

Basic Factors affecting Television Transmission and Reception

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1. Gross structure
2. Image continuity
3. Number of scanning lines
4. Flicker
5. Fine structure
6. Tone gradation

1. Gross Structure

- Frame adopted is rectangle with Aspect Ratio (Width/Height) = 4/3

Reasons:

1. Most of the motion occurs in horizontal plane
2. Eyes can view more easily and comfortably
3. For enabling direct television transmission of film programs without wastage of any film area - Motion pictures use a rectangular frame with width/height ratio of 4/3 – so adopted this aspect ratio in TV

Requirements:

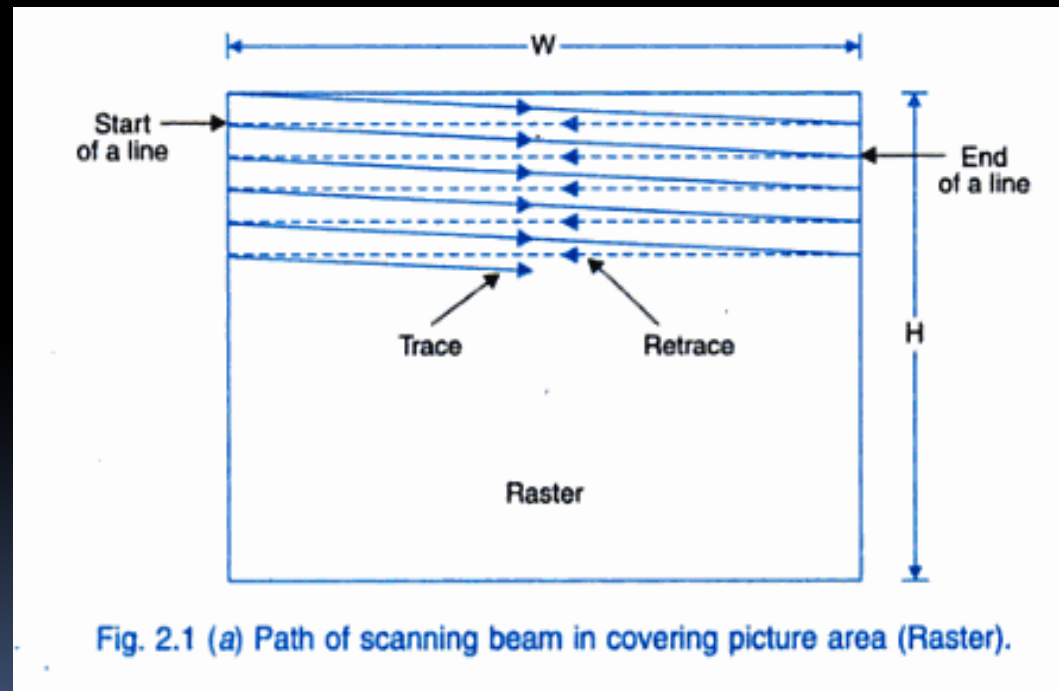
1. Aspect ratio of the size of the picture produced on the receiver screen and the picture being televised must be the same
 - ▶ achieved by setting the magnitude of the current in the deflection coils to correct values both at the TV camera and the receiving picture tube
2. Same coordinated should be scanned at any instant both by the camera tube beam and the picture tube beam
 - ▶ achieved by transmitting synchronizing pulses along with the picture information

2. Image Continuity

- To create an illusion of continuity we make use of persistence of vision : sensation produced when nerves of the eye's retina are stimulated by incident light does not cease immediately after the light is removed but persists for about $1/16^{\text{th}}$ of a second
- Scanning rate is made greater than 16 per second i.e. number of pictures shown per second is more than 16 – hence our eye can able to integrate the changing levels of brightness in the scene
- Present day motion pictures – 24 still pictures of the scene are taken per second and projected on the screen at the same rate

Scanning in Television systems

- The scene is scanned rapidly both in the horizontal and vertical directions simultaneously
- Frame repetition rate is 25 per second



Horizontal scanning

- Linear rise of current in the deflection coils deflects the beam across the screen with a continuous uniform motion for the trace from left to right .
- At the peak of the rise, the saw tooth wave reverses its direction and decreases rapidly to its initial value, producing the retrace or flyback

