6.3V and the required current is around 0.6A = 600mA.

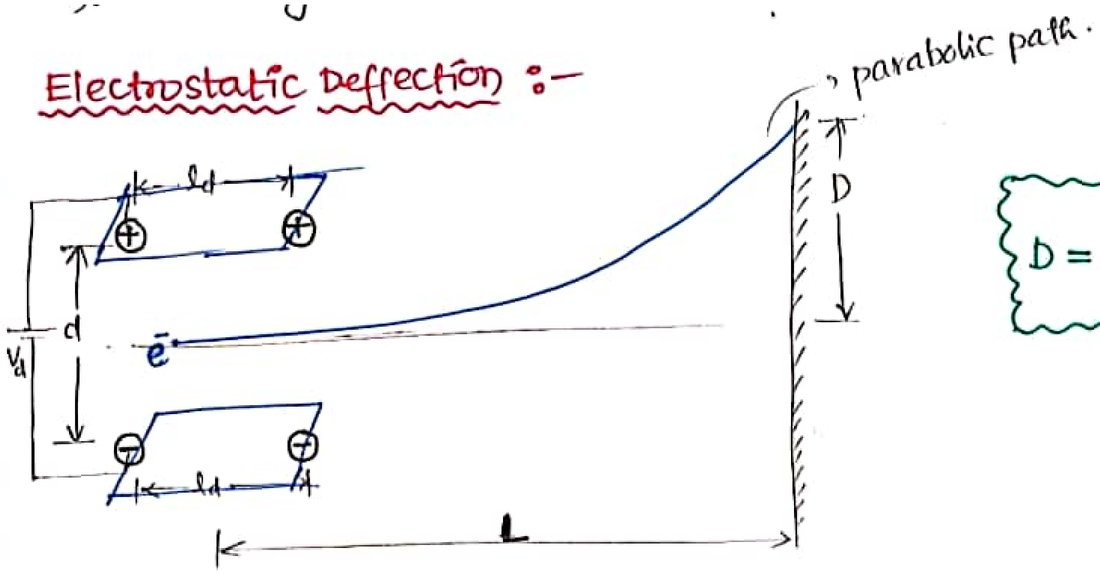
Cathode, which is cylindrical shape, at the end of which a layer of barium oxide (or) stransium oxide is deposited in order to high emission of electrons at moderate temperature.

control grid, which is in cylindrical shape usually prepared by nickel material and always connected to -ve potential, it is used to control the intensity of electron beam which is released from cathod.

pre & post accelerating anodes, these are the anodes responsible for imparting the acceleration to the electron beam. in order to maintain constant velocity. so their voltage is 1500V.

Focusing anode

Electrostatic Deflection :-



$$D = \frac{V_d L . l_d}{2 V_a d}$$

Let
- $l_d \rightarrow$ Length of the deflecting plates
- $d \rightarrow$ separation distance b/w two plates
- $D \rightarrow$ electrostatic deflection
- $L \rightarrow$ distance of screen of CRO from deflecting plates
- $V_d \rightarrow$ potential difference b/w the two deflecting plates.
- $V_a \rightarrow$ accelerating potential.

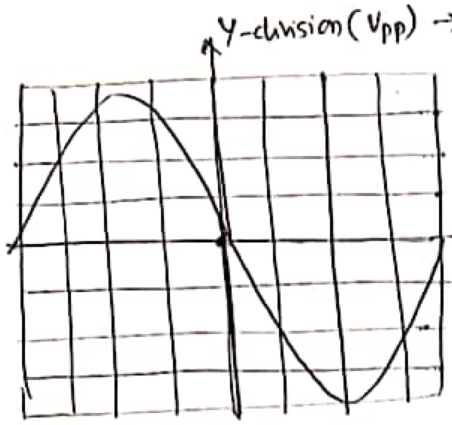
$$S\ (\text{Sensitivity}) = \frac{\Delta O/P}{\Delta I/P} = \frac{D}{V_d} = \frac{L l_d}{2 d V_a}$$

Deflection-factor = Scaling factor = $\frac{1}{\text{Sensitivity}}$ = Inverse sensitivity

$$DF = \frac{\Delta I/P}{\Delta O/P} = \frac{V_d}{D} = \frac{2 d V_a}{L l_d}$$

Measurements by CRO

1. **Voltage measurement** :-



$V_p = V_m = \sqrt{2} V_{Rms}$

$V_{pp} = 2V_p = 2\sqrt{2} V_{Rms}$

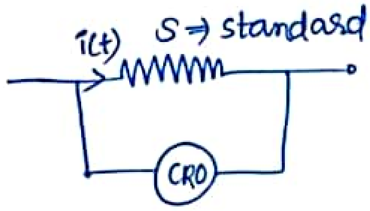
$\therefore V_{Rms} = \frac{V_{pp}}{2\sqrt{2}}$

CRO is voltage control device, it never display the current waveform.

