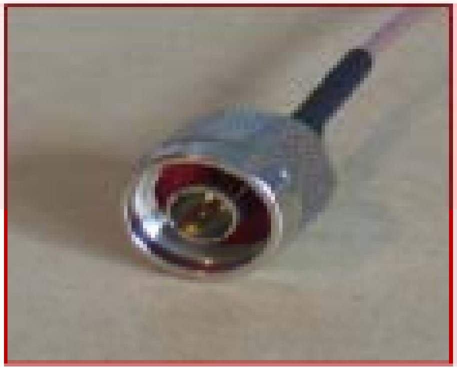
Section-A
Oscilloscope

BNC Cables

BNC Connector

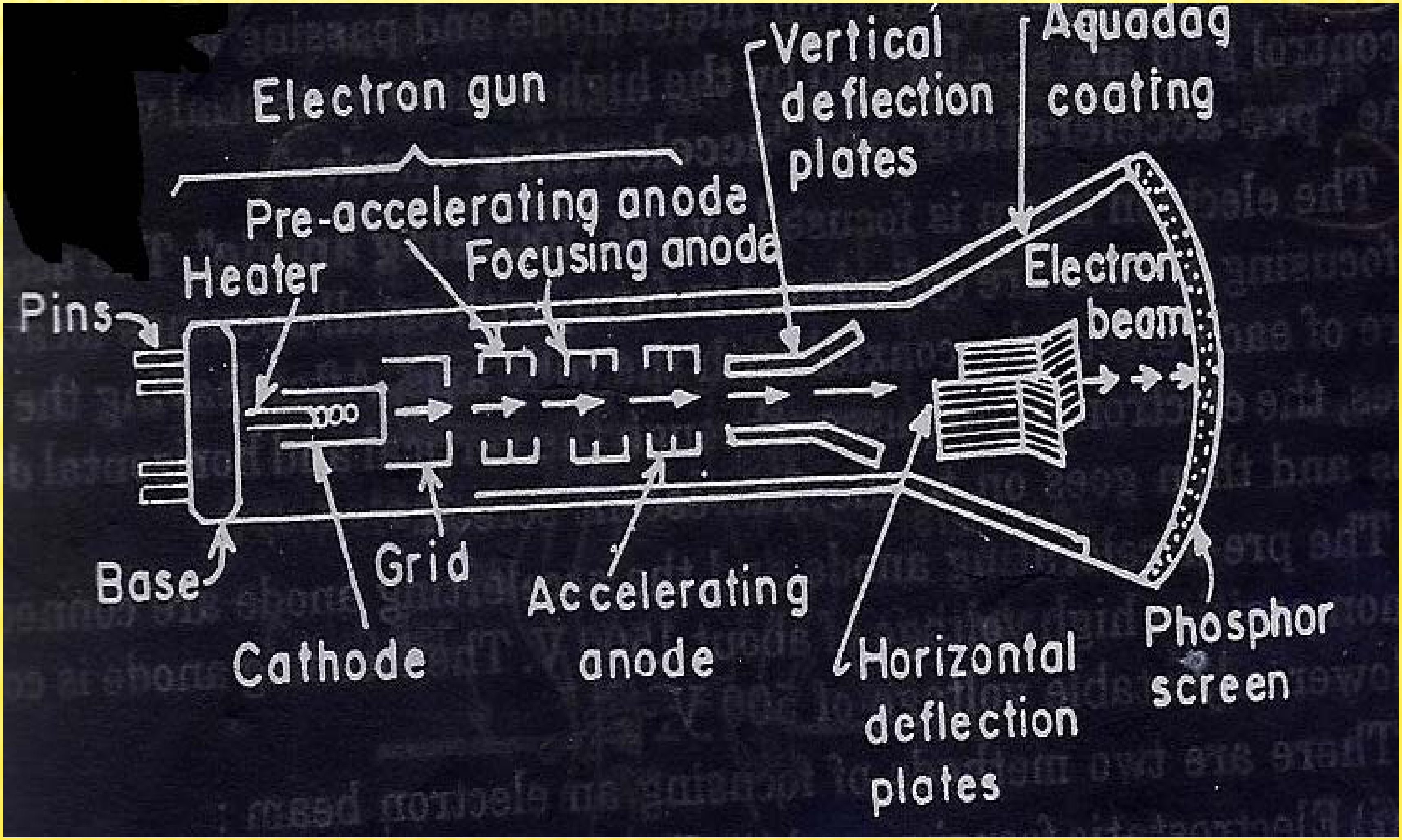


N type Connector
-For RF signal
-Capable of carrying microwave signal

Introduction

- Cathode Ray Oscilloscope (CRO) is probably the most versatile tool for the development of electronic circuits and systems.
- The CRO depends on the movement of an electron beam which is deflected on the X and Y- axis.
- Cathode Ray Tube (CRT) is the heart of the oscilloscope.
- The CRT makes the applied signal visible by the deflection of a thin beam of electrons.
- Oscilloscope can be used in any field where a parameter can be converted into a proportional voltage for observation, eg. biology and medicine.

CATHODE RAY TUBE(CRT)



CATHODE RAY TUBE(CRT)

- Main parts of CRT are-

-Electron gun assembly

-Deflection Plate assembly

-Fluoroscent screen

-Glass envelope

-Base

ELECTRON GUN ASSEMBLY

-Heater

-Cathode

-Grid

-Pre-accelerating anode

-Focusing anode

-accelerating anode

DEFLECTION PLATES

- Vertical deflection plates or Y-plates-

-mounted horizontally

- produces an electric field in the vertical plane.
- produces a vertical deflection.

DEFLECTION PLATES

- Horizontal deflection plates or X Plates-

-mounted vertically

- produces an electric field in the horizontal plane.
- produces a horizontal deflection.

SCREENS FOR CRTS

-The front of the CRT is called the face plate.

-It is flat for screens sizess upto about 100mm x 100mm,and slightly curved for larger displays.

-Face plate is formed by molten glass or fibre optics.

-Inside surface of face plate is coated with phosphor.

-phosphor converts electrical energy to light energy

SCREENS FOR CRTS

- **Cathodoluminescence:-**When an electron beam strikes phosphor crystals it raises their energy level.
- **Fluorescence:-**Light is emitted during phosphor excitation.
- **Phosphorescence or Persistance:-**When the electron beam is switched off the phosphor crystals return to their initial state ,and release a quantum of light energy..

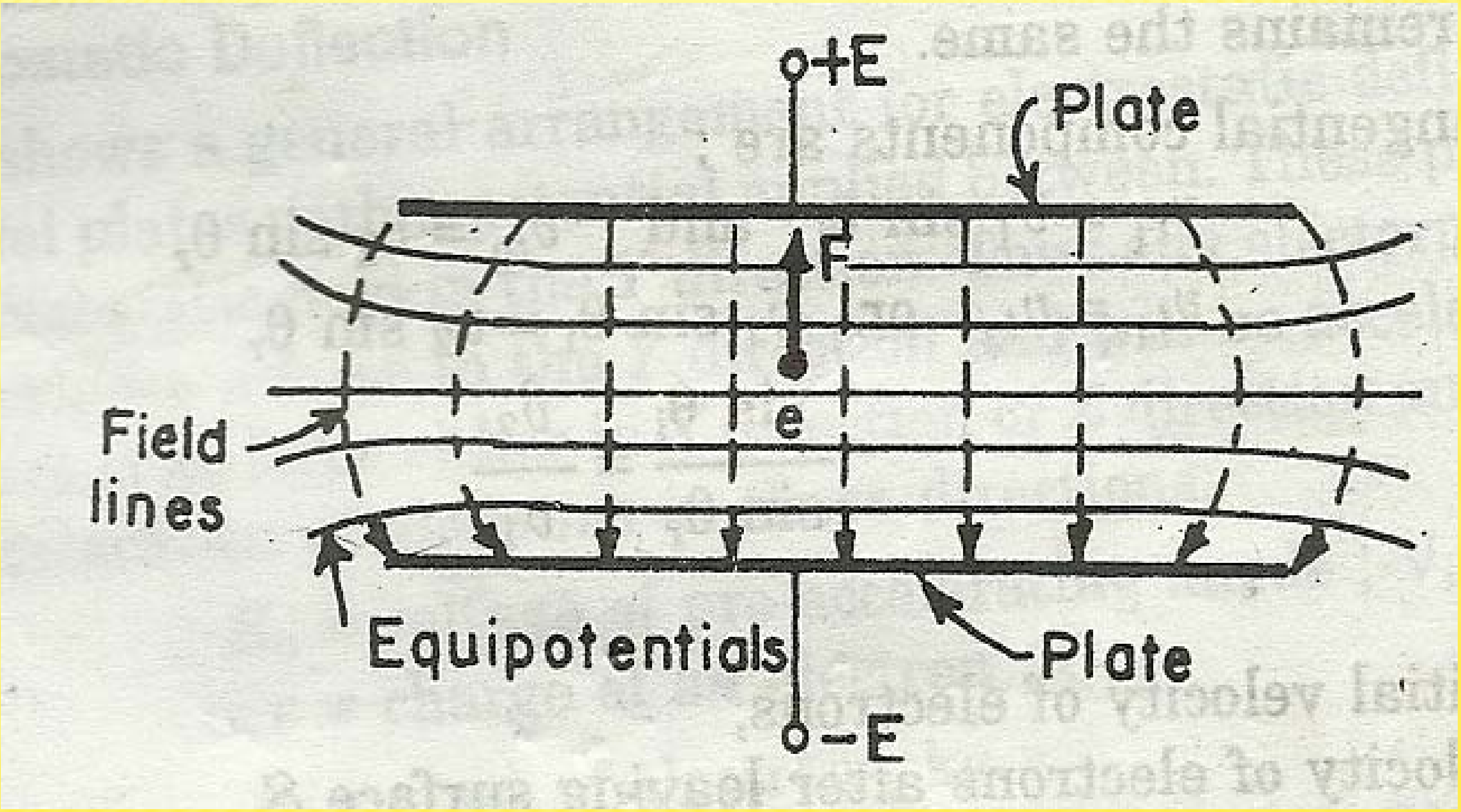
SCREENS FOR CRTS

- **P1,P2,P11,P31**-short persistence phosphors(laboratory Oscilloscopes)
- **P7 and P39-** longer persistence phosphors(Storage Oscilloscope)
- **P19,P26,P33** –Very long persistence phosphors(In Radars)

GLASS ENVELOPE & BASE

- The working parts are enclosed in an glass envelope so that the emitted electrons are able to move about freely from one end of the tube to the other.
- Base,through which connections are made to various parts.