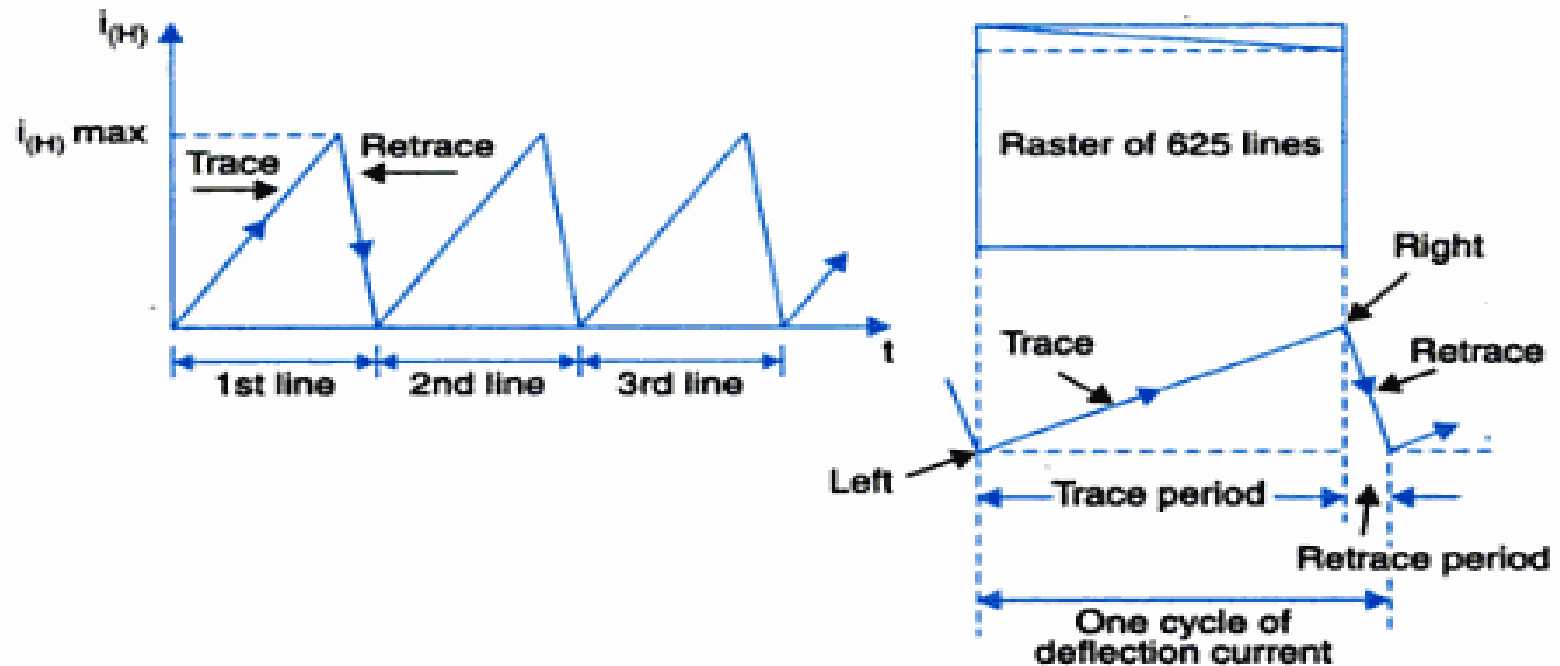
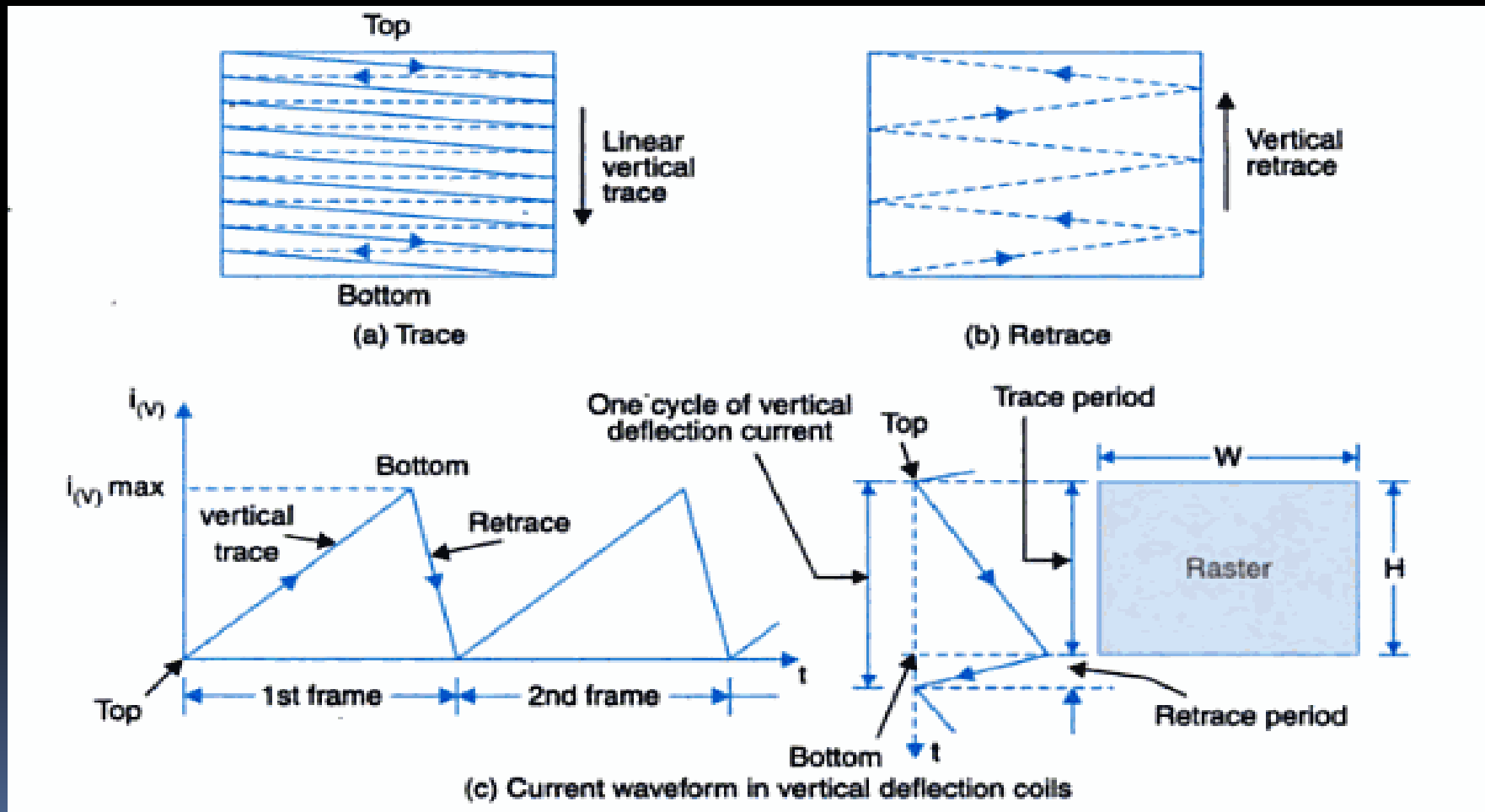


