Department of Systems and Biomedical Engineering

Medical Equipment: Ultrasound Imaging (4)

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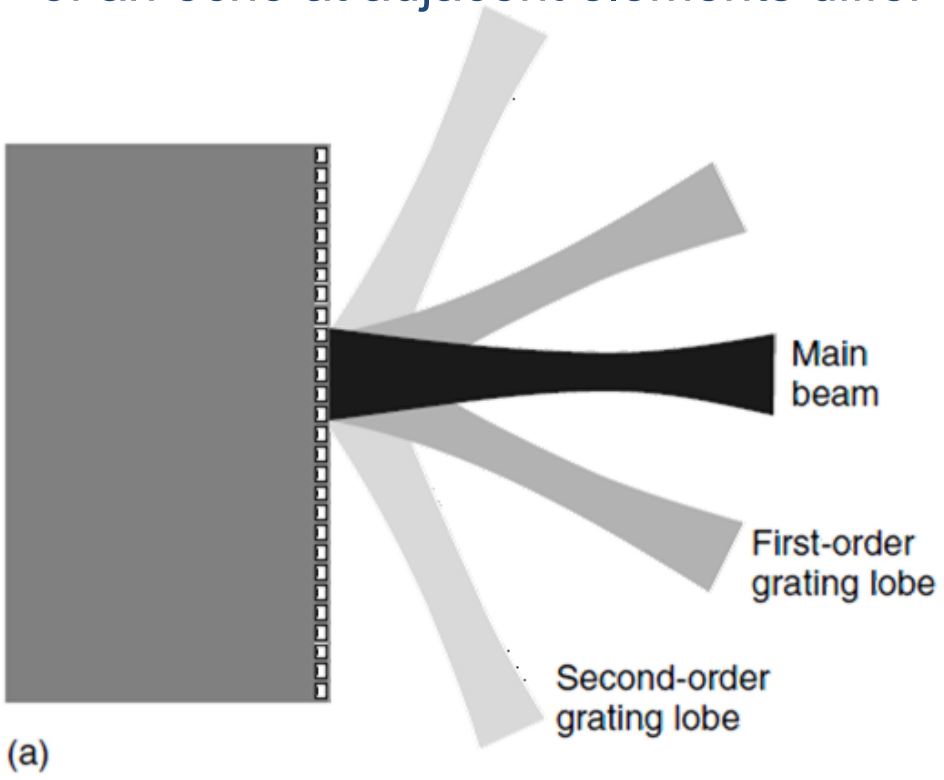
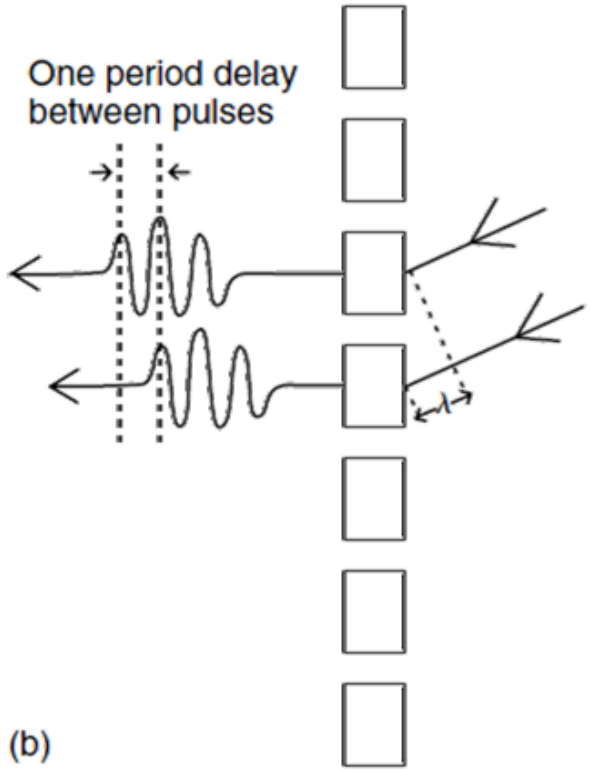
Grating Lobes

Grating lobes are weak replicas of the main beam, at angles of up to 90°. The first grating lobe occurs at that angle for which the arrival times of an echo at adjacent elements differ by one period.





