UNIT II
SOUND WAVE AND ITSAPPLICATIONS

CHAPTER-03
Ultrasonic Waves

Sound Waves

Subsonic or infrasonic waves

The sound waves of frequencies less than the lower limit (i.e.,20 Hz) of audible range are known as subsonic or infrasonic waves.

Sonic or audible waves

The human ear can perceive the sound waves of frequency ranging from 20 Hz to 20 kHz. The waves of this frequency range are known as audible waves.

Ultrasonic waves

The sound waves having frequencies greater than the upper limit of the audible range (i.e., above 20 kHz) are known as ultrasonic or supersonic waves.

PRODUCTION OF ULTRASONIC WAVES

- Mechanical Method
- Piezoelectric Generator
- Magnetostriction Generator

Mechanical Method

➢Mechanically, the ultrasonic waves are produced by Galton whistle, sirens, wedge resonators, vortex generators, hydrodynamic oscillators, vibrating blade transducer, etc.

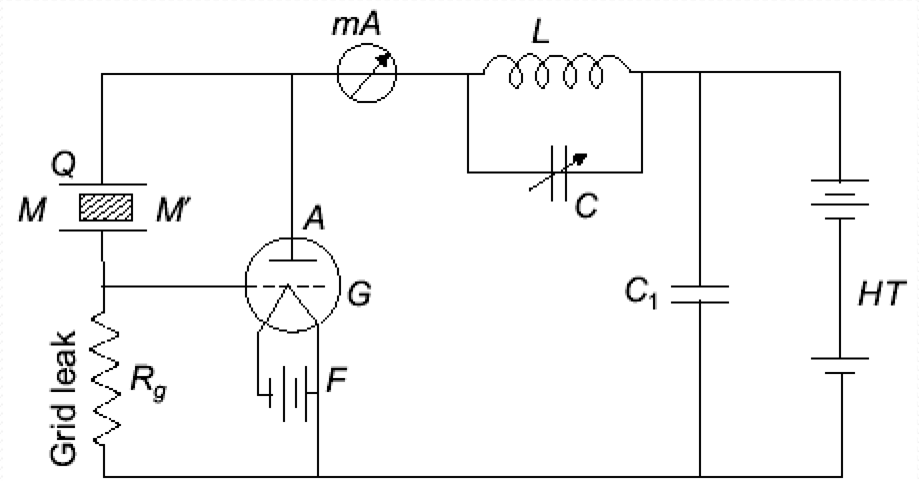
Piezoelectric Generator

➢Use of piezoelectric generator for the production of ultrasonic waves is the most modern method. With the help of these generators, we can produce ultrasonic weaves of very high and constant frequencies.

Principle: *This generator is based on the principle of piezoelectric effect.*

Construction: An arrangement of a piezoelectric generator for the production of ultrasonic waves consists of A slice of a quartz crystal Q is placed between two highly polished metal plates serving as electrodes, connected to anode A and grid G of a triode valve. Anode A is also connected with an L-C circuit and high-tension battery, shunted through a by-pass capacitor C_1. This by-pass capacitor is used to stop the high-frequency currents from passing through battery.

The circuit diagram of piezoelectric generator is shown in following fig.



The natural frequency of quartz crystal of thickness *t for its fundamental mode of vibration is* given as

$$\nu = \frac{1}{2t}\sqrt{\frac{E}{\rho}}$$

where *E is young's modulus (which is also denoted by Y) and ρ is the density of the material.*

Magnetostriction Generator

***Principle**: The principle of this generator is based on the manetostriction effect.*

Construction: In this arrangement, AB is a rod of ferromagnetic material clamped at the middle. There are two coils L_1 and L_2 on AB. The diameter of the turns of the coils is greater than that of rod so that the rod can move freely lengthwise. Coil L_1 is forming a tuned circuit with the variable condenser C which is also connected to the plate of triode valve through milliammeter. Coil L_2 is connected between the grid and the cathode The frequency of the oscillatory circuit is determined by the values of L_1 and C. If the frequency of the tuned circuit becomes equal to the natural frequency of the rod, then the longitudinal oscillations are set up and ultrasonic waves are produced in the surrounding medium. as it is shown in following fig.

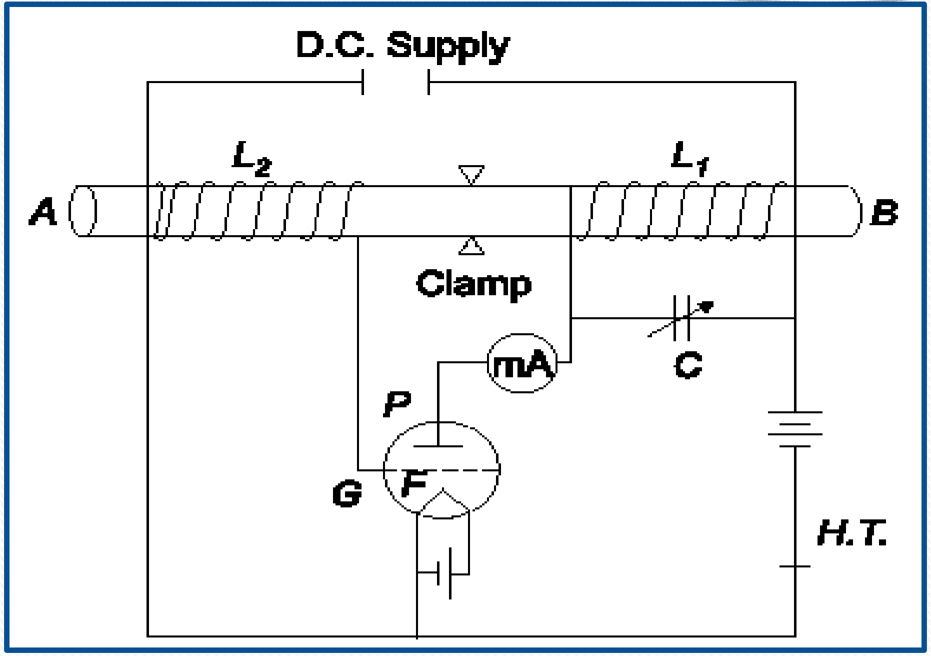
Magnetostriction Generator Contd..

