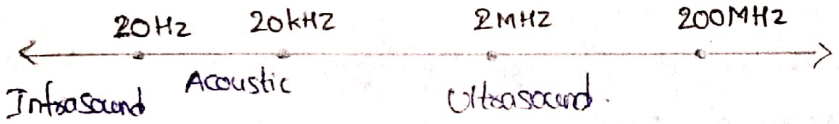
Unit 3.

Waves

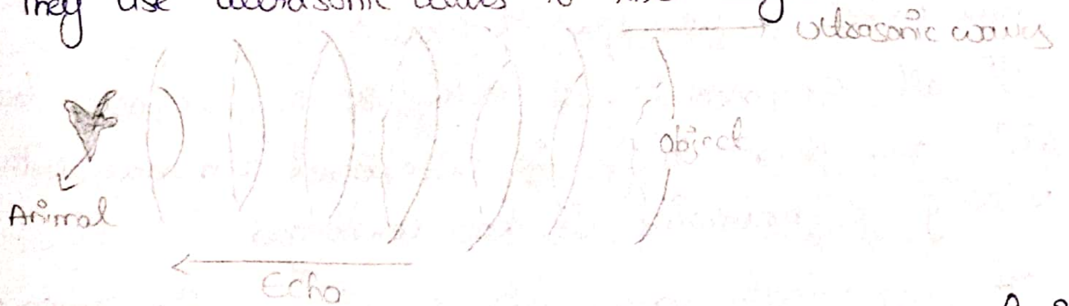
Ultrasonic waves: Ultrasonic wave is defined as "inaudible sound with high frequency for human", frequency exceeds 20khz.
(or)
Sound at frequencies greater than 20khz.

→ In air at atmospheric pressure, ultrasonic waves have wavelengths of 1.9cm or less.

→ In field of industrial material testing ultrasonics is used at frequencies 0.25 to 10MHz & for medical field it is 1-20MHz.



→ Animals can hear high frequency sounds. Bats & dolphins can generate ultrasonic waves & bats produce 20 to 60khz. They use ultrasonic waves to find way...



⇒ In fluids ultrasonic waves are propagated as longitudinal waves whereas in solids they travel as both longitudinal as well as transverse waves.

→ The wavelengths of ultrasonic waves are very small & this smallness in wavelength make useful in many applications.

→ They travel in straight lines & are used in medical diagnostics, marine applications & non-destructive testing.

Acoustics: Acoustics is study of mechanical waves in gases, liquids and solids including topics such as vibration, sound, ultrasound & infrasound.

Phase velocity: The phase velocity of a wave is rate at which the wave propagates in some medium.

→ The velocity of individual wave is phase velocity. It is also velocities with which component waves of wavepacket move inside the wave packet.

→ phase velocity represents velocity of a point of constant phase on wavefront.

let x be position of a point on wave front of wave, then

Phase velocity $V_p = \frac{dx}{dt}$, we know, $\omega t \pm kx$ = constant or $\frac{dx}{dt} = \frac{\omega}{k}$

$$\Rightarrow \boxed{V_p = \frac{\omega}{k}}$$

⟹ we can also get it by $k = \frac{2\pi}{\lambda}$, $\omega = 2\pi\nu$, $V = \lambda\nu$, ν, is linear frequency of wave.

Group velocity:

Group velocity is defined as physical velocity with which a wave packet or wave group travels.

→ If all component waves making up a wave packet travels with same phase velocity, the wave packet also move with same velocity & maintains its form unchanged.

→ If phase velocity varies with wave length, the component waves do not proceed together. In this case wave packet have different velocity from v_p of component waves of wavepackets

⟹ Group velocity is defined as rate of variation of angular frequency with wave number.

$$V_g = \frac{d\omega}{dk}$$ Here, ω = angular frequency of wave

$k = \frac{2\pi}{\lambda}$ = magnitude of propagation vector

Note:

"The phenomenon of variation of V_p with λ of component waves of wavepacket is called Dispersion."

⇒ If constituent waves of wavepacket travel with same velocity of wave packets then, $V_p = V_g$. This happens in case of light waves moving in vaccum.

→ If wave packet moves with V_g & within it constituent waves may moves with V_p then, V_p can't defined for a wave packet.

Eg: Electromagnetic signals transmitted with V_g & not with V_p.

Generation of ultrasonic waves:

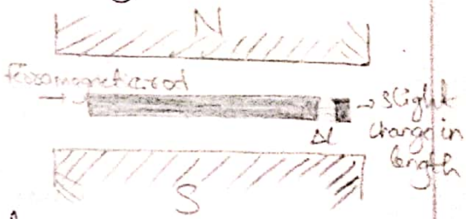
We discuss magnetrostriction method & piezoelectric effect for generation of ultrasonic waves.

Magnetostriction Effect:

→ Magnetostriction is a property of ferromagnetic materials that causes them to change their shape when subjected to a magnetic field.

Magnetrostriction method is used to produce waves in frequency range of 20khz to 100khz. & discovered by "Joule".

⇒ when a rod of ferromagnetic materials such as iron or nickel is kept in magnetic field parallel to its length, the rod suffers a change in its length. The Δl is in order of 1ppm. The Δl is independent of direction of B_0 & depends only on magnitude of field & nature of material.



This phenomenon is known as magnetostriction.

Note: Nickel exhibits large magnetostriction effect compared to other ferromagnetic materials.

*→ A simple way of producing longitudnal vibrations is to apply an AC magnetic field parallel to axis of rod of a ferromagnetic material. An AC magnetic field is produced by wounding coil of wire to rod & pass alternating current through it.

→ If Alternating B_0 oscillates at frequency f, rod changes in length once in each half cycle.

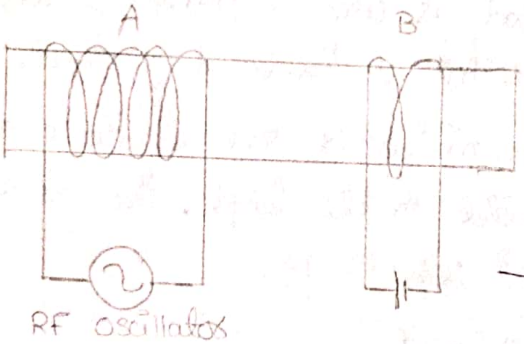
→ It makes vibrations in rod having 'f' twice the 'f' of B_0.

→ If rod is not magnetized initially, the resulting changes in its length are independent of direction of field. The change may be either elongation or contradiction depends on material.