Slice Thickness

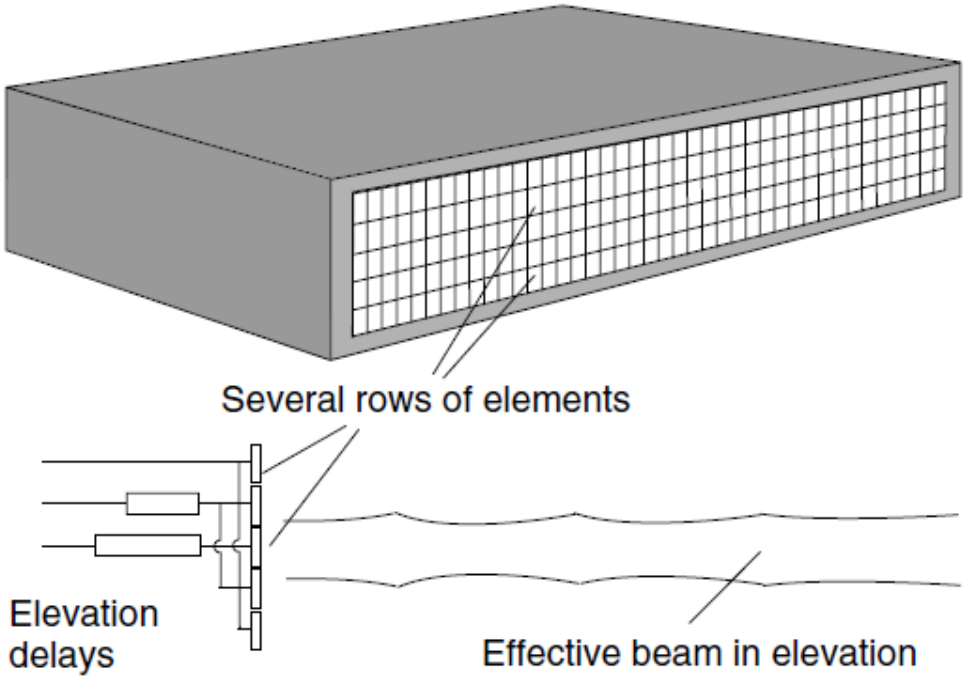
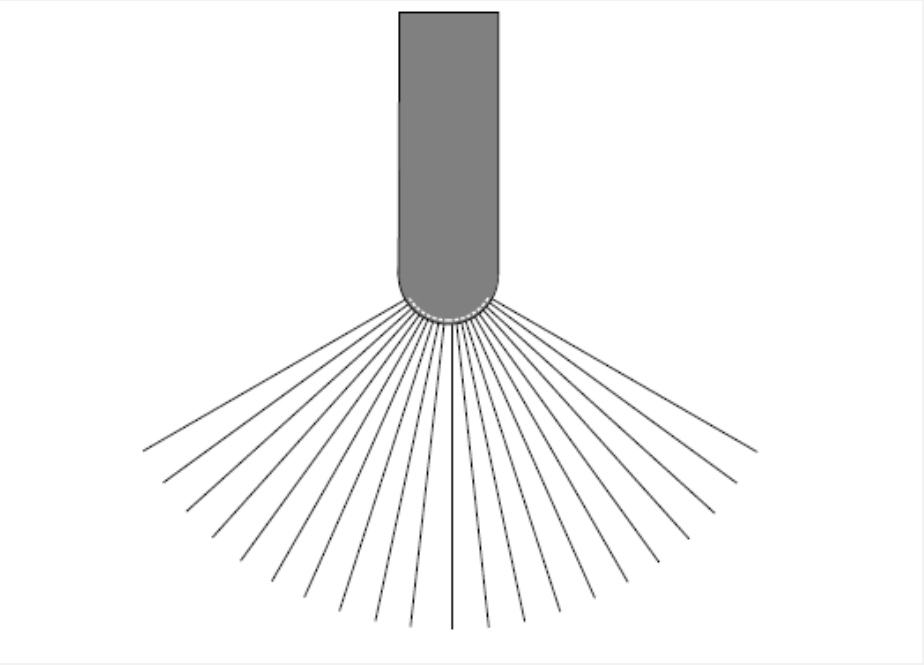


Fig. 3.17 Multiple-row (1.5D) linear-array probe. Transmission and receive focusing techniques normally used for beam-forming in the scan plane can be used to control focusing in the elevation plane. This means a narrower slice thickness and hence less acoustic noise.

Strongly Convex Curvilinear Arrays



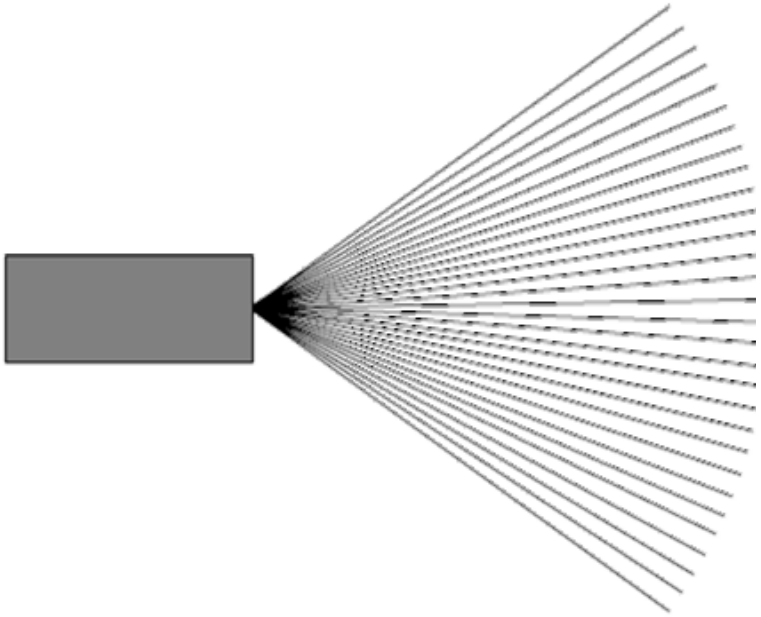
Advantage:

It offers a small acoustic window at the body surface and an increasingly wide field of view at depth.

Disadvantage:

Less suitable in situations where the flat face is needed. This motivated the development of the phased-array transducers.

