Chapter 1

ACOUSTICS AND ULTRASONIC

1.1 ACOUSTICS

1.1.1 INTRODUCTION:

Acoustics is the science of sound and deals with origin, propagation and auditory sensation of sound. The branch of the science which deals with the planning of a building or a hall with a view to provide best audible sound to the audience is called '**Acoustics of building**' or '**Architectural acoustics**'.

Before 1900, the architects and building engineers has no consideration about the acoustical properties of rooms and halls etc. some times a building was found to be unsatisfactory for the purpose for which it was built. The Fogg Art Museum hall of Harvard University, U.S.A. was highly defective when it was built. The lectures given in it were not intelligible to audience.

1.1.2 BASIC REQUIREMENT FOR THE ACOUSTICALLY GOOD HALL:

Prof. Wallace C. Sabine, Professor of Physics, Harvard University in 1911 was entrusted with the responsibility of eliminating the acoustical defects of the hall. He was the first scientist to tackle the problem of satisfactory speech and music in a hall and laid down the following essential features about good acoustics.

1. The sound heard must be sufficiently loud in every part of the hall and no echoes should be present.
2. The total quality of the speech and music must be unchanged i.e. the relative intensities of the several components of a complex sound must be maintained.
3. For the sake of clarity, the successive syllables spoken must be clear and distinct i.e. there must be no confusion due to overlapping of syllable.
4. The reverberation should be quite proper i.e. neither to large nor too small. The reverberation time should be 1-2 seconds for music is and 0.5-1 second for speech.
5. There should be no consideration of sound in any part of the hall.
6. The boundaries should be sufficiently sound proof to exclude extraneous noise.
7. There should be no Echelon effect.
8. There should be resonance within the building.

1.1.3 REVERBERATION AND TIME OF REVERBERATION:

When a sound is produced in a building, it lasts too long after its production. It reaches to the listener a number of times. Once it reaches directly from the source and subsequently after reflection from the walls, windows, ceiling and flour of the hall. The listener therefore receives series of sounds of diminishing intensity. By reverberation is meant the prolonged reflection of sound from the walls, floor and ceiling of a room.

The reverberation is defined as the persistence of audible sound after the source has stopped to emit sound. The duration for which the sound persists is called **reverberation time.** This time is measured from the instant the source stops emitting sound.

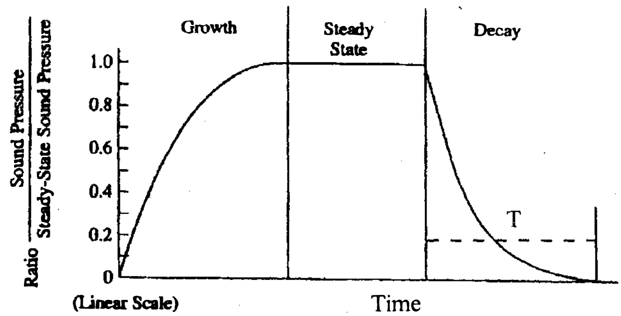

Fig . 1.1.1

The **time of reverberation** is defined as the time taken from the sound to fall below the minimum audibility measured from the instant when the source stopped emitting sound.

According to Prof. W. C. Sabine, the **standard reverberation time** is defined as the time taken by sound to fall to one millionth of its intensity just before the sound is cutoff.

1.1.4 SABINE's FORMULA FOR REVERBERATION TIME:

According to W. C. Sabine, the time of reverberation depends up on

1. Size of hall,
2. Loudness of the sound,
3. Kind of music or sound for which hall is to be used.

$$\text{Reverberation Time} = T = \frac{0.165\,V}{\sum aS}$$

$$T = \frac{0.165\,V}{A}$$

Where V - Volume of hall in m^3

a - Absorption coefficient

S - Area of reflecting surface in a square meter

$\sum aS$ A = Total absorption of hall.

1.1.5 ABSORPTION COEFFICIENT (a):

The **coefficient of absorption** of material is defined as the ratio of the sound energy absorbed by the surface to that of the total incident sound energy on the surface i.e.

$$\text{Absorption Coefficient (a)} = \frac{\text{Sound energy absobed by the surface}}{\text{Total sound energy incident on the surface}}$$

As all sound waves falling on an open window pass through, it can be assumed that an open window behaves as perfect absorber of sound and hence the standard of absorption is taken as the unit area of an open window as a standard unit of absorption.

Thus, the **absorption coefficient** of a material is defined as the rate of the sound energy absorbed by a certain area of the surface to that of an open window of same area.

The **absorption coefficient** of a surface is defined as the reciprocal of its area which absorbs the same sound energy as absorbed at a unit area of an open window.

Let 10 m^2 of certain carpet absorbed the same amount of sound energy as absorbed by 1 m^2 of the open window, and then the absorption coefficient of a carpet is The absorption coefficient is measured in open window unit and it is written as O.W.U. or Sabine.