→ Normally, amplitude of vibration is small but when 'f' of alternating field is equal to natural frequency of rod, resonance occurs & 'A' of vibrations considerebaly larger.

→ If 'f' of alternating field lies in ultrasonic range, an ultrasound of frequency 2f will be generated in medium that is in contact with ends of rod.

As rod vibrates longitudinally... $f = \frac{m}{2L}\sqrt{\frac{Y}{\rho}}$ is frequency of oscillations, where L is length of rod, Y = young's modulus, ρ = density of rod & m = 1, 2, 3....

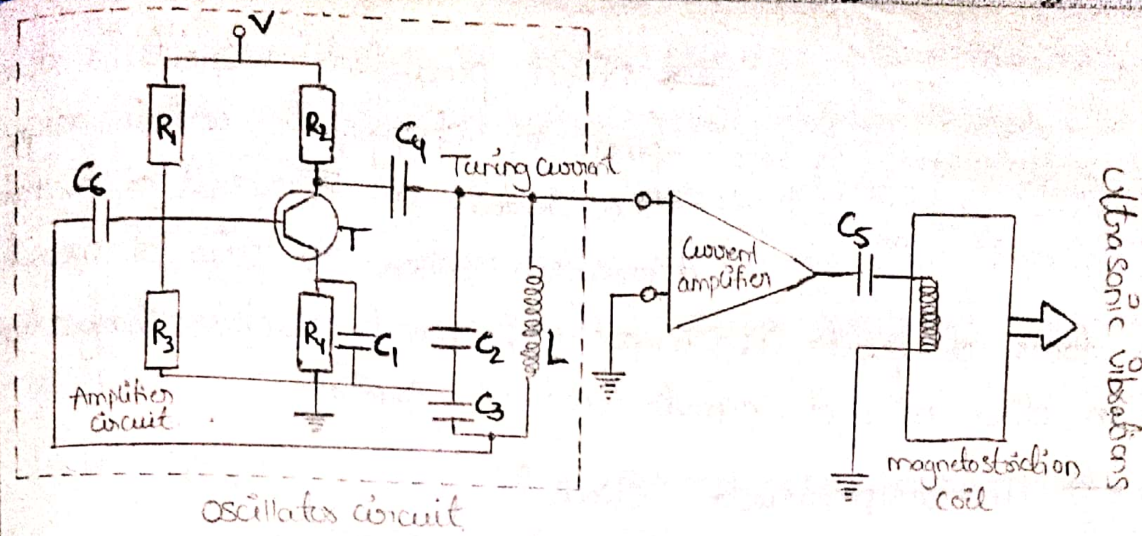


If it is desired that 'f' of vibration of bar be same as that of A.C current, a steady "polarizing B_0" must be applied to bar. The polarizing B_0 can be produced by passing DC current through a 2nd coil as shown in fig.

→ If magnitude of polarizing B_0 > ac field, the 'f' of vibration of bar will be equal to that of ac B_0. [B_0 = magnetic field]

Magnetostriction Generator :-

The circuit diagram of a magnetostriction ultrasonic generator using transistors is shown in fig. It's a "colpitts Oscillator. The transistor T is biased with the help of resistances R_1, R_2, R_3 & R_4. The inductance L & capacitors C_2 & C_3 constitute the tank circuit. When circuit is switched on, oscillations buildup in tank & are fed back to transistor base through feedback capacitor C_6. The appropriate 'f' are



amplified & the oscillations corresponding to them are sustained.
The oscillations appearing at output terminals of oscillator circuit are fed to a current amplifier, which raises level of oscillations. The output of I amplifier is fed to magnetostriction coil through coupling capacitor C_5. Under action of high 'f' electrical signal passing through coil, the magnetization of nickel bar within coil varies & it produce ultrasonic waves.

Advantages :-

1. Magnetostrictive materials are inexpensive.
2. Large output power can be produced.

Disadvantages :-

1. Frequencies higher than 300khz can't be generated.
2. Single frequency oscillations can't be generated.

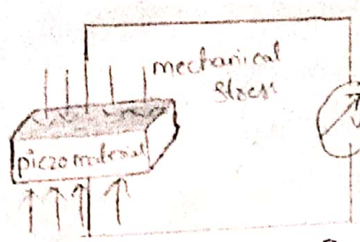
Piezoelectric Effect :-

"piezoelectric effect is ability of certain materials to generate an electric charge in response to applied mechanical stress."

→ pierre curie & paul-Jean Curie discovered this in 1880.

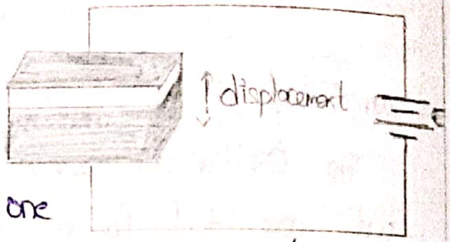
→ Ammonium phosphate, Quartz, PZT (lead zirconate titanate) etc., are examples of piezoelectric materials.

Two types of piezoelectric effect, Direct and inverse are possible. The inverse piezoelectric effect is used in producing ultrasonic waves.



→ Direct piezoelectric effect is development of charges in certain assymetric crystals as a result of mechanical deformation. When one pair of opposite faces of quartz is compressed, opposite electric charges appear on other pair of opposite faces of crystal.