Fig. 2.1 (b) Waveform of current in the horizontal deflection coils producing linear (constant velocity) scanning in the horizontal direction.

Vertical Scanning

- Saw tooth current in the vertical deflection coils moves the electron beam from top to bottom of the raster at uniform speed while the electron beam is being deflected horizontally



- Because of the motion in the scene being televised, the information or brightness at the top of the target plate or picture tube screen normally changes by the time the beam returns to the top to recommence the whole process. This information is picked up during the next scanning cycle and the whole process is repeated 25 times to cause an illusion of continuity
- During the horizontal and vertical retrace intervals, the scanning beams at the camera tube and the picture tube are blanked and no picture information is either picked up or reproduced
- Synchronizing pulses are transmitted during this period – resulting in distortionless reproduction of the picture details

3. Number of scanning lines

- Most scenes have brightness gradations in the vertical directions
- The ability of the scanning beam to allow reproduction of electrical signals according to these variations and the capability of the human eye to resolve these distinctly (while viewing) depends on the total number of lines employed for scanning
- Number of scanning lines is judged by considering the bar pattern as shown where alternate lines are black and white

- If the thickness of the scanning beam is equal to the width of each black and white bar and the number of scanning lines is chosen equal to the number of bars, then the electrical information corresponding to the brightness of each bar will be correctly reproduced during the scanning process
- Greater the number of lines, better will be the resolution

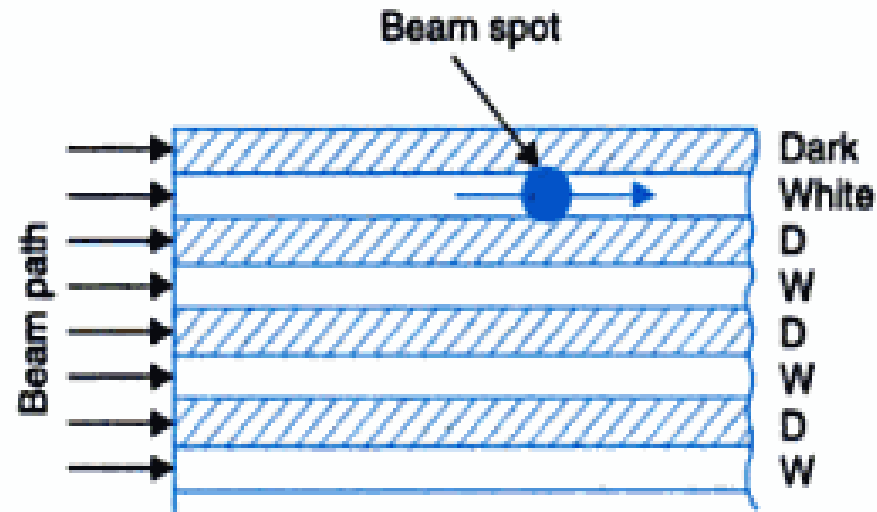


Fig. 2.3 (a) Scanning spot perfectly aligned with black and white lines.