Phased-Array Transducers



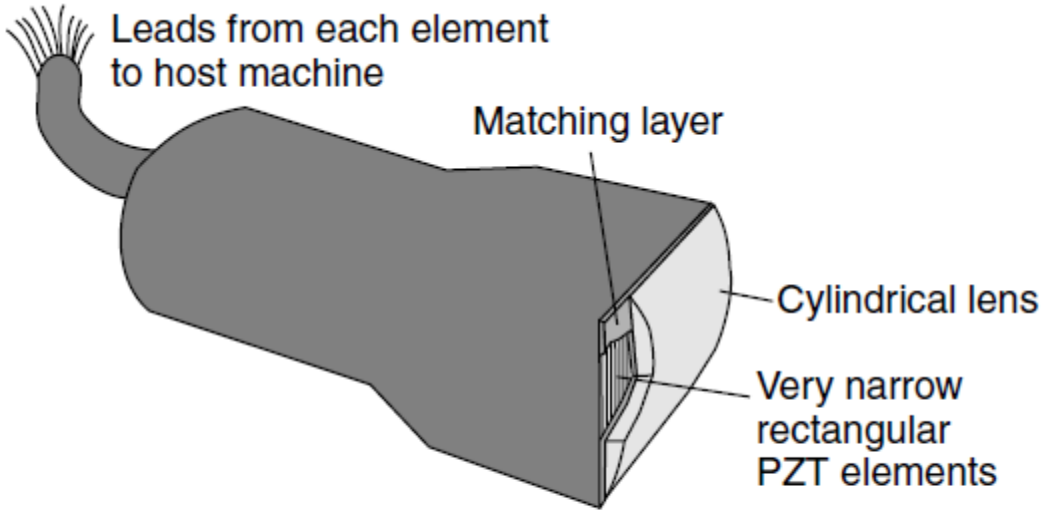
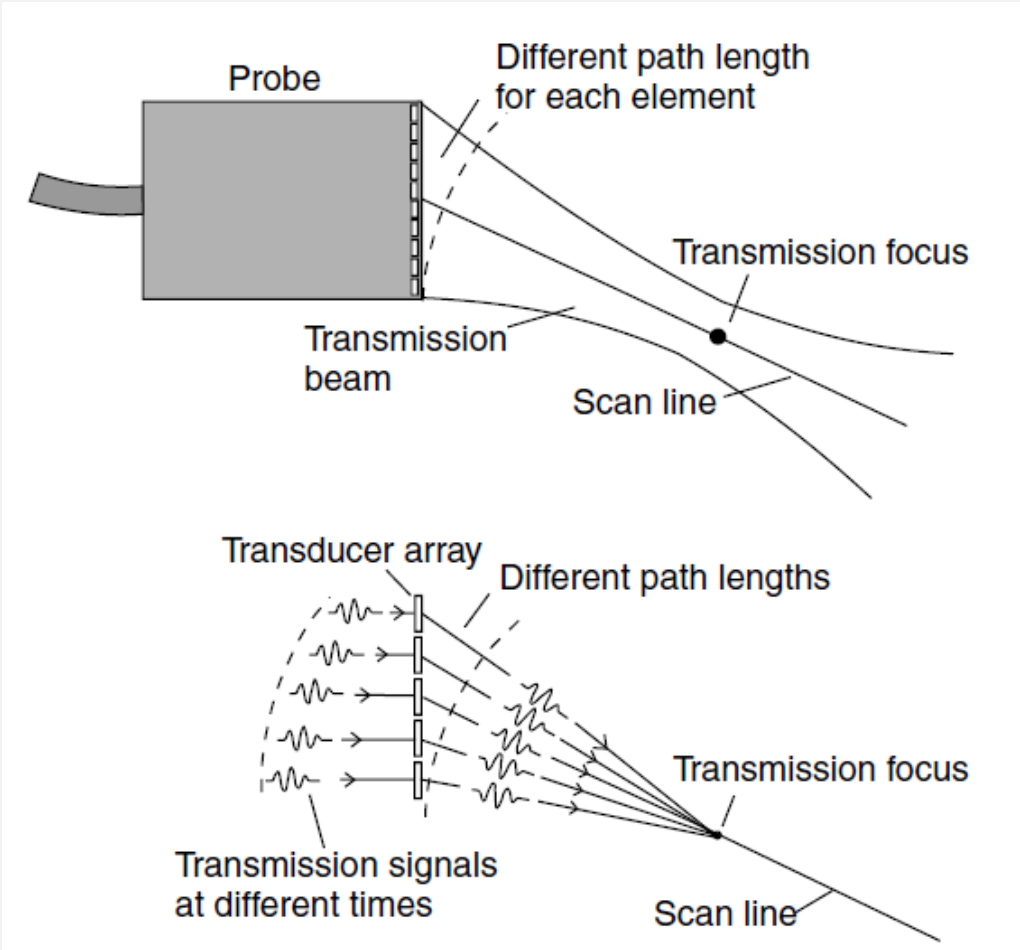


Fig. 3.20 Cut-away view of the elements, matching layer and lens of a phased-array transducer.