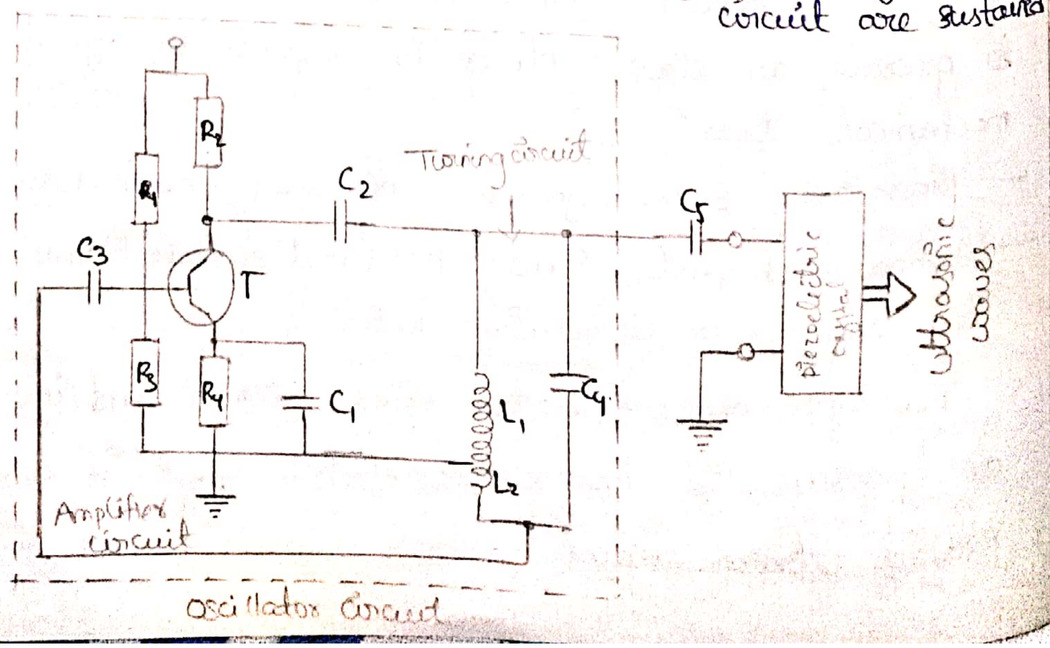
→ Inverse piezoelectric effect is mechanical deformation of piezoelectric materials caused by an electric field.



If Electric field is applied across one pair of faces of crystal, it gets deformed along direction of other opposite pair of faces. If an alternating voltage is applied b/w two opposite faces of crystal it vibrates with 'f' of field.

Piezoelectric Generator :-

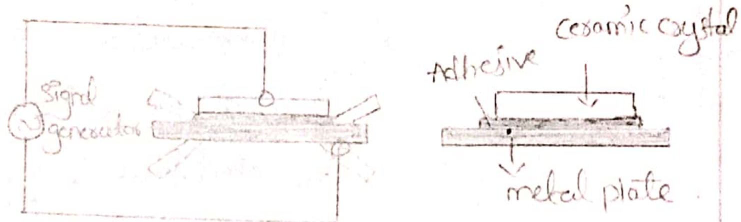
The circuit diagram of piezoelectric ultrasonic generator using transistors is shown in fig. It is "Hartley oscillator". The Transistor is biased using network of resistances R_1, R_2, R_3 & R_4. The coils L_1 & L_2 & capacitor C_4 constitute tuning circuit. The tuning circuit is coupled to transistor T through coupling capacitor C_2, Capacitor C_3 provides +ve feed-back to amplifier T. The oscillations generated by tank circuit are sustained



& Electrical ~~Energy~~ is signal obtained at output is applied to electrodes of piezo electric crystal through the coupling capacitor C_5. Bcs of high 'f' electrical signal applied to it, it produces ultrasonic waves. The frequency of these waves can be varied by varying values of components of tuning circuit.

piezoelectric diaphragm: It consists of piezoelectric plate with electrodes on both sides. Applying DC voltage to electrodes causes mechanical distortion by expanding in radial direction causing metal plate to bend due to piezoelectric effect.

Reversing polarities of DC voltage causes the ceramic plate to shrink, bending metal plate in opposite direction. when AC voltage is applied across electr-odes the diaphragm bending in two directions. The repeated bending motion produces ultrasonic waves in air.



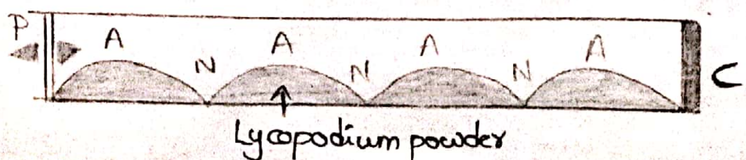
Advantages:

1. High frequency waves of 'f' up to 500 mhz can be generated.
2. Single frequency output can be obtained
3. A range of frequencies can be covered using different transducers.

Detection of ultrasonic waves:-

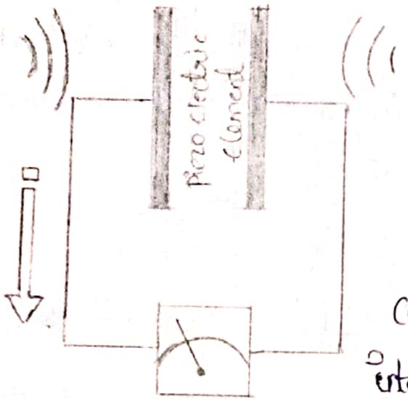
1. Kundt's tube method :- In 1866, Adolph Kundt developed a method to detect ultrasonic waves of relatively longer λ's. Kundt's tube consists of horizontal glass tube about 1m long & 5cm in diameter supported horizontally. The tube has a vibrating piston at one end & is closed at other.

A small amount of lycopodium powder is sprinkled along inner surface of tube. when longitudnal waves are excited at



piston 'p' & pass through tube. the lycopodium powder collects in tube in form of heaps at antinodes & is blown off at nodes. The appearence of heaps indicates presence of waves & means distance b/w two successive heaps is equal to half the magnitude of wavelength ($\lambda/2$) of ultrasonic waves.

2. piezoelectric Transducer:



A Transducer is a device that converts small amounts of energy from one kind into another. Crystals which acquire a charge when compressed are said to be piezoelectric. The piezoelectric transducer convert mechanical Energy (ultrasonic waves) into electrical Energy & vice versa.

In case of detection of waves, ultrasonic waves are applied to one pair of faces of a quartz crystal. As a result, varying electric charges are produced on other pair of faces of crystal. These charges are very small & amplified and detected.

3. Thermal detection:

A fine platinum wire probe is used in this method of detection of ultrasonic waves. Due to alternate compressions in the medium resulting from ultrasonic waves, there occurs a change of temp. at nodes. As platinum probe moves in medium, resistance changes at nodes & is detected by using a sensitive bridge.

4. Sensitive flame method:

when a narrow senstive flame is moved along medium, the flame remains steady at nodes, & flickers at antinodes, because there is a change of pressure. The avg dist. b/w 2 adjacent antinodes is half the wavelength. Given 'f' of ultrasonic wave, the velocity of wave through medium can also be determined.

Cavitations :

Cavitation is a phenomenon in which static pressure of liquid reduces to below liquid's vapour pressure, leading to formation of small vapor-filled cavities in liquid.

→ The pressure & vaccum waves in liquid medium produces the ultrasonic cavitation.