CRO cannot measure the current directly but we can measure the current indirectly

(2) **current measurement,**

The current waveform is passed through known standard resistance and observe the voltage waveform across standardar resistance.



$I_{Rms} = \frac{V_{Rms}}{S} = \frac{V_{pp}}{2\sqrt{2} S}$

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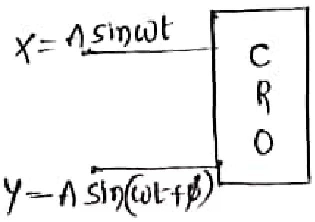
The input impedance of CRO is in the order of 10 MΩ so that loading effect of CRO is negligible.

$Z_{i/p}$

1. Ordinary voltmeter ⇒ KΩ
2. CRO ⇒ 10MΩ
3. Modern multimeter ⇒ (10–40MΩ) → Loading effect is almost negligible. (preferred choice of volt measurement 37271).

3. Phase angle measurement

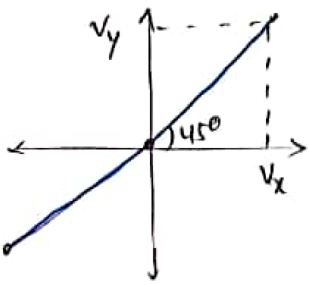
By operating CRO in dual mode (or) X-Y mode we can measure the phase angle for that the two sinusoidal signals are having equal amplitude but having a phase difference given to the X-& Y -Channels of CRO so that we can obtain the pattern on the CRO screen is known as lissajous patterns.



case(i) $\phi = 0°$

$X = A\sin\omega t$

$Y = A\sin(\omega t + 0) \Rightarrow Y = X = mX.$



$\therefore \tan\theta = m = \text{slope} = 1$

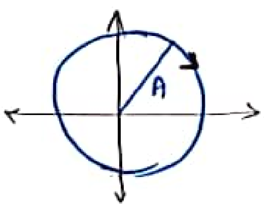
$\therefore \theta = 45° = \text{phase angle}.$

case(ii) :- $\phi = 90°$; $X = A\sin\omega t$

$Y = A\sin(\omega t + 90°) = A\cos\omega t$

$X^2 + Y^2 = A^2$ (circle).

radius = A.



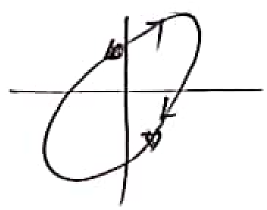
case(iii) :- $\phi = (0° \text{ to } 90°) = 30°$

$X = A\sin\omega t \Rightarrow A\cos\omega t = \sqrt{1-x^2}$

$Y = A\sin(\omega t + 30°) = A(\sin\omega t\cos 30° + \sin 30°\cos\omega t)$

$Y = \frac{A}{2}(\sqrt{3}\sin\omega t + \cos\omega t)$

$Y = \frac{1}{2}(\sqrt{3}X + \sqrt{1-X^2})$



$\left(Y - \frac{\sqrt{3}}{2}X\right) = \sqrt{1-x^2} \Rightarrow Y^2 - \frac{3}{2}X^2 - 2\sqrt{3}XY = 1 - x^2$

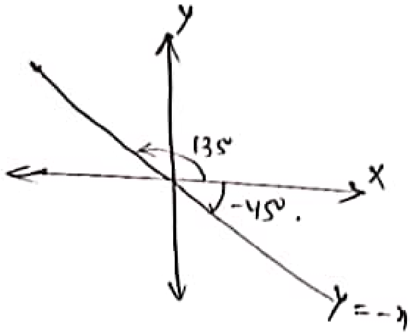
$Y^2 - \frac{X^2}{2} - 2\sqrt{3}XY = 1$ (ellipse).

Case (IV) :- $\phi = 180^\circ$

$x = A\sin\omega t$

$y = A\sin(\omega t + 180^\circ) = -A\sin\omega t$

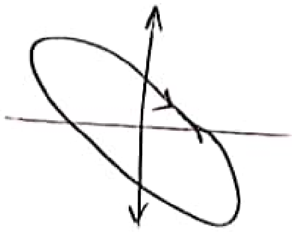
$y = -x$



Case (V) :- $\phi = (90^\circ \text{ to } 180^\circ) = 120$ (say)

$x = A\sin\omega t$

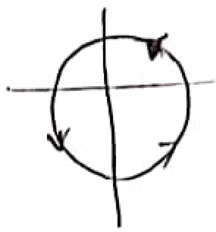
$y = A\sin(\omega t + 120^\circ) \Rightarrow$ (ellipse)