The absorption coefficient of some common material is as follows -

Sr. No.	Material	Absorption coefficient (a) in O. W. U. or Sabine
1	Marble	0.01
2	Brick wall 30 cm thick	0.03
3	Brick wall painted	0.016
4	Carpet	0.15-0.30
5	Hair Felt (2.5 cm. Thick)	0.58
6	Wooden chair	0.06
7	Glass	0.02
8	Ordinary chair	0.17
9	Human body	0.43-0.47
10	Open window	1.0

1.1.6 FACTORS AFFECTING THE ARCHITECTURAL ACOUSTICS AND THEIR REMEDY:

Acoustically good hall we mean that in which every syllable or musical note reaches an audible level of loudness at every point of the hall and then quickly dies away to make room ready for the next syllable or group of notes.

Following are the factors affecting architectural acoustics:

1. Reverberation

In a hall, if the reverberation is large, there is overlapping of successive sounds, which results in loss of clarity in hearing. However if the reverberation is very small, the loudness is inadequate. Thus the time of reverberation for a hall should neither too large nor too small. The preferred value of the time of reverberation is called the optimum reverberation time. According to W. C. Sabine **standard reverberation time** is given by:

$$\text{Reverberation Time} \quad T = \frac{0.165V}{\sum aS} = \frac{0.165V}{A}$$

where V - Volume of hall in m^3

a - Absorption coefficient of surface

S - Area of reflecting surface in square meter

$\sum aS$ A Total absorption of hall.

The reverberation can be controlled by the following factors:

a. By providing windows and ventilators which can be opened and closed to make the optimum time of reverberation.
b. Decorating the walls by pictures and maps.
c. Using heavy curtains with folds.
d. The walls are lined with absorbent material such as felt, fiberboard, glass wool etc.
e. Having full capacity of audience.
f. By covering floor with carpet.
g. By providing acoustics tiles.

2. Adequate Loudness

With large absorption the time of reverberation will be smaller which will minimize the chances of confusion, and may go below the level of intelligibility of hearing. Hence, sufficient loudness in every portion of the hall is an important factor for satisfactory hearing. The loudness can he maintained at desired level by :

a. Using large sounding boards behind the speaker and facing the audience.
b. Large polished wooden reflecting surfaces immediately above the speakers.
c. Low ceiling are also useful in reflecting the sound energy towards the audience.
d. By providing additional sound energy using more number of speakers.

3. Focusing due to Walls and Ceilings

If there are focusing surfaces like concave, spherical, cylindrical or parabolic etc. on the walls or ceiling or the floor of the hall, they produce concentration of the sound in to particular region, while in some other parts no sound reaches at all. Thus there will be non-uniformity in the distribution of sound energy in the hall. For uniform distribution of sound in the hall:

a. There should he no curved surfaces. If such surfaces are present, they should be covered with absorbent material.
b. Ceiling should be low.
c. Arrange speaker at the focus of parabolic reflecting surface. This will helpful to reflect beam of sound in the hall.

4. Echoes

An echo is heard, when direct and reflected sound waves coming from the same source reach the listener with time interval of about $\left(\frac{1}{10}\right)^{th}$ second. It should be avoided as far as possible by absorption. Echoes can he avoided by:

a. covering long distant walls with curtain or absorbent material.
b. covering high ceiling with absorbent material.

5. Echelon effect

A set of railings, pillars or any regular spacing of reflected surfaces may produce a musical note due to regular succession of the echoes of the original sound to the listener. This makes the original sound confused. This can be avoided by:

a. covering steps with carpet.
b. covering flour with carpet
c. avoid pillars in the hall.

6. Balconies

There are chances of reflection of sound from the railing of balcony. This may lead to the problem like echelon effect or echoes. This can be eliminated by:

a. adjust height to depth ratio as 2:1.
b. use grills and bars for railings instead of bricks.

7. Seating arrangement

This is one of the factors to be taken care at the time of arranging the seats. It preferred to arrange:

a. seats perpendicular to the direction of sound for better audibility and
b. seats must be gradually elevated to take care of absorption of sound energy by human body.

8. Extraneous Noise and Sound Insulation

In a good hall no noise should reach from outside. Noise may be defined as unwanted sound such as:

Outside Noise: street traffic, hammering, drilling, operating machinery, moving of furniture, electrical generator etc.

Inside Noise: machinery, typewriters, telephone, mobiles, projector etc.

This **extraneous noise** can be avoided by:

a. avoiding openings for pipes and ventilators.
b. allotting suitable locations for doors and windows.
c. using heavy glasses to doors and windows.
d. by providing double wall construction with air space between them.
e. by interposing layers of some acoustical insulators.
f. use of soft floor finish e.g. carpet, rubber etc.
g. insulating machines like refrigerators, lifts, typewriters, projector etc.
h. constructing small sound proof cabin for machine and office staff.
i. making hall sound proof.