→ In vaccum phase A. No. of bubbles forms in -ve pressure & in phase B they all compresses by huge -ve pressure. In phase C temp. of gas increases and as a result bubble collapse in-ward and energy is released.

→ Caviations means formation of Bubbles - Empty space. These Bubbles Collapse inwards, implode as fast as they created. It happens millions of times per second.

Determination of velocity in a liquid :

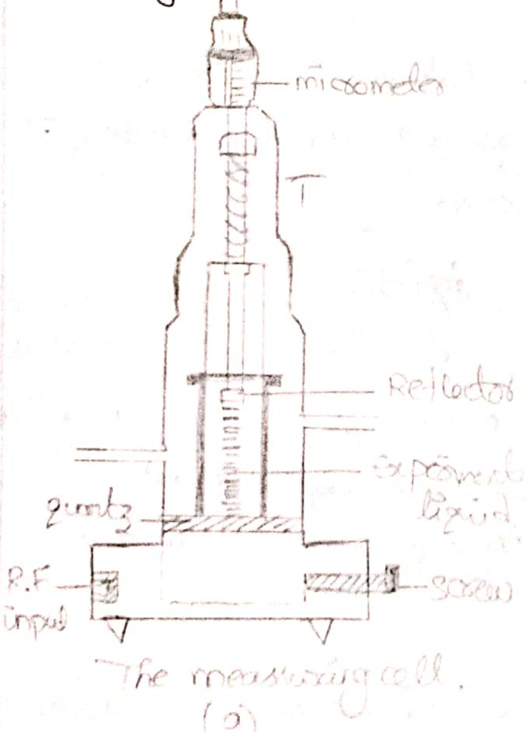
Determination of velocity of ultrasonic waves in a medium basically consists of determing wavelength of wave in medium. There are two methods : 1. Interferometer method.
2. Acaustic diffraction method.

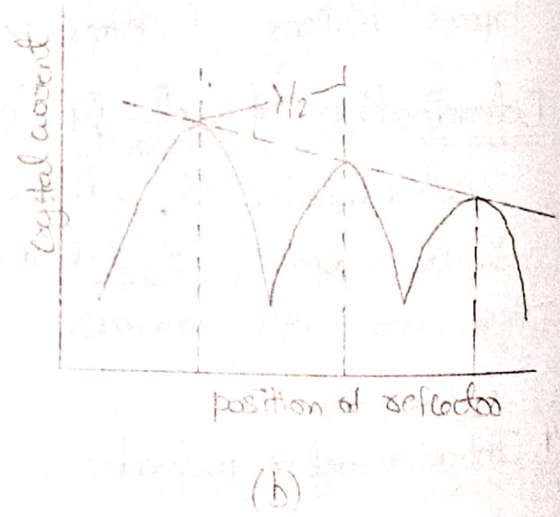
1. Interferometer method :

The velocity of ultrasonic waves is determined using an ultrasonic interferometer.

Experimental setup: The interferometer consists of an ultrasonic generator having a liquid cell connected to its tank circuit. The cell, T is a vertical cylindrical tube filled with liquid medium under test. A quartz crystal is mounted at bottom of cell. Reflector is a metallic plate, mounted at top end of cell & it can be moved parallel to itself with help of a micrometer screw. The surface of crystal & reflector are made exactly parallel to each other.

Working: when quartz crystal is excited, the ultrasonic waves of known 'f' are produced & propogate through liquid. These waves are reflected at reflector & travel back to quartz crystal. " Standing waves are produced when the separation among these plates is a whole multiple of sound wavelength in medium & acoustic resonance happens. The resonant waves causes a max. in anode current of piezoelec--tric generator. If dist. is now increased or decreased & the variation is exactly one-half wavelength or multiple of it, anode 'I' again becomes max. If d is separation b/w success--ive adj. maxima of anode 'I', then, $\boxed{d = \frac{\lambda_u}{2}}$





Ultrasonic interferometer (a) liquid cell & (b) current variation.

Determination of velocity: The velocity (v) of a wave is related to its wavelength (λ) by relation. where 'f' is frequency of wave.

$$\boxed{v = \lambda f}$$

Then, knowing value of frequency of ultrasonic waves used, the velocity of wave in liquid v_u is computed by..

$$\boxed{v_u = f\lambda_u = 2df}$$

Determination of adiabatic compressibility of liquid :- It indicates relative volume change of fluid of a response to pressure change. Compressibility β is reciprocal of Bulk modulus.

Adiabatic Compressibility $\beta = \frac{1}{\rho v^2}$

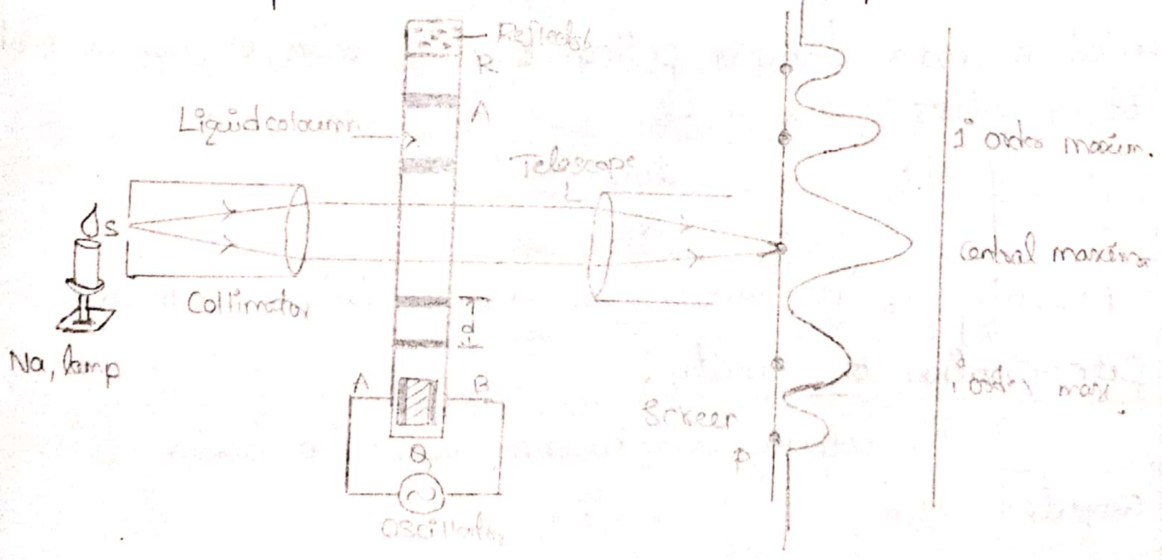
ρ = density of material of medium, v = velocity.