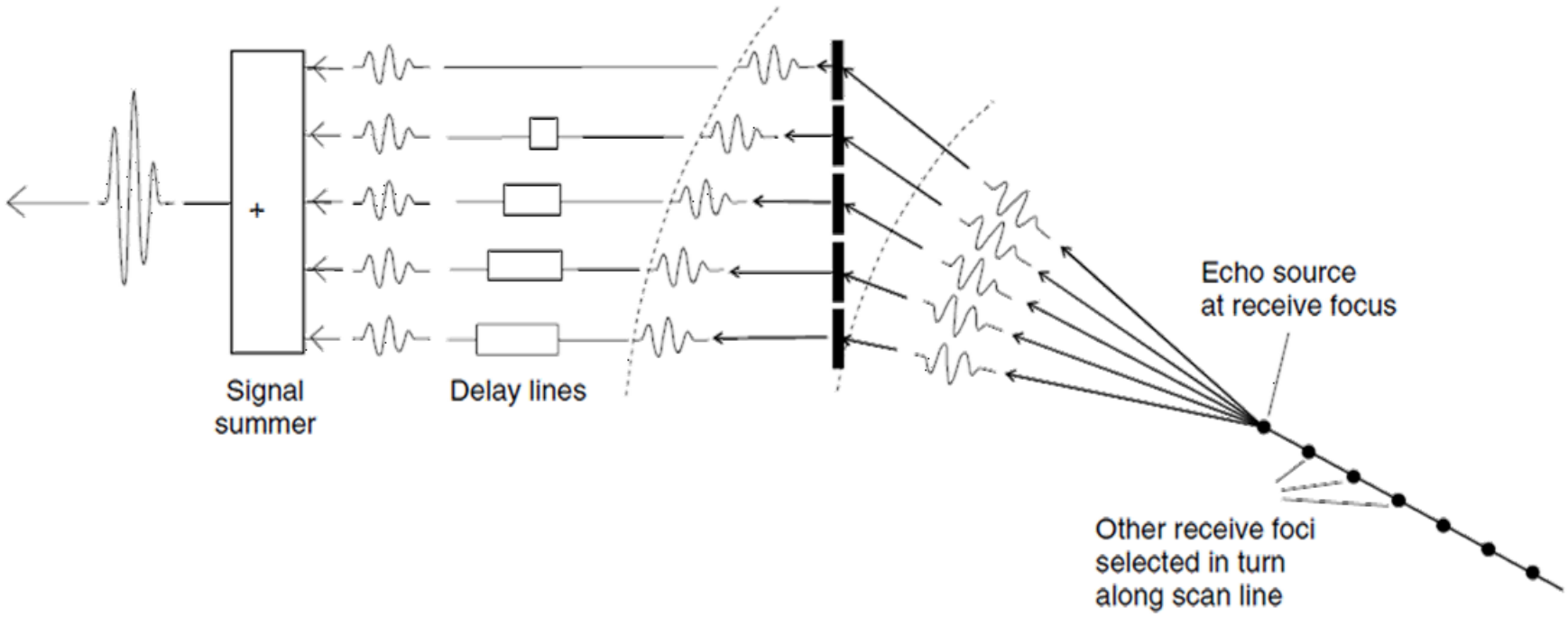
- They consist typically of 128 rectangular elements. A lens provides fixed weak focusing in the elevation direction.
- The transducer array is much shorter in the scan plane.
- Unlike the linear array, all elements are used for every scan line.

Electronic Beam-Steering and Focusing

Phased-array transducers uses time-delaying techniques for beam focusing similar to those adopted for the linear arrays. However, an extra time-delaying component is added to steer the beam by up to ±45^{o} .



Electronic Beam-steering and Focusing



Dynamic focusing is used in reception. All the receive foci lie along a scan line at some angle to the probe's axis as long as each element can detect a signal from the focal point.

Image Quality (Phased-Arrays)

- When using a phased-array transducer, the operator should angle the probe so that any region of interest is in the center of the field of view. Why?
- The beam deflections and widths are least and the signal-to-noise ratio is highest.
- This leads to the best lateral resolution, the highest sensitivity and the best contrast resolution.

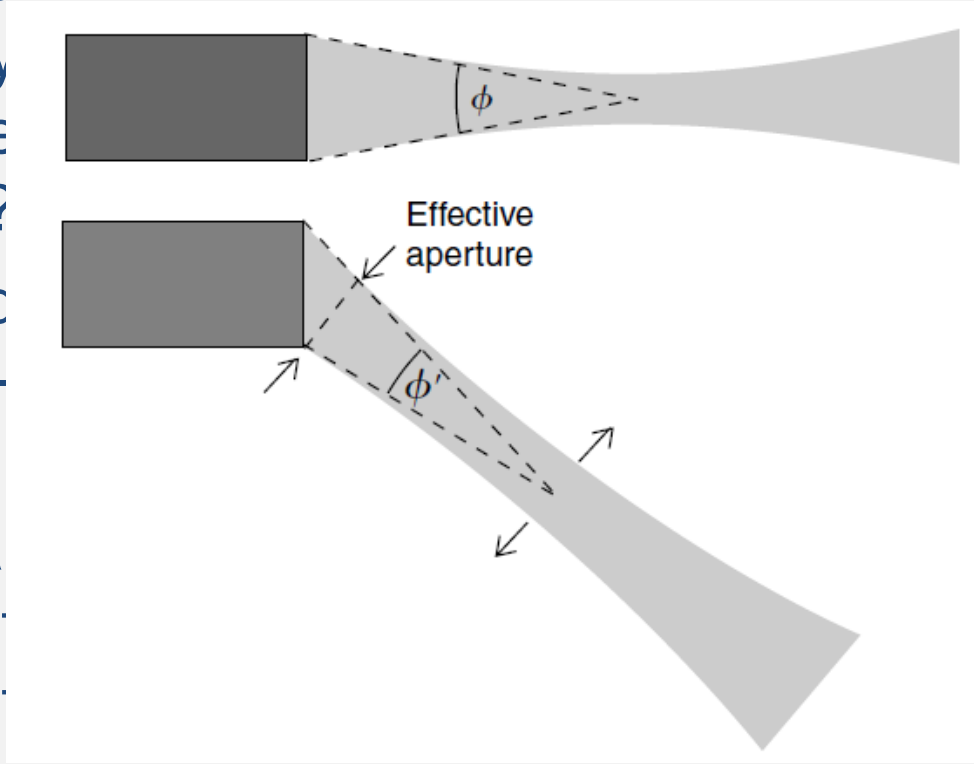
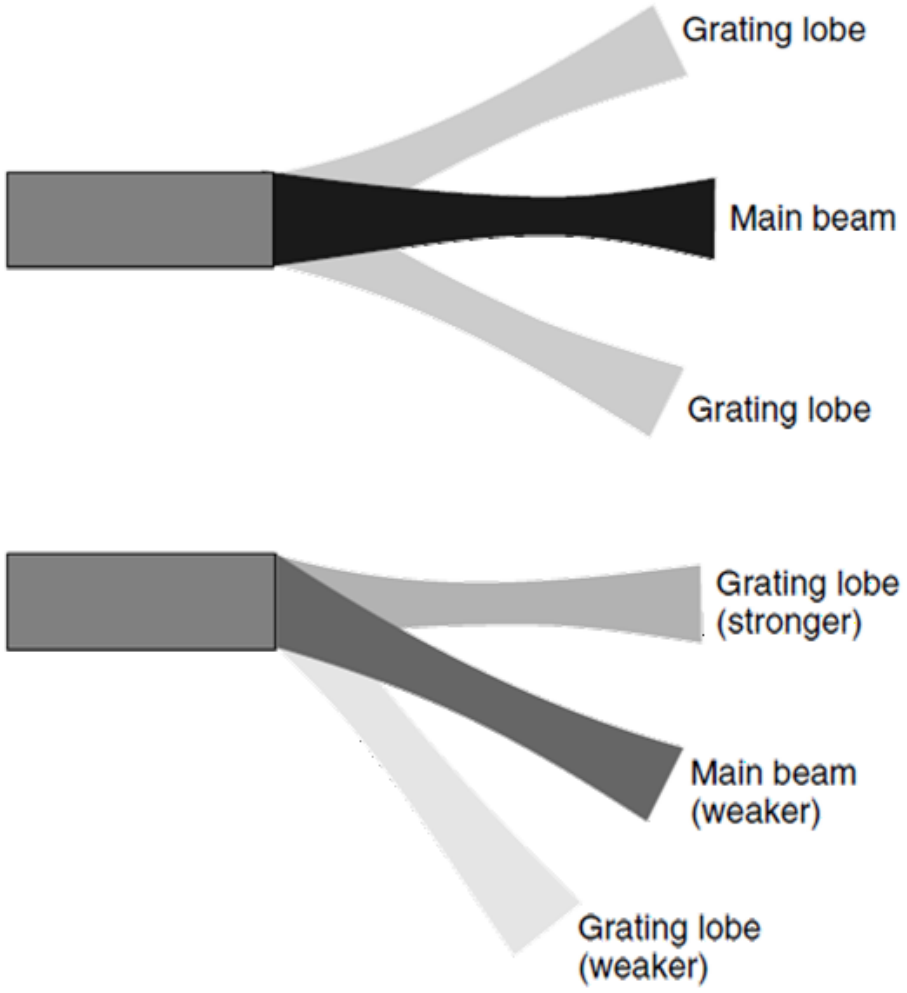


