Department of Electronics & Communication Engineering

Audio Video Systems

By : Raj Kumar

What is Sound….???

- ✓ Sound is the generalized name given to "acoustic waves"
- ✓ Sound is basically a waveform of energy that is produced by some form of a mechanical vibration
- ✓ The sound waves have frequencies ranging from 16Hz up to 20 kHz but speech range from 300Hz to 3400Hz
- ✓ Sound requires a medium for transmission either through the air, a liquid, or a solid to be "heard"
- ✓ The ***speed of sound*** **experienced by most of us is about** ***1000 ft per second*** **or** ***344 m per second***

Microphone

- T*ransducer*-converts sound pressure variations into electrical signals of the same freq. and phase and of amplitudes in the same proportion as in pressure variations
- Early microphones were invented for communication purposes
- Later modifications were made to design as the microphone was used more in entertainment industry

Microphone…

- Diaphragm—part of microphone which receives the vibration from sound waves
- Thickness and material of diaphragm are changed depending on the sound waves you wish to pick up
- How it works?
  - Electrical circuit is used to change these detected vibrations into an electrical signal that "images" the sound with an output voltage or current

Microphone…

- Quality – determined by following *characteristics:*
  - Sensitivity
  - SNR
  - Frequency Response
  - Non-Linear Distortion
  - Directivity
  - Output Impedance

Quality…

Sensitivity:

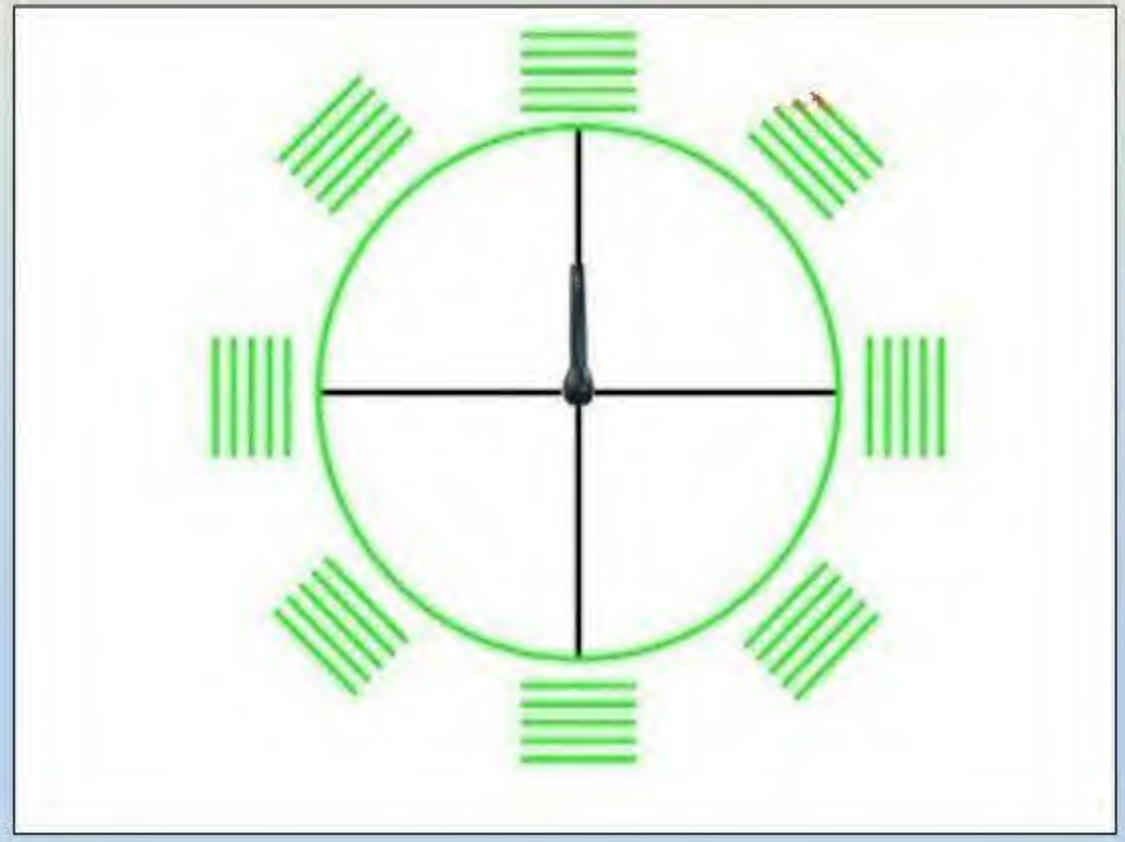
- Output in electrical form in milli Volt (or in dB below 1 volt) for the sound pressure of 1 micor-bar (or 0.1 Pa) at 1000 Hz

- *SNR:*
  - Noise – due to resistance of circuit, built-in transformer etc.
  - ratio in dB of output to the output in the absence of sound.

- *Distortion*:
  - *Non-linear :* distorts amplitude – produces harmonics other than original input sound – should not be more than 5% (for quality microphones) – should not be more than 1% (for hi-fi system)
  - *Phase distortion :* relative path difference due to multiple microphones

Directivity:

- Omni-Directional (pressure μP)