Case (VI) :- $\phi = 270^\circ$

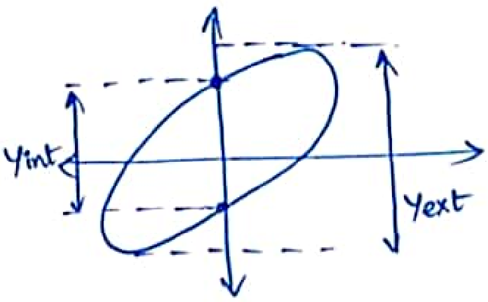
$x = A\sin\omega t$

$y = A\sin(\omega t + 270^\circ) = -A\cos\omega t.$



anticlockwise;

Note :- If the phase angle is lieing in b/w 0° to 180° the direction rotation of pattern is in clockwise. If the phase angle is lieing in b/w 180° to 360° the direction of rotation of pattern is in the anti-clockwise.



$$\phi = \pm\sin^{-1}\left(\frac{Y_{int}}{Y_{ext}}\right)$$

+ → CW (Clock-wise)

− → CCW (anti-clock)

4. Measurement of frequency

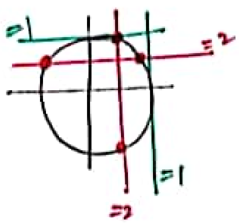
$f_x \Rightarrow$ Known signal frequencies;

$f_y \Rightarrow$ Unknown signal frequencies;

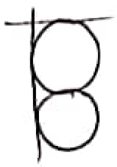
LP → Lissajous figure

$$\frac{f_y}{f_x} = \frac{\text{Max no. of horizontal tangents drawn to L.P.}}{\text{Max no. of vertical tangents drawn to L.P.}} \quad \text{(or)}$$

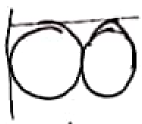
$$= \frac{\text{max. no. of horizontal intersections drawn to L.P}}{\text{Max no. of vertical intersections drawn to L.P.}}$$



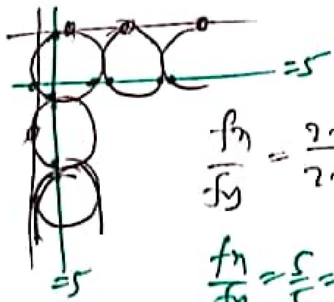
$\Rightarrow \frac{f_x}{f_y} = \frac{1}{1}$ (or) $\frac{2}{2}$



$\frac{f_x}{f_y} = \frac{2}{1}$



$\frac{f_x}{f_y} = \frac{1}{2}$



$\frac{f_x}{f_y} = \frac{2.5}{2.5} = 1$

$\frac{f_x}{f_y} = \frac{5}{5} = 1$

∴ $V_o = (1)\left(\overline{1592 + 177}\right)$

21.17. Basic CRO Circuits. Fig. 21.27 shows a block diagram of a typical oscilloscope. In the following few pages, we describe the basic circuitry of cathode ray scilloscope.

1. Vertical (Y) Deflection System. The signals to be examined are usually applied to the vertical or Y deflection plates through an input attenuator and a number of amplifier stages. Vertical amplifier is required because the signals are not strong enough to produce measurable deflection on the CRT screen. The amplifier response must be wide enough to pass faithfully the entire band of frequencies to be measured.

When high voltage signals are to be examined, they must be attenuated to bring them within the range of vertical amplifiers. The vertical amplifier output is also applied to the synchronizing amplifier through the synchronizer selector switch in the internal position. This permits the horizontal sweep circuit to be triggered by the signal being investigated.

2. Horizontal (X) Deflection System. The horizontal (X) deflection plates are fed by a sweep voltage that provides a time base. The horizontal plates are supplied through an amplifier, but they can be fed directly when voltages are of sufficient magnitude. When external signals are to be applied to the horizontal deflection system, they can also be fed through the horizontal amplifier, *via* the sweep selector switch in the external position. When the sweep selector switch is in the internal position, the horizontal amplifier receives an input from the saw tooth sweep generator which is triggered by the synchronizing amplifier.

the threshold of persistence of vision. Below this threshold limit, a moving spot is perceived. On the other hand, the comparatively rapid movement of spot will appear as a thin and dim line, or may be invisible. Thus if the retrace or flyback time is very small, the spot remains invisible. In an ideal case the flyback time, T_r is zero and hence the spot while moving from right to left remains invisible. However in actual practice the flyback time is not zero and therefore the retrace (moving of beam from right to left *i.e.*, its starting point) may cause confusion. Thus the retrace should be eliminated or blanked out. The retrace is blanked out by applying a high negative voltage to the grid during the flyback period T_r. The blanking voltage is usually developed (or triggered) by sweep generator.

