ULTRASONICS

by

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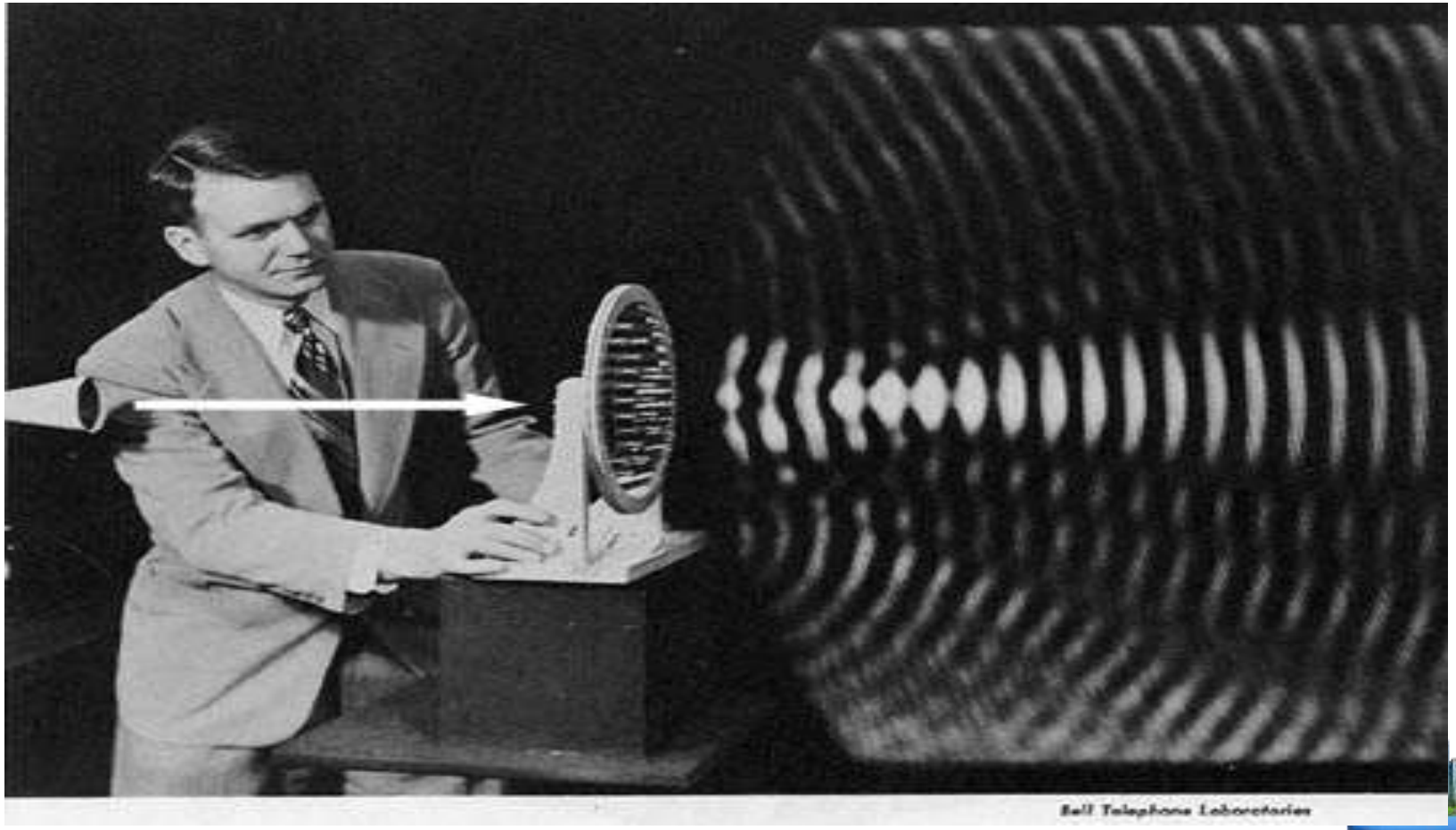
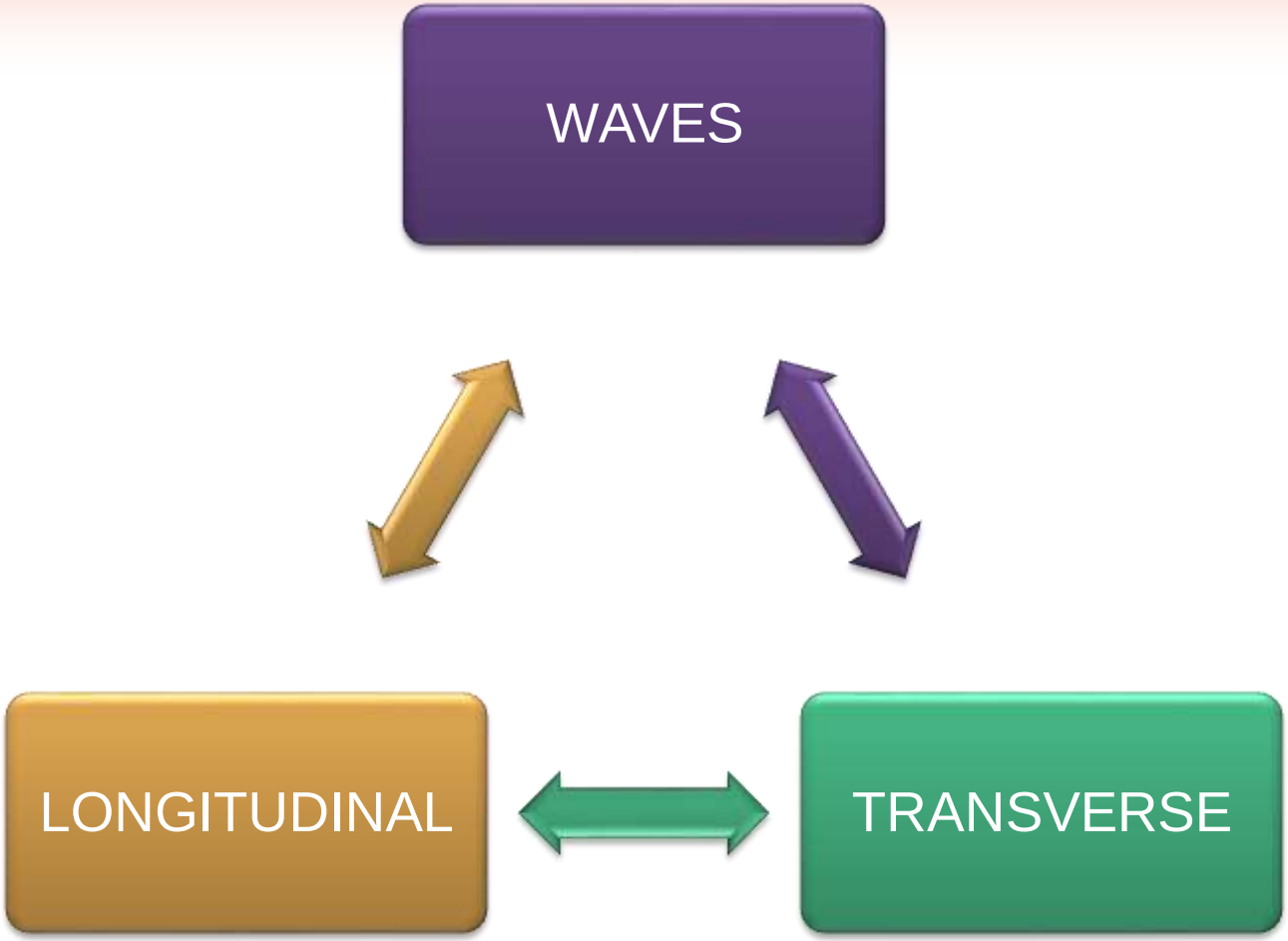
ULTRASONICS