- However the total number of lines is limited by the resolving capability of the human eye at the minimum viewing distance

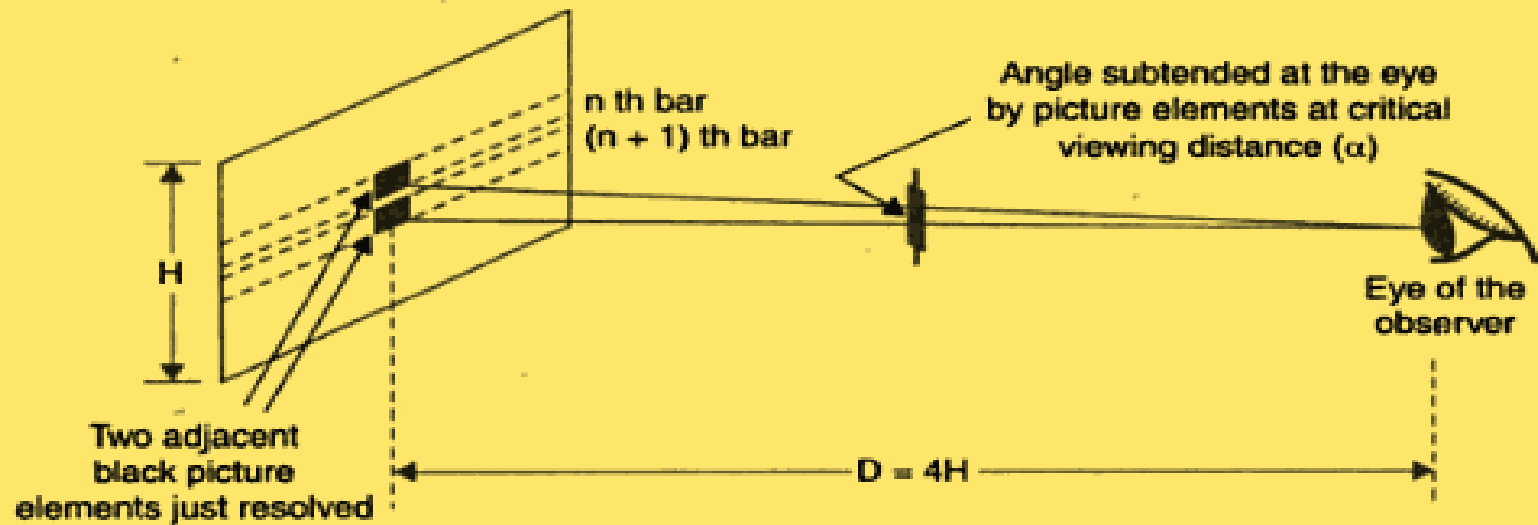


Fig. 2.3 (b) Critical viewing distance as determined by the ability of the eye to resolve two separate picture elements.

The maximum number of alternate light and dark elements (lines) which can be resolved by the eye is given by

$$N_v = \frac{1}{\alpha \rho}$$

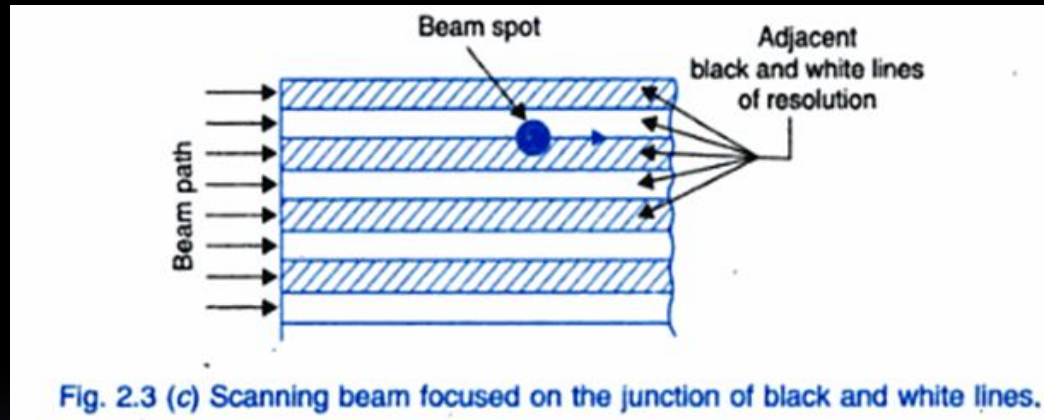
where N_v = total number of lines (elements) to be resolved in the vertical direction, α = minimum resolving angle of the eye expressed in radians, and $\rho = D/H$ = viewing-distance/picture height.