Cardioid or Heart Shaped

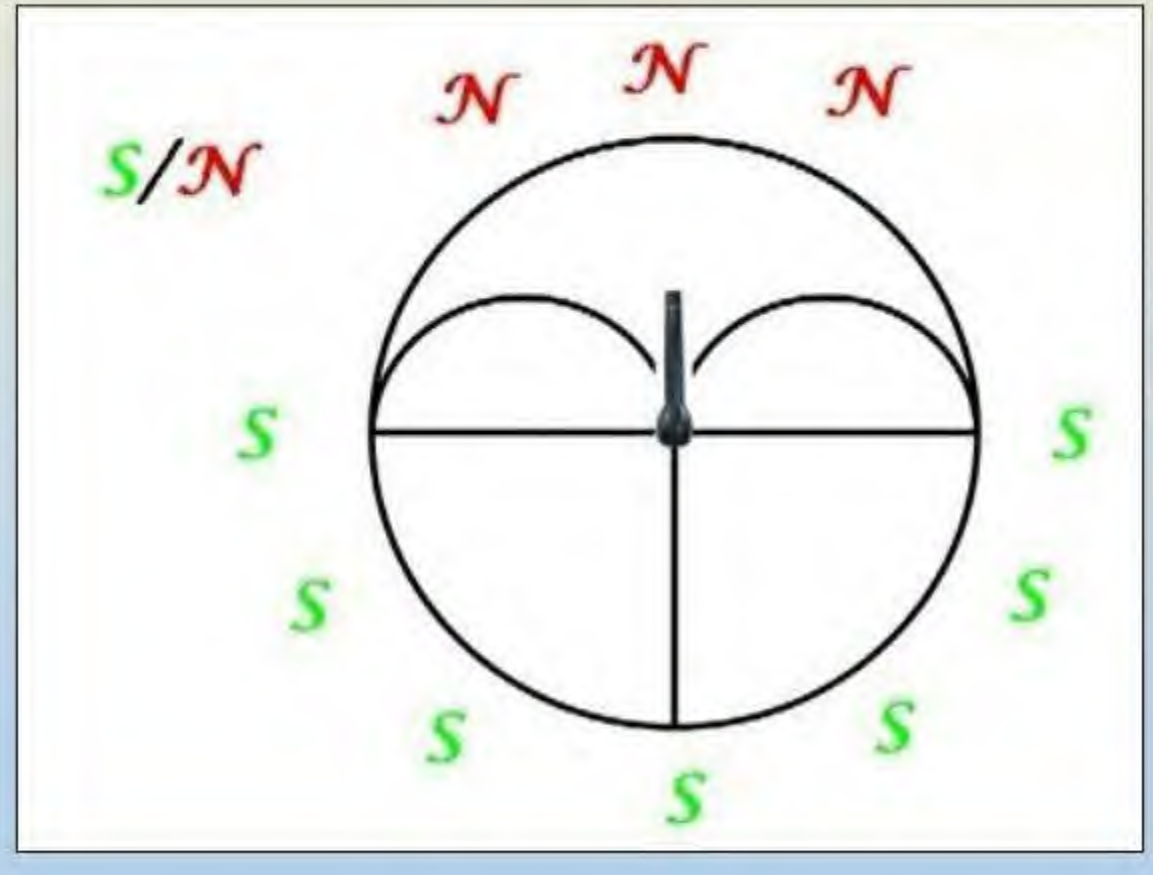
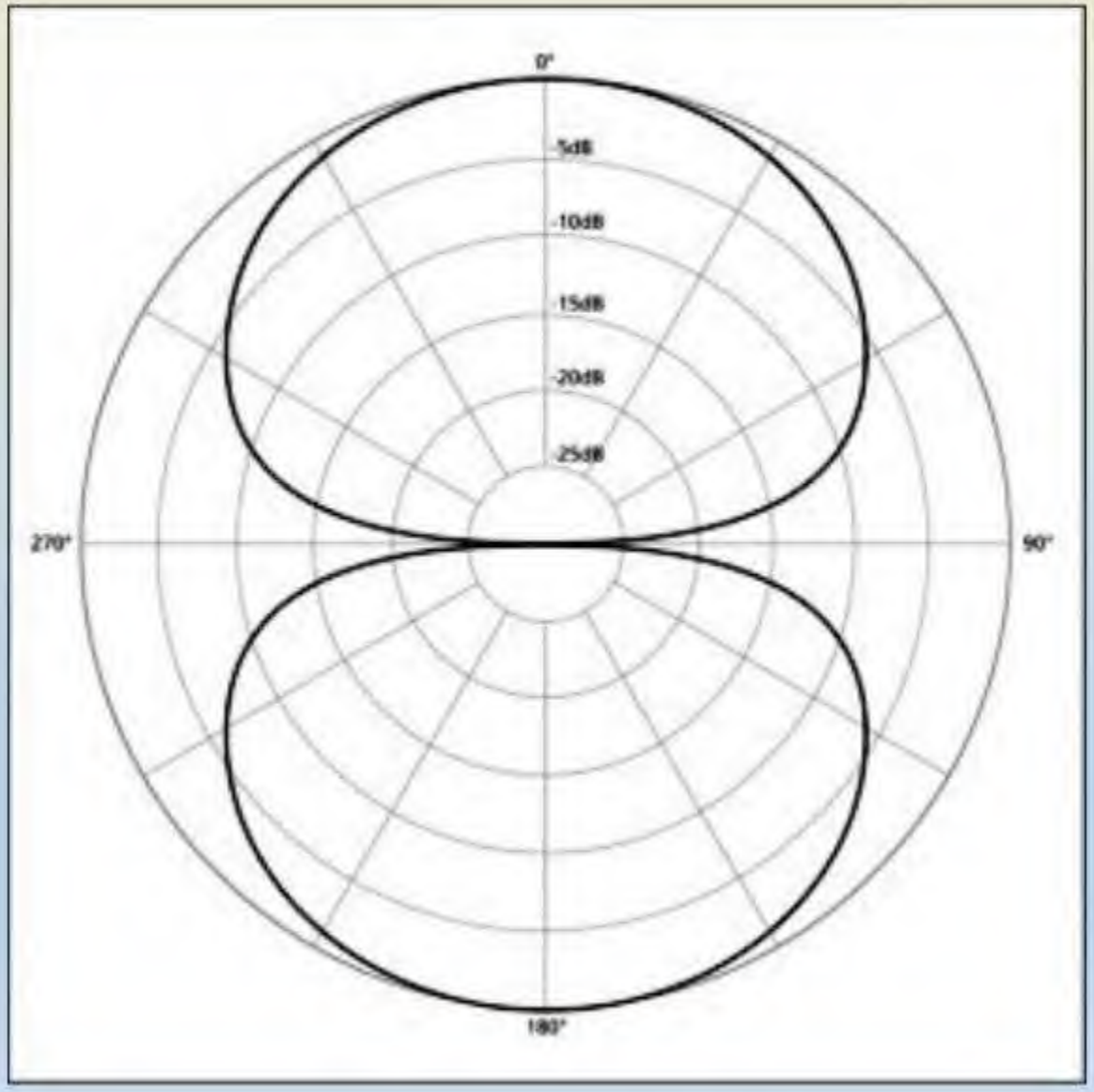


Figure of Eight (ribbon µP)



Output Impedance:

- Impedance matching is require to deliver maximum power to the preamplifier
- To determine which type of match needed to transfer the power efficiently line and then to the amplifier
- If output impedance quite low (e.g. transformer to match line impedance) built-in step up transformer is used to match line impedance

Requisites of a good μP

- High sensitivity
- High SNR
- Flat freq. response over most of the audible freq. range
- Low distortion
- Correct output impedance
- Required directivity

Dynamic or Moving-coil Microphone

- It produces an electrical analog output signal which is proportional to the "acoustic" sound wave acting upon its **flexible diaphragm**

- Many types are available such as **Dynamic Moving-coil , condenser , Piezo-electric Crystal microphones**