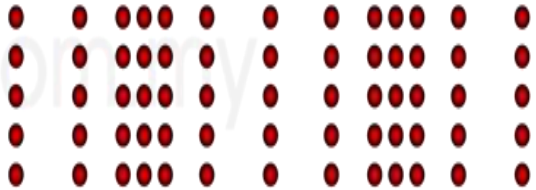


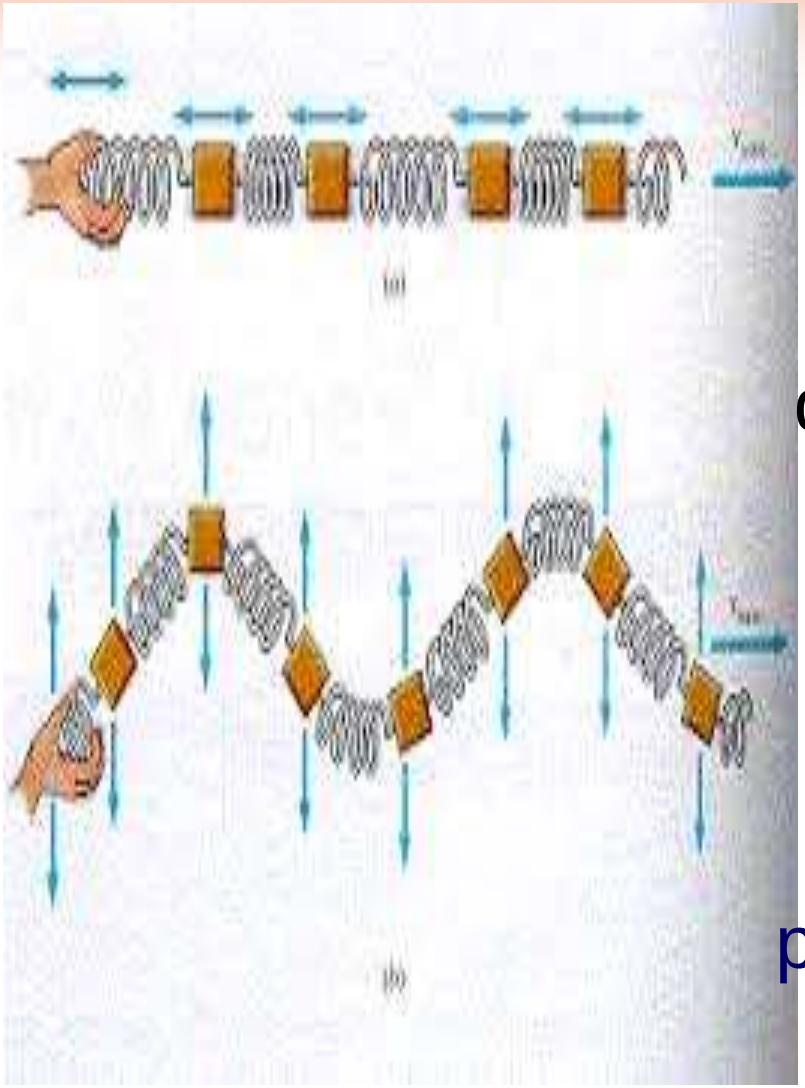
- Introduction to ultrasonics
- Properties of ultrasonis
- Production of ultrasonics
    1. Magnetostriction method
    2. Piezo-electric method
- Detection of ultrasonics
- Applications of ultrasonics


WAVES
LONGITUDINAL
TRANSVERSE

Waves

- Transverse Wave
- Longitudinal Wave



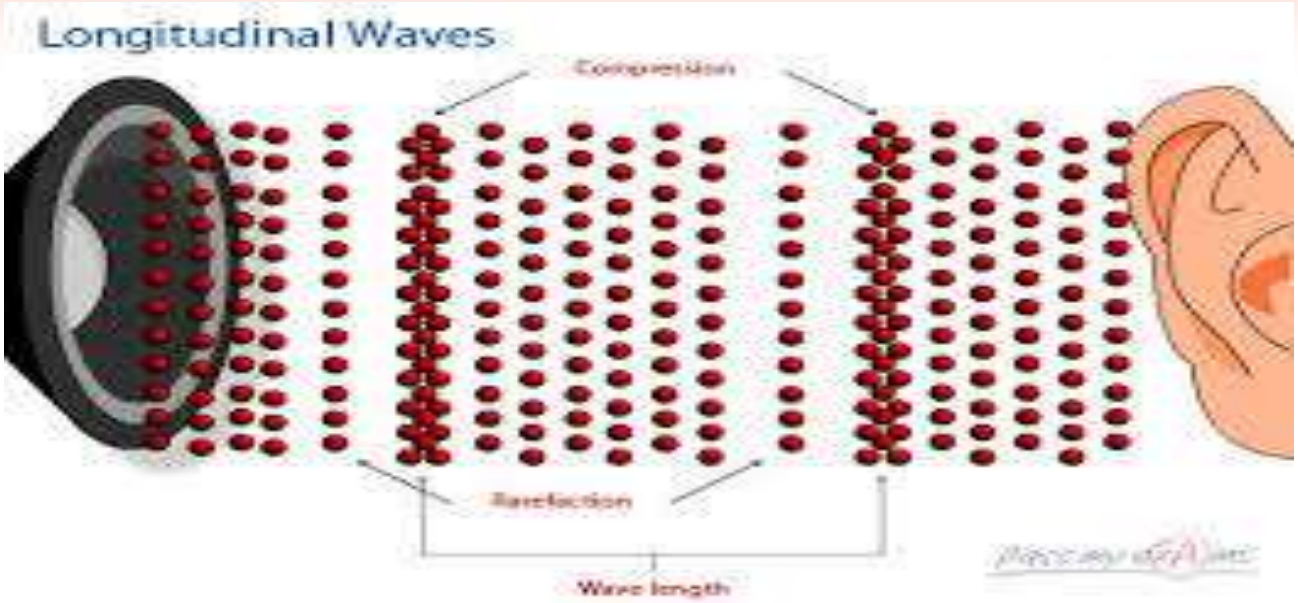


Longitudinal waves:-

Displacement of the medium is in same direction of propagation.