- With reasonable brightness variation and a minimum viewing distance of 4 times the picture height ($D/H = 4$), the angle that any two adjacent elements must subtend at the eye for distinct resolution is approximately one minute ($1/60$ degree)

Substituting the above values

$$N_v = \frac{1}{(\pi / 180 \times 1 / 60) \times 4} \approx 860$$

- In practice, the picture elements are not arranged as equally spaced elements but have random distribution of black, grey and white depending on the nature of the picture details.
- Analysis and tests suggests that about 70% of the total line get separately scanned in the vertical direction and the remaining 30% get merged with other elements due to the beam spot falling equally on two consecutive lines (as shown in figure)



Thus the effective number of lines distinctly resolved

$$N_r = N_v \times K$$

where K is the resolution factor whose value lies between 0.65 & 0.75

Assuming the value of k = 0.7;

$$N_r = 860 \times 0.7 = 602$$

Other factors influencing the choice of total number of lines

- *Improvement in resolution is not very significant with line numbers > 500*
- *Channel bandwidth increases with the increase in number of lines*
 - *cost of the system increases*
 - *reduces the number of channels in a given VHF/UHF transmission band*

NB: As a compromise between quality and cost, the total number of lines (inclusive of those lost during vertical retrace) has been chosen to be 625 in the 625-B monochrome TV system.

4. Flicker

- 25 frames per second in television picture is not rapid enough to allow the brightness of one picture or frame to blend smoothly into the next during the time when the screen is blanked between successive frames
- Produces **flicker**
- *Eliminated in motion pictures by showing each picture twice – ie 48 views of the scene per second – still the same 24 picture frames per second*
- *ie increased blanking rate*

Interlaced scanning

- In Television pictures *50 vertical scans per second* – to reduce flicker
- Downward rate of travel of scanning electron beam is increased
- Alternate lines get scanned instead of every successive lines
- Here total number of lines are divided into two groups called 'fields'
- ie each field is scanned alternatively – called as *interlaced scanning* – reduces flicker

Interlaced scanning

contd..

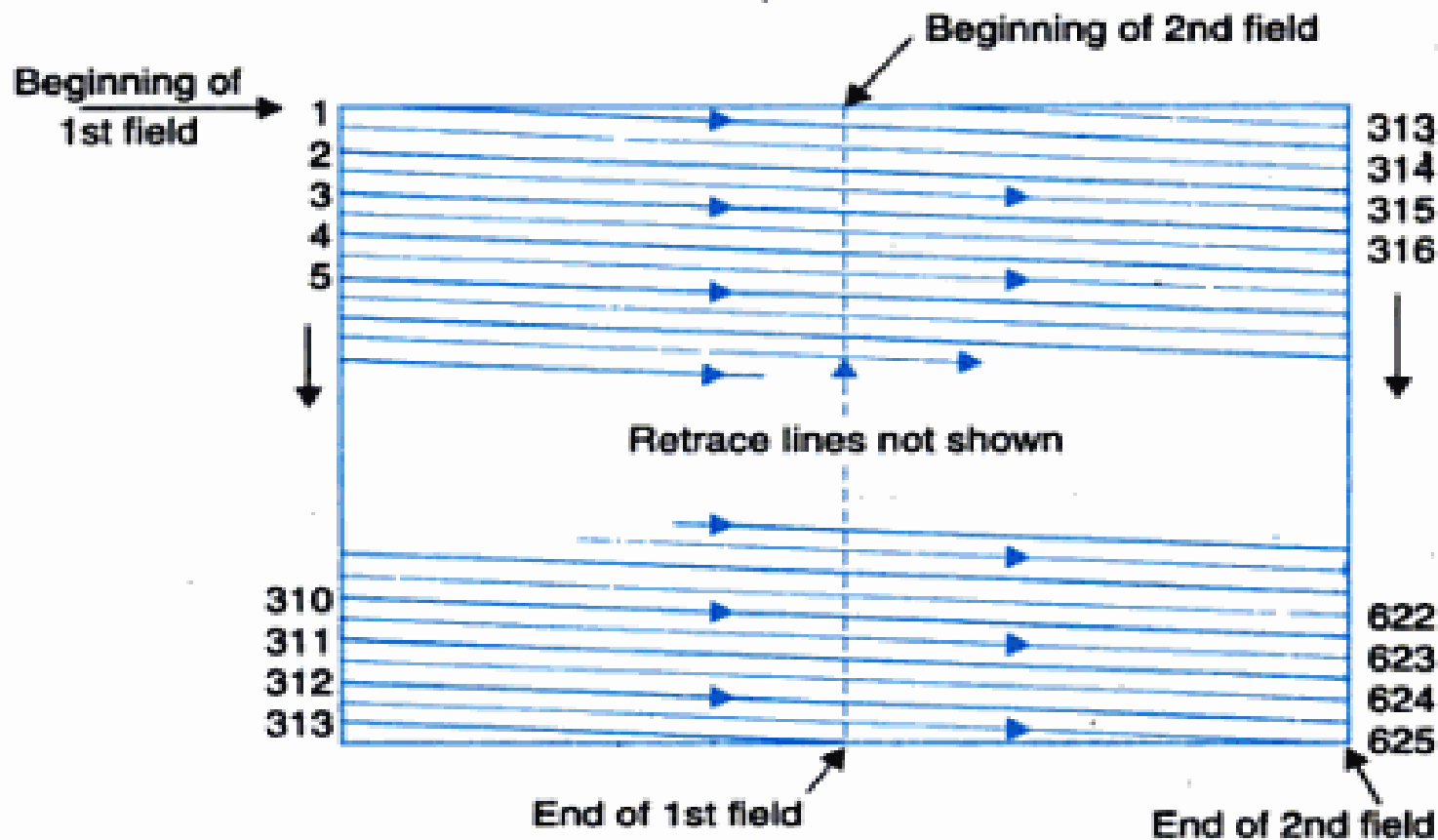


Fig. 2.4 Principle of interlaced scanning. Note that the vertical retrace time has been assumed to be zero.