9. Freedom from Resonance

If the frequency of the created sound is equal to original sound, then the original music will be reinforced. Due to the interference between original sound is distorted. Enclosed air in the hall also causes resonance. This can be avoided by:

a. using absorbing material on reflecting surfaces.
b. provideing decoration which include holes in the design on interior wall.
c. using ventilators whenever necessary.

1.2 ULTRASONICS

1.2.1 INTRODUCTION:

We all know that sound is due to vibrations of one or the other kind of particles. The human ear is sensitive to sound waves of frequency ranging from 20 Hzs to 20 KHz. This range is known as **audible range.** The sound waves having frequencies above the audible range (i.e. Frequencies more than 20 KHz) are known as **ultrasonic** or **supersonic waves**. The sound waves which have frequencies less than the audible range (i.e. 20 Hzs) are called **infrasonic waves.**

Human ear cannot sense ultrasonic sounds but dogs and other animals like bats, rats etc. are endowed with an ability to hear the high frequency sounds. The wavelengths of ultrasonic waves are very small and are responsible for many of their interesting applications such as flaw detection, drilling, welding, soldering, cleaning, marine applications, medical diagnostics, nondestructive testing of finished products and so on. Bats and dolphins generate ultrasonic waves and use the reflections of the waves to find their path.

Sr. No.	Frequency Range	Type of Wave
1	0 Hzs - 20 Hzs	Infrasonic waves
2	20 Hzs - 20 KHzs	Audible waves
3	20 KHzs - above	Ultrasonic waves or supersonic waves

1.2.2 PRODUCTION OF ULTRASONIC WAVES:

There are only two important methods for generating ultrasonic waves, which are based on two different phenomenons, namely magnetostriction and piezoelectric effect. Magnetostriction method is used to produce waves in the frequency range of 20 KHz to 100 KHz, where as piezoelectric method is used for the production of waves of frequencies greater than 100 KHz. Here we shall discuss these two methods.

1.2.2.1 Megnetostriction Method :

Principle:

This method is based on the phenomenon of megnetostriction. According to this phenomenon, when a rod of ferromagnetic material such as iron or nickel, is kept in a magnetic field parallel to its length, the rod suffers a change in its length. The change in length is independent of the direction of the magnetic field and depends only on the magnitude of the field and nature of the material.

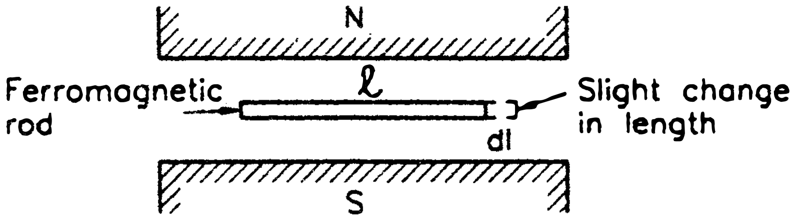

Fig. 1.2.1

(If the rod is kept in an alternating magnetic field of frequency f, the rod changes in length once in each half cycle. It results in setting up vibrations in the rod whose frequency is twice the magnetic field frequency. Normally, the amplitude of the vibrations is small. But when the frequency of the alternating field is set equal to the natural frequency of the rod, resonance occurs and the amplitude of the vibrations will be considerably larger. Further, if the frequency of the alternating field lies in ultrasonic range, an ultrasound of frequency 2f will be generated in the medium that is in contact with the ends of the rod.)

As the rod vibrates longitudinally, the frequency of oscillations is governed by the relation

$$f = \frac{n}{2L}\sqrt{\frac{Y}{\rho}}$$

where L - Length of the rod
Y - Young's modulus
ρ - the density of the rod.
N - 1,2,3, ... integer.

Pierce oscillator:

G. W. Pierce was the first to design an ultrasonic oscillator based on the phenomenon of megnetostriction.

The circuit diagram of magnetostriction ultrasonic generator using transistors is shown in Fig. 1.2.2. It is basically a Colpitt's oscillator. The transistor T is biased with the help of the resistances R_1, R_2, R_3, and R_4. The inductance L and capacitors C_2 and C_3 constitutes the tank circuit. When the circuit is switched on oscillations build up in tank circuit. The oscillations are fed back to the transistor base through the feed back capacitor C_6. The