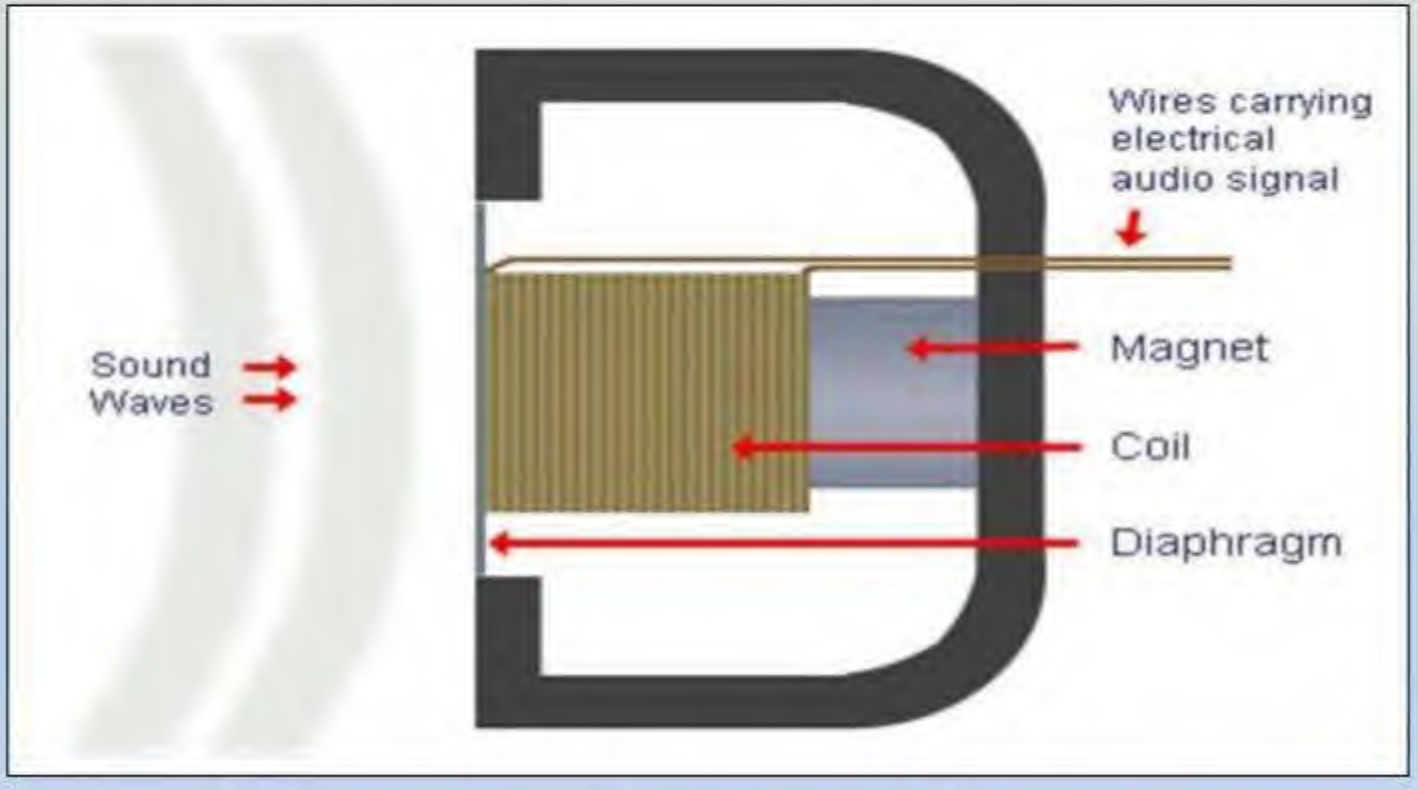


Fig. Dynamic or Moving-coil Microphone

Dynamic or Moving-coil Microphone...

- Sound wave hits the flexible diaphragm and diaphragm moves back and forth in response to the sound pressure acting upon it