Interlaced scanning

contd..

- 625 lines of each frame /picture are divided into sets of 312.5 lines
- Each set is scanned alternatively
- Horizontal sweep oscillator is made to work at a frequency of 15625 Hz ($312.5 \times 50 = 15625$)
- Vertical sweep circuit run at a frequency of 50 Hz instead of 25 Hz
- Reduces the undesired effects of hum due to pickup from mains

Scanning periods

- Normal duration of the horizontal line is $64\mu\text{s}$
($1/15625 = 64\mu\text{s}$)
active line period = $52\mu\text{s}$
line blanking period = $12\mu\text{s}$
- Normal duration of the vertical trace is 20 ms ($1/50 = 20\text{ ms}$)
 18.720 ms - for bringing the beam from top to bottom
 1.280 ms - to commence the next cycle

Scanning periods

contd. .

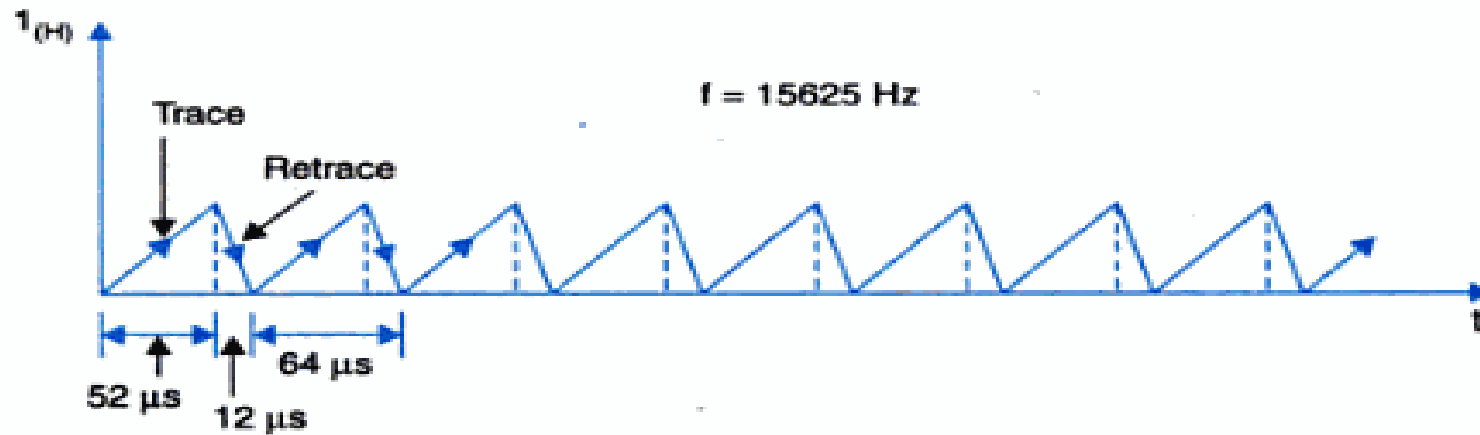


Fig. 2.5 (a) Horizontal deflection current.