ELECTROSTATIC FOCUSING



ELECTROSTATIC FOCUSING

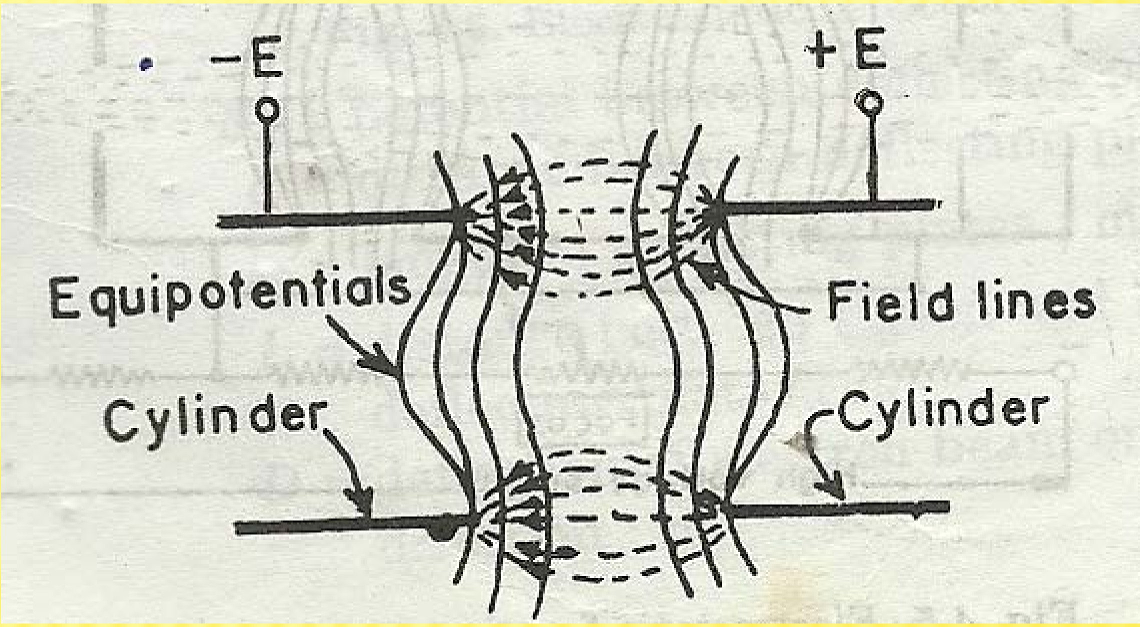
- F=-eE newton

Where e=charge on electron

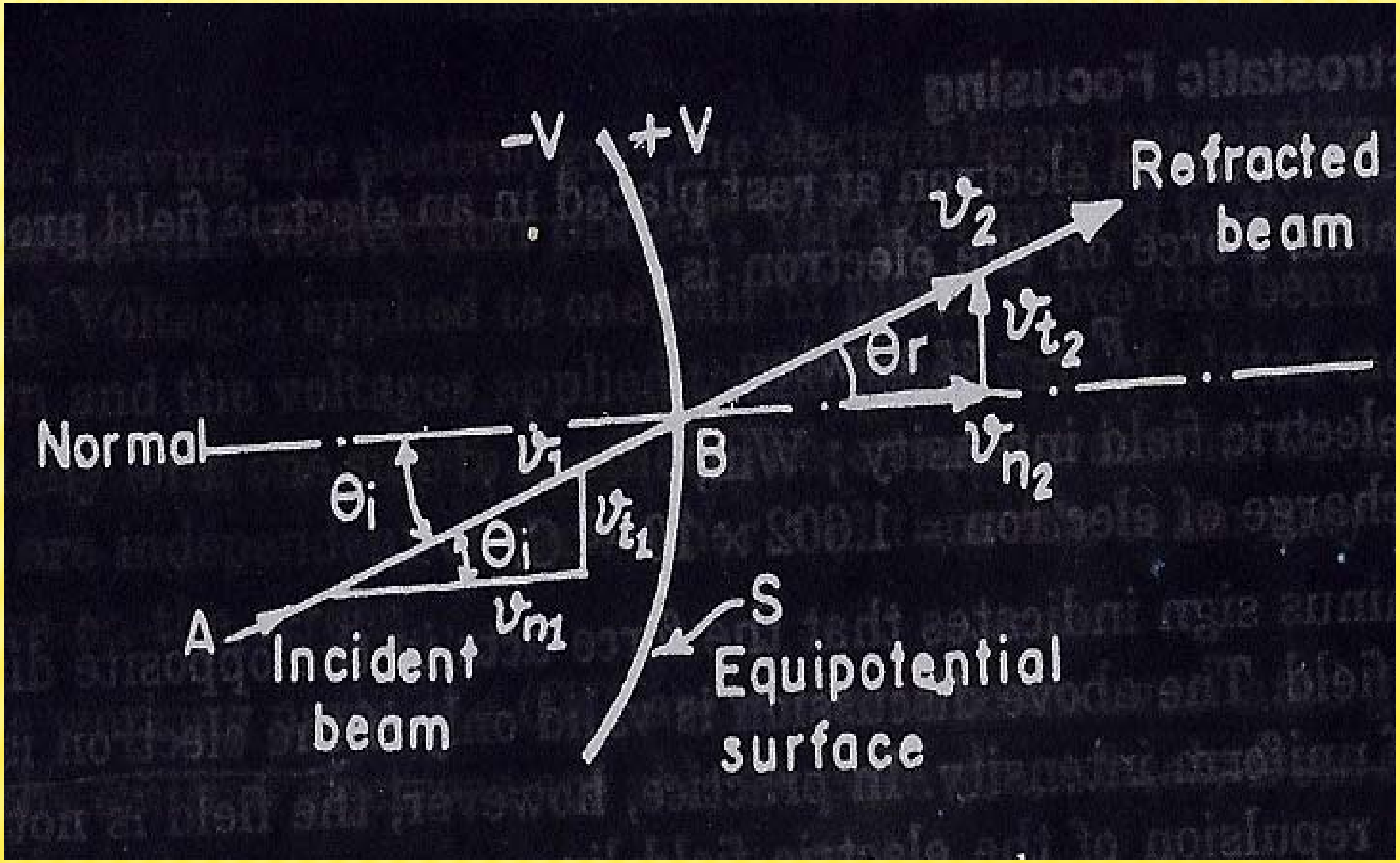
E=electric field intensity;V/m

-It is valid only if the eletron is situated in a field of uniform intensity.

ELECTROSTATIC FOCUSING



ELECTROSTATIC FOCUSING



$v_{t1}=v_1\sin\theta_i$ and $v_{t2}=v_2\sin\theta_r$

$v_{t1}=v_{t2}$ or $v_1\sin\theta_i=v_2\sin\theta_r$

$\sin\theta_i/\sin\theta_r=v_2/v_1$

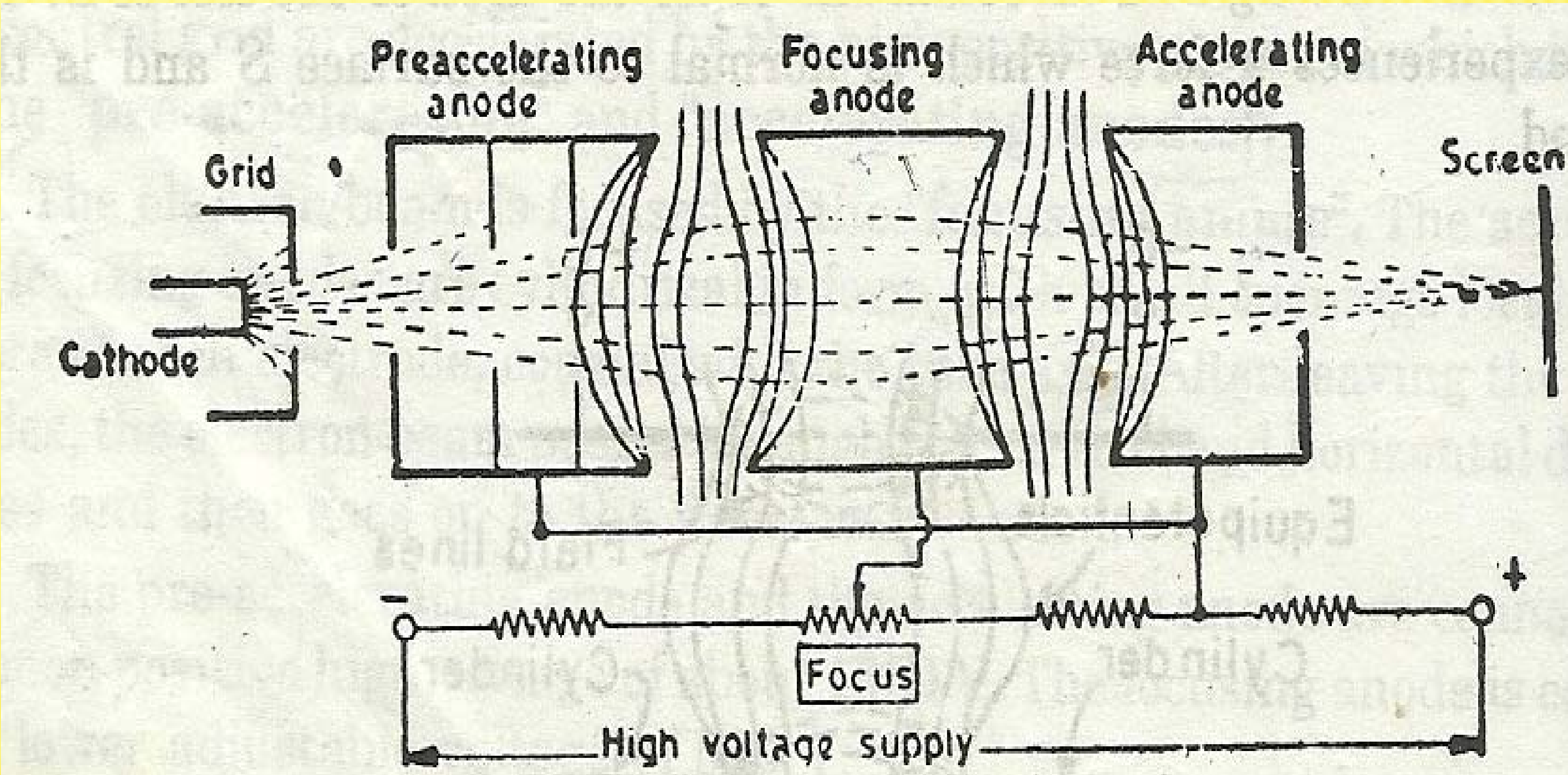
v_1=initial velocity of electrons,

v_2=velocity of electrons after leaving surface S,

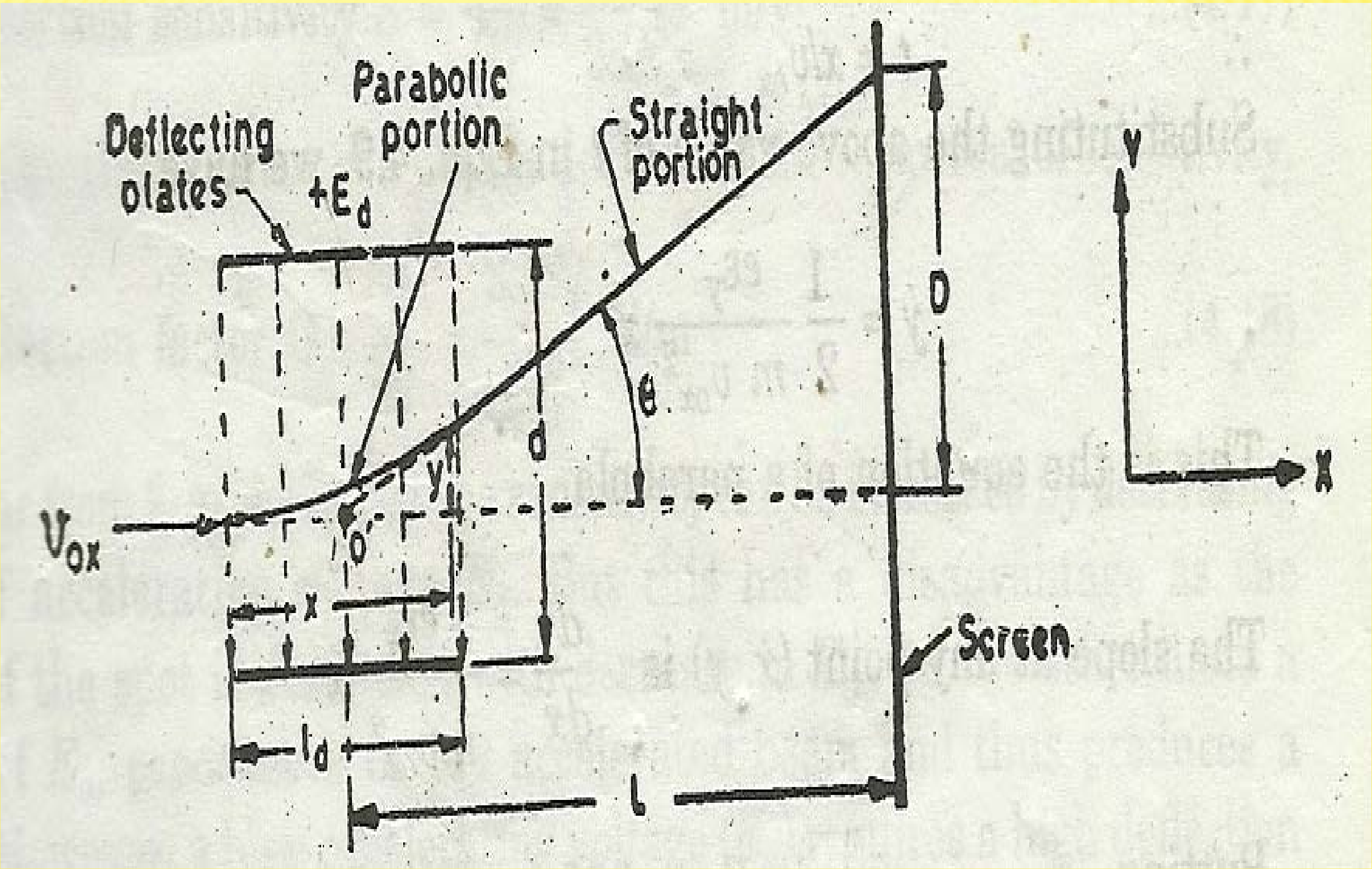
θ_i=angle of incidence,

θ_r=angle of refraction.