2. Acoustic Diffraction method :-

when ultrasonic waves travel in liquid medium, the density of liquid undergoes changes due to alternating compressions & refractions, which produces periodic variation of refractive index of liquid. Consequently, a liquid coloumn subjected to ultrasonic waves act as grating called acoustic grating.

→ If monochromatic light is passed normally, the liquid causes diffraction of light.

→ Diffraction pattern is used to determine λ & v of waves.



Experimental setup :- A glass tube is filled with liquid. The piezoelectric transducer Q is positioned at bottom of glass tube and a reflector, R, is arranged at top. The surfaces of crystal, Q & reflector, R are held perfectly parallel to each-other. S is a slit through which monochromatic light passes & gets collimated & rendered parallel. The image of slit is focused on screen P by the lens 'L'.

Working: when quartz crystal Q is at rest, light forms single image on slit on screen, when it excites, it goes vibration & produce ultrasonic waves. They propagate through liquid coloum & reflects at reflector at top. The two waves combine to form statio-nary waves in liquid coloumn.

The density & hence refractive index of liquid is max. at nodal points & min. at antinodal points. ∴ Nodal points acts as opaque regions & antinodes as transparent region for light. The liquid thus resembles a ruled grating & causes diffraction of light. Image formed on screen consists pattern having central maxima flanked by 1°, 2° maxima & minima & so on...

Determination of λ:

Grating Eq. $(a+b)\sin\theta = m\lambda$ is applicable to acoustic grati-ng also. The grating constant $(a+b)$ in this case equals $\lambda_u/2$ & is...

$$\frac{\lambda_u}{2}\sin\theta = m\lambda$$

$\lambda_u = \lambda$ of ultrasonic waves.

$\lambda = \lambda$ of monochromatic light used to produce diffraction pattern & m is order of maxima & takes integer values 1, 2, 3, ... etc.

$$\therefore \boxed{\lambda_u = \frac{2m\lambda}{\sin\theta}}$$

Determing λ_u is known as acoustic diffraction method.

Determination of velocity:

1st the velocity of ultrasonic wave in liquid v_u is computed from

$$v_u = f\lambda_u$$

$$\boxed{v_u = \frac{f\,2m\lambda}{\sin\theta}}$$

f is frequency of waves

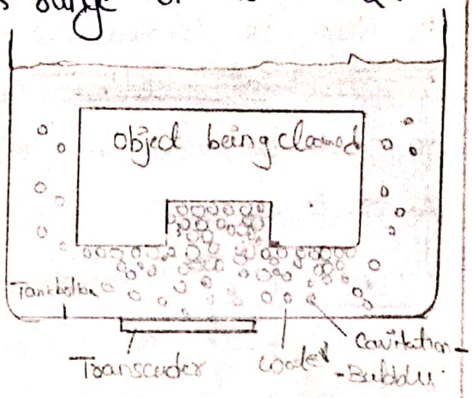
Q If $\lambda = 6000\text{Å}$, 1st order angle of diffraction is $0.046°$ & $f = 2\text{MHz}$. find velocity in liquid.

A $v_u = \frac{2m\lambda f}{\sin\theta} = \frac{2\times 1\times 6000\times 10^{-10}\times 2\times 10^{6}\,\text{Hz}}{\sin 0.046°} = 2989\ \text{m/s}$

Industrial applications :

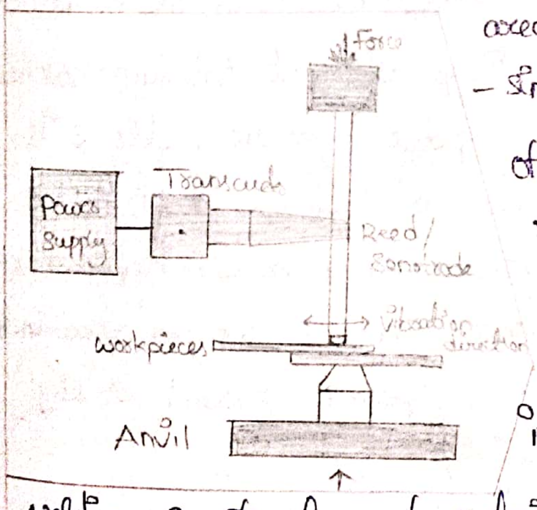
1. Ultrasonic Cleaning : It uses concept of cavitation. used to clean hard materials such as metals, glass, ceramics etc which reflect sound. operates normally in range of 20-50 khz.

An ultrasonic cleaning tank is a stainless steel metal tank that has piezo ceramic transcuders attached on base or side. water with detergent & parts to be cleaned are suspended in liquid. A high 'f' (20 to 50 kHz) Voltage is used to excite transuder, which makes tank bottom move rapidley & induces compression & rare-fraction ~~wat~~ waves at ultrasonic 'f'. Cavitation happens & creates tiny pressure wave & cleans dirt in the particles.



2. Ultrasonic Metal welding :

All metals & plastics can be welded using U.S waves of suitable Energy. The U.S Energy converts to heat at contact area as a result of friction arising b/w surfaces. As temperature of surface layers exceeds the recrystillisation point, layers melt and bond together to form a strong joint. In this process it doesn't cause stress at spot of welding & structure of materials remain unchanged.



US welding makes use of vibration Energy at interface of joint to create Bonding. The US Energy is delivered to interface by a horn that is in contact with top part. The joint forms by diffusion & there is no melting point at joint. The Equipment ranges from low power microbonders (40 & 60 khz)

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to machines of output capacity (10 & 20 khz) for welding of larger parts.

Drawbacks:

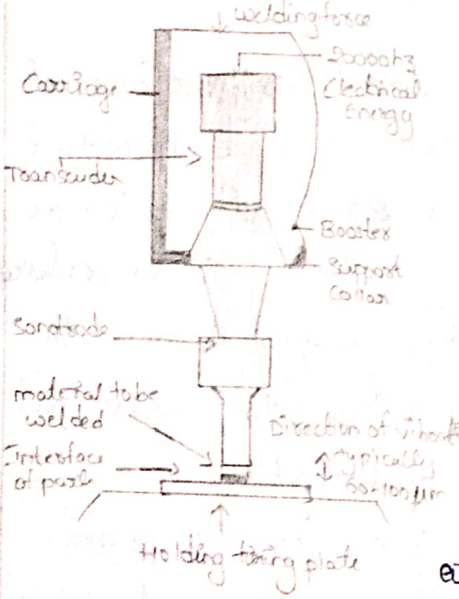
1. Mechanical contact is required on either side of joint.
2. Horn is consumable, so inspection & replacement is required.
3. Speed of welding cycle is low.
4. Joint geometry is limited to lap welding only.