- Very small coil of thin wire suspended within the magnetic field

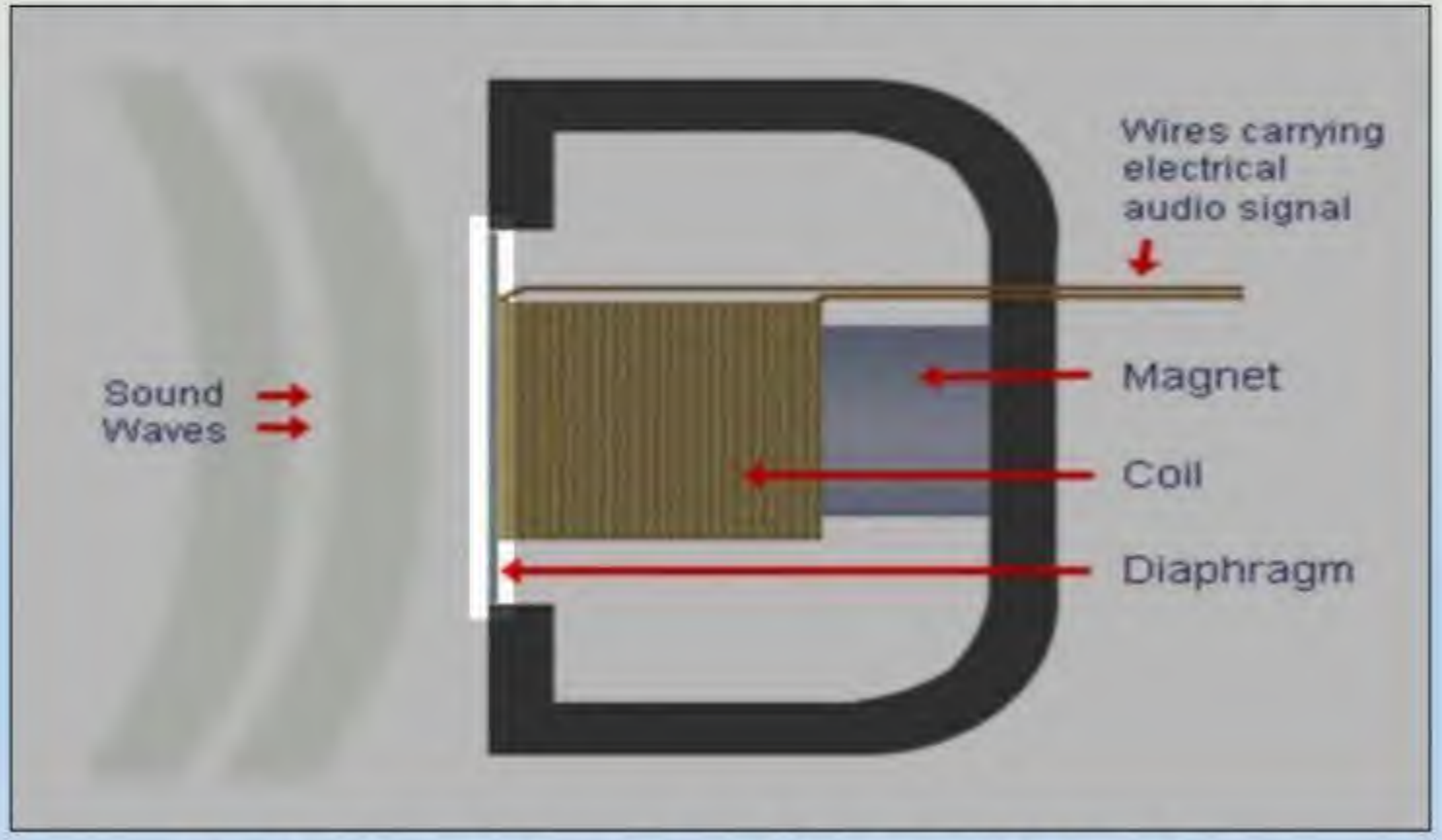


Fig. Working of Dynamic or Moving-coil Microphone

Dynamic or Moving-coil Microphone...

- Due to diaphragm motion, attached coil move within the magnetic field

- The movement of the coil within the magnetic field causes a voltage to be induced in the coil as defined by Faraday's law

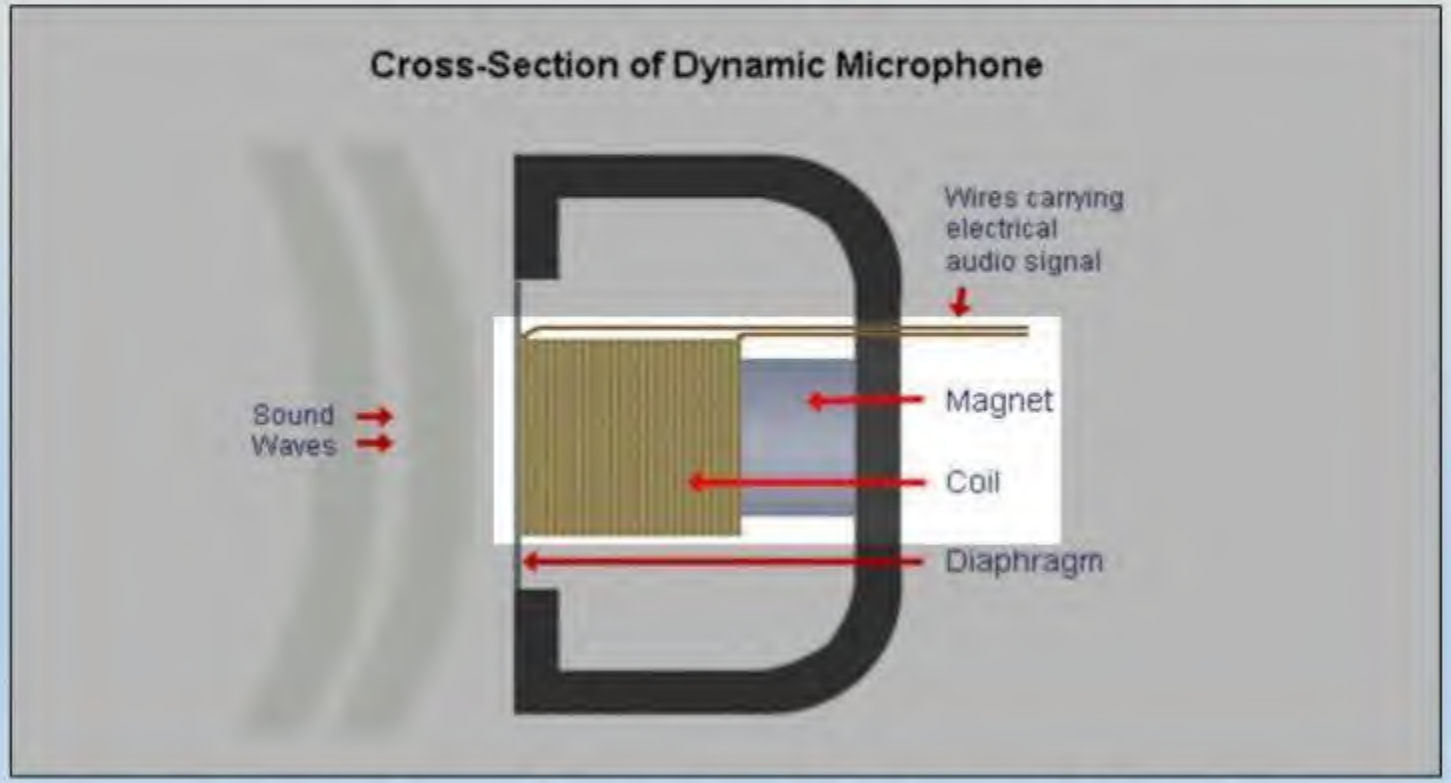


Fig. Working of Dynamic or Moving-coil Microphone

Dynamic or Moving-coil Microphone...

- The resultant output voltage signal from the coil is proportional to the pressure of the sound wave