ELECTROSTATIC FOCUSING ARRANGEMENT



ELECTROSTATIC DEFLECTION



ELECTROSTATIC DEFLECTION

E_0 = voltage of pre-accelerating anode ; V,

e = charge of an electron ; C,

m = mass of electron ; kg,

v_{ox} = velocity of electron when entering the field of deflecting plates ; m/s,

E_d = potential between deflecting plates ; V,

d = distance between deflecting plates ; m,

l_d = length of deflecting plates ; m,

L = distance between screen and the centre of the deflecting plates ; m,

D = deflection of electron beam on the screen in Y direction ; m.

ELECTROSTATIC DEFLECTION

- The loss of potential energy when the electron moves from cathode to accelerating anode

$$P.E = eE_a \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

- The gain in K.E. by an electron

$$K.E = (1/2)mv_{ox}^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where $m = 9.109 * 10^{-31}$kg

Equating two energies,we have $v_{ox} = (2eE_a/m)^{1/2} \ldots\ldots(3)$

$$\varepsilon_y = E_d/d \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

$$F_y = e\varepsilon_y = eE_d/d \ldots\ldots\ldots\ldots\ldots(5)$$

$F_y = ma_y$

$$a_y = e\varepsilon_y /m \ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

No initial velocity in the Y direction the displacement y at any instant t in the Y direction is:

$$y = \frac{1}{2} a_y t^2 = \frac{1}{2} \frac{e\varepsilon_y}{m} t^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

As velocity in X direction is constatnt , the displacement in X direction is given by:

$$x = v_{ox}t \ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

$$\therefore t = x/v_{ox} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

ELECTROSTATIC DEFLECTION CONTD…..

- Substituting the above value of t in eqn.(7) we have:

$$Y = \frac{1}{2}\frac{e\varepsilon_y}{mv_{ox}^2} x^2 \ldots\ldots\ldots\ldots\ldots\ldots(10)$$

This is the eqn.of parabola

The slope at any pt(x,y) is $\frac{dy}{dx} = \frac{e\varepsilon_y}{mv_{ox}^2} x \ldots\ldots\ldots(11)$

putting $x = l_d$ in eqn (11),we get the value of tan θ

$$\tan\theta = \frac{e\varepsilon_y l_d}{mv_{ox}^2} = \frac{e E_d l_d}{mdv_{ox}^2} \ldots\ldots\ldots(12)$$

The straight line of travel of electrons is tangent to the parabola at $x = l_d$ & this tangent intersects the X-axis at pt O' .The location of this point is given by:

$$x = \frac{y}{\tan\theta} = \frac{e\varepsilon_y l_d^2}{2\, mv_{ox}^2} / \frac{e E_d l_d}{mv_{ox}^2} = ld\ /2 \ldots\ldots\ldots(12)$$

The deflection D on the Screen is given by:

$$D = L\tan\theta = \frac{Le\, E_d l_d}{mv_{ox}^2} \ldots\ldots\ldots\ldots\ldots\ldots(13)$$

Substitute the value of $v_{ox}^2 = 2e\, Ea/m$ in eqn.(13) we get:

$$D == \frac{L\, l_d E_d}{2d\, E_a} \ldots\ldots\ldots\ldots\ldots\ldots(14)$$

ELECTROSTATIC DEFLECTION

Deflection Sensitivity:-The deflection sensitivity of a CRT is defined as the deflection of the screen per unit deflection voltage.

$$S=D/E_d=Ll_d/2dE_a \text{ m/V}$$

Deflection Factor:-It is reciprocal of sensitivity.

$$G=1/S=2dE_a/Ll_d \text{ V/m}$$

ASSIGNMENT

Q.Explain electrostatic deflection in detail.

POST DEFLECTION ACCELERATION

- After electrons pass beyond the deflection plates,they may or may not experience additional acceleration.
- This depends primarily upon on the maximum frequencies to be applied to CRT.
- For good sensitivity E_a should be low below 4 kV but reduces brightness,which can be seriously impaired at high frequencies.
- Below 10 MHz ,monoaccelerator may be used.
- If signals of frequencies higher than 10 MHz are to displayed,post deflection acceleration tubes(PDA) or post accelerators is necessary to increse the brightness of the trace which otherwise would be dim.

GRATICULE

- The graticule is a grid of lines that serves as a scale when making time and amplitude measurements.

AQUADAG

- The bombarding electrons ,striking the screen ,release secondary emission electrons.these secondary electrons are collected by an aqueous solution of graphite called **Aquadag** which is connected to the second anode,collection of secondary electrons is necessary to keep the CRT screen in a state of electrical equilibrium.