Transverse waves

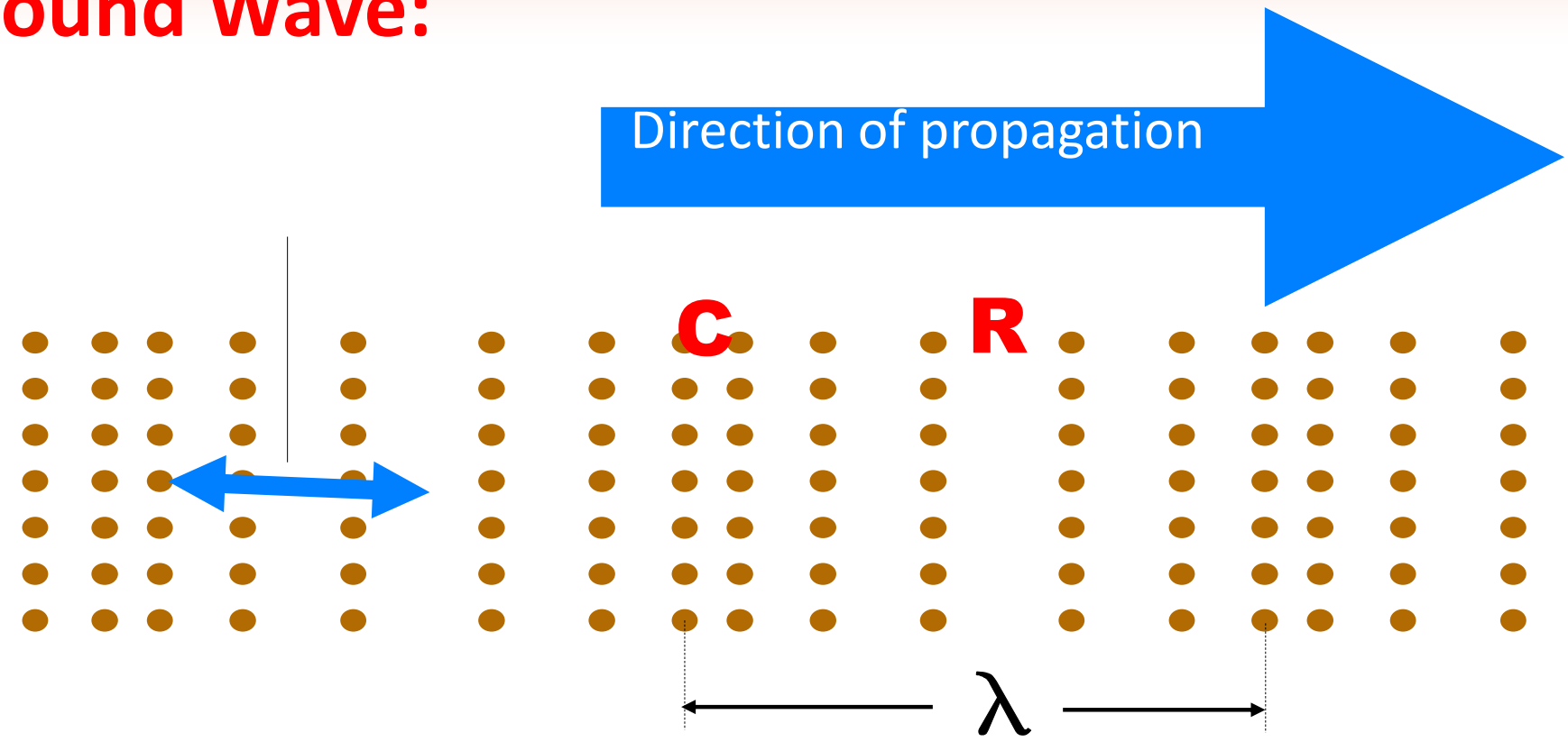
Displacement of the medium is in perpendicular direction of propagation



Sound Waves are the example of longitudinal waves

Introduction

Sound Wave:



Travels : Longitudinal Wave Motion

Form of Energy : Emitted by a vibrating body

Propagation : In all directions

Depend on frequency sound waves are classified in three categories

SOUND WAVES

Infrasonic waves

0-20HZ

EARTHQUAKE

Audible Range

20HZ----
20000HZ

Ultrasonic waves

20000HZ-5 MHZ

BATS,QUARTZ CRYSTAL

Rhinoceroses use infrasonic frequencies as low as 5 Hz to call one another

Bats use ultrasonic frequencies up to 100 kHz for locating their food sources and navigating

Properties of ultrasonic waves

1. They have a high energy content.
2. Just like ordinary sound waves, ultrasonic waves get reflected, refracted and absorbed.
3. They can be transmitted over large Distances with no appreciable loss of energy.
4. If an arrangement is made to form stationary waves of ultrasonics in a liquid, it serves as a diffraction grating. It is called an ***acoustic grating.***
5. They produce intense heating effect when passed through a substance.

ULTRASONICS PRODUCTION

Ultrasonic waves are produced by the following methods.

(1) Magneto-striction generator or oscillator

(2) Piezo-electric generator or oscillator

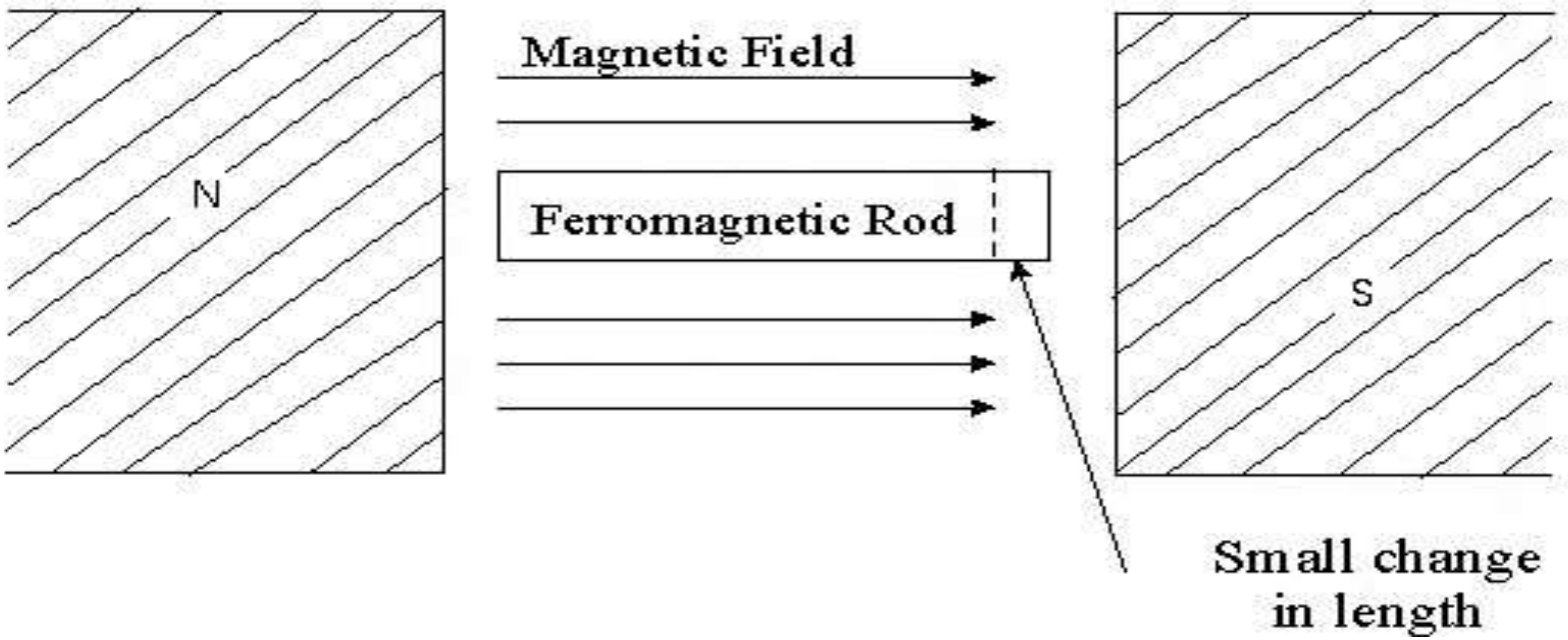
MAGNETOSTRICTION METHOD

To produce low frequency Ultrasonics

Principle: Magnetostriction effect

When a magnetic field is applied parallel to the length of a ferromagnetic rod made of ferromagnetic materials such as iron or nickel, a **small elongation or contraction**