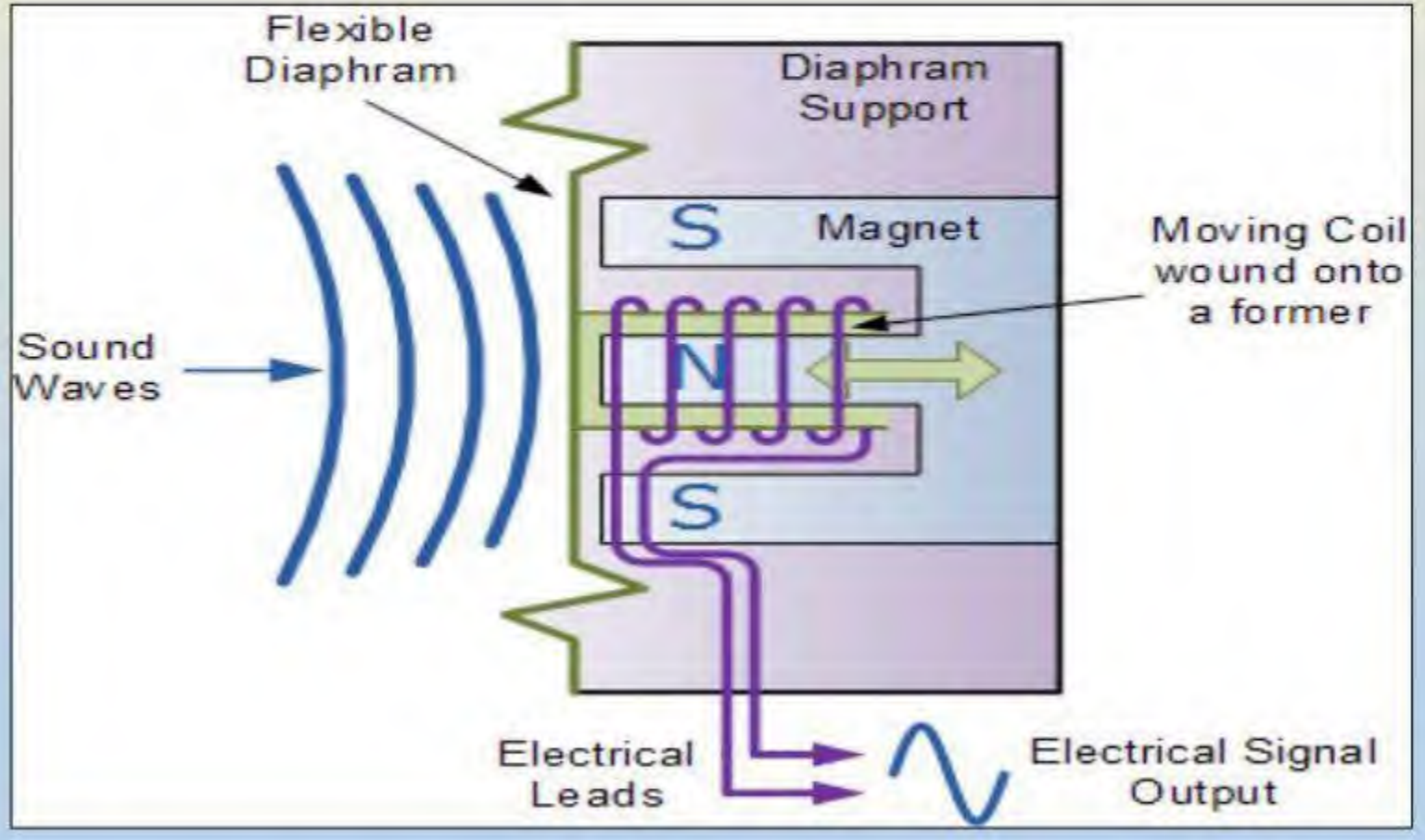


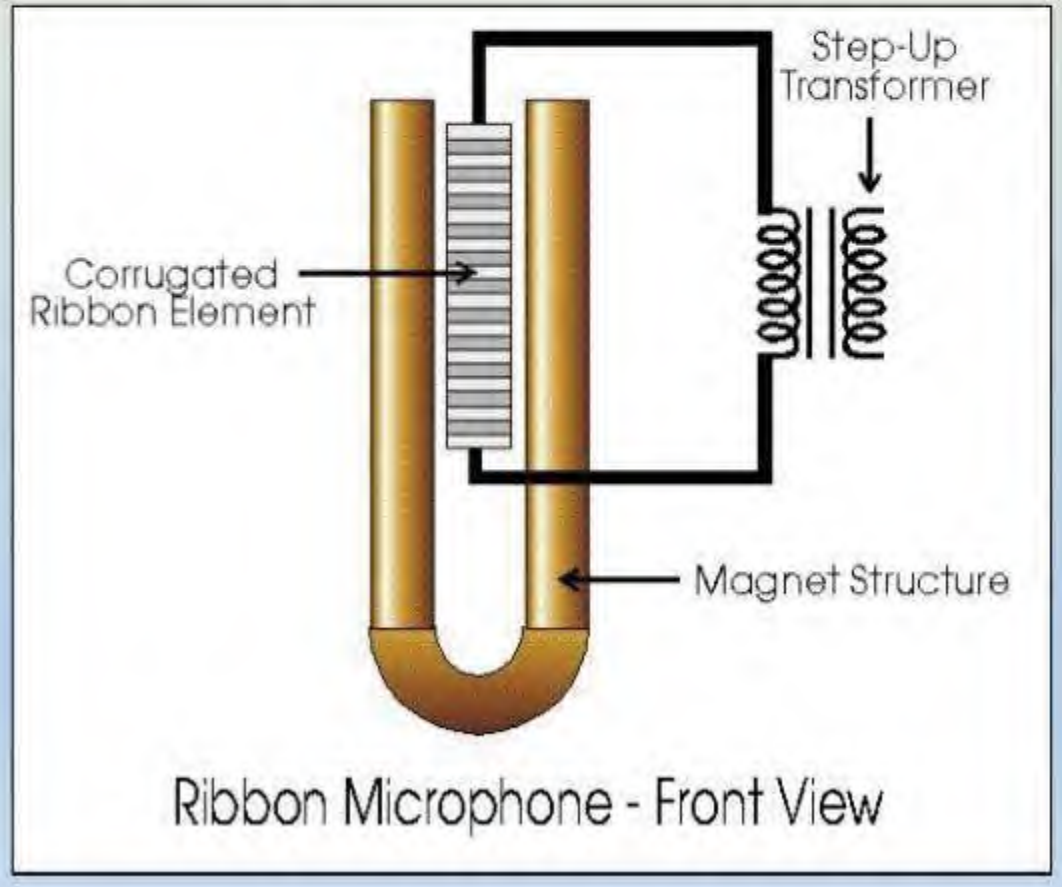
Fig. Working of Dynamic or Moving-coil Microphone

Characteristics

- Sensitivity: 30 μvolts
- SN ratio: 30 dB
- Frequency response: 60Hz to 8000Hz for ±1 dB
- Distortion: less than 5%
- Directivity: Omnidirectional
- Output Impedance: quite low about 25 ohm.
  - Need Step up transformer to match a line 200 ohm
- Does not need external Bias
- Less expensive

Ribbon Microphone

- Diaphragm: Thin piece of metal foil suspended in a magnetic field
- Light aluminium foil – corrugated at right angles to its length to provide greater surface area



Ribbon Microphone…

- Horse shoe magnet with extended pole pieces provides strong magnetic field
- Vibrations in ribbon produce a small voltage which is then stepped up by a transformer
- Ribbon is about 0.2 mg, a few microns thick and about 3 mm wide
- Diaphragm is very easily damaged by wind or loud incoming sounds