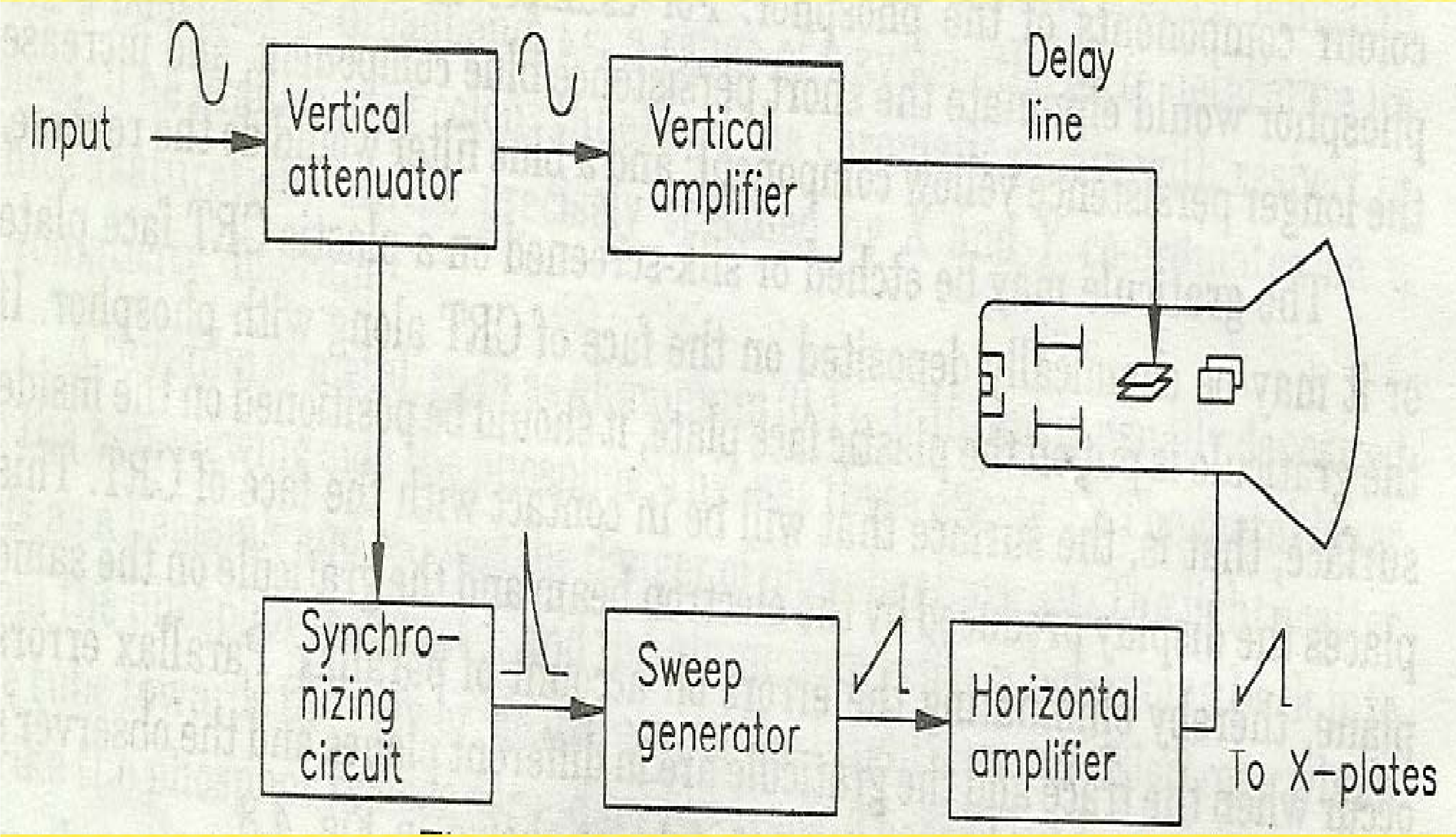
REAL TIME OSCILLOSCOPE

- Real time oscilloscopes can be

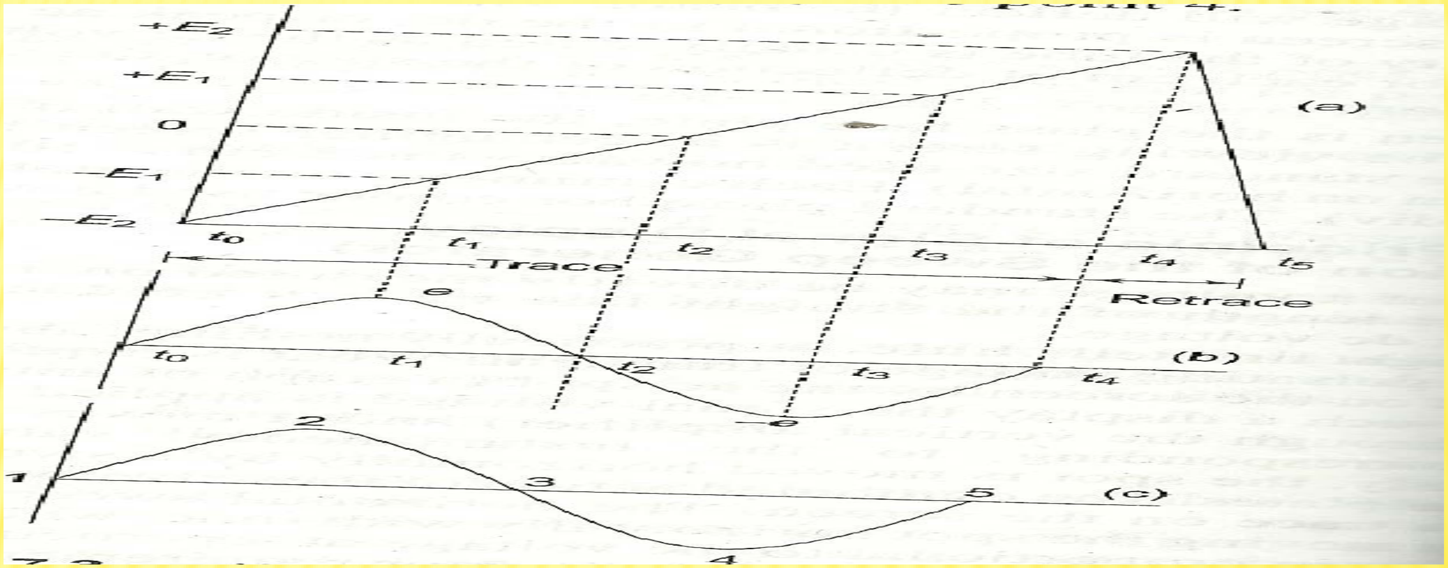
-Single input or display oscilloscope

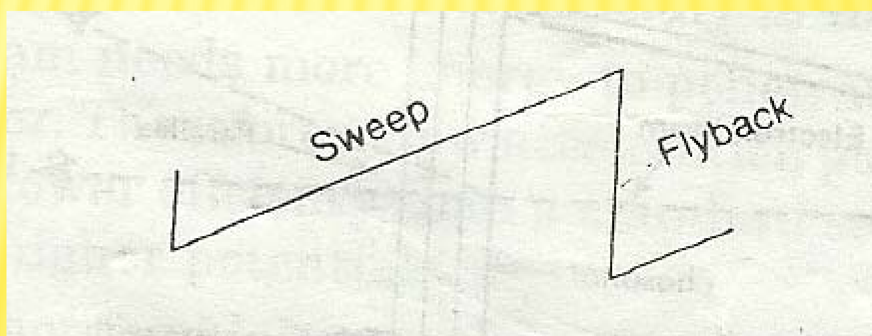
-Multiple input or display oscilloscope

SINGLE DISPLAY OSCILLOSCOPE



TIME BASE WAVEFORM

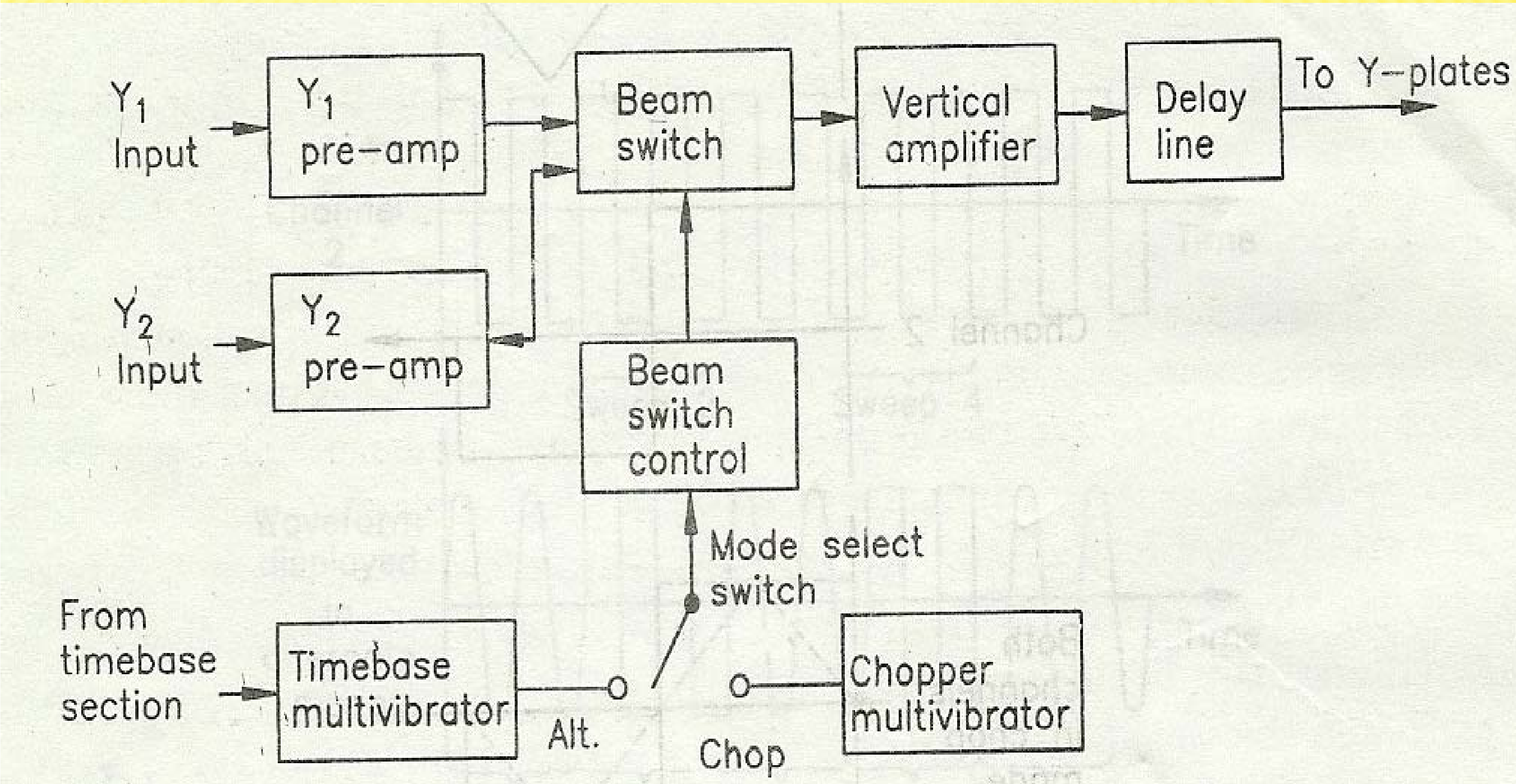




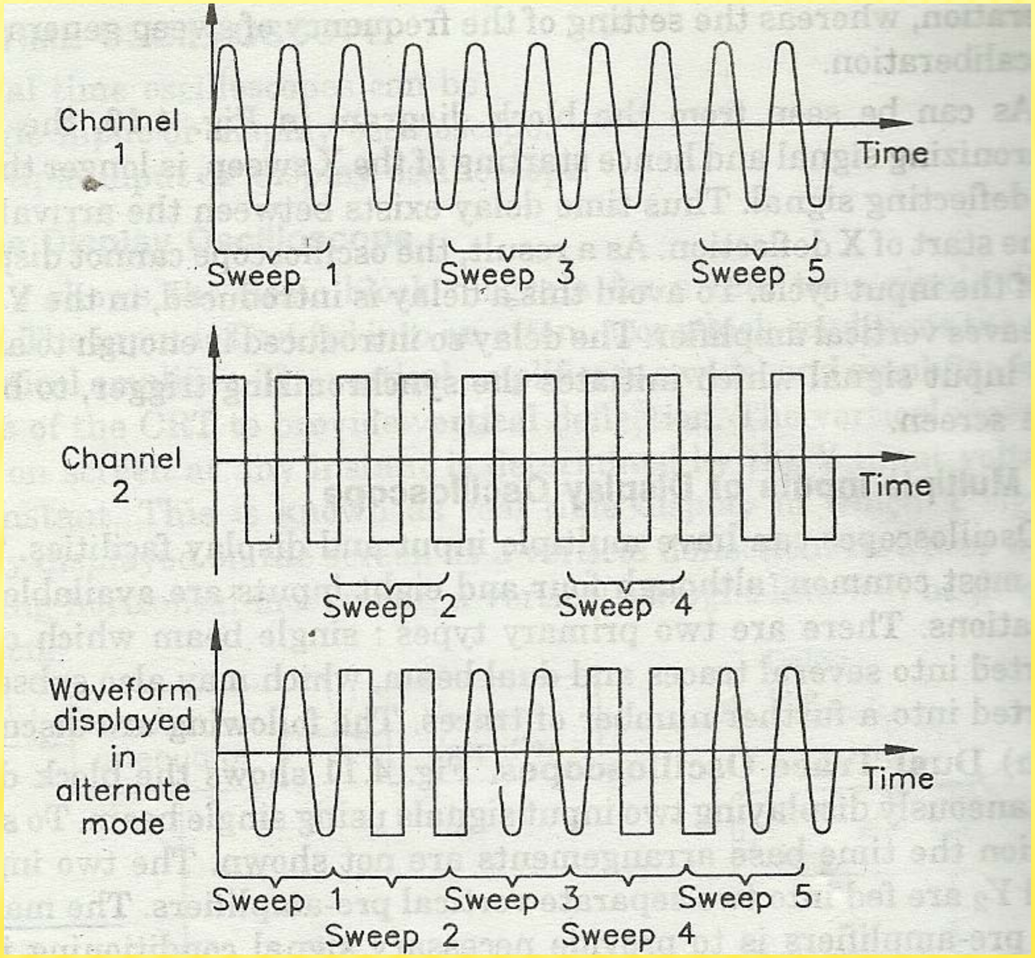
MULTIPLE DISPLAY OSCILLOSCOPE

- Dual trace oscilloscope
- Dual beam oscilloscope

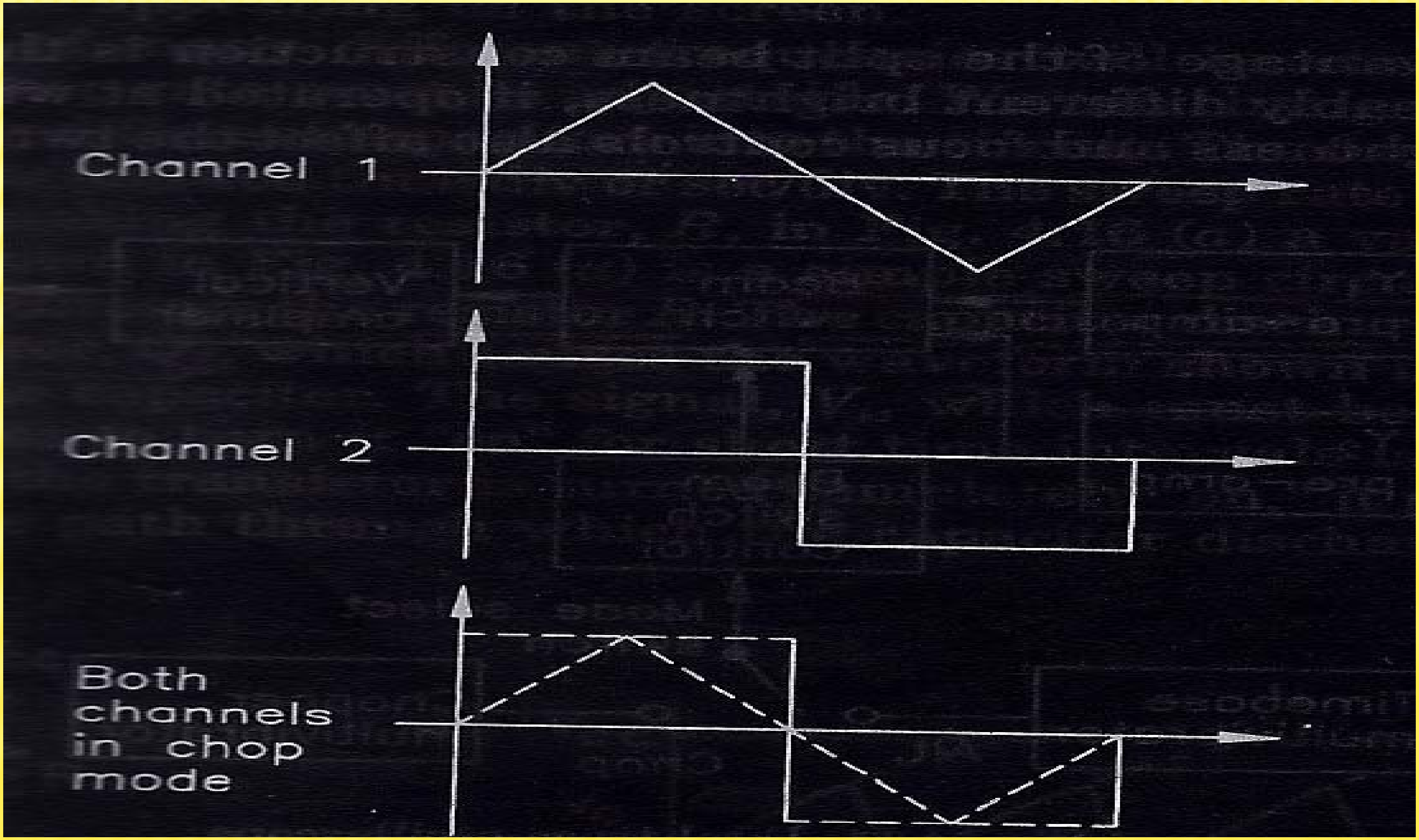
DUAL TRACE OSCILLOSCOPE



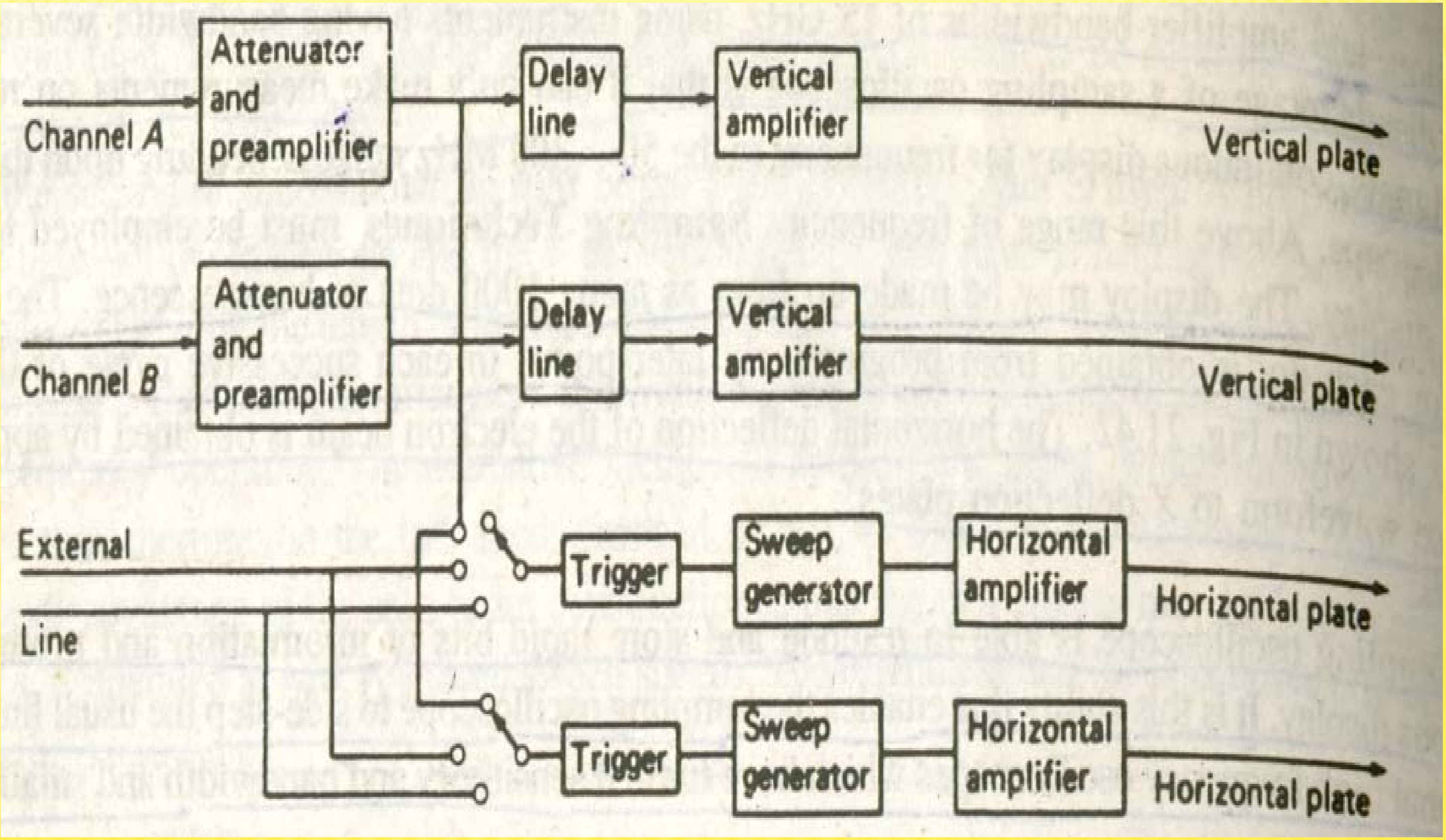
ALTERNATE MODE



CHOP MODE



DUAL BEAM OSCILLOSCOPE



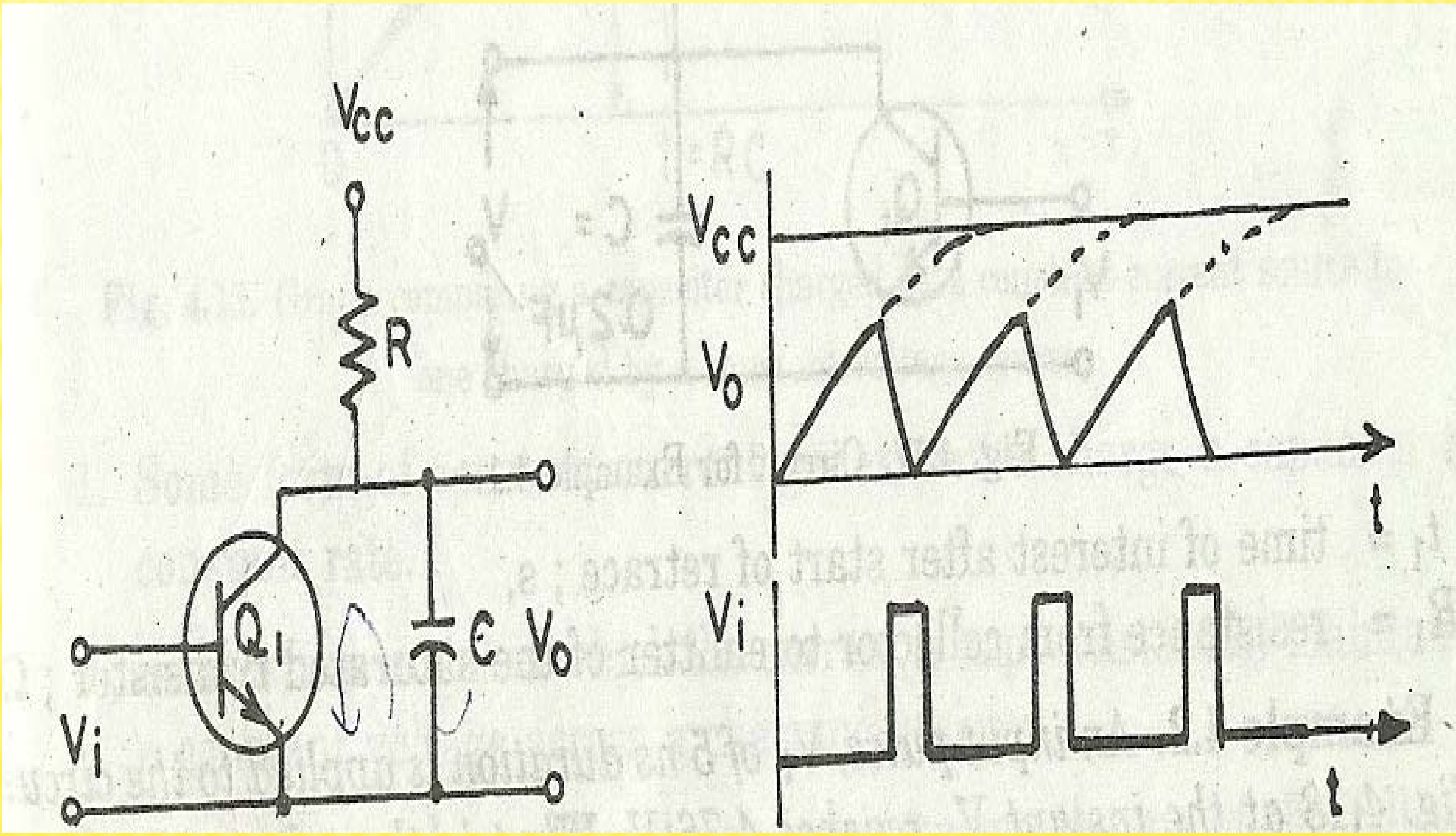
DUAL BEAM OSCILLOSCOPE

Two methods are used for generating the two electron beams within CRT-

1)Uses a double gun tube.

2)Split beam method.

TIME BASE GENERATOR



OSCILLOSCOPE PROBES