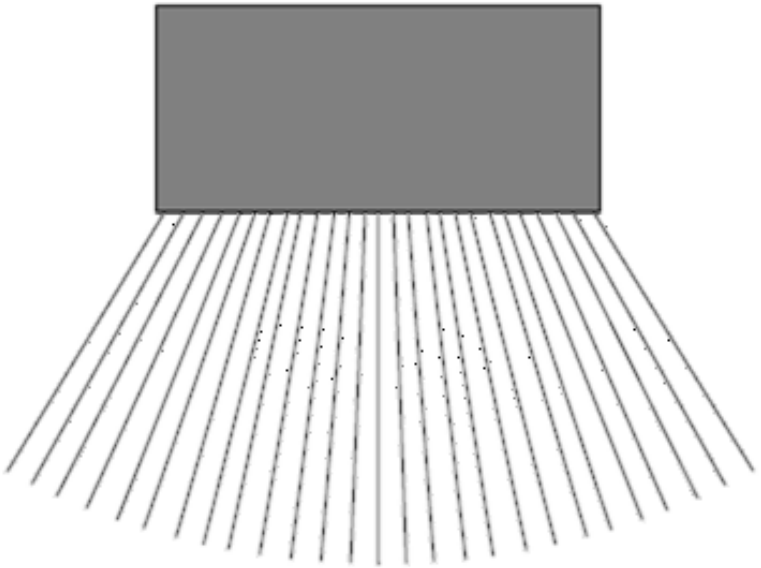
Image Quality (Phased-Arrays)

- Grating lobes from phased array transducers are weak.
- As the deflection of the main beam increases, some grating lobes point more ahead and may become stronger than the main beam.