Working…

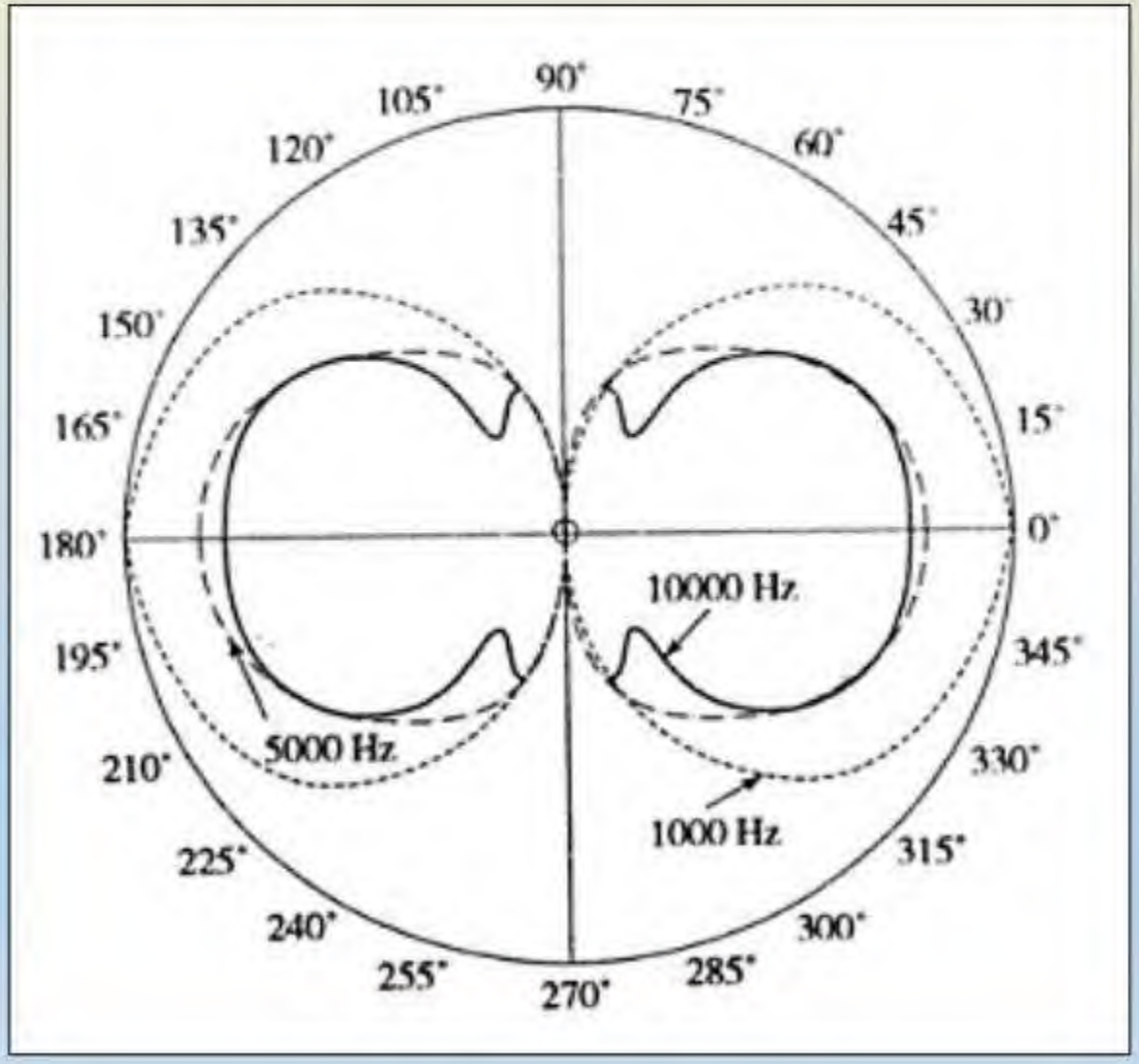
- Ribbon (an electric conductor) placed in magnetic field, it moves at right angles to magnetic field
  - Change in magnetic flux through ribbon, EMF is induced across ribbon
- EMF is proportional to the rate of change of flux i.e. proportional to sound waves striking the ribbon
- Driving mechanical force is proportional to the difference of the pressures acting on two sides of ribbon
  - It also known as Pressure Gradient or Velocity microphone

Characteristics

- Sensitivity: 90 μvolts
- Frequency response: 20Hz to 12KHz for ±1 dB
- Output Impedance: quite low about 0.25 ohm
  - Need Step up transformer to match a line of 200 ohm
- SN ratio: 50 dB
- Does not need external Bias
- Distortion: Low 1%

Characteristics…

- Directivity: Bi-directional (Figure of Eight)



Crystal Microphones

- Based on the principle of 'Piezo Electric Effect'
- Difference of potential between the opposite faces of some crystals is produced when these are subjected to mechanical pressure
- Crystals : Quartz, Tourmaline, Rochelle salt and ceramic
- Rochelle Salt : high piezo electric effect but is susceptible to moisture cannot withstand with high temperature of 50^0 C
- Quartz and Tourmaline : low piezo electric effect
- Ceramic : most suitable for crystal microphones as it is not susceptible to moisture and can withstand high temp up to 100^0 C

Construction (Crystal Microphones)