MAGNETOSTRICTION METHOD



change in length

depends upon

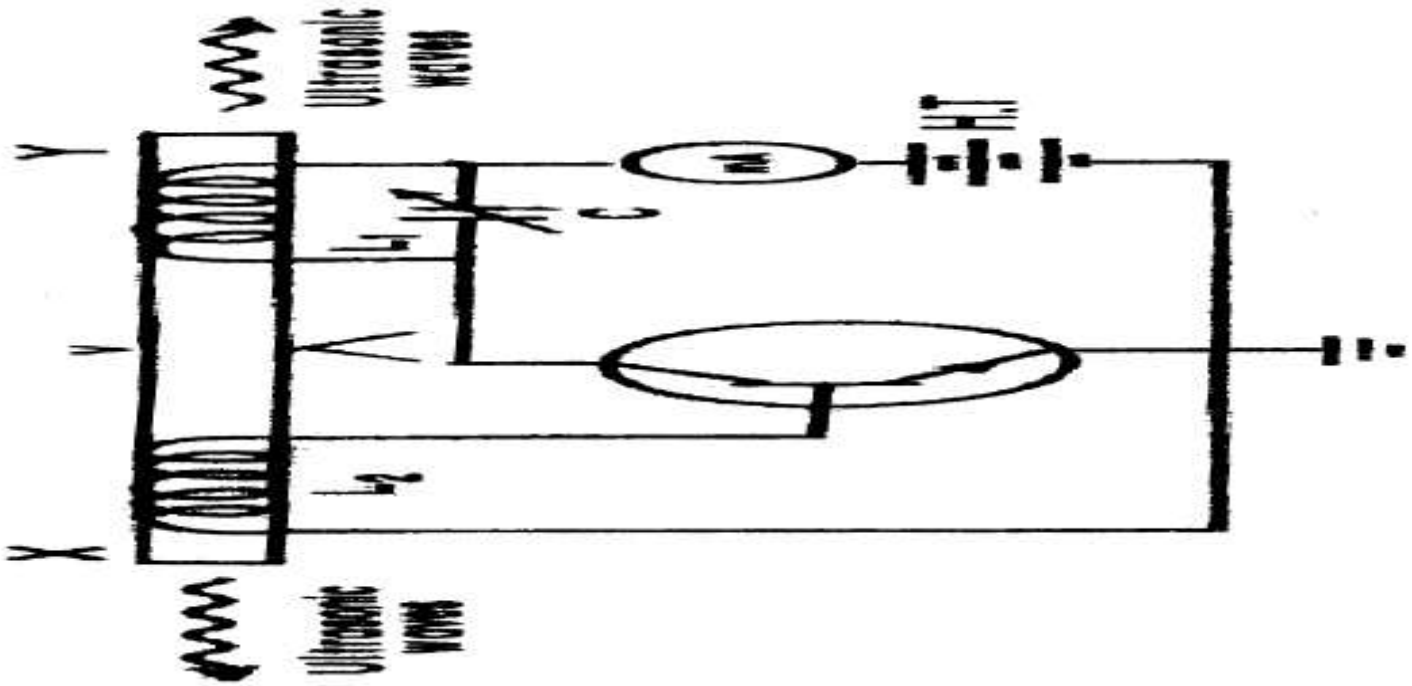
i) the strength of the magnetic field,

ii) the nature of the ferromagnetic materials

iii) does not depend of the direction of the field.

MAGNETOSTRICTION METHOD

Construction



The experimental arrangement is shown in Figure

MAGNETOSTRICTION METHOD

XY is a rod of ferromagnetic materials like iron or **nickel.** The rod is clamped in the middle.

The alternating magnetic field is generated by electronic oscillator.

The coil L_1 wound on the right hand portion of the rod along with a variable capacitor C.

This forms the ***resonant circuit*** of the collector tuned oscillator. The frequency of oscillator is controlled by the variable capacitor.

The coil L_2 wound on the left hand portion of the rod is connected to the base circuit. The coil L_2 acts as ***feed –back loop*.**

MAGNETOSTRICTION METHOD

Working

- When High Tension (H.T) battery is switched on, the collector circuit oscillates with a frequency,

$$f = \frac{1}{2\pi\sqrt{L_1 C}}$$

- This alternating current flowing through the coil L_1 produces an alternating magnetic field along the length of the rod. The result is that the rod starts vibrating due to magnetostrictive effect.

MAGNETOSTRICTION METHOD

The frequency of vibration of the rod is given by

$$n = \frac{1}{2l}\sqrt{\frac{Y}{\rho}}$$

where l = length of the rod

Y = Young's modulus of the rod material and

ρ =density of rod material

- The capacitor C is adjusted so that the frequency of the oscillatory circuit is equal to natural frequency of the rod and thus resonance takes place.
- Now the rod vibrates longitudinally with maximum amplitude and generates ultrasonic waves of high frequency from its ends.

MAGNETOSTRICTION METHOD

Advantages

1. The design of this oscillator is very simple and its production cost is low
2. At low ultrasonic frequencies, the large power output can be produced without the risk of damage of the oscillatory circuit.

Disadvantages

1.It has low upper frequency limit and cannot generate ultrasonic frequency above 3000 kHz (ie. 3MHz).

2.The frequency of oscillations depends on temperature.

3.There will be losses of energy due to hysteresis and eddy current.

PROPERTIES OF ULTRASONICS

(1) They have a high energy content (high freq)

(2) Speed of ultrasonic waves depends on frequency .

(3) To propagation the ultrasonic waves --
Medium is compulsory

(4)Just like ordinary sound waves, ultrasonic waves get reflected, refracted and absorbed.

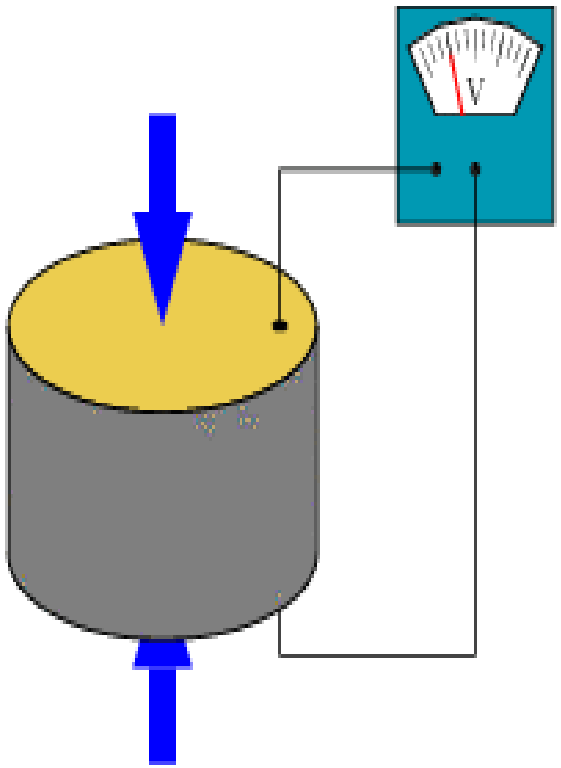
(5) Polarisation: can not be polarized.

(6) Shows negligible diffraction.

(7) Acoustic grating can be constructed.