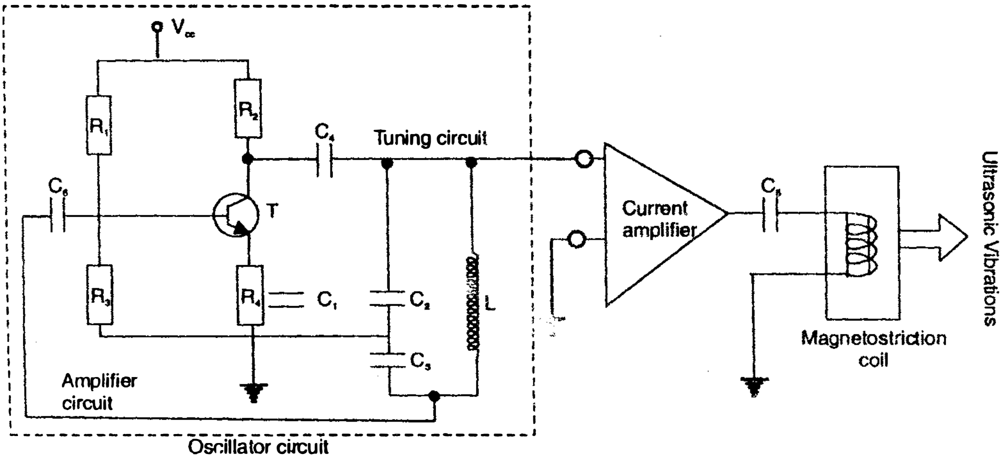

Fig 1.2.2

appropriate frequencies are amplified and the oscillations corresponding to them are sustained. The oscillations appearing at the output terminals of the oscillator circuit are fed to a current amplifier, which raises the level of the oscillations. The output of the current amplifier is fed to the magnetostriction coil through a coupling capacitor C_5. Under the action of the high frequency electrical signal, the magnetostriction coil pro ultrasonic waves. The varying the values of capacitors C_2 and C_3, the tank circuit oscillation frequency can be varied which in turn varies the frequency of the ultrasonic waves at the output.

1.2.2.2 Piezoelectric method:

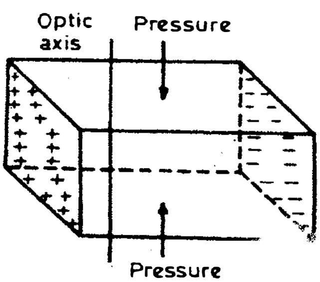

Fig. 1.2.3

Principle: This method is based on piezo-electric effect. According to this effect when certain crystal like quartz, Rochelle salt, tourmaline crystal etc. are stretched or compressed along certain axis (known as mechanical axis) an electric potential difference is produced along a perpendicular axis (known as electrical axis) (Fig. 1.2.3). The converse of this effect is also true i.e. when an alternating potential difference is applied along the electrical axis; the crystal is set in to elastic vibration along the corresponding mechanical axis. If the frequency of electric oscillations coincides with the natural frequency of the crystal, the vibration will be of large amplitude to produce ultrasonic waves. This can be also explained as follows:

When an ac voltage is applied across a piezoelectric crystal, such as a quartz crystal, it vibrates at the frequency of the applied voltage. Vibrations of maximum amplitude occur at the natural resonant frequency of the crystal, which is determined by the physical dimensions and by the way the crystal is cut. The frequency of the vibrations is given by :

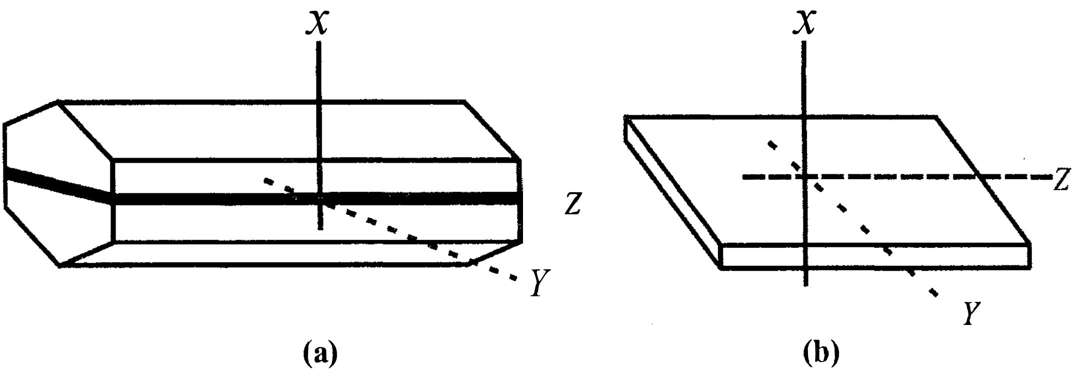

Fig. 1.2.4

$$f = \frac{n}{2L}\sqrt{\frac{Y}{\rho}}$$

where L - Length or thickness of crystal plate.
Y - Young's modulus along the appropriate direction.
ρ - the density of the crystal.