-In high frequency and pulse applications,the input capacitance of the oscilloscope begins to load the circuit.

-The effect of probe is to increse the input resistance of the oscilloscope.

TYPES OF PROBES

1)Passive Probes

- It is simplest of all the probes.
- Uses shielded co-axial cable.
- Avoids stray pick-ups which may create problems when low level signals are being measured.
- Usually used for low frequency or low impedence circuits.

TYPES OF PROBES

- Using the shielded probe,the shunt capacitance of the probe and cable is added to the input impedance and capacity of the scope and acts to lower the response of the oscilloscope to high impedance and high frequency circuits.
- External high impedance probes are used to increse the input resistance and reduce the effective input capacitance of an oscilloscope.

TYPES OF PROBES

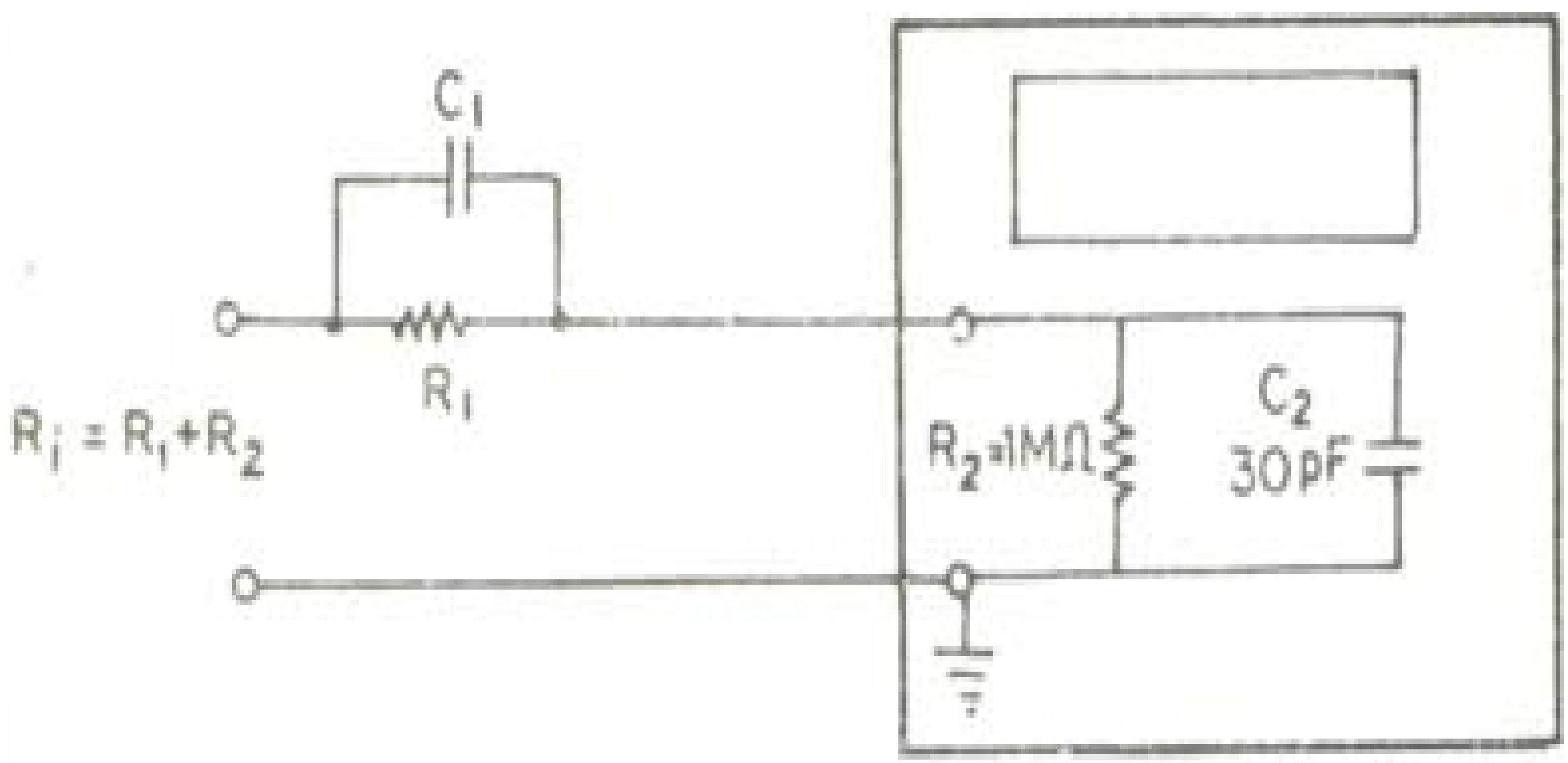
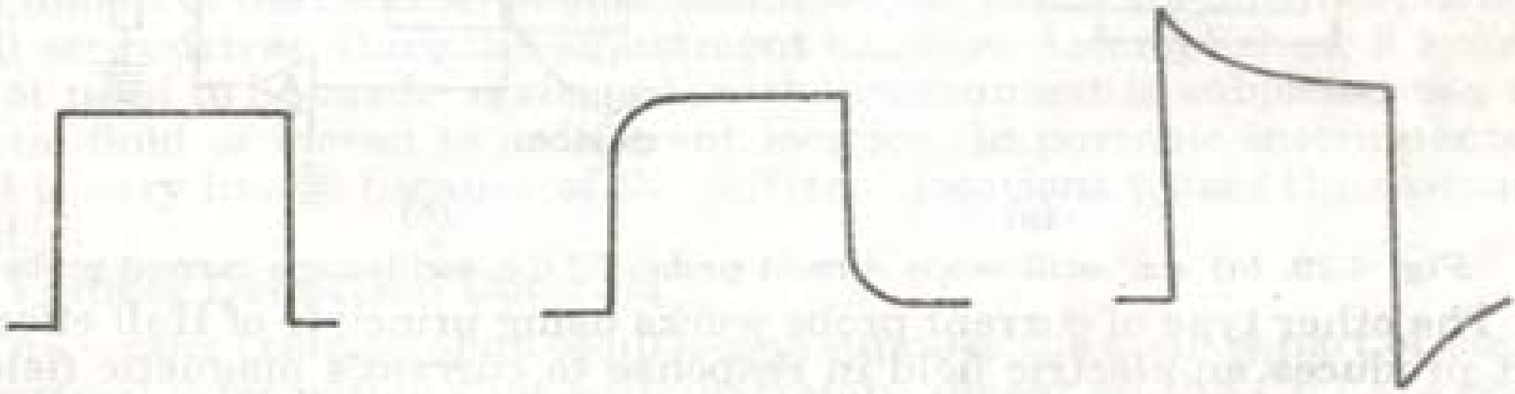


Fig. External High Impedance Probe.