PIEZO ELECTRIC EFFECT

If mechanical pressure is applied to one pair of opposite faces of certain crystals like quartz, equal and opposite electrical charges appear across its other faces. This is called as piezo-electric effect

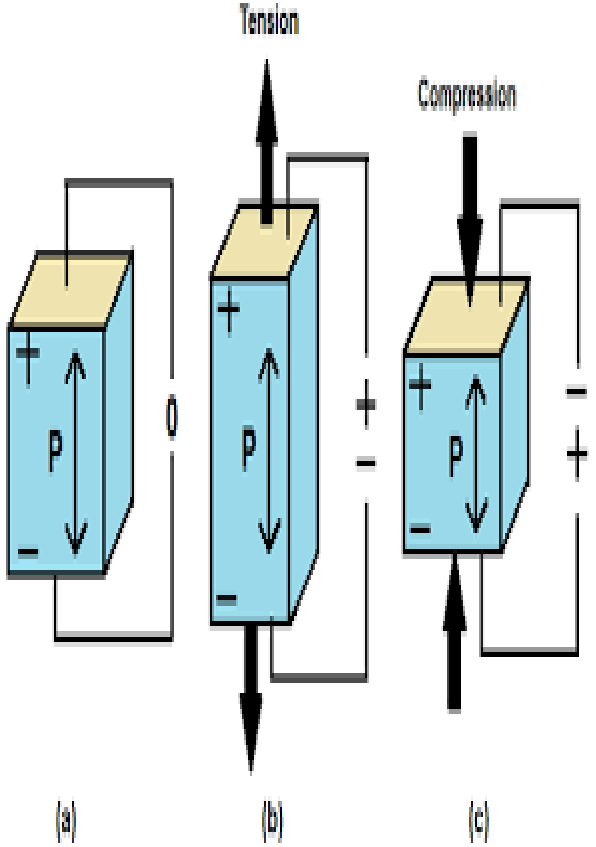


PIEZO ELECTRIC METHOD

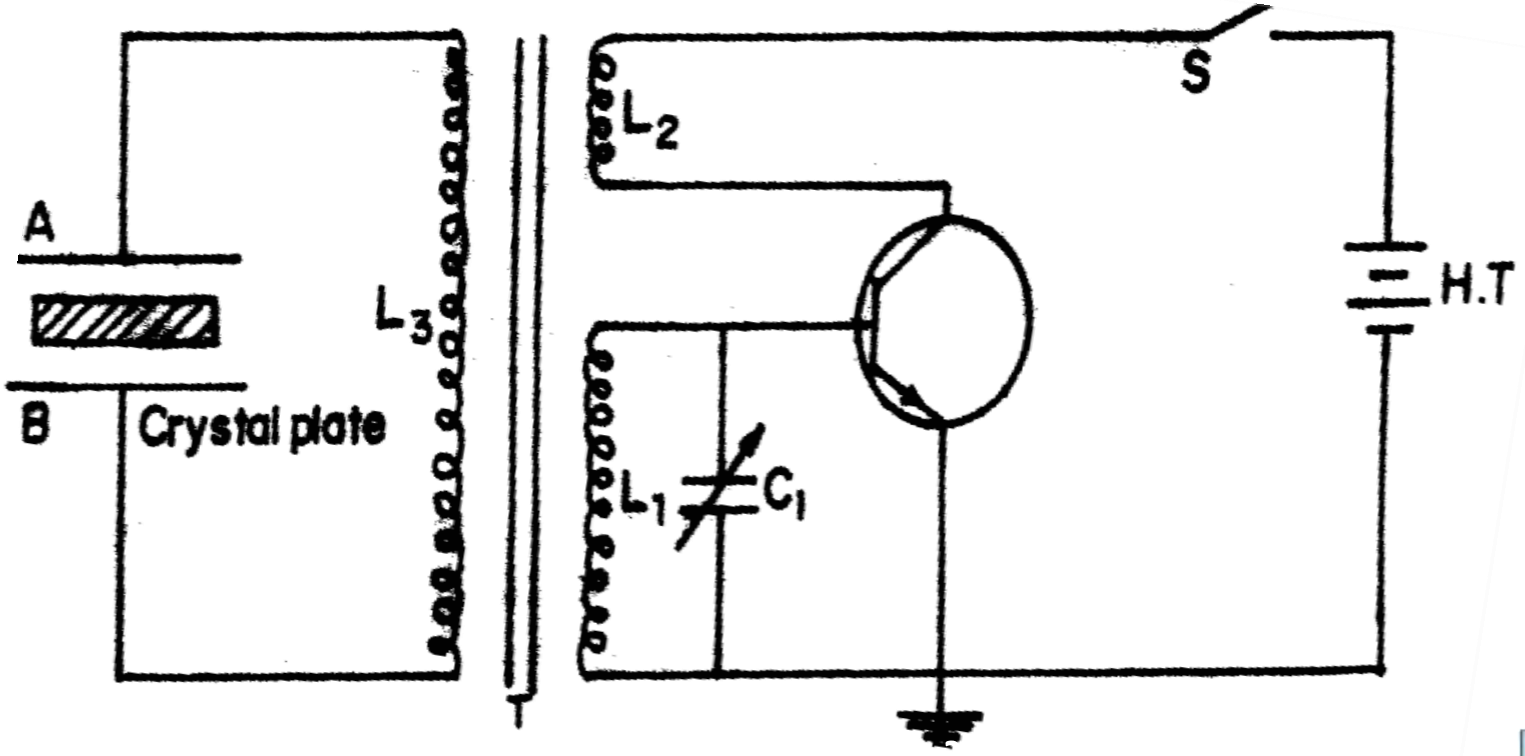
Principle : Inverse piezo electric effect

- The converse of piezo electric effect is also true.

- If an electric field is applied to one pair of faces, the corresponding changes in the dimensions of the other pair of faces of the crystal are produced. This is known as ***inverse piezo electric*** effect or ***electrostriction***.

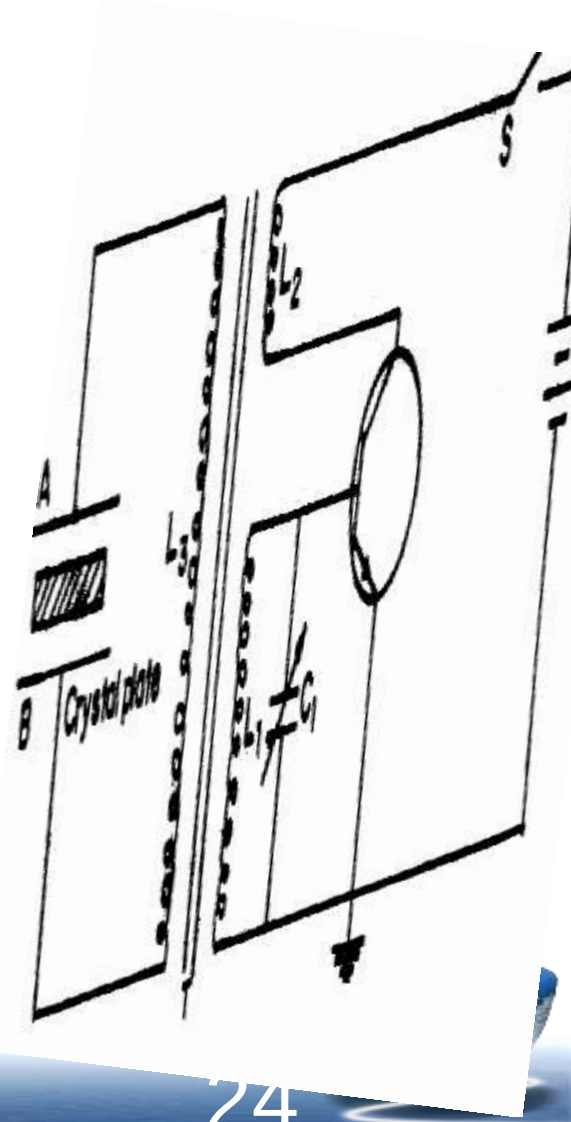


PIEZO ELECTRIC METHOD



PIEZO ELECTRIC METHOD

- The quartz crystal is placed between two metal plates A and B.
- The plates are connected to the primary (L_3) of a transformer which is inductively coupled to the electronics oscillator.
- The electronic oscillator circuit is a base tuned oscillator circuit.
- The coils L_1 and L_2 of oscillator circuit are taken from the secondary of a transformer T.
- The collector coil L_2 is inductively coupled to base coil L_1.
- The coil L_1 and variable capacitor C_1 form the *tank circuit* of the oscillator.