Piezoelectric crystals can oscillate in either of two modes; namely fundamental and overtone. The fundamental frequency of a crystal is the lowest frequency at which it is naturally resonant. Because a slab of crystal cannot be cut too thin without fracturing, there is an upper limit on the fundamental frequency. For most crystals, the upper limit is less than 20 MHz. For obtaining higher frequencies; the crystal must be operated in the overtone mode. The overtone frequencies are usually but not always odd multiples (3, 5, 7 ....) of the fundamental. Thus, frequencies from about 150 kHz to 500 MHz can be generated using quartz crystals. (Fig. 1.2.4)

Piezoelectric oscillator:

The ultrasonic wave generator using piezoelectric phenomenon was first designed in 1917 by Langevin.

The circuit diagram of a piezoelectric ultrasonic generator using transitors is shown in fig. 1.2.5. It is basically a Hartley oscillator. The transis or T is biased using the network of resistances R_1, R_2, R_3 and R_4. The coils L_1, L_2 and capacitor C_4 constitute the tuning circuit.

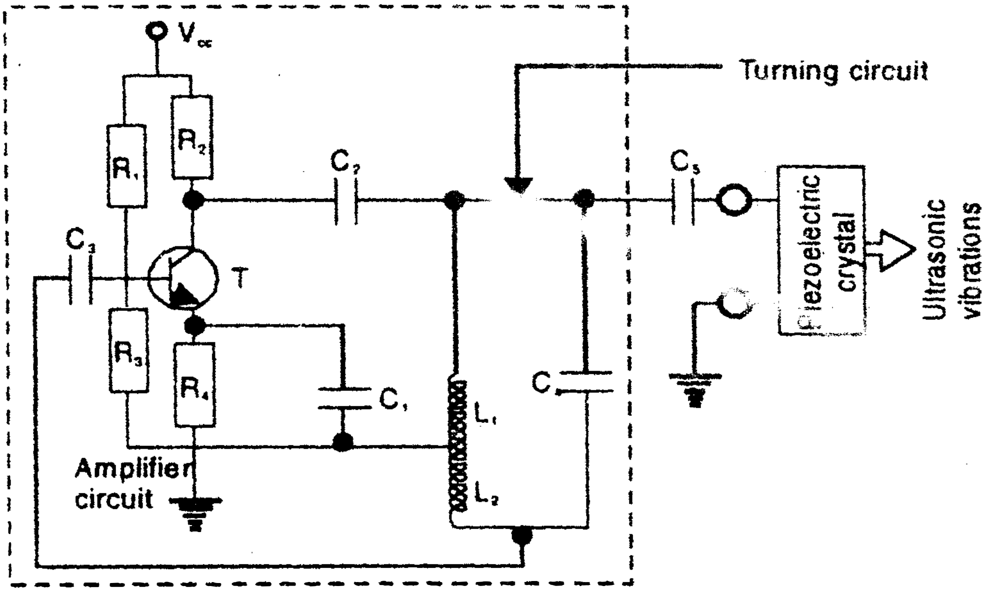

Fig. 1.2.5

The tuning circuit is coupled to the amplifier T through the coupling capacitor C_2. Capacitor C_3 provides the positive feed back to the amplifier. The oscillations generated by the tuning circuit are sustained and the electrical signal obtained at the output is applied to the electrodes of piezoelectric crystal through the coupling capacitor C_5. Because of high frequency electrical signal applied to it, the piezoelectric crystal produces ultrasonic waves. The frequency of these ultrasonic waves can be varied by varying the values of the components of the tuning circuit.

1.2.3 PROPERTIES OF ULTRASONIC WAVES:

1. The speed of propagation of ultrasonic waves increases with increase in frequency.
2. The wavelength of the wave is very small and the waves exhibit negligible diffraction effect.
3. Hence they can be transmitted over long distances without any appreciable loss of energy.

4. They are highly energetic. Owing to the high frequencies involved, ultrasonic waves may have intensities up to 10 KW/m^2. Normally 1 to 2 KW/m^2 intensities are used.
5. When ultrasonic waves are propagated is to a liquid media, they include alternate regions of rarefaction and compression. A negative local pressure at the spot of rarefaction causes local boiling of the liquid accompanied by the bubble growth and collapse. This phenomenon is known as cavitation.
6. When ultrasonic waves are propagated in to a liquid bath, stationary wave pattern is formed due to the reflection of wave from the other end. The density of the liquid thus varies from layer to layer along the direction of propagation. In this way the plane diffraction grating is formed which can diffract light.

1.2.4 DETERMINATION OF WAVELENGTH AND VELOCITY OF ULTRASONIC:

The phenomenon of diffraction of light by ultrasonic waves passing through a liquid was first observed by Debye and Sears in America in 1932. When ultrasonic waves are propagated in a liquid, the density varies from layer to layer due to periodic variation of pressure. If under this condition, monochromatic light is passed through the liquid at right angles to the waves, the liquid behaves as a diffraction grating. Such a grating is known as acoustical grating. This grating behaves in the same way as a ruled grating. Hence this method can be used for finding the wavelength and the velocity of ultrasonic waves in liquid. This method is known as acoustic diffraction method.