TYPES OF PROBES

- A resistor and capacitor combination can be added to an oscilloscope.
- $R_1=R_2(k-1)=(1x10^6)(10-1)=9M\Omega$
- $C_1=C_2/(k-1)=30X10^{-12}/(10-1)=3.33$ pF
- New input impedance R1 is the total resistance,
- $R_i=R_1+R_2=10M\ \Omega$
- $C_i=C_1C_2/C_1+C_2=3pF$

TYPES OF PROBES



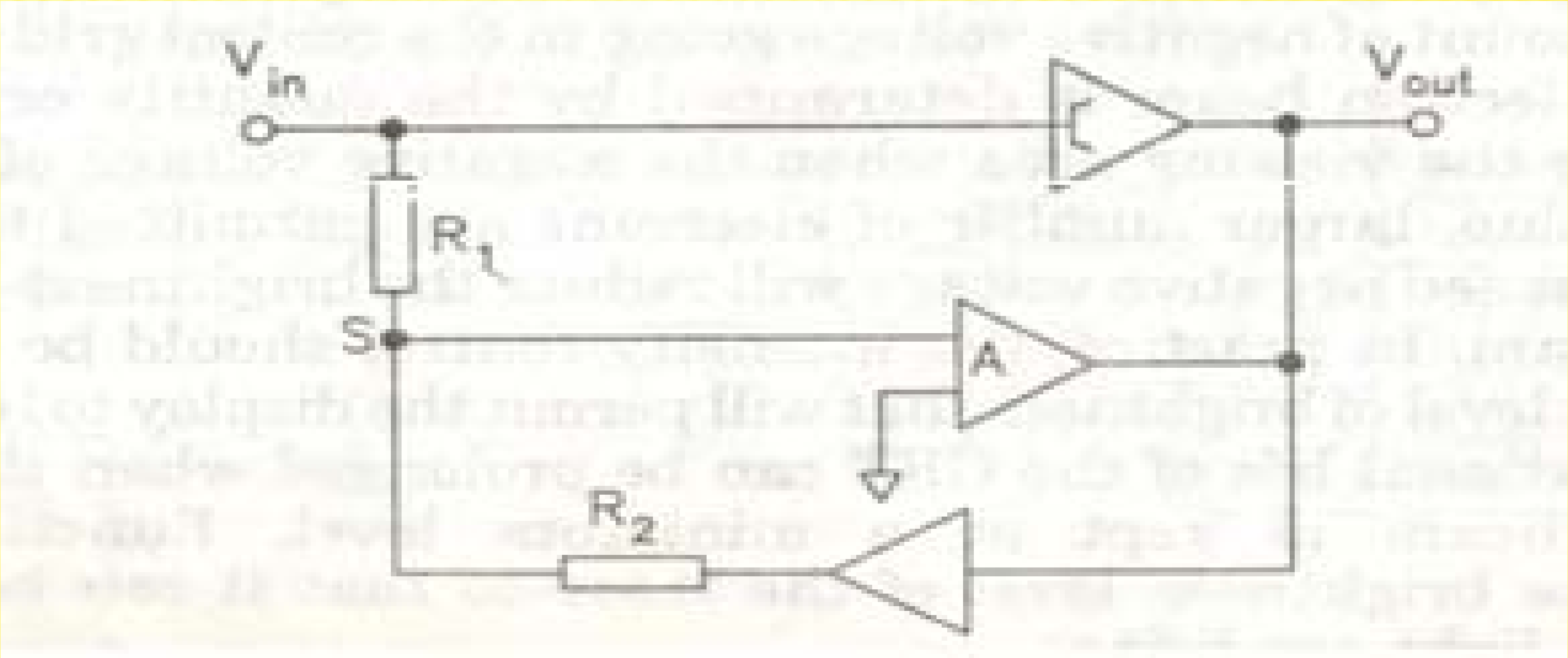
(*a*) Correct compensation. (*b*) Value of C_1 too small. (*c*) Value of C_1 too large.

Effect of probe capacitance compensation on display of square waveform.

TYPES OF PROBES

2)Active Probes:-

Block diagram of FET probe



TYPES OF PROBES

- Passive probe is mostly used voltage probe.
- It is apparent that low capacitive loading can be obtained at the expense of considerable attenuation.
- These problems can be overcome by using active(FET) probe.

TYPES OF PROBES

3)CURRENT PROBES-

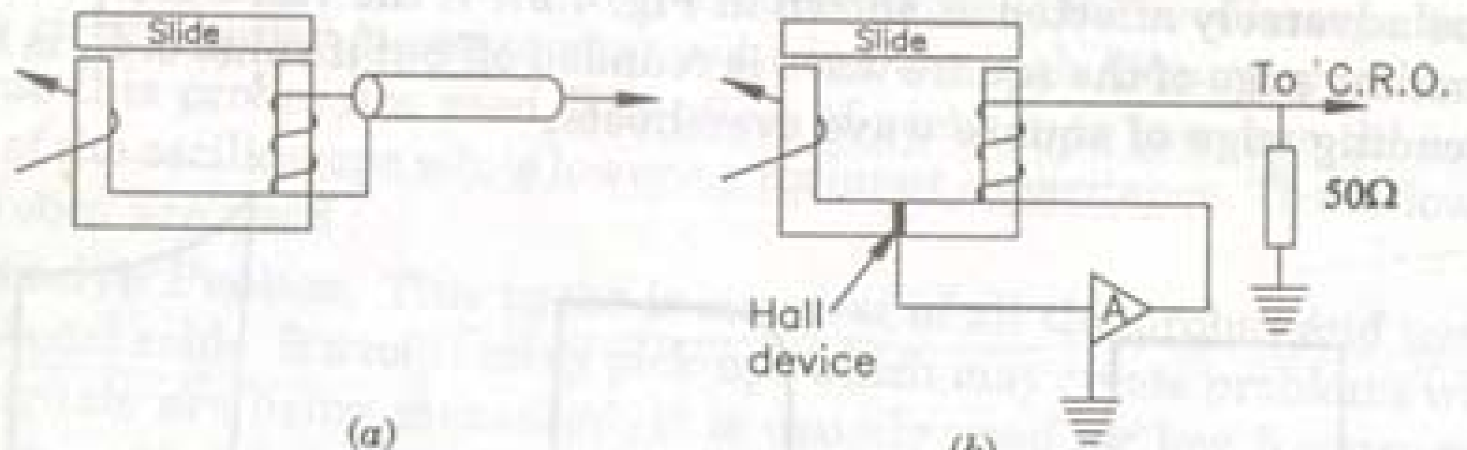


Fig. (a) a.c. oscilloscope current probe, (b) d.c. oscilloscope current probe.

TYPES OF PROBES

- The arrangement of figure which have a core that may be slid open to allow the current carrying conductor to be inserted.
- This works on principle of transformer,with one winding of the transformer being the measured wire.
- The probes using this principle are used for a.c. measurements only.

TYPES OF PROBES

- Oscilloscopes are designed for voltage,but can be used to measure current using current probe.
- The current probe has set of jaws which encloses the wire that the measured current is flowing through.
- No connection is required.

HIGH FREQUENCY CRT OR TRAVELLING WAVE TYPE CRT

- When the signal to be displayed is of a very high frequency ,the electron beam does not get sufficient time to pick up the instantaneous level of the signal.
- Also at high frequencies the numbers of electrons striking the screen in a given time and the intensity of the beam is reduced.
- Instead of one set of deflection plates,a series of vertical deflection plates are used.
- The plates are so shaped and spaced that an electron travelling along the CRT receives from each set of plates an additional deflecting force in proper time sequence.

HIGH FREQUENCY CRT OR TRAVELLING WAVE TYPE CRT

- This synchronisation is achieved by making the signal travel from one plate to the next at the same speed as the transit time of the electrons.
- The signal is applied to each pair of plates,and as the electron beam travels the signal also travels through the delay lines.
- The time delays are so arranged that the same electrons are deflected by the input signal.

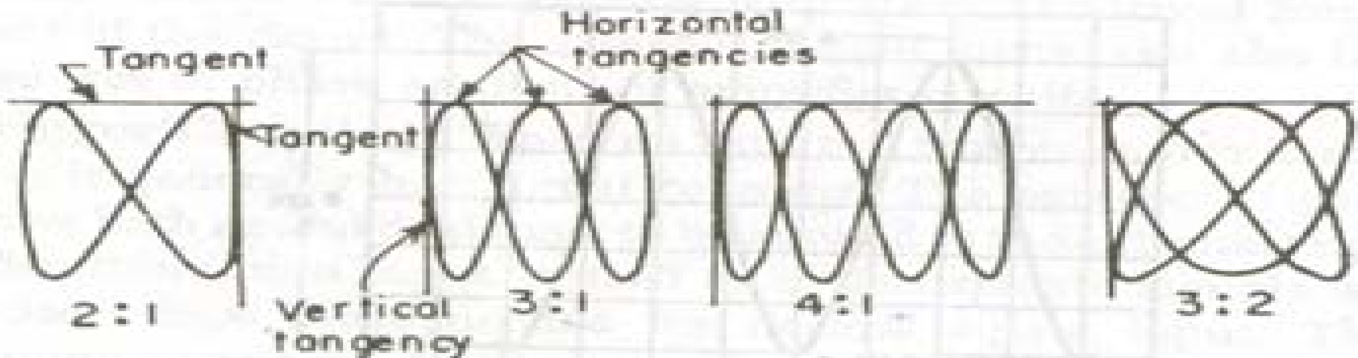
CHARACTERISTICS OF A HF CRO(HF IMPROVEMENT IN A CRO)

1. The vertical amplifier must be designed both for high B.W. and high sensitivity or gain.Making the vertical amplifier a fixed gain amplifier simplifies the design.The input to the amplifier is brought to the required level by means of an attenuator circuit.the final stages is the push-pull stage.
2. The LF CRT is replaced by an HF CRT.
3. A probe is used to connect the signals,e.g. a high Z passive probe acts like a compensated attenuator.
4. By using a triggered sweep,for fast rising signals,and by the use of delay lines between the vertical plates,for improvement of HF characteristics.

LISSAJOUS PATTERN

- Lissajous patterns may be used for accurate measurement of frequency..
- The signal whose frequency is to be measured is applied to the Y-plate.An accurately calibrated standard variable frequency source is used to supply voltage to the X-plates with the internal sweep generator switched off.