PIEZO ELECTRIC METHOD

Working

- When H.T. battery is switched on, the oscillator produces high frequency alternating voltages with a frequency.

$$f = \frac{1}{2\pi\sqrt{L_1 C_1}}$$

- Due to the transformer action, an oscillatory e.m.f. is induced in the coil L_3. This high frequency alternating voltages are fed on the plates A and B.
- Inverse piezo-electric effect takes place and the crystal contracts and expands alternatively. The crystal is set into mechanical vibrations.
- The frequency of the vibration is given by

$$n = \frac{P}{2l}\sqrt{\frac{Y}{\rho}}$$

etc.

for fundamental, first over tone, second over tone etc.,

Y = Young's modulus of the crystal and

ρ = density of the crystal.

PIEZO ELECTRIC METHOD

Advantages

- Ultrasonic frequencies as high as 5 x 108Hz or 500 MHz can be obtained with this arrangement.
- The output of this oscillator is very high.
- It is not affected by temperature and humidity.

Disadvantages

- The cost of piezo electric quartz is very high
- The cutting and shaping of quartz crystal are very complex.

Applications of Ultrasonic Waves in Engineering

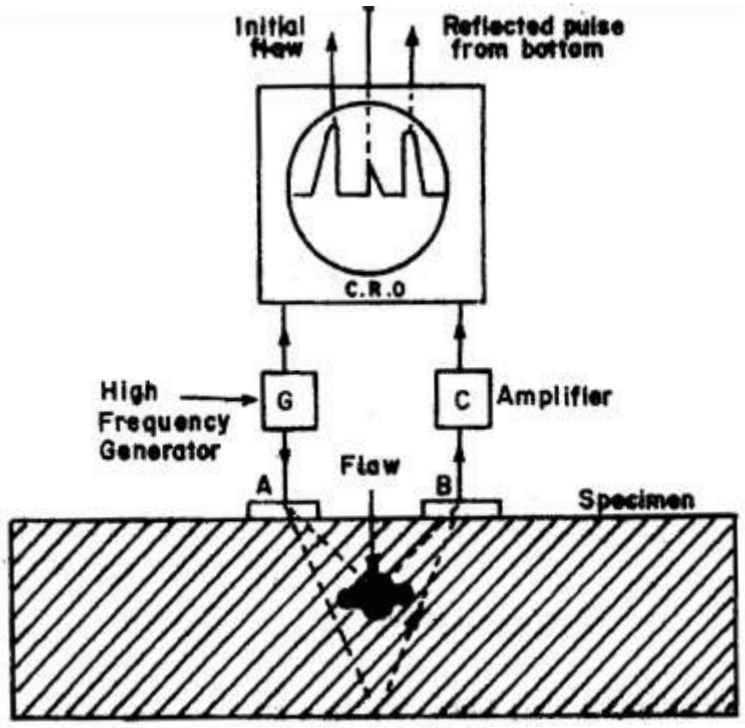
Testing –NDT

Principle

- Ultrasonic waves are used to detect the presence of flaws or defects in the form of **cracks, blowholes porosity etc**., in the internal structure of a material

  sending out ultrasonic beam and by measuring the time interval of the reflected beam, flaws in the metal block can be determined.

Non Destructive Testing –NDT



It consists of an ultrasonic frequency generator and a cathode ray oscilloscope (CRO),transmitting transducer(A), receiving transducer(B) and an amplifier.

Working

- In flaws, there is a change of medium and this produces reflection of ultrasonic at the cavities or cracks.
- The reflected beam (echoes) is recorded by using cathode ray oscilloscope.
- The time interval between initial and flaw echoes depends on the range of flaw.
- By examining echoes on CRO, flaws can be detected and their sizes can be estimated.

Features

- This method is used to detect flaws in all common structural metals and other materials like rubber tyres etc.
- The method is very cheap and of high speed of operation.
- It is more accurate than radiograph

Uses of Ultrasound

Obstetrics and Gynecology

The development and monitoring of a developing foetus

Cardiology

Seeing the inside of the heart to identify abnormal structures or functions and measuring blood flow through the heart and major blood vessels

Urology

- measuring blood flow through the kidney
- seeing

Doppler Images

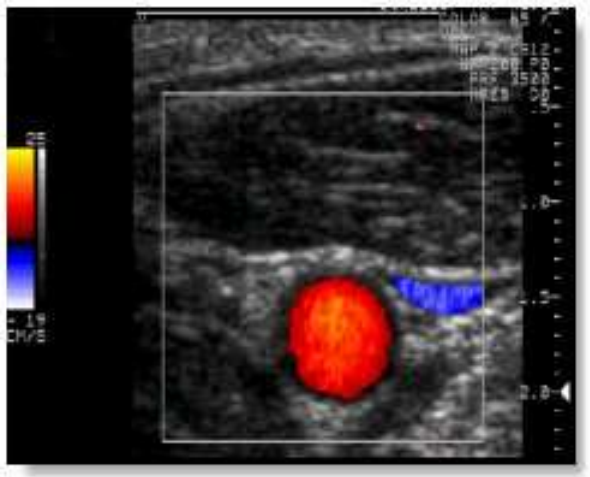
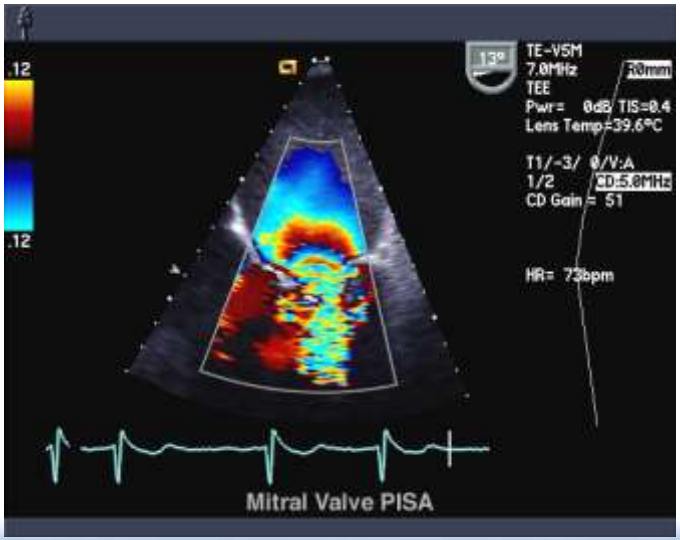


Figure 3

Red represents blood moving towards the transducer (increased frequency).