Working

- Any change in the plate current passing through L_1 *causes corresponding change in magnetisation of the rod with* the coil L_1, *and therefore the length of the rod changes.*

- Variations in length cause a change in the magnetic flux through the grid coil L_2. *Therefore, by converse magnetostriction effect, an* induced emf is set up in L_2.

- Induced emf modifies the grid potential of the valve and produces an amplified current change in the plate circuit and in the coil L_1. *In this way, the oscillation of the* rod is maintained.



Result: At the condition of resonance, the frequency of wave produced by a tank circuit of capacitance C and inductance L is given as

$$\nu = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$$

DETECTION OF ULTRASONIC WAVES

•***Piezoelectric detector:*** This detector works on the principle of piezoelectric effect.

•***Kundt's tube:*** Kundt's tube is used to detect the ultrasonic waves of relatively large wavelength.

•***Sensitive flame method:*** When a narrow sensitive flame is moved in a medium, where ultrasonic waves are present, it is observed that the flame remains steady at the positions of antinodes and flickers at nodal points.

Thermal detector method: In this method, platinum wire is moved through the medium of ultrasonic waves to observe the compressions and rarefactions occur at the nodal points; due to the adiabatic change in temperature .

MEASUREMENT OF WAVELENGTH OF ULTRASONIC WAVES

➢The wavelength and velocity of ultrasonic waves can be determined with the help of diffraction pattern produced through acoustical grating.

Experimental Setup:

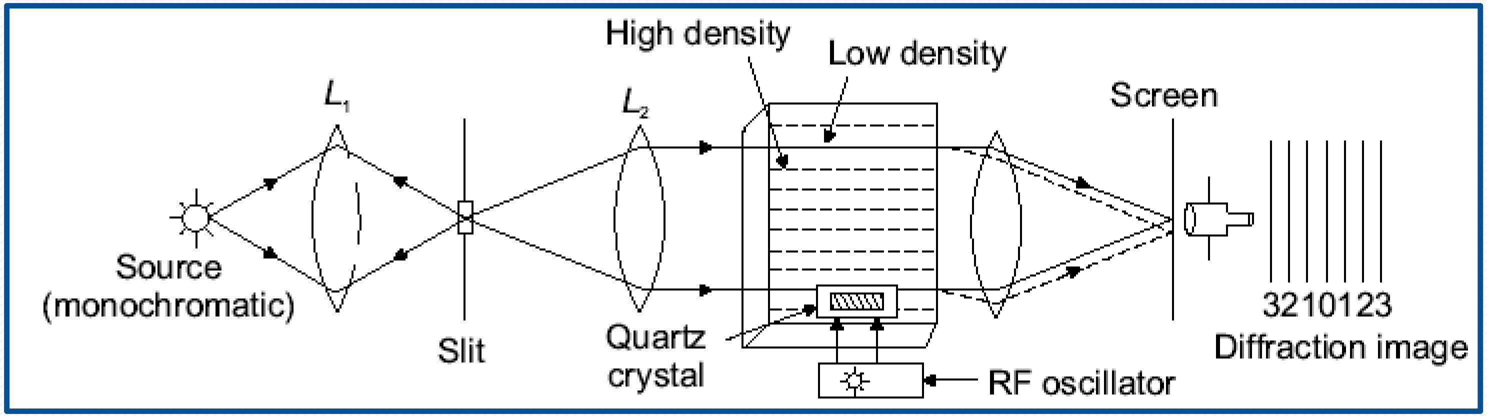
➢A quartz crystal is placed in a glass cell containing the liquid and is connected to an RF oscillator.

➢The oscillator is tuned to resonance frequency.

➢ Due to the longitudinal compression and expansion of the crystal, ultrasonic waves are generated.

➢ It travel through the liquid and form regions of high and low densities alternatively in the liquid column.

➢This medium behave as acoustic grating, set up is shown in following fig.



- If λ is the wavelength of monochromatic light and (a + b) is the grating element, then for nth order diffraction, we can write

$$(a + b) \sin \Theta = n\lambda$$

- For the acoustic grating, grating element is equal to the wavelength of ultrasonic wave (λc). *Hence,*

$$\lambda c = n\lambda / \sin \Theta$$

- If ν_c *is the frequency of ultrasonic wave, then the velocity of ultrasonic wave is given as*

$$\upsilon_c = \nu_c \lambda c = \nu_c (n\lambda / \sin \Theta)$$

APPLICATIONS OF ULTRASONIC WAVES

The major fields of applications of ultrasonic waves are :

- *Communication: such as in SONAR , directional signaling and for echo depth sounding.*
- *Elastic symmetries of the crystal*
- *Industrial applications*
- *Chemical applications*
- *Biological and medical applications*
- *Applications in Engineering and NDT*