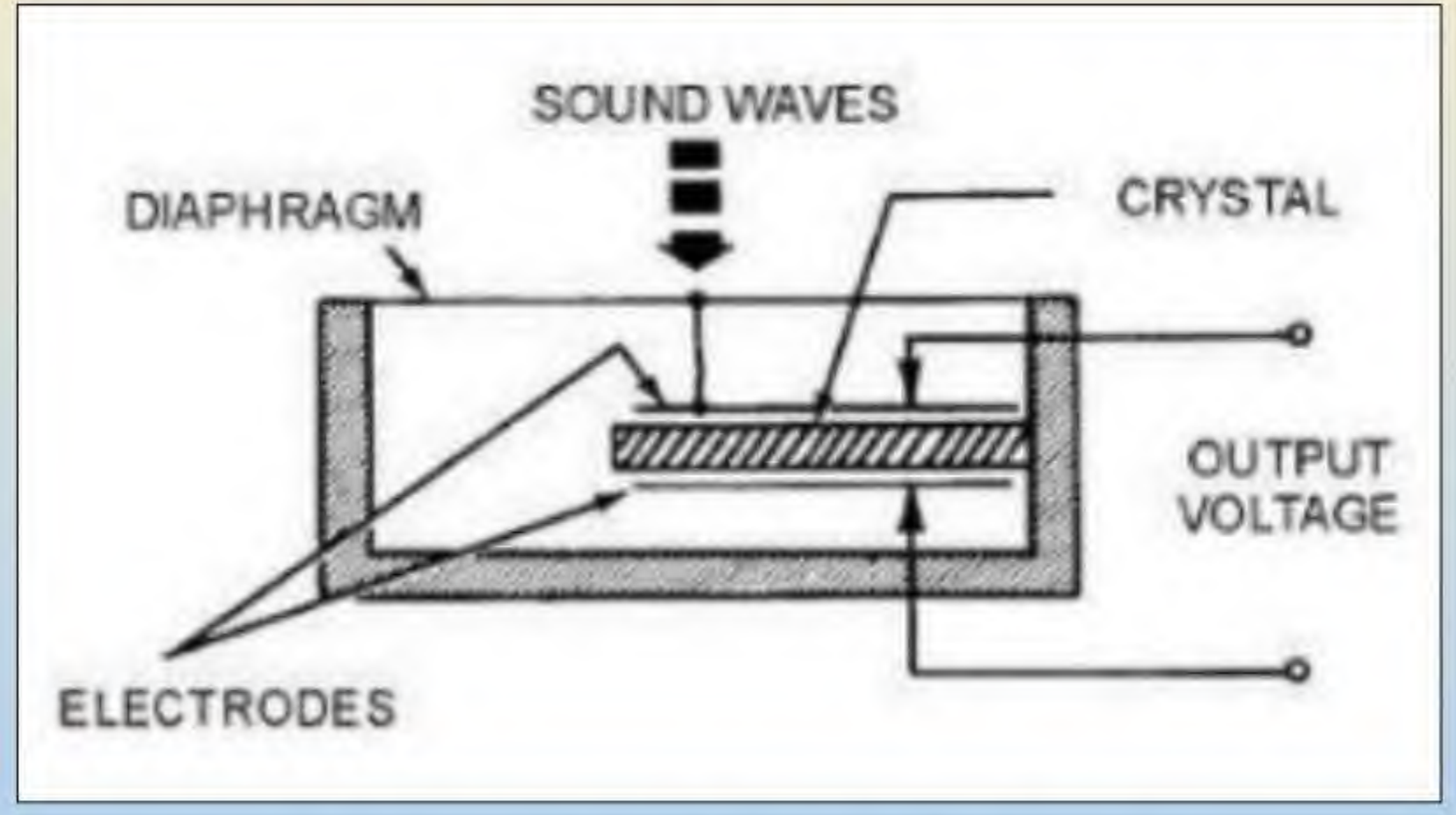


Fig. Construction of Crystal Microphones

Crystal Microphones…

- Crystal is cut along certain planes to form a slice
- Metallic foil electrodes are attached to two surfaces to carry the potential difference to the output terminals
- Two thin crystal slices suitably cut are placed in an insulating holder with an air space between them. Large number of such elements are combined to increase EMF
- Diaphragm : made of Aluminium, is attached to the crystal surface through a push road
- The whole unit is enclosed in a protective case

Crystal Microphones…

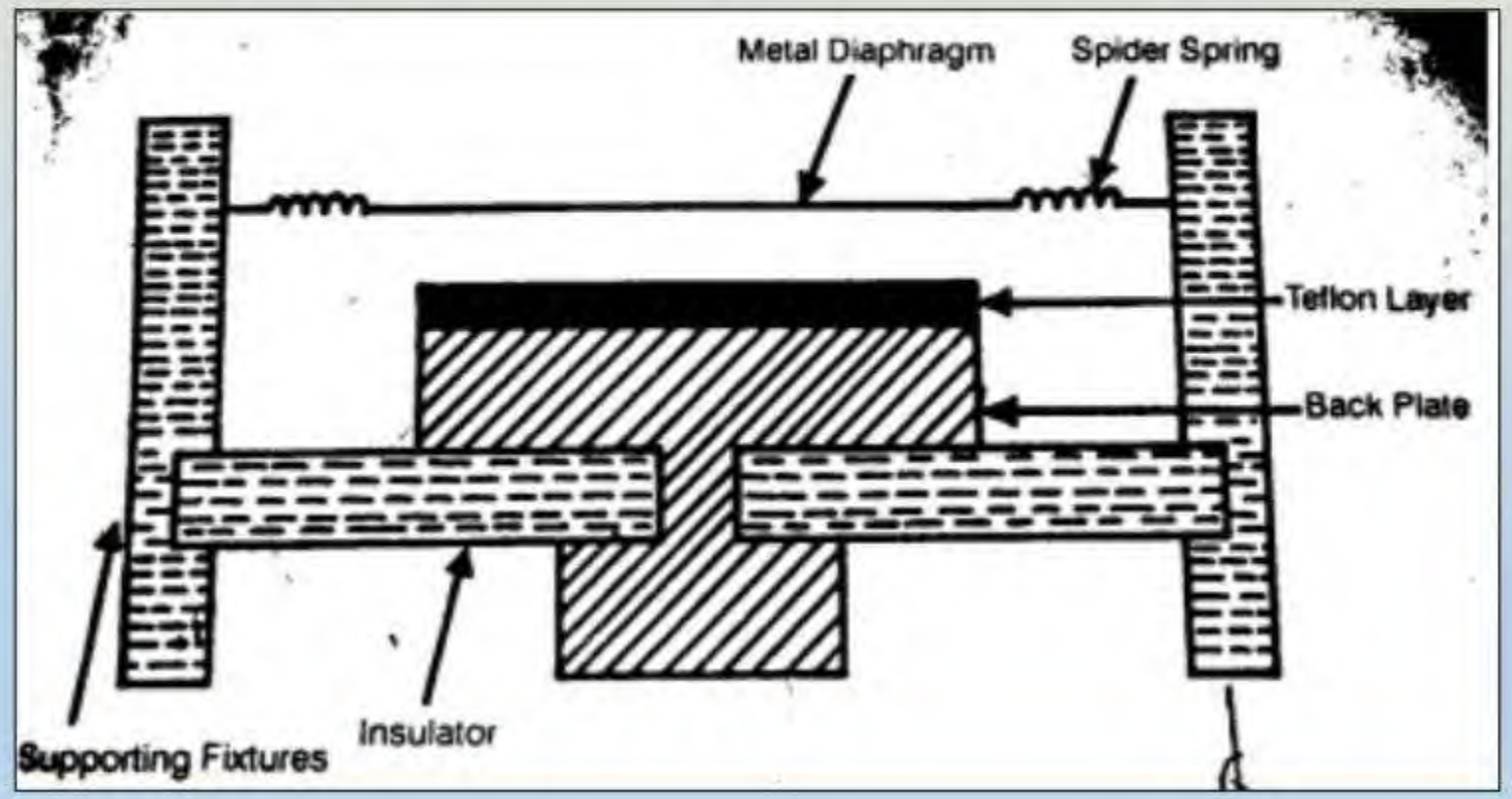
- Sound wave compression – compresses crystal
- Rarefaction - converse takes place, crystal is extended and is under tension
- Due to this compression and extension – varying potential difference is generated which is proportional to the mechanical pressure applied to the crystal by the sound waves
- Type of Pressure Microphone