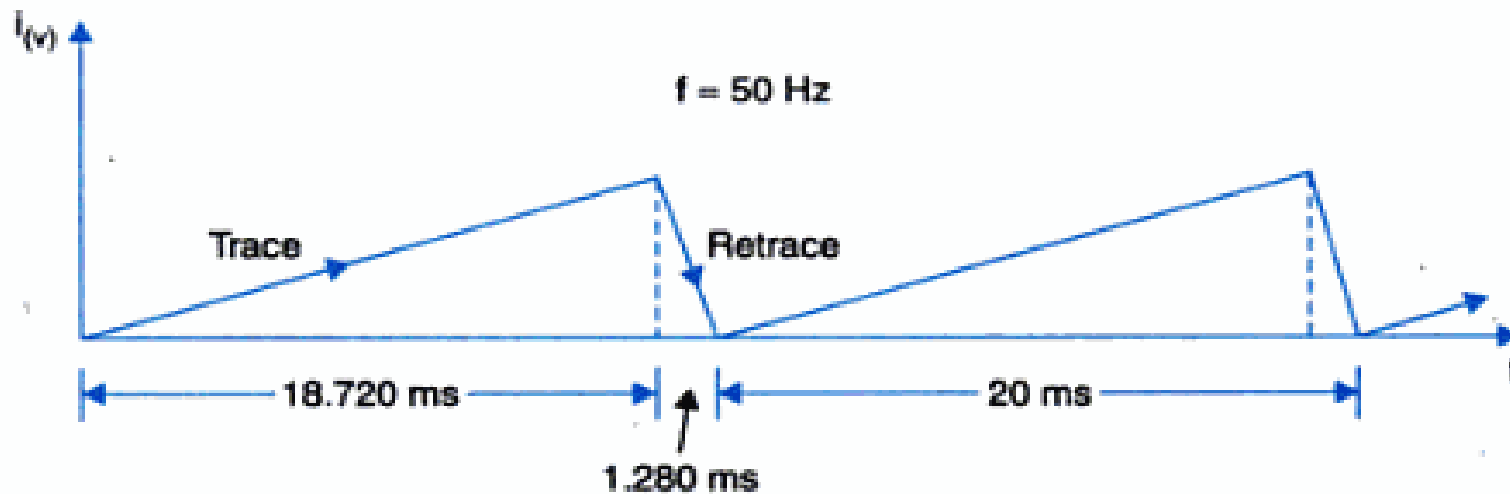


Fig. 2.5 (b) Vertical deflection current.

Scanning periods

contd. .

- 20 horizontal lines could be scanned during each vertical retrace interval $\frac{1280 \mu\text{s}}{64 \mu\text{s}} = 20 \text{ lines}$
- Thus 40 scanning lines are lost per frame
- Now active number of scanning lines $N_a = 625 - 40 = 585$

5. Fine Structure

- The ability of the image reproducing system to represent the fine structure of an object – resolving power or resolution
- *Vertical resolution* $V_r = N_a \times K$; N_a -active number of lines
- K-resolution factor
- Assuming $K=0.69$; $V_r = 585 \times 0.69 = 400$ lines
- *Horizontal resolution*

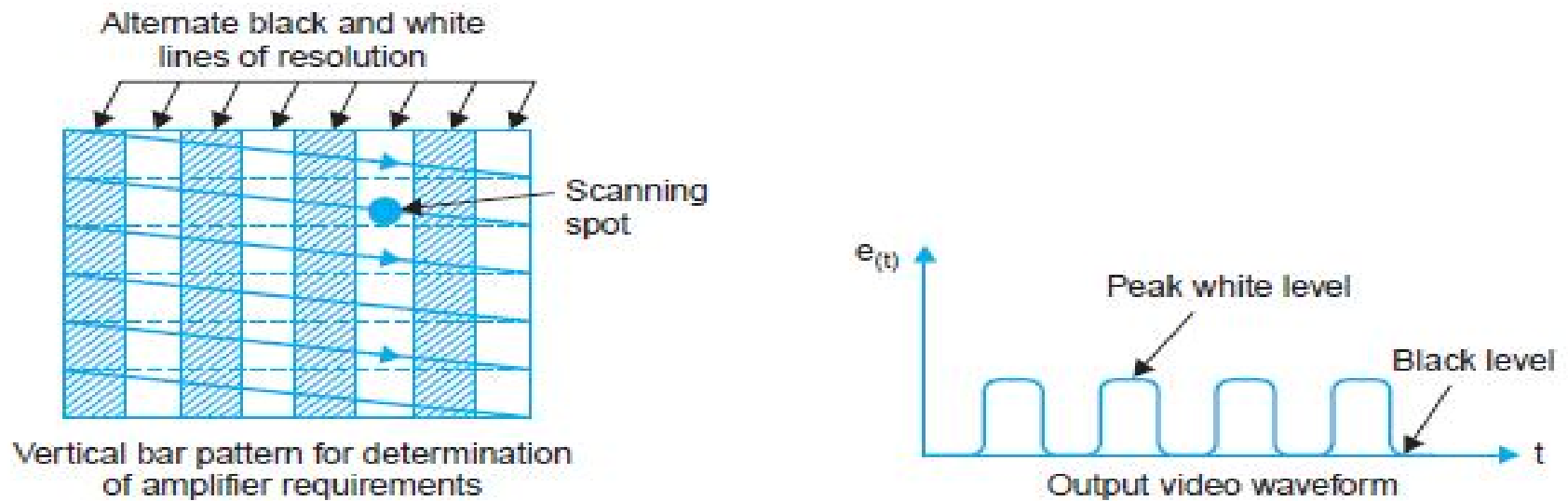


Fig. 2.7 (a) Determination of horizontal resolution.