Applications:

1. Useful for high resistance inter metallic compounds in dissimilar metal welds as process is relatively cold.
2. Suitable for producing spot welds & line welds.
3. Useful in electric & electronic industries in assembly of electric motors, transformers, switches and relays.

3. Ultrasonic plastic welding:

Useful in automotive industry for assembly of taillights, dash-boards, heater ducts, & other components. Welding is carried out from high-frequency mechanical motion.

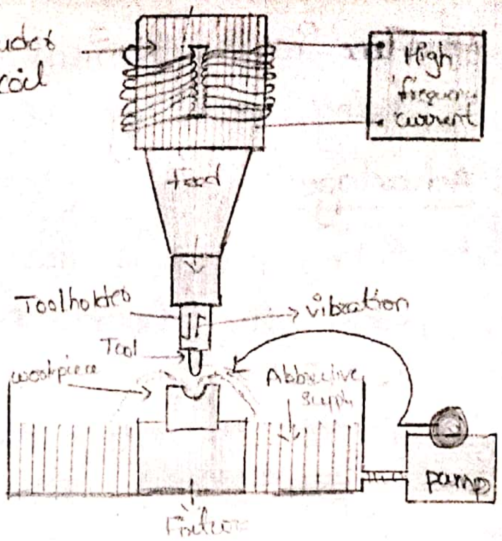


High-f. Electrical 'E' is converted into high-f mechanical 'E' in thermoplastics. When temp. at joint interface reaches melting point, plastic melts & is allowed to cool & solidifies. U.S plastic welding needs higher power densities, 100s of wt per square inch at weld & operate around 20 khz.

Advantages:

1. It is fast, clean, efficient & repeatable process that consumes very little energy.
2. Solvents, adheshives & mechanical fastness are not required.
3. The finished assemblies are strong and clean.
4. Process doesn't require skilled operator.

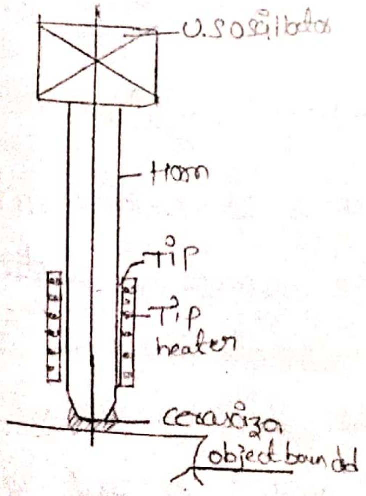
4. Ultrasonic Drilling :-



Ultrasonic machining is a vibratory process useful for mechanical treatment of hard & brittle solids such as ceramics, glasses, stones & hard alloys. The tool motion is produced by an acoustic concentrator to which tool holder is threaded. The acoustic concentrator consists of needle type magnetostriction vibrator made of thin isolated ferromagnetic plates of high magnetostriction such as 'Ni'. A coil is wound on needle, through which an A.C of frequency 'f' passes. The core of vibrator vibrates at frequency '2f'. By choosing the 'f' ~~to~~ be equal to $\frac{1}{2}$ natural vibrational 'f' of vibrator, the system is held at resonance & vibrations of needles will be of large amplitudes.

→ Abrasive particles bombard work surface at high velocity & shear off small pieces of material. The action rapidly chips away work piece in a pattern controlled by tool shape & contour.

5. Ultrasonic soldering :-



U.S soldering is a flux free soldering method where surface oxide layers are cleaned by using vibrations & cavitations. During process, the solder is 1st heated by a separate source till it melts & then vibrational Energy is applied to it. The U.S vibrations induce cavitation at tip of soldering tool which cleans metal surfaces & liquid solder bonds them.

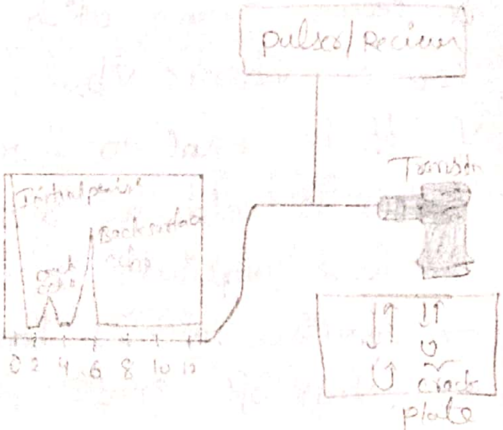
• This method is not suitable for soldering aluminum.

⇒ Flux is a chemical cleaning agent used befor & after during soldering.

<u>Advantages</u>:

1. Solder joint is free of voids because vibrational Energy pushes the liquid solder into crevices & micro-pores in the substrate.
2. U.S soldering allows for fusing dissimilar materials which is not possible with usual methods.
3. As no flux is required, it saves time & costs of cleaning flux residues. these corrosion is less and durability of soldered joints is more.

6. <u>Ultrasonic Testing</u>:-



This method is used for detecting the internal & surface defects in sound conducting mate-rials. The wave velocity is related to youngs modulus of material & its charecteristic of that material. For contact testing, a probe with the oscillating crystal is used. To enable transfer of energy across the thin air gap b/w crystal & test piece, a layer of liquid usually oil, water or grease, is applied to surface of the test piece.

$$V = \sqrt{\frac{Y}{\rho}} \quad V = \text{velocity}, \quad Y = \text{young's modulus}.$$

The crystal oscillates in short pulses of ultrasound (1Mhz to 6Mhz) have less attenuation in homogenous elastic material, such as metals. piezo electric crystals translate elec-trical pulses into mechanical oscillations & vice versa. Thus, it acts as generator of sound waves as well as detector of reflected pulses. As crystal oscillates in short pulses b/w each of which is inactive, in this state crystal detects reflected pulses. The machine consists transducer, pulser, reciever/amplifier, & display.