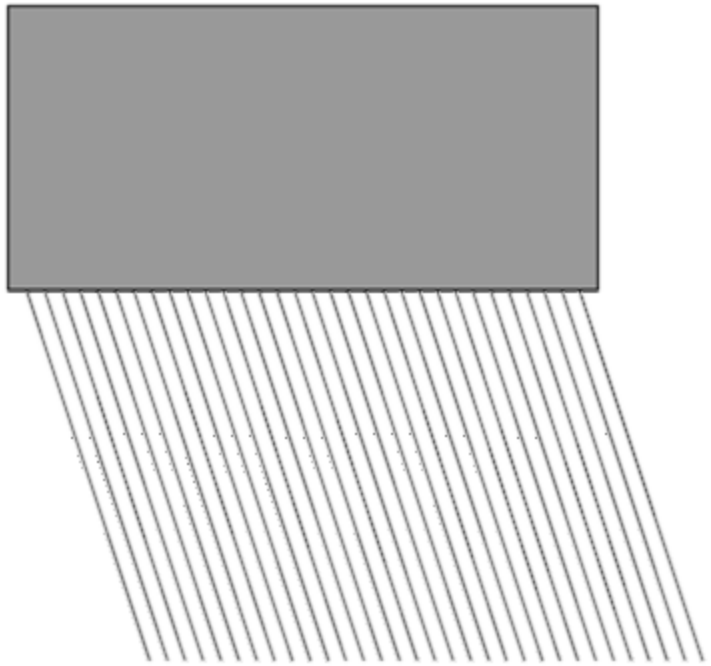
Hybrid Beam-Stepping/Beam-Steering

Trapezoidal scanning format



Increases the field of view without tissue compression

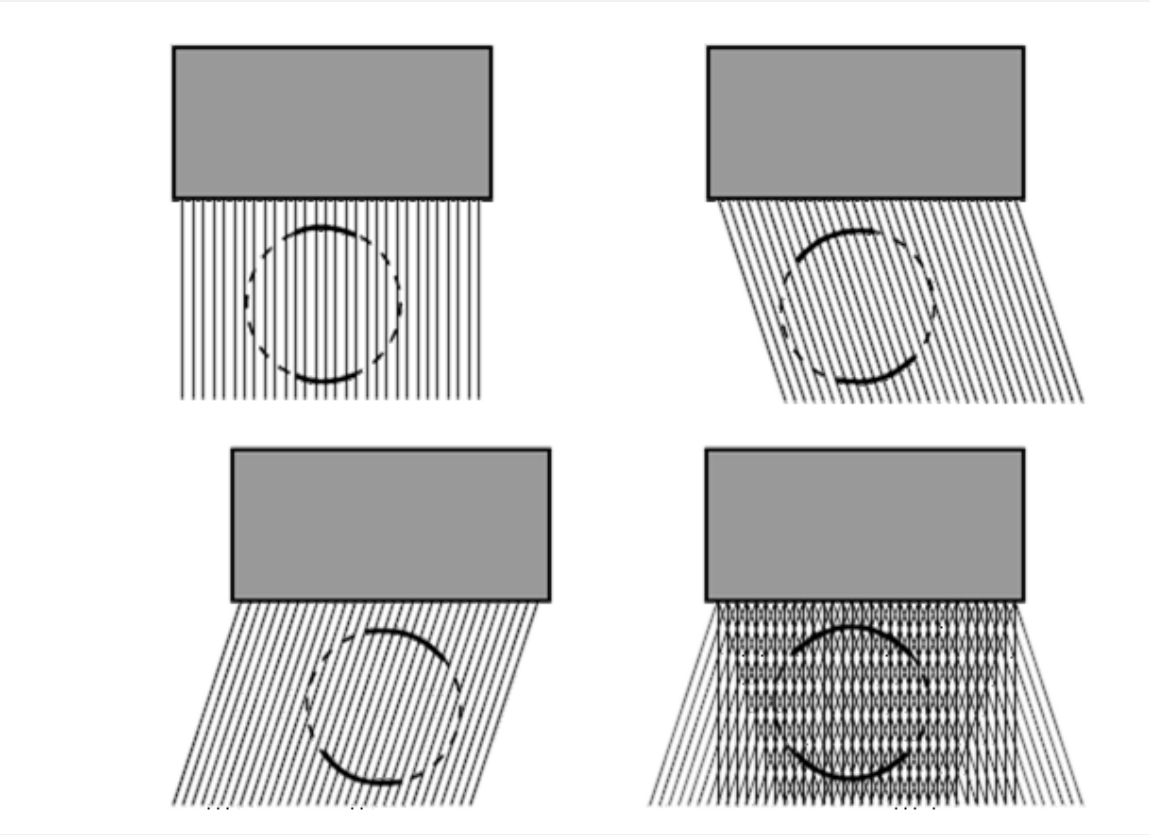
Linear array with beam steering



Problems: As the beam deflected there is great reduction in the sensitivity and greater acoustic noise from grating lobes.

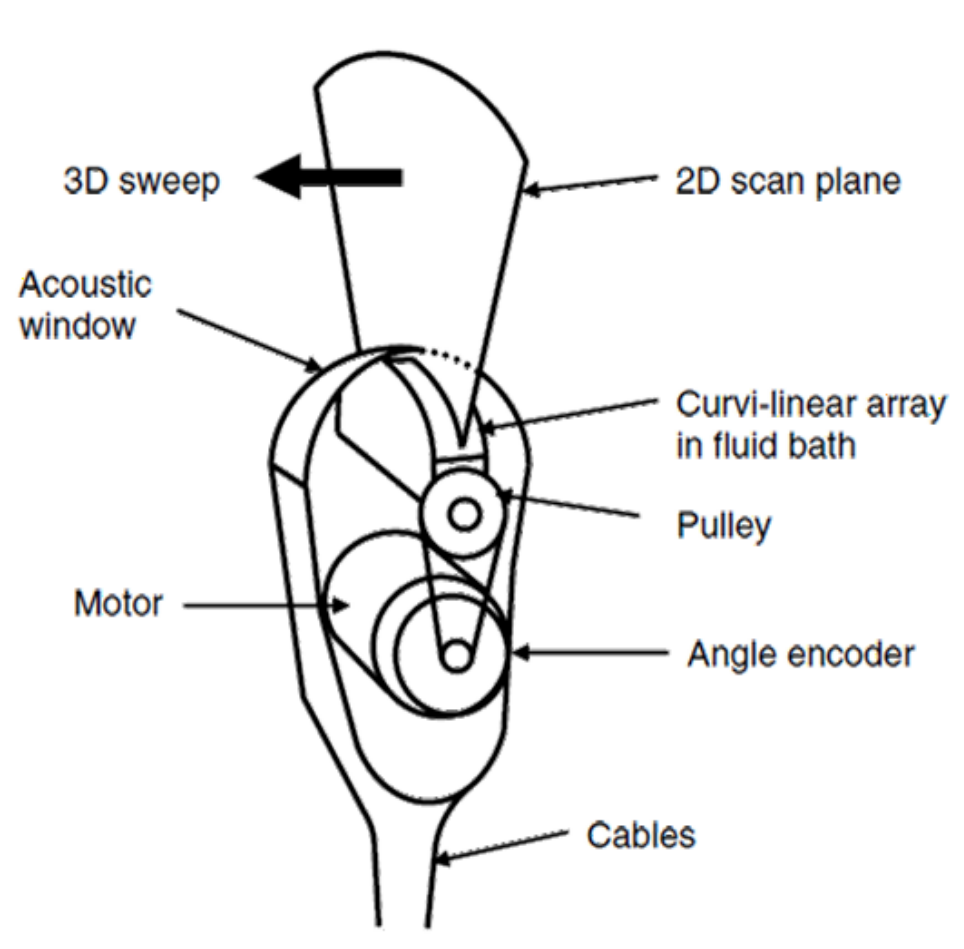
Compound Scanning

- Several scans from different directions averaged.
- It provides more accu deception of or boundaries as well reduced noise and speckl
- Since frame averagin used, the temp resolution, or frame rate decreased.