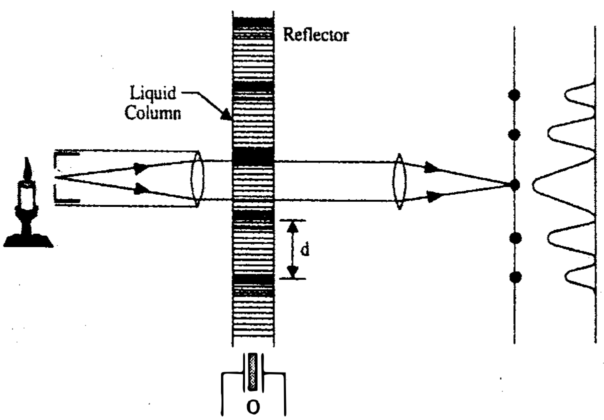

Fig 1.2.6

Fig. 1.2.6 shows the experimental arrangement to determine wavelength and velocity of ultrasonic waves. Stationary ultrasonic waves are produced in a liquid contained in glass tube. The density and hence refractive index of liquid is maximum at nodal point and minimum at antinodal points. Therefore, the nodal areas act as opaque regions while antinodal areas act as transparent regions for light. The liquid column thus resembles a ruled grating.

When the crystal is at rest a single image of the slit is formed on the screen. When the crystal is excited a diffraction pattern is produced. It consists of a central maxima flanked by 1st order, 2nd order maxima and minima etc. the grating period d equals to $\frac{\lambda_u}{2}$ and is given by

$$d \sin\theta = n\lambda \qquad \left(\because d = \frac{\lambda_u}{2}\right)$$

where λu - the wavelength of ultrasonic waves.
λ - the wavelength of monochromatic light beam.
n - the order of the maxima.

$$d \sin\theta \quad \frac{\lambda_u}{2} \sin\theta \quad n\lambda$$

$$\therefore \lambda_u \quad \frac{2n\lambda}{\sin\theta}$$

by knowing λ and n and by measuring θ the value of λ_u can be determined. The frequency f of the waves is known from the frequency of the oscillator. The velocity of waves in the liquid can be found out by the relation

$$\nu = f\lambda_u.$$

1.2.5 APPLICATIONS OF ULTRASONICS:

Ultrasonic are extensively used in industry, medicine and marine applications. We study here some typical applications.

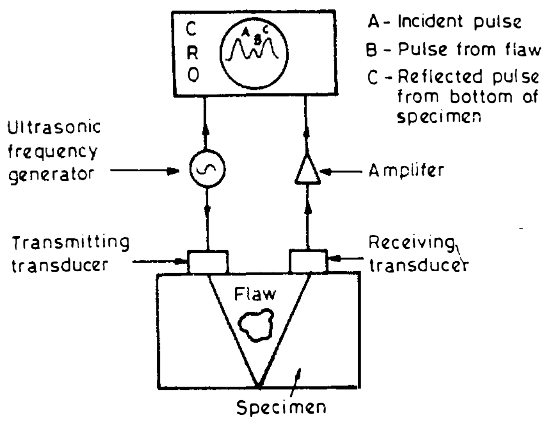

Fig. 1.2.7

1. Detection of flaws in metal or non destructive testing:

The purpose of non destructive testing is to find out whether any flaws exist in a finished product without causing damage to the body. Ultrasonic waves can be used to detect flaws in metal. We know that flaw in the metal produces a change in the medium due to which reflection of ultrasonic waves takes place. Hence when ultrasonic waves pass through a metal having some hole or crack inside it, an appreciable reflection occurs. The reflection also takes place at the back surface of the metal. The reflected pulses are picked up by receiver and are suitably amplified. These pulses are now applied to one set of plates of cathode ray oscillograph. The transmitted signal and reflected signal from the flaw and back surface of metal produce a peak each. The position of the second perk on the time base of oscillograph will give distance of flaw.

The experimental arrangement is shown in Fig. 1.2.7. Here the transmitting transducer sends a beam of ultrasonic through the material under test. In the presence of flaw in the specimen, the waves will be reflected back and the corresponding recorded intensity in the receiver will be very weak. Similarly, if there is a crack in the specimen, the transmitted waves will have the intensity extremely small. The reflected beam is recorded by using cathode ray oscillograph (CRO).