5. **Intensity (Z-Axis) Modulation.** Intensity modulation (Z-axis modulation) is done by inserting a signal between the ground and the cathode (or control grid). Z axis modulation is applied during normally visible portion of the trace.

The Z-axis modulation can be used for brightening the display. Periodic positive pulses are applied to the grid (alternatively negative pulses are applied to cathode) to brighten the beam during its sweep period. These periodically brightened spots may be used as markers for time calibration of the main waveform.

6. **Positioning Controls.** It is necessary to provide some means of positioning the trace on the screen. The positioning of the trace is done by applying small independent, internal d.c. voltages to the deflecting plates and control can be exercised by varying the voltage with help of potentiometers.

7. **Focus Control.** As mentioned earlier, the focusing electrode acts like a lens whose focal length can be changed. This change can be brought about by changing the potential of the focusing anode.

8. **Intensity Control.** The intensity of the beam is varied by the Intensity control potentiometer which changes the grid potential with respect to cathode. The grid potential determines the amount of electrons leaving the cathode and thus controls the intensity of the beam.

9. **Calibration Circuit.** Laboratory oscillosoopes normally have an internally generated and stabilized voltage of known amplitude which is used for calibration purposes. Usually the calibrating voltage has a square waveform.

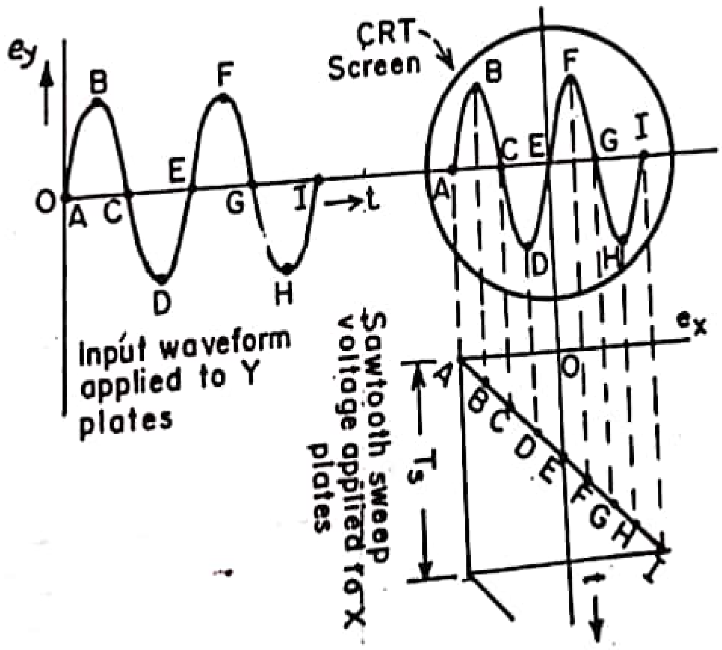


Fig. 21.29. Observation of waveform on CRO.

10. Astigmatism. In most modern oscilloscopes there is an additional focusing control marked **Astigmatism.** This is used to correct an effect which exactly is analogous to astigmatism in optical lenses. To focus the spot correctly, it is necessary to stop it near the centre of the screen by switching off the time base and adjusting the *X* and *Y* positioning controls. The spot is then made as sharp as possible by successive adjustment of focus and astigmatism controls.

21.18. Observation of Waveform on CRO. In order to observe waveform on a CRO, the waveform of voltage under test is applied to *Y* plates and a voltage obtained from a sawtooth generator is applied to *X* plates. Let us assume that the sawtooth waveform has an idealized waveshape.

When simultaneously with the horizontal sawtooth (ramp) voltage, an input voltage is applied to vertical deflection (*Y*) plates, the beam is under the influence of two forces : (*i*) one in the horizontal direction moving the beam at a linear rate from left to right, and (*ii*) second in the vertical direction moving the beam up and down. Since the deflection is proportional to the voltage applied to the deflection plates, the horizontal movement is proportional to the voltage applied to *X* plates at any instant and since the ramp voltage is linear it traces a straight line on the CRT screen. The vertical deflection is proportional to the voltage applied to the *Y* plates at any instant and thus the beam moves up and down according to the magnitude and polarity ofl the input voltage. Fig. 21.29 shows the waveform displayed on a CRT tube due to an input sinusoidal voltage.

At the end of one sweep cycle, the sweep voltage abruptly drops down and the spot is immediately transferred to its original position. The process is then repeated again, with the result, that a stationary image is seen on the screen.

For the case shown the frequency of the input voltage is twice that of sawtooth (sweep) voltage. T observe more than one cycle of the input voltage, the sweep voltage frequency has to be a submultiple of the input voltage frequency.