Characteristics

- Sensitivity : Good – about 50 mV for 0.1 Pa
- SNR : high – About 40 dB
- Frequency Response : 100-8000 Hz
- Distortion : Low – about 1%
- Directivity : Omni-directional
- Output Impedance : High – about 1 MΩ
- Mixer circuit will load it and cause severe loss of bass – hence cannot be used in multi microphone system
- Does not need a bias supply
- Should not be exposed to direct sun light for long time
- Less Expensive

Electret Microphone

- Capacitor mic – costly and unsuitable for field work – due to external bias
- Electret Mic – capacitor mic but it has built-in charge



Electret Microphone…

- Insulating Material – Teflon – can trap large quantity of fixed charge and can retain it indefinitely
- Back Plate – coated with thin layer of Teflon
- Charged negatively at the time of manufacturing and this charge remains trapped for long period
- Induces positive charge on the diaphragm
- (+ve) charge on diaphragm, (-ve) charge on Teflon, establish an electric field across the gap of capacitor plates
- Due to Sound pressure 'C' changes, Q remains constant
- Same characteristics as capacitor mic except that it does not need external bias and less costly
- Sensitive to temperature and humidity which cause leakage of charge
- Used as tie clip mic for lecturers and as wireless mic in sports meet

MOVING COIL L.S.

- It is also known as Cone Type L.S. or Direct Radiating Type L.S.
- Works on principle of interaction between magnetic field and current
- A coil placed in uniform magnetic field and audio current passes through it, resulting in force
- Generated force is proportional to the audio current and hence causes vibratory motion in the coil, which makes conical diaphragm to vibrate resulting in sound waves.

MOVING COIL CONE TYPE L.S.

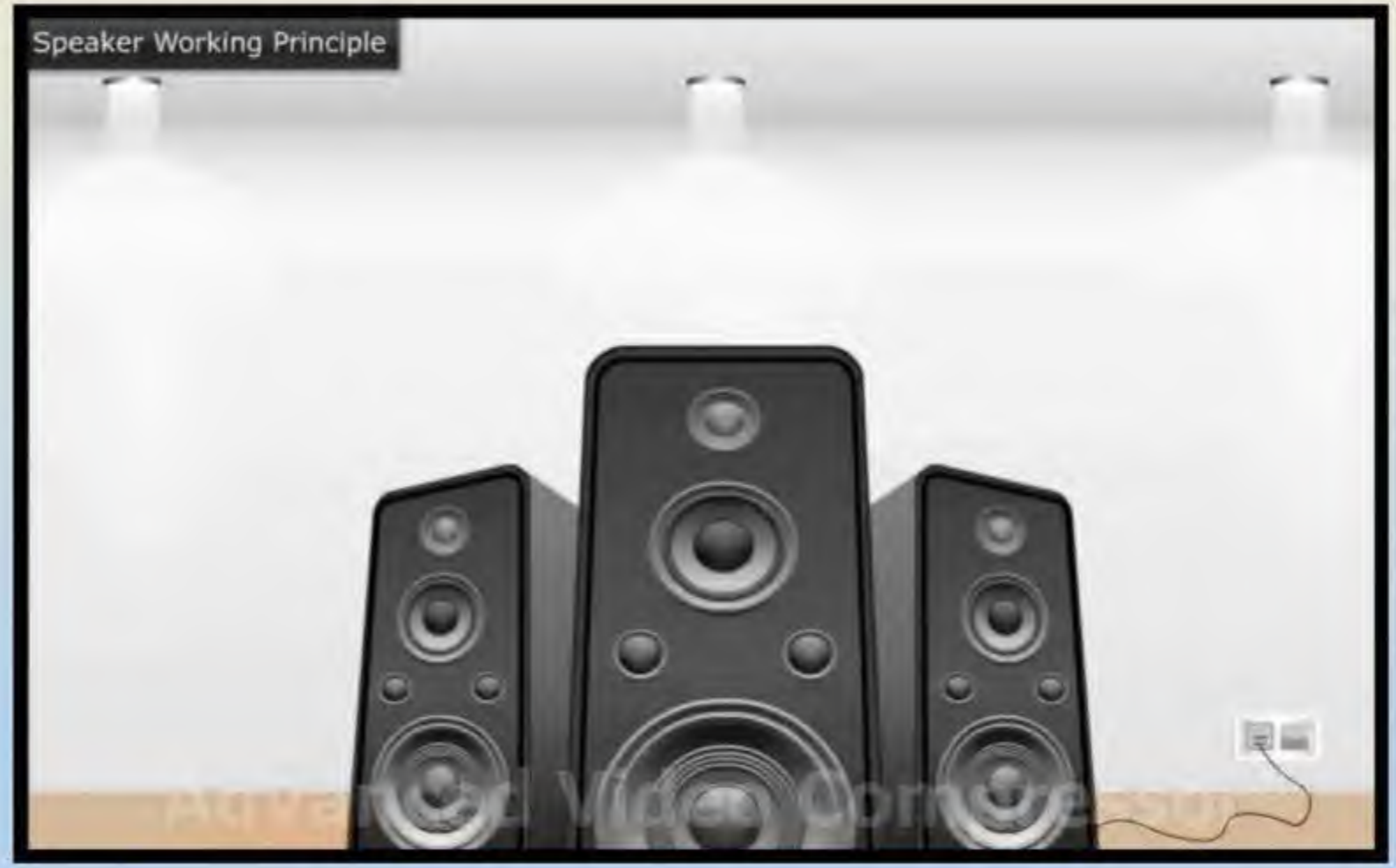


Fig. Workimg of Moving Coil Type L.S.

MOVING COIL CONE TYPE L.S.

- Force on coil due to interaction current and magnetic field is given by

$$F = B * L * I * \sin\alpha$$

Where as F = Force in newton

B = Flux density in tesla

L = length of coil wire in m

α = Angle between coil and field

Normally, $\alpha = 90^\circ$ and hence,

$$F = B * L * I$$

MOVING COIL CONE TYPE L.S.