Blue represents blood moving away from the transducer (decreased frequency

Cardiac B-scan images with Doppler scans overlaid



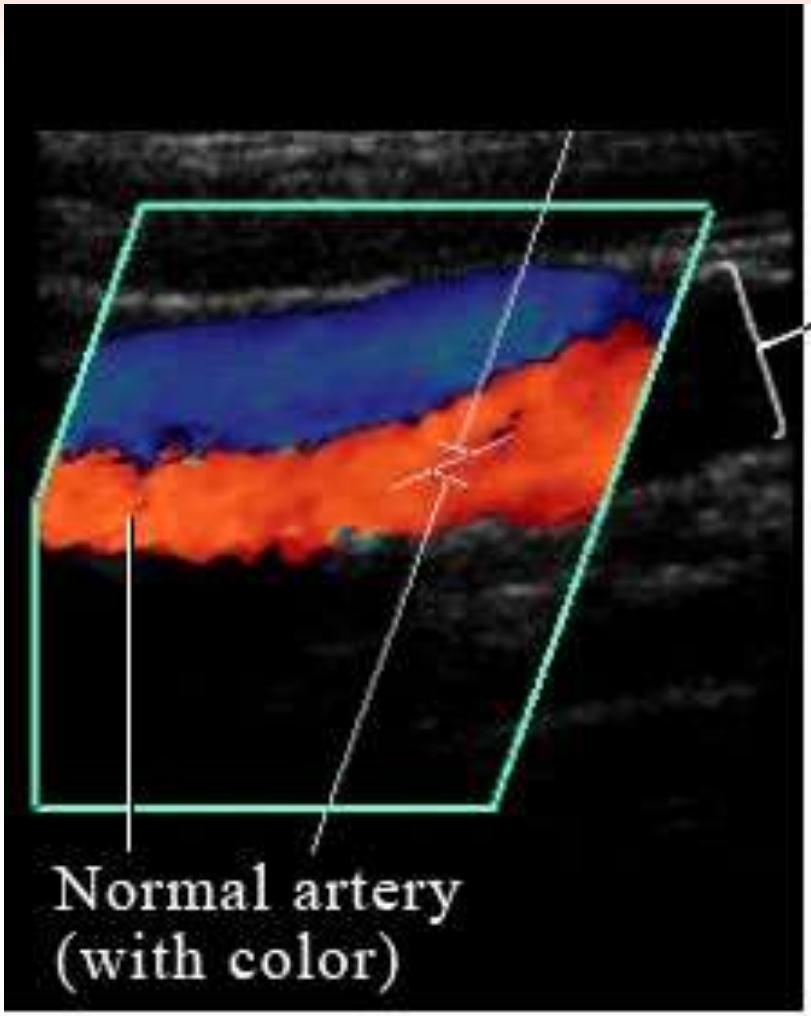


Figure 1

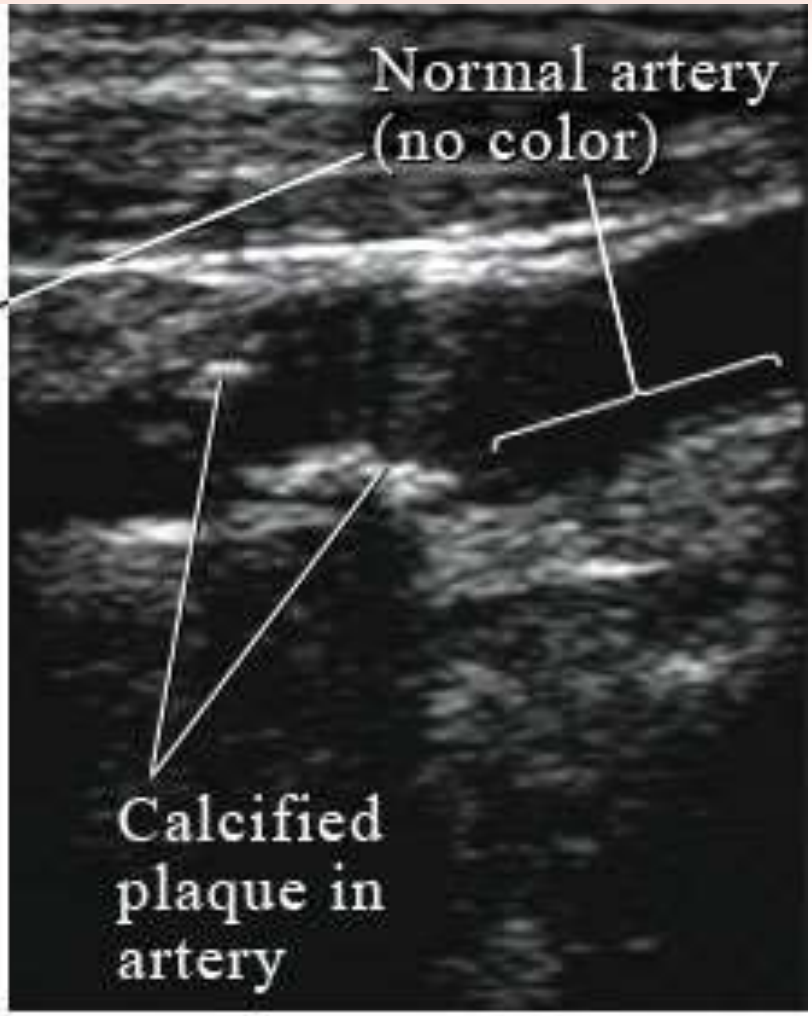


Figure 2

B-Scan

B-Scan (Brightness scan)

- An array of transducers are used and the ultrasound beam is spread out across the body.
- Returning waves are detected and appear as spots of varying brightness.
- These spots of brightness are used to build up a picture.