LISSAJOUS PATTERN



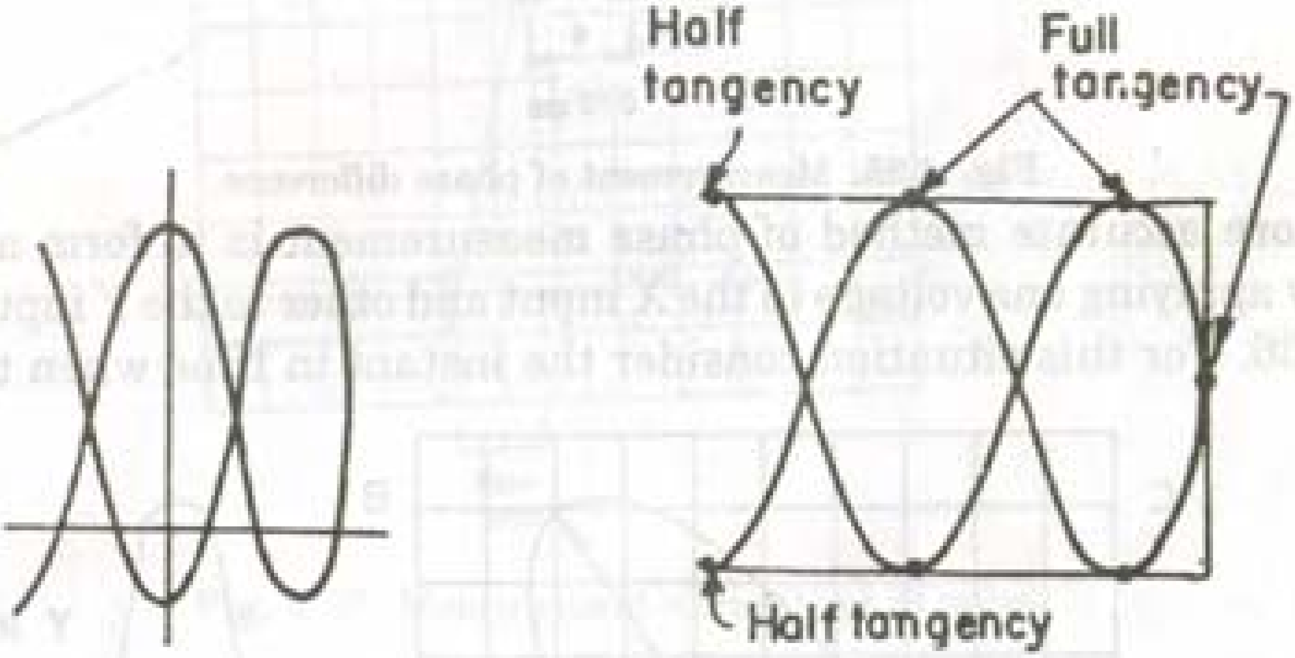
$$\frac{f_y}{f_x} = \frac{\text{number of times tangent touches top or bottom}}{\text{number of times tangent touches either side}}$$

$$= \frac{\text{number of horizontal tangencies}}{\text{number of vertical tangencies}}$$

where f_y = frequency of signal applied to Y plates,

and f_x = frequency of signal applied to X plates.

LISSAJOUS PATTERN

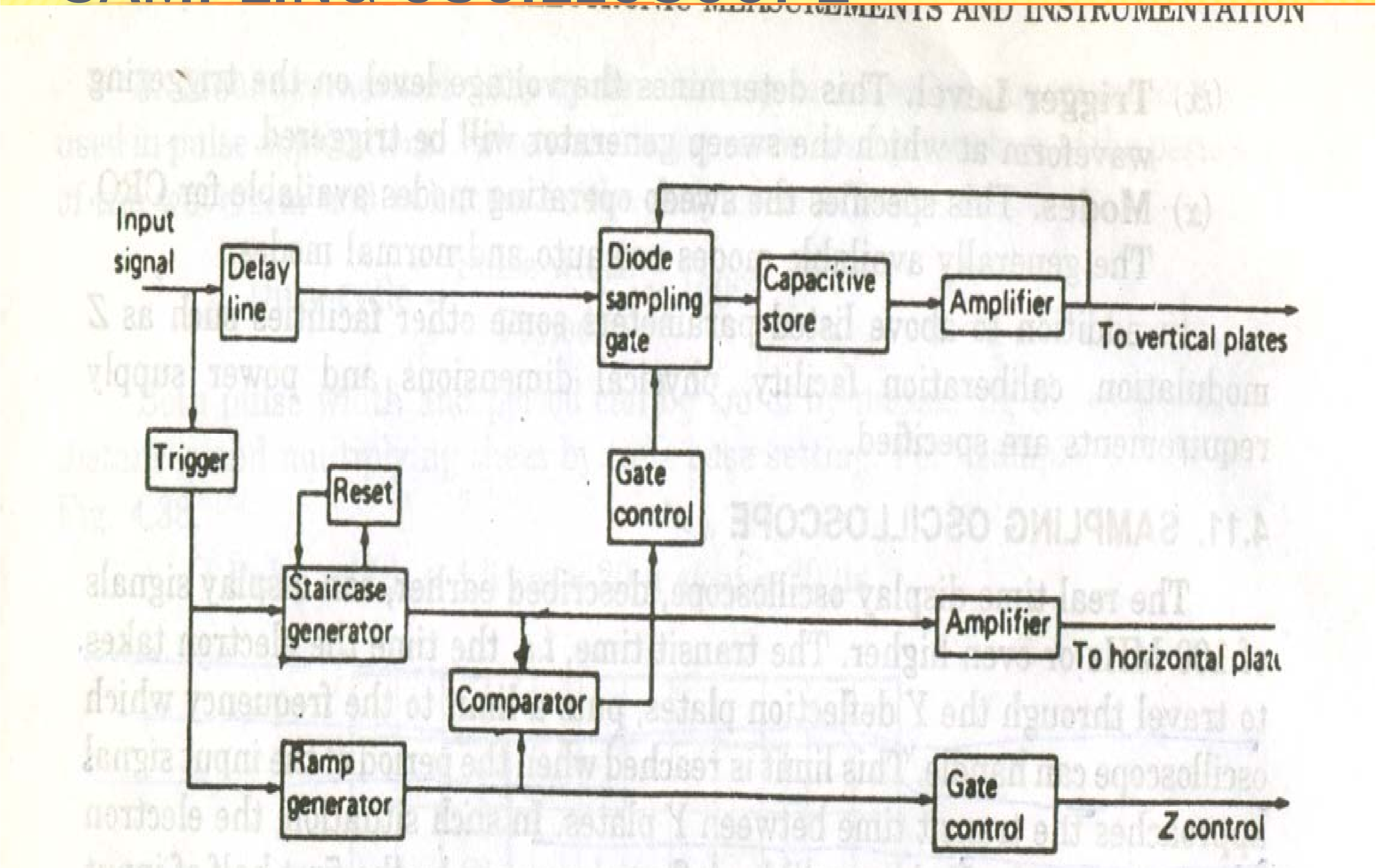


(a) (b)

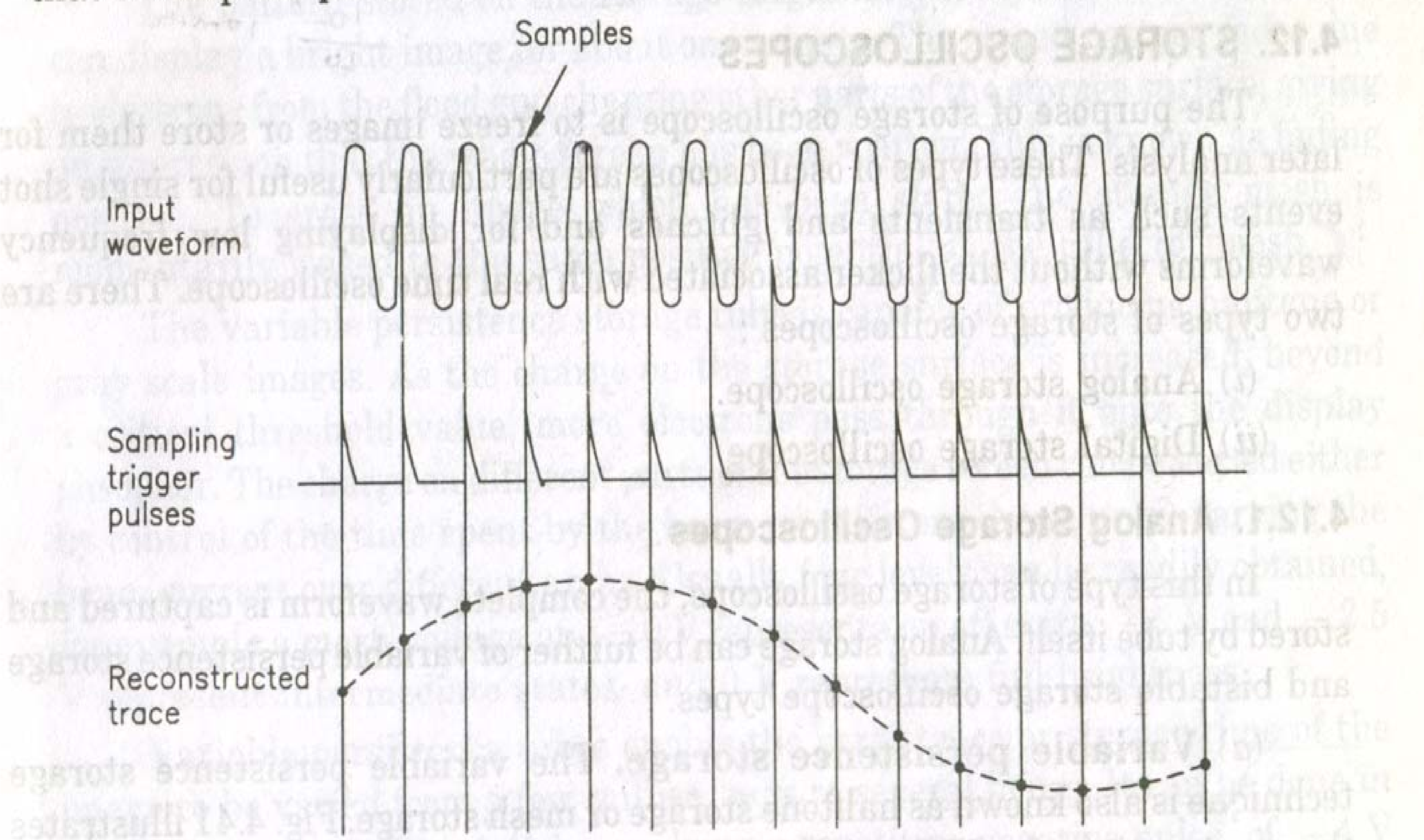
Lissajous patterns with half tangencies.

$$\frac{f_y}{f_x} = \frac{\text{number of horizontal tangencies}}{\text{number of vertical tangencies}} = \frac{2 + 1/2}{1} = \frac{5}{2}.$$

SAMPLING OSCILLOSCOPE



SAMPLING OSCILLOSCOPE



STORAGE OSCILLOSCOPE

- The purpose of storage oscilloscope is to freeze images or store them for later analysis. These types of oscilloscopes are useful for single shot events such as transients ,glitches.
- Types of storage oscilloscopes are:

1.Analog Storage oscilloscope

2.Digital Storage oscilloscope

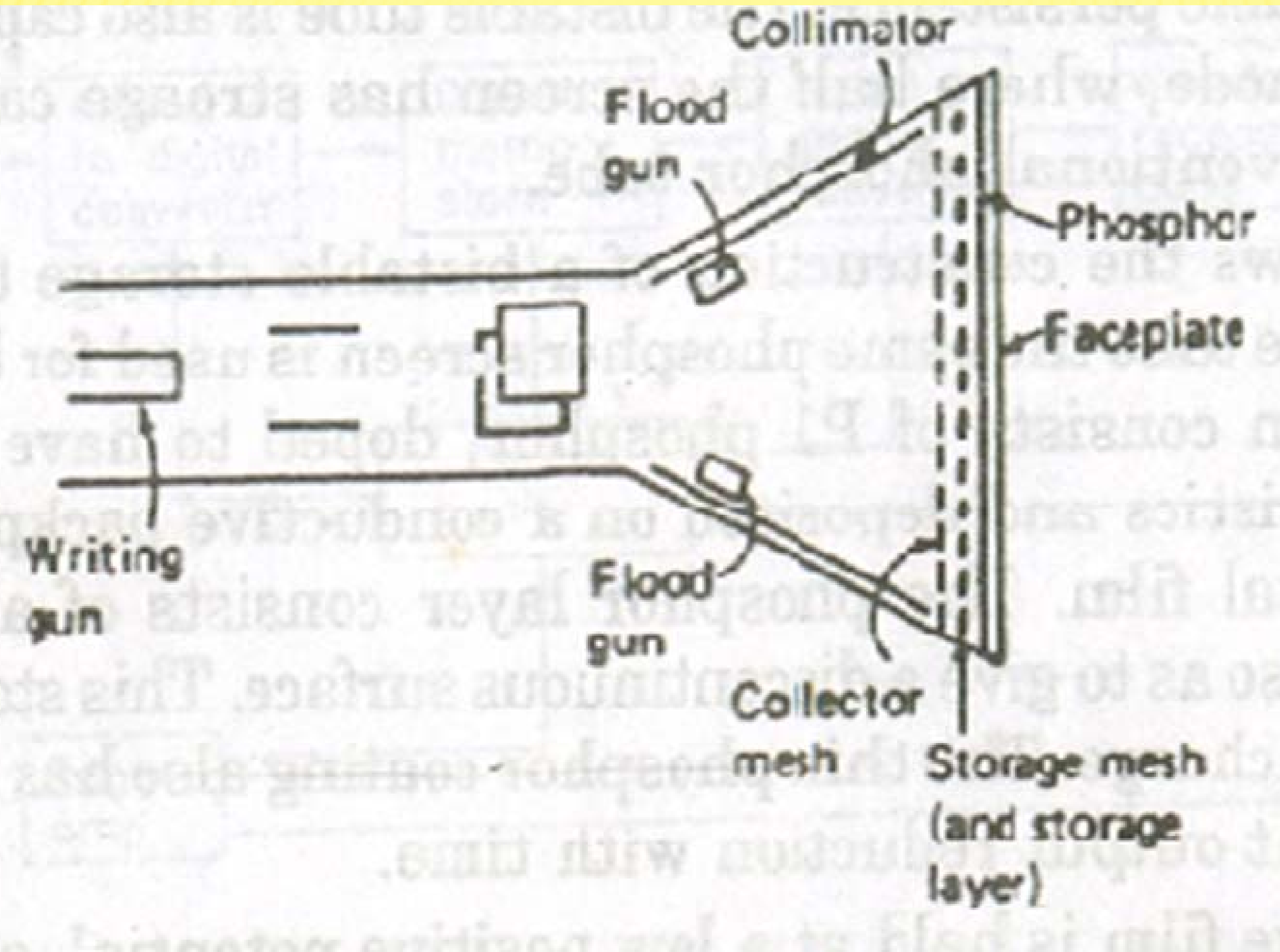
ANALOG STORAGE OSCILLOSCOPE

- Analog Storage oscilloscope are of two types:

1. Variable persistence storage.
2. Bistable Storage oscilloscope.

The principle of secondary emission storage is applicable to both variable persistence storage and bistable Storage oscilloscope.

VARIABLE PERSISTENCE OSCILLOSCOPES



Construction of a vraiable persistence storage tube.

VARIABLE PERSISTENCE OSCILLOSCOPES CONTD……..

- Writing gun is at high –ve potential.
- Flood gun at a few volts –ve
- Collector mesh is at about 100v +ve
- Storage mesh is at gnd potential or a few volts

  -ve

VARIABLE PERSISTENCE OSCILLOSCOPES CONTD……..

- This technique is also known as **Halftone Storage or Mesh Storage.**
- **It consist of 2 screens:**

1.Storage Mesh 2.Phosphor screen

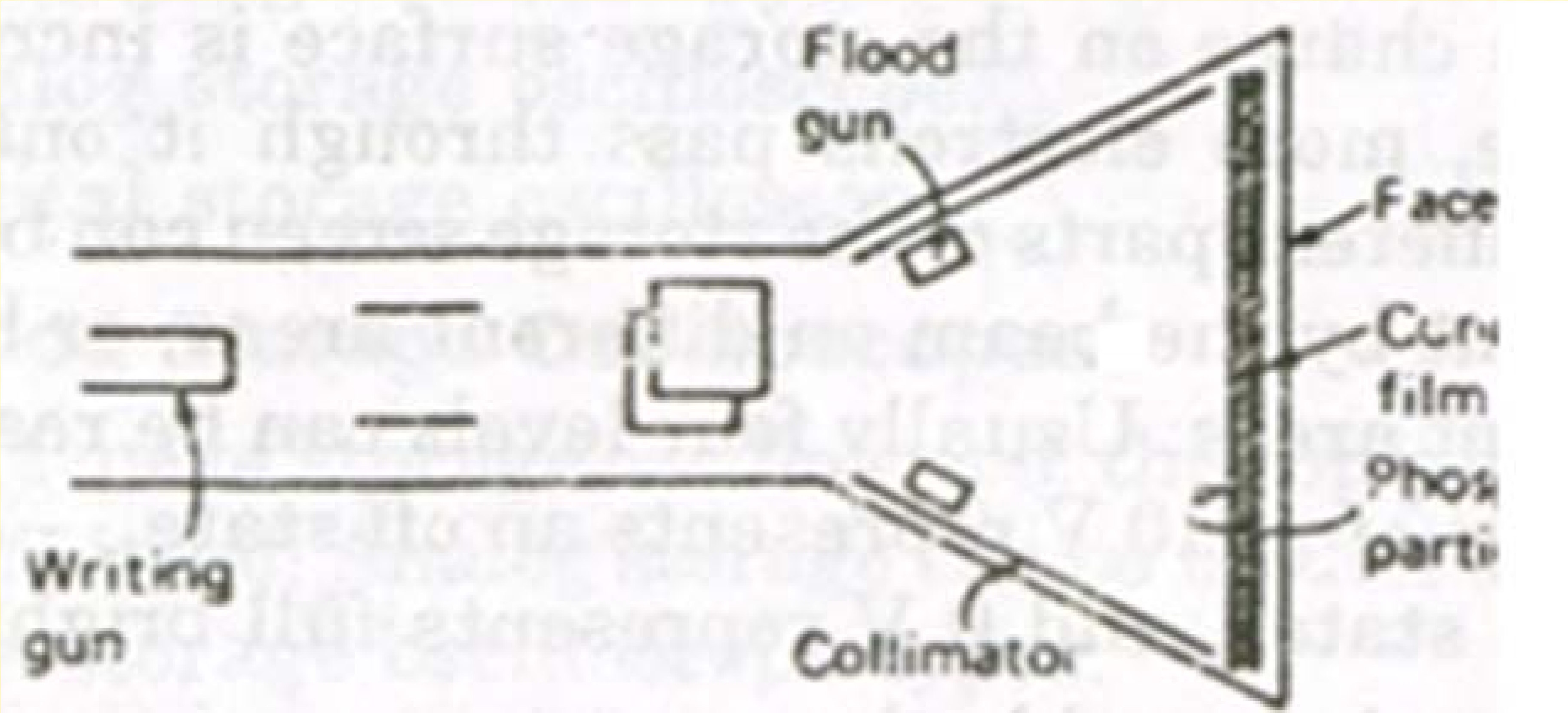
VARIABLE PERSISTENCE OSCILLOSCOPES CONTD…..

- The stored pattern fades due to electrons from the flood gun charging other parts of the storage surface, given an impression that the whole pattern has been written. This is known as **Fading Positive.**

Applications:

- For storage of an entire waveform of a slow moving signal, which then fades before the next trace is written.
- It can also be used to store several traces before the first one fades, so as to see how the signal changes with time

BISTABLE STORAGE OSCILLOSCOPE



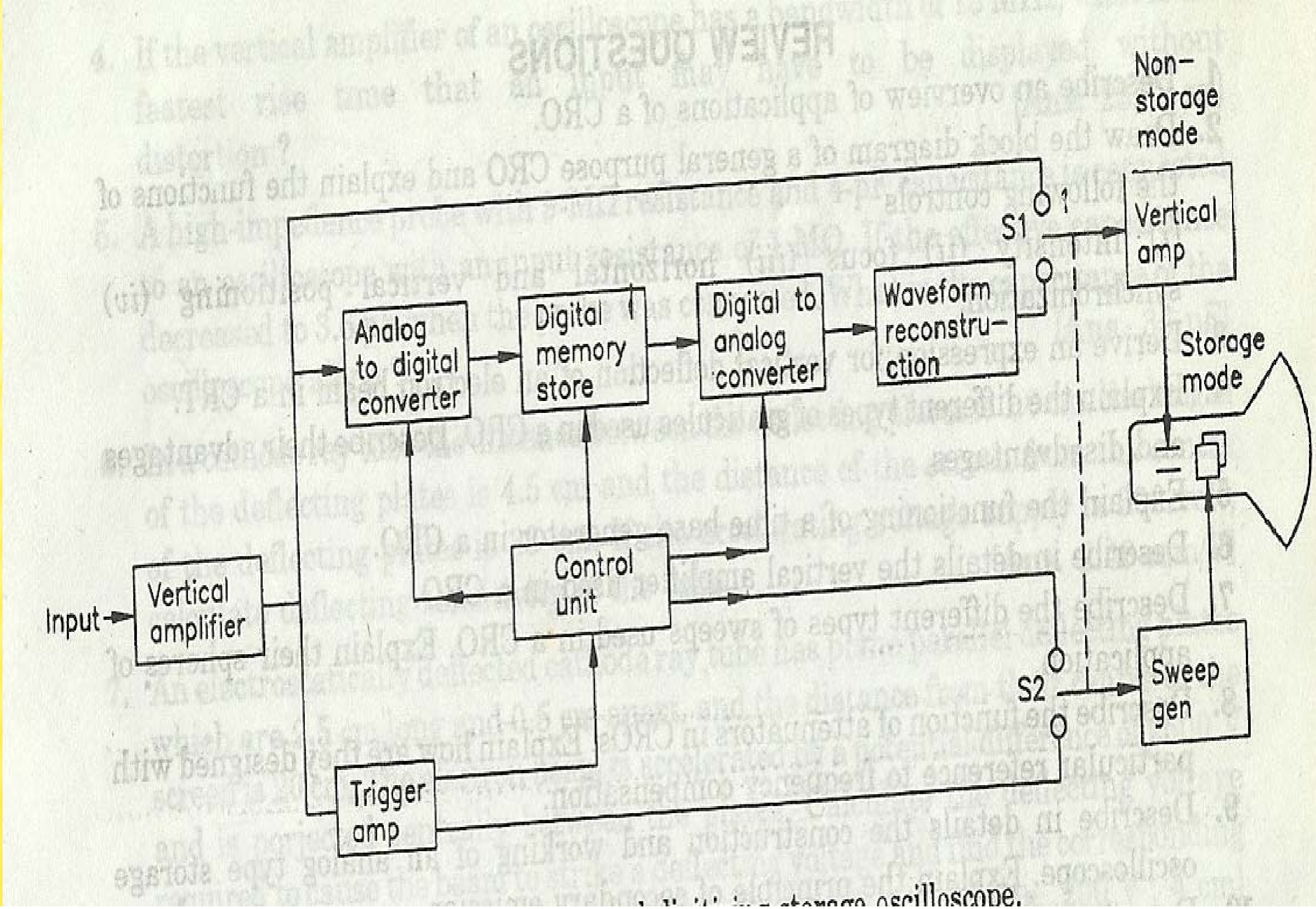
BISTABLE STORAGE OSCILLOSCOPE CONTD........

- The Bistable storage tube is between two & ten times slower than a variable persistence tube.
- It is capable of much longer storage times, measured in hours rather than in minutes as for variable persistence.
- It is also capable of operating in a split screen mode, where half the screen has storage capability and other half is a conventional phosphor screen.
- Here the same phosphor screen is used for both storage & display.

BISTABLE STORAGE OSCILLOSCOPE CONTD……..

- The phosphor layer consists of a thin coating of scattered particles,so as to give a discontinuous surface.
- It stops the boundary migration of stored charge.
- The thin phosphor coating also has a short life since it suffers from light output reduction with time.
- The conductive film is held at a low positive potential,so as to attract a cloud of low energy to penetrate the phosphor and are gathered by the collimator.

DIGITAL STORAGE OSCILLOSCOPE(DSO)



DIGITAL STORAGE OSCILLOSCOPE(DSO)

- The input signal is converted into a digital form and stored in memory.It is then converted back into analog signal,reconstructed and presented to CRT display.

DIGITAL STORAGE OSCILLOSCOPE(DSO)

- The logic control provides the synchronous operation of the oscilloscope.its functions include:

1)To receive trigger pulses.

2)To determine sampling rate of ADC.

3)Controlling entry of data into store.

4)Controlling the release of data stored into DAC.

5)Controlling DAC by determining its speed and release of data of the CRT.

DIGITAL STORAGE OSCILLOSCOPE(DSO)

- Applications of storagee oscilloscope:-
- To display and analyse trasient waveform .
- To display low frequency waveforms without flicker.
- To provide comparison between stored and real time waveforms.
- Pre triggering viewing.
- Interfacing to computer/printer etc.

OSCILLOSCOPE AMPLIFIERS

- A.C.coupled amplifiers
- D.C.coupled amplifiers
- Narrow bandwidth amplifiers
- Broad bandwidth amplifiers
- Vertical amplifier
- Horizontal amplifier