The sequence of operation of system:

1. The pulser provides short, high-voltage pulse to transducer and at same time it supplies voltage to time-base trigger module. It gives spot on CRT screen.
2. The voltage pulse given to transducer is converted into mechanical vibrations & pass through testpiece. All this time spot is moving horizontally across CRT.
3. The energy in test piece now reflects off the back towards transducer, where it is reconverted into voltage & amplified.
4. By using delay (or zero) control, the spot on CRT is set to start at instant that energy goes into test piece.
5. The above process repeats until energy in test piece atten-uates. The display will show multiple repeat signals.
6. The clock now sends a pulse 2nd time and next pulse is produced. It is again repeated n numbers of times per second. The n no. of pulses per second is referred to as pulse repetition frequency (PRF) or pulse repetition rate (PRR)

7 Emulsification:

Immiscible liquids like water and oil can mix thoroughly and form stable emulsions when their mixture is subjected to strong U.S waves. The U.S emulsification is used in industry to mix molten metal & form alloys of uniform composition.

Non Destructive Testing:

NDT is a testing and analysis technique used by industry to evaluate the properties of a material, component, structure or system for characteristic differences or welding defects & discontinuities without causing damage to original part.

→ Also called as ND examination (NDE), N-D inspection (NDI) and ND evaluation (NDE).

Types of Defects:

The defects found in components are classified into external and internal defects.

External Defects	Internal defects
Blow holes in castings	Overstressed parts
Forging defects	Fatigue blow holes
metallic inclusions on surfaces	porosity in casting
surface finish	micro- segregation
micro - cracks	Axial segregation

methods of NDT:

The common methods of NDT are 1. visual inspection 2. Liquid penetrating Testing 3. Magnetic particle testing 4. Eddy current testing 5. U.S testing 6. Radiography

1. Visual Inspection:

Visual NDT is mainly used for detection of surface defects. In this, the component is first adequately cleaned and illuminated with light and examined with unaided eye or with help of optical devices. Visual inspection can reveal info. on..

1. General condition of component.
2. presence or absence of corrosive product on surface.

3. presence or absence of cracks & orientation & position of cracks
4. surface porosity etc.

Magnifying devices or lightning aids are used if nece- -ssary. microscopes, Borescopes, endoscope & flexiscopes are some optical aids used in visual NDT. These are used to figure out minute defects.

2. Liquid penetrant Testing:-

Also known as dye penetrant testing is used for detecting minute discontinuities such as cracks & surface openings. cracks of 150 nanometers can also be spotted. This is useful to any non-porous clean material, metallic or non-metallic. primilarly this method used for non-magnetic materials & it can also applicable for magnetic materials. simple to perform & cheaper.

principle:- when liquid penetrant is applied over clean surface the pentrant seeps into defect by combined action of surface Tension and Capillary action gives recognizable size of defect & location, size and nature of discontinuity.

Basic process steps:-

1. Surface preparation:- It is initial cleaning and drying of the surface area of component. surface should be free from oil, grease, water or etc that avoid penetrant from entering flaws.
2. penetrant application:- Now penetrant is applied by spraying, brushing etc & should be spread uniform over surface.
3. penetrant dwell:- penetrant left for some time to dwell into crack. generally it takes 5 to 60 minutes.
4. Removal of excess penetrant:- Excess penetrant should be removed from surface. The cleaning of surface is first treated with water & then rinsing with water.
5.

5. Developer application: Now, the surface is covered with thin layer of developer which draws out trapped penetrant from surface imperfections & makes them visible & left for 10min. Developers available in many ways & applied by dusting, dipping or spraying.

6. Inspection & fine cleaning: After inspection, surface is cleaned.

Materials used:

1. penetrants: These are oil-like liquids which have coloured dyes & classified is flourescent, visible dye etc. Dye gives colour contrast under white light or UV light illumin-ation so that defect becomes clearly visible
These are classified as a. water-washable b. solvent removable c. post emulsifiable.

2. Developers: This enhance the conspicuity of indication. Two types used are a). Dry developers (amorphous silica powder) b) wet developers (contain powdered material in liquid). The developer must be highly absorptive to draw penetrant from defect & provide contrast background for location of defect.

Advantages:

1. NO elaborate setup required & simply to apply & low cost.
2. portable and fast., Results are easy to interpret.
3. Can be used to inspect any non-porous material.
4. Defects of any size & orientation can be detected.

Limitations:

1. Can be used only to detect surface-breaking defects.
2. surface must be cleaned.
3. Can't be applied to porous materials.

3. Magnetic particle Testing :

It is used for detecting occurances of cracks, inclusions etc at surface and subsurface in ferromagnetic materials. Not applicable for nonmagnetic materials.

when a test sample is magnetized, lines of force flow inside material, wherever there is flaw, magnetic lines are interrupted and lines leak out of material. The exit and entry points of leakage lines form opposite magnetic poles. If small magnetic particles sprinkled on material they attracted by magnetic poles & give image of size & shape of defect.

4. Eddy Current Testing :

It is used to inspect electrically conducting materials for defects, irregularities in structure and variations in compositions. In testing, a varying magnetic field is produced if a source of A.C is connected to coil. when field is placed near a conducting test specimen, eddy currents will be induced in test specimen. The Eddy current, in turn will produce a magnetic field of their own. The detector measures new B_0 & converts signal into a voltage that can be displayed on a CRO.

5. U.S Inspection method :-

This method is versatile and widely used NDT method. Suggested by Sokolov in 1935 & applied by Firestone in 1940.

Principle: This is based on solid material's good conduction of sound waves. The waves are reflected at interfaces & by internal faults. The frequencies are generally in range of 0.5mhz ~~and~~ 25 mhz are used.

The U.S waves are generated by piezoelectric devices. A pulse transmitter can generate high voltage electric pulses. when these bursts of alternating voltage are applied to transducer, & it emits high frequency U.S energy.

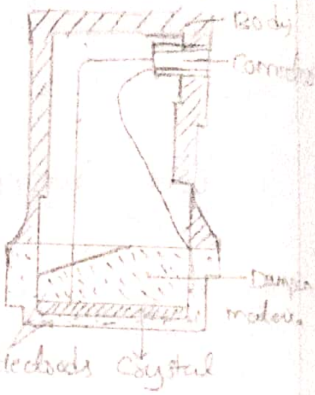
The U.S beam is passed through test piece. when there is a crack in wave path, a part of Energy will be reflected back from the fault surface & converted into electrical signal by transducer. Signal is displayed on screen of CRT

Transducer probes:

The 3 common piezoelectric materials used in probes are quartz, lithium sulphate & ceramics such as Barium Tita-nate and lead zirconate Titanate. The general used probes are.

a. Normal beam probe:

Electrodes are fitted on both faces of piezoelectric crystal & wire from these electrodes lead to connector socket of probe. Damping material is fitted at back of crystal. A wear plate is used to protect crystal. The entire assembly mounted in casing to protect transducer from mech. damage.