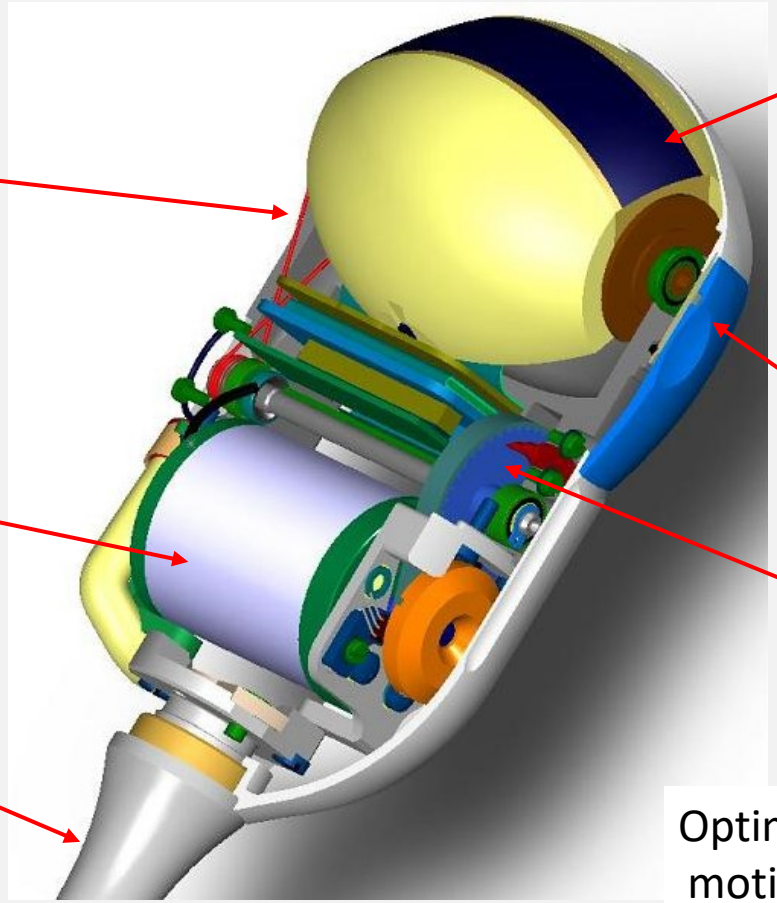


3D/4D Ultrasound Transducers

- The first configuration for 3D imaging describes the use of mechanical 3D transducer.
- The transducer contains a stepped array mounted on a swivel in an enclosed fluid bath beneath a thin acoustic window.
- Due to the mechanical nature of the transducer movement, 4D acquisition rates are limited to a few volumes per seconds.



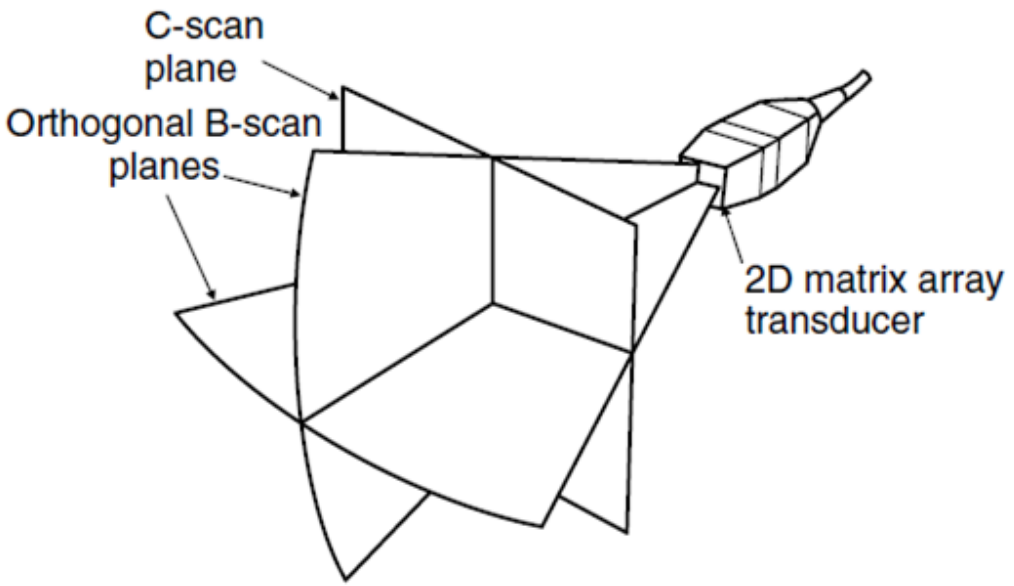
Mechanical 4D Array



Optimized for high-speed motion, up to 18 vol/sec

3D/4D Ultrasound Transducers

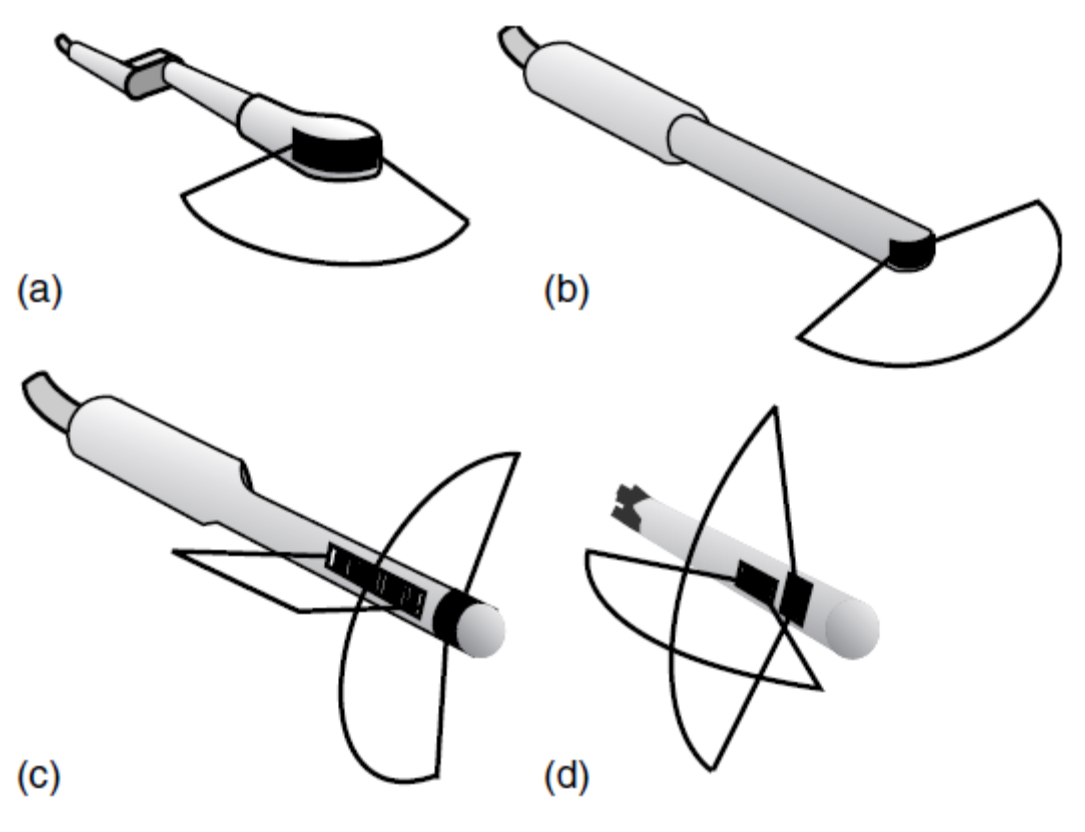
- The second configuration for 3D imaging incorporates the use of 2D matrix-array transducer.
- The matrix has a square array of elements such as 50 x 50 to achieve equivalent resolution in the lateral and elevation directions.



- It uses beamforming techniques to sweep a 2D sector scan through a 3D volume or interrogate orthogonal B-scan planes.
- Volume data can be displayed as a series of B-scan planes or as a c-scan, or 3D volume.

Endo-Cavity Transducers

- They are intended for insertion into a natural body cavity or through a surgical opening.
- Higher frequencies (better resolution) may be used since the transducer is closer to the target organ.
- Linear, curvilinear, or phased arrays may be used depending on the anatomy.



Endo-Cavity Transducers

- 360 mechanically scanned endo-probes rotate the transducer about the axis of a probe so that the beam sweeps through a 360° circle.
- Such probes consist of an outer tube within which is a rotating inner rod, bearing the outwardly pointing transducer.

Intra-luminal and intra-cardiac catheter probes using transducer arrays

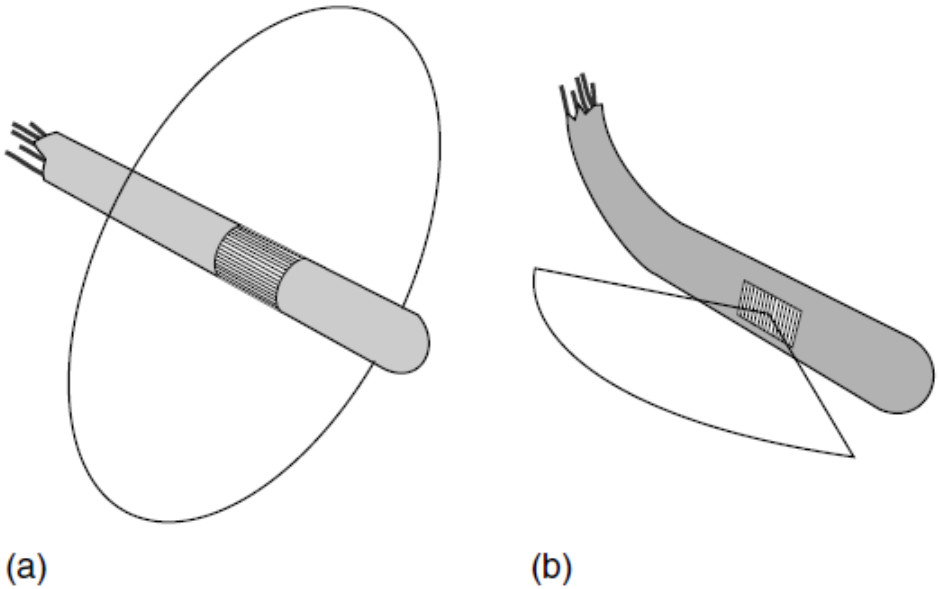


Fig 3.37 (a) Intra-luminal transducer with a cylindrical high-frequency (typically 30 MHz) array, providing 360° transverse images of blood-vessel walls. (b) Intra-cardiac phased-array transducer mounted on the end of a steerable catheter.

Spatial resolution VS Temporal

Real-time operation requires compromising between three competing qualities:
(1) Temporal resolution, (2) Size of the field of view, and (3) Image quality (e.g. lateral resolution, contrast resolution, dynamic range).

- **High-frame-rate imaging**

Topics Covered

- This lecture covered mainly chapter Ch 3 in the book of Hoskins et al.