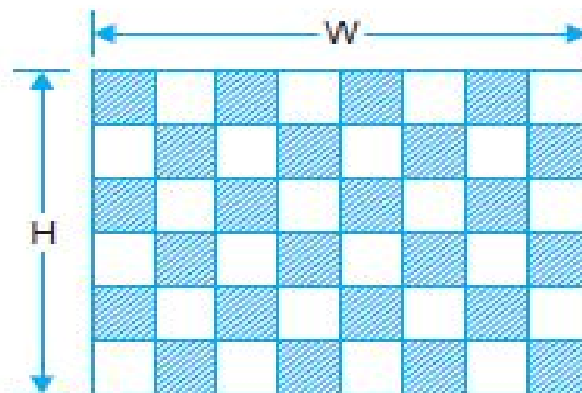


Fig. 2.7(b) Chess-board pattern for studying vertical and horizontal resolution.

time duration t_h of one square wave cycle is equal to

$$t_h = \frac{\text{active period of each horizontal line}}{\text{number of cycles}}$$
$$= \frac{52 \times 10^{-6}}{267} \text{ seconds}$$

∴ thg frequency of the periodic wave

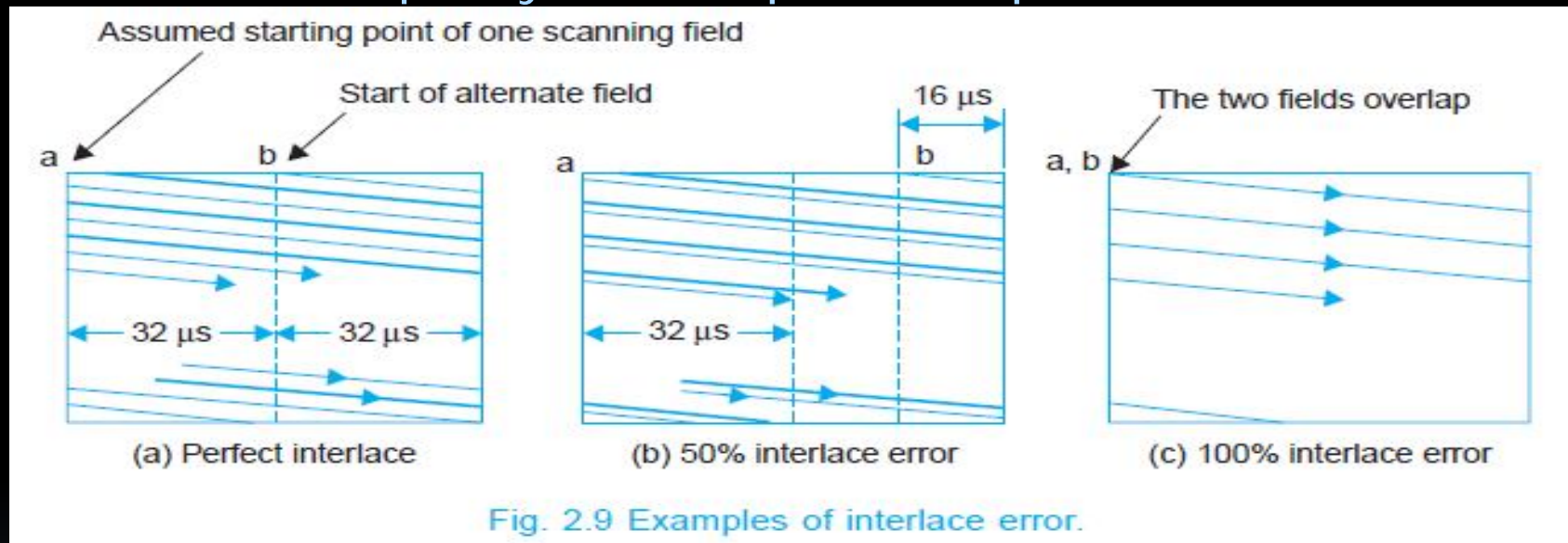
$$f_h = \frac{1}{t_h} = \frac{267 \times 10^6}{52} = 5 \text{ MHz}$$

Therefore, the highest approximate modulating frequency ' f_h ' that the 625 line television system must be capable of handling for successful transmission and reception of picture details is

$$f_h = \frac{\text{No. of active lines} \times \text{aspect ratio} \times \text{resolution factor}}{2 \times \text{time duration of one active line}}$$
$$= \frac{585 \times 4/3 \times 0.69}{2 \times 52 \times 10^{-6}}$$
$$\approx 5 \text{ MHz}$$

Interlace error

- Usually the interlace ratio is 2:1
- Any error in the scanning timings and sequence would reduce the quality of the reproduced picture



percentage interlace error

$$= \frac{48 - 32}{32} \times 100 = 50\%$$

For interlaced scanning, the total number of lines in any TV system must be odd

6. Tonal Gradation

Factors that affect the tonal quality of the reproduced picture are

- a) Contrast
- b) Contrast ratio
- c) Viewing distance

COMPARISON OF VARIOUS TV SYSTEM

CCIR 625 B monochrome system – most parts of Europe and India. BW: 5MHz, Resolution factor: 0.69, Line frequency: 15625

625 line – Britain - BW: 5.5MHz, Resolution factor: 0.73

819 line – France. BW: 10.4MHz (improved vertical and horizontal resolution)

525 line – America. Frame frequency: 30, Line frequency: 15750, BW: 4MHz (ie lesser horizontal resolution)

**Note: Greater the no. of lines, better the vertical resolution
Greater the BW, better the horizontal resolution**