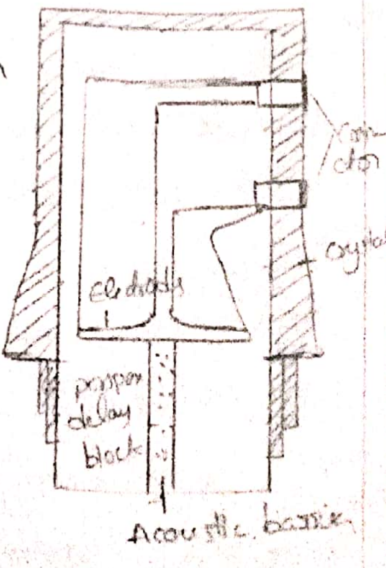


b. Angle beam probe:

In this transducer is mounted on a perspex wedge. The U.S beam reaches bottom flat surface of probe at an angle & refracts into material to be tested. The part of beam refracted from wedge is damped with damping material

c. Transmitter - receiver probe:

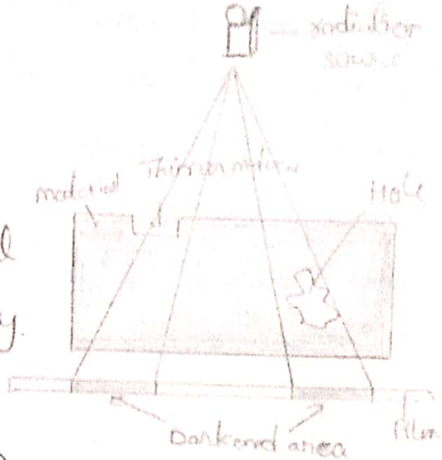
This consists of seperate transmitter and reciever incorporated in a single housing. The transmitter & reciever transducers are of same frequency. They are arranged inclined slightly towards each other. Delay blocks of perspex are added to both transducers & an acoustic barrier is kept b/w them to prevent any cross-talk.



Scanned with CamScanner

6. X-Ray Radiography:

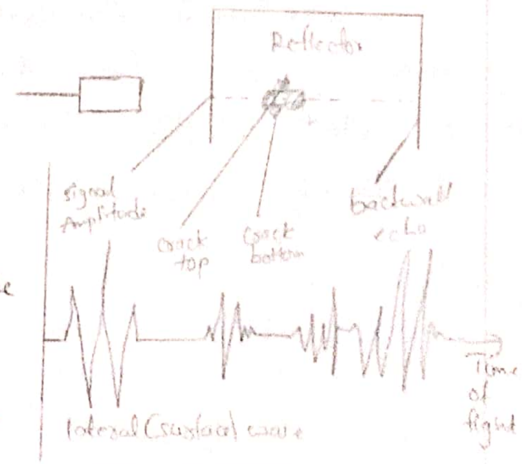
It is used for detecting presence and location of internal cavities. X-Ray examination of material carried out by radiography & fluoroscopy.



If a beam of x-rays is directed normal to surface of an object & if object is uniform thickness it will give equal intensity of transmitted beam, or if it has groove or cavity or discontinuity a variation in X-ray transmission will result at these points. As X-rays are invisible these are recorded on a photosensitive film. The image of cavity inside object will appear darker than surrounding area bcs of greater X-ray transmission at that point.

Generally A-scan, B-scan & C-scan formats are used for U.S data presentation.

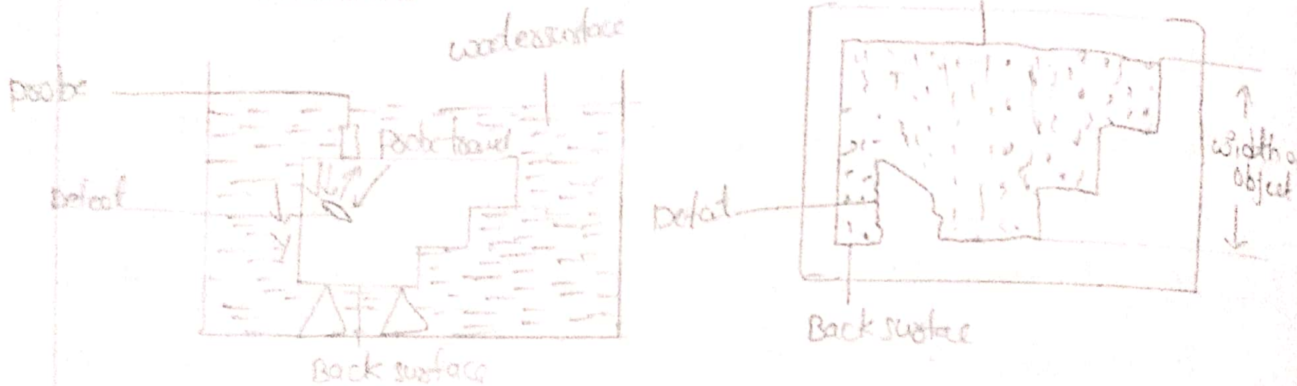
i, A-Scan presentation:



It is most used mode of display in U.S testing. The X-axis represents time taken by pulse to the reflecting surface & return back to transcuder. Y-axis represents ampli--tude of echos. The defect location is estimated by position of Echo given it on X-axis & size of defect from Y-axis. The info. available is 1-D.

ii, B-scan presentation:

This gives a cross-sectional view of test object and shows position, orientation & depth of defects in specimen. In this mode of display, Y-axis represent elapsed time while X-axis gives location of transcuder along a line on surface of specimen in relation to starting position. Thus, the probe movement is displayed in x-direction while dist. of defect is displayed in y-direction. Echo amplitude is indicated by relative Brightness of echo indications. If a storage oscilloscope is used, whole picture will be displayed which reveals depth of defect beneath surface & its size in the lateral direction.



(ii) C-scan presentation:

The depth of defects is not relevant in some testing problems, but info. about their distribution parallel to test surface is required. In C-scan mode, transducer is moved over surface of test piece & the echo intensity object as viewed ~~from~~ is recorded as a variation in line shading (fig.). The image shows plan of object as viewed from the top & is true to scale reproduction of defect in object. C-scan presentations is produced with a computer controlled immersion scanning systems.