2. Ultrasonic machining/drilling:

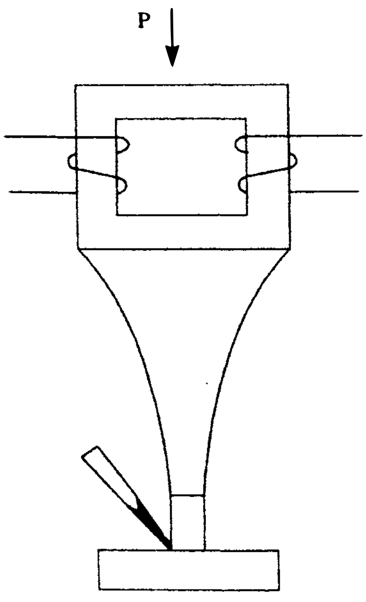

Fig. 1.2.8

Machining or drilling is one of the most important applications of ultrasonic waves. Ultrasonic machining is a vibratory process which is now in common use for the mechanical treatment of hard and brittle solids such as ceramics, glasses, precious stones, semiconductors and hard alloys. The tool motion is produced by an acoustic concentrator to which the tool holder is threaded. The acoustic concentrator consists of a needle type magnetostriction vibrator, illustrated in Fig. 1.2.8. The vibrator is made of thin isolated ferromagnetic plates of high magnetostriction such as nickel. A coil is wound on the needle, through which an alternating current of frequency f passes. The resulting magnetic field magnetizes the core and thus changes its length. The core of the vibrator vibrates at frequency $2f$. By choosing the frequency f to be equal to half the natural vibration frequency of the vibrator, the system is held at resonance as a result of which the vibrations of the needle will be of large amplitudes. A tapered waveguide of appropriate dimensions and rigidly attached to the vibrator concentrates the vibrational energy and communicates to the tool. The tool oscillates linearly with amplitude of 0.013 to 0.1 mm at ultrasonic frequency of 20 KHz to 30 KHz. In operation, the needle vibrator is set in oscillation and the tool shank is pressed against the work piece.

An aqueous suspension of a solid abrasive powder is then fed through a tube to the working zone. Abrasive particles bombard the work surface at high velocity and shear off small pieces of the material. This action rapidly chips away the work piece in a pattern controlled by the tool shape and contour.

3. Ultrasonic Welding:

Practically, all metals and plastics can be welded using ultrasonic waves of suitable energy. The surfaces of the work pieces are cleaned and held together. They are subjected to ultrasonic oscillations at the spot where they are to be welded. The ultrasonic energy converts to heat at the contact area a result of friction arising between the surfaces. As the temperature of surface layers exceed the re-crystallization point, the layers melt and bond together to form a strong joint. The merits of this process are that it induces negligible stress at the spot of welding and that the structure of the materials remains unchanged.

4. Ultrasonic Soldering:

Normally, surfaces are covered with contaminants grease and oxide films. Such films prevent formation of a good joint. Therefore, prior to soldering the surfaces are cleaned with active fluxes. The fluxes, when heated, dissolve the oxide film and uncover the clean metal surfaces which readily allow the molten solder to forma firm joint. This method is however not suitable for soldering aluminum. Active metals such as aluminum can be soldered without fluxes with the help of ultrasonic waves. In this case soldering is done by a special iron which vibrates at a frequency of tens of kilohertz. Ultrasonic waves can also be used for drilling and cutting processes in metals. These waves can also be used for soldering, for example, aluminum cannot be soldered by normal methods. To solder aluminum ultrasonic wave along with electrical soldering iron is used. Ultrasonic welding can be done at room temperatures.

5. Ultrasonic Cleaning:

In the fabrication of electronic devices, it becomes highly essential to clean the surfaces of parts and components at different stages of production. Cleaning of the surfaces is commonly carried out in either organic solvents or weakly alkaline acqueous solutions containing surface active agents. To make the scrubbing of surfaces more effective, the phenomenon of cavitation is utilized. Ultrasonic cleaning baths are used for the purpose. The hydraulic shock arising at the surface of a part due to cavitation destroys any layer of contaminants. Bubbles penetrate under the layer, tear it off and break it down into minute pieces. The surface active agent pulls them away into the solution.

The chief advantage of this method is that it enables cleaning the surfaces of small products of intricate configuration. Jewelers make use of ultrasonic baths to clean jewelry.

6. Echo Sounder:

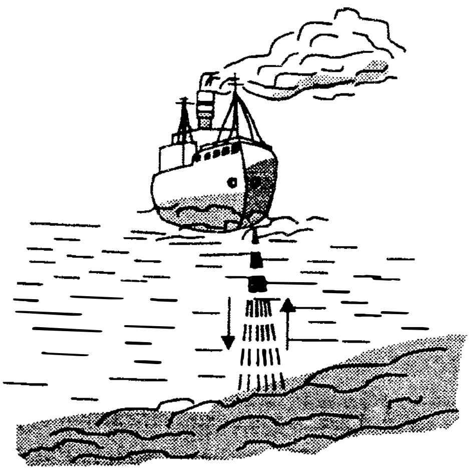

Fig. 1.2.9

Ultrasonic waves can be produced in the form of directed beams like beams of light. Further, ultrasonic waves can travel long distances in water. As a result, ultrasound is widely used in marine applications. The depth of an ocean is determined using an echo sounder. The ship is equipped at its bottom with a source and a receiver of ultrasound of a definite frequency. The source sends out short pulses of ultrasonic waves and the receiver receives reflected pulses. Measuring the time interval between the pulse sent and the pulse received, the depth of the ocean can be computed with the help of the formula:

$$\text{Depth / Distance} \qquad l = \frac{\upsilon t}{2} \text{ ---------(1)}$$

7. Sonar:

The world sonar stands for sound navigation and ranging. The ultrasonic waves which are highly directional can be used for locating objects and determining their distance in the seas. The idea of ultrasonic sonar was put forward first by the French Physicist Paul Langevin and was successfully used by him during the first world war for detecting enemy submarines. The sonar acts in a way much similar to echo sounder. In the absence of an obstacle the ultrasonic pulses do not return to the ship. In the presence of an obstacle, pulses are reflected and are picked up by the receiver. Knowing the speed of the ultrasound and elapsed time, the distance of the object can be determined using the formula (1).

8. Fish Finder:

Ultrasound can be used to locate shoals of fish, utilizing the fact that the swimming bladder of fish is filled with air which scatters ultrasonic waves. Ultrasonic sonar is used for this purpose. At present, ultrasonic locators are mainly used for detecting icebergs, fish shoals.

An interesting fact is that some animals have organs operating on the sonar principle. For example, bats find their way in darkness and hunt for their prey using the sonar techniques. The bat emits a constant series of short ultrasonic pulses at a frequency of 20 kHz to 60 kHz. Its large ears are highly specialized to perceive these sounds and to determine the direction and distance of objects from which the sounds are reflected. Some of the sea animals such as whales and dolphins use ultrasound to locate their prey, avoid collision with obstacles and even to converse with each other. In the depths of the sea, visibility is highly restricted because of the strong absorption of light by water. It may be therefore that these animals use ultrasound which is relatively less absorbed.

9. Formation of Alloys:

The constituents of alloys, having widely different densities, can be kept mixed uniformly by a beam of ultrasonic. Thus it is easy to get alloy of uniform composition.

10. Ultrasonic Mixing:

A colloid solution or emulsion of two non-miscible liquids like oil and water can be formed by simultaneously subjecting to ultrasonic radiations. Now-a-days most of the emulsions like polishes, paints, food products and pharmaceutical preparations are prepared by using ultrasonic mixing.

11. Coagulation and Crystallization:

The particles of suspended liquid, by ultrasonics, can be brought quite close to each other so that coagulation may take place. The crystallization rate is also affected by ultrasonics. The size of crystals, when molten metal is put to crystallization can be made smaller and more uniform by the use of ultrasonics.

12. Ultrasonic in Metallurgy:

To irradiate molten metals which are in the process of cooling so as to refine the grain size and to prevent the formation of cores and to release trapped gases, the ultrasonic waves are used.

13. Cleaning and Clearing:

These waves can be used for cleaning utensils, washing clothes, removing dust and soot from the chimney.

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14. Direction Signaling:

The ultrasonic waves can be concentrated into a sharp beam due to smaller wavelength and hence can be used for signaling in a particular direction.

15. Destruction of Lower Life:

The animals like rats, frogs, fishes etc. can be killed or injured by high intensity ultrasonics.

16. Treatment of Neuralgic Pain:

The body parts affected due to neuralgic or rheumatic pains on being exposed to ultrasonics gets great relief from the pain.

17. Detection of Abnormal Growth:

Abnormal growth in the brain, certain tumors which cannot be detected by X-rays can be detected by ultrasonic waves.

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Question Bank

	Objectives Type Questions	**Marks**
1.	List out essential features of good acoustics, according to W. C. Sabine	4
2	Explain the concept of reverberation and time of reverberation in brief.	2 each
3	Define and explain in brief 'Absorption coefficient'	4
4	List out various types of waves you know. How will you differentiate them?	3
5	What is magnetostriction? Explain in brief.	4
6	What is piezoelectric effect? Explain in brief.	4
7	List out various properties of ultrasonic waves.	4

Descriptive Type Questions or Notes

1 Explain in brief the magnetostriction method to generate ultrasonic waves. 8

2 Explain in brief the piezoelectric method to generate ultrasonic waves. 8

3 How will you determine wavelength and velocity of ultrasonic waves? 8

4 Write note on applications of ultrasonic waves. 8

5 Explain any four applications of ultrasonic waves in detail. 8

Numericals

Numericals will be asked based on articles such as: reverberation, time of reverberation, Sabine's formula, absorption coefficient, determination of wavelength and velocity of ultrasonic waves etc.

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