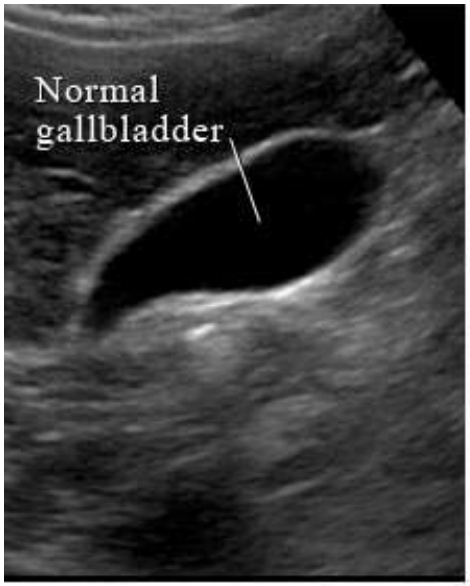


Figure 1

Figure 2

Ultrasound Equipment

Screen/Displa
y

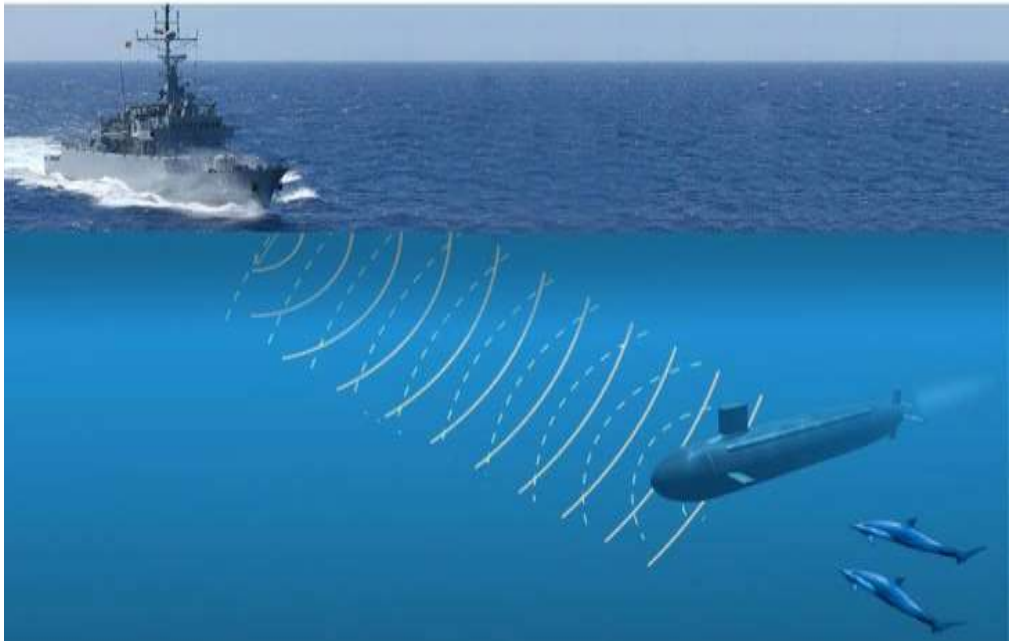
Transducer
pulse controls

Computer

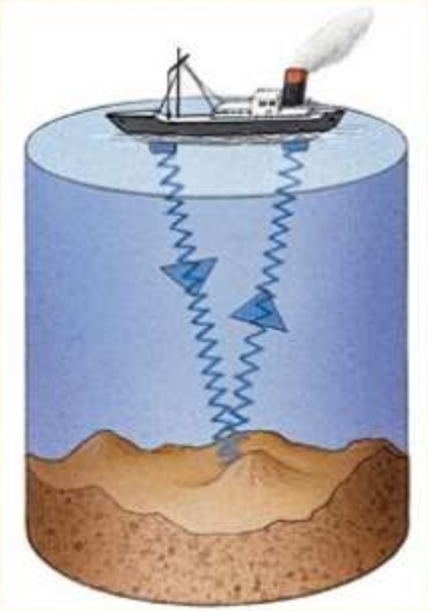
Various
Transducer

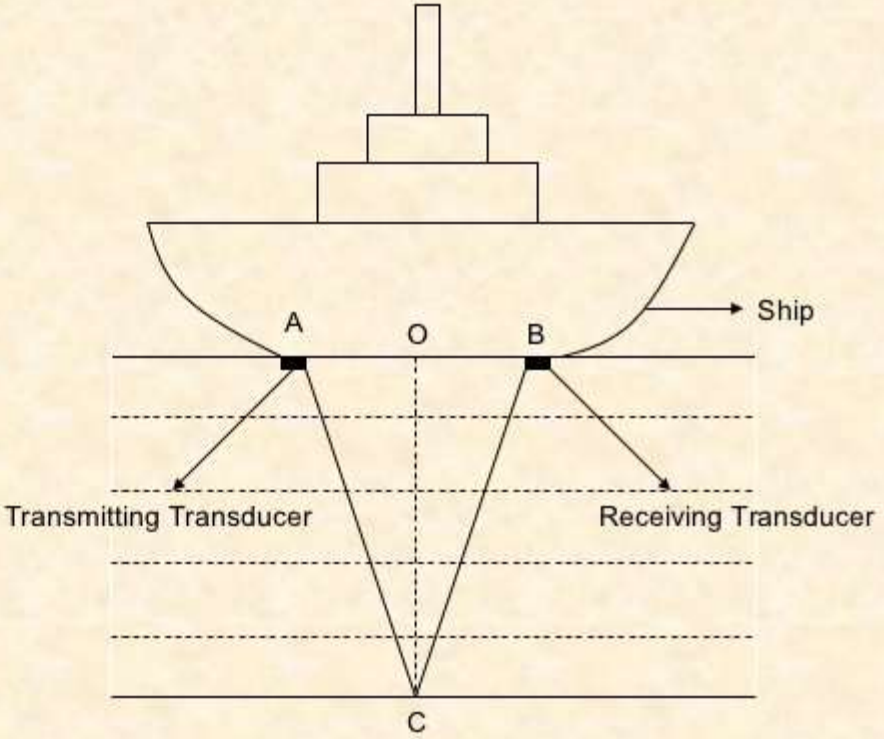
Portable

Detection of submariens,iceberg and other objects in ocean

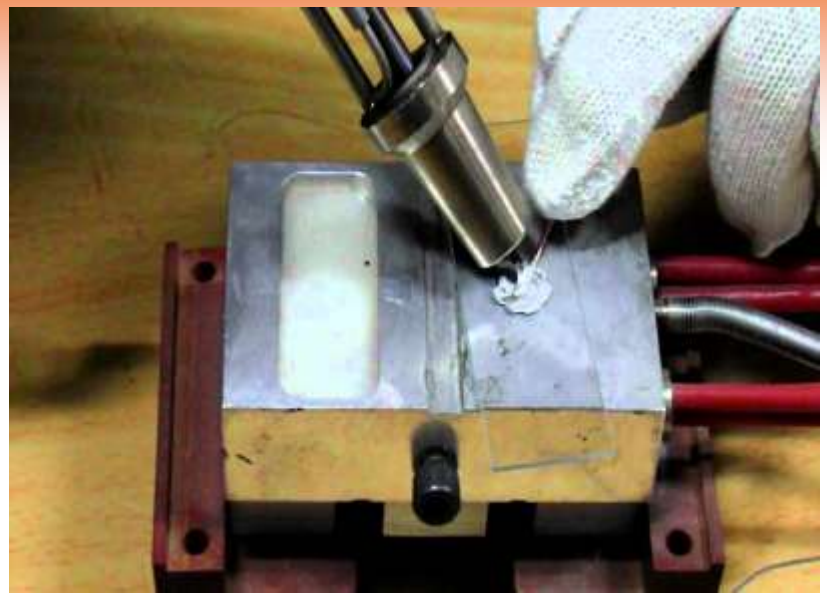


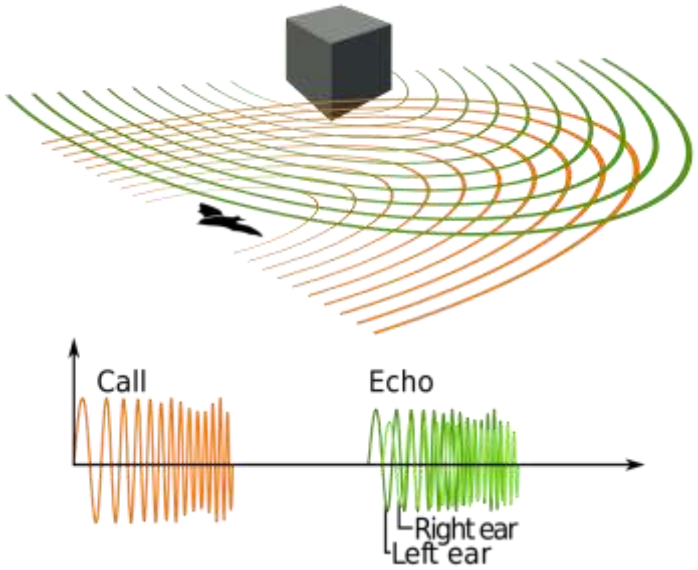
4 How is the depth of sea measured using Ultrasonic waves?





Soldering and metal cutting





Direction signaling


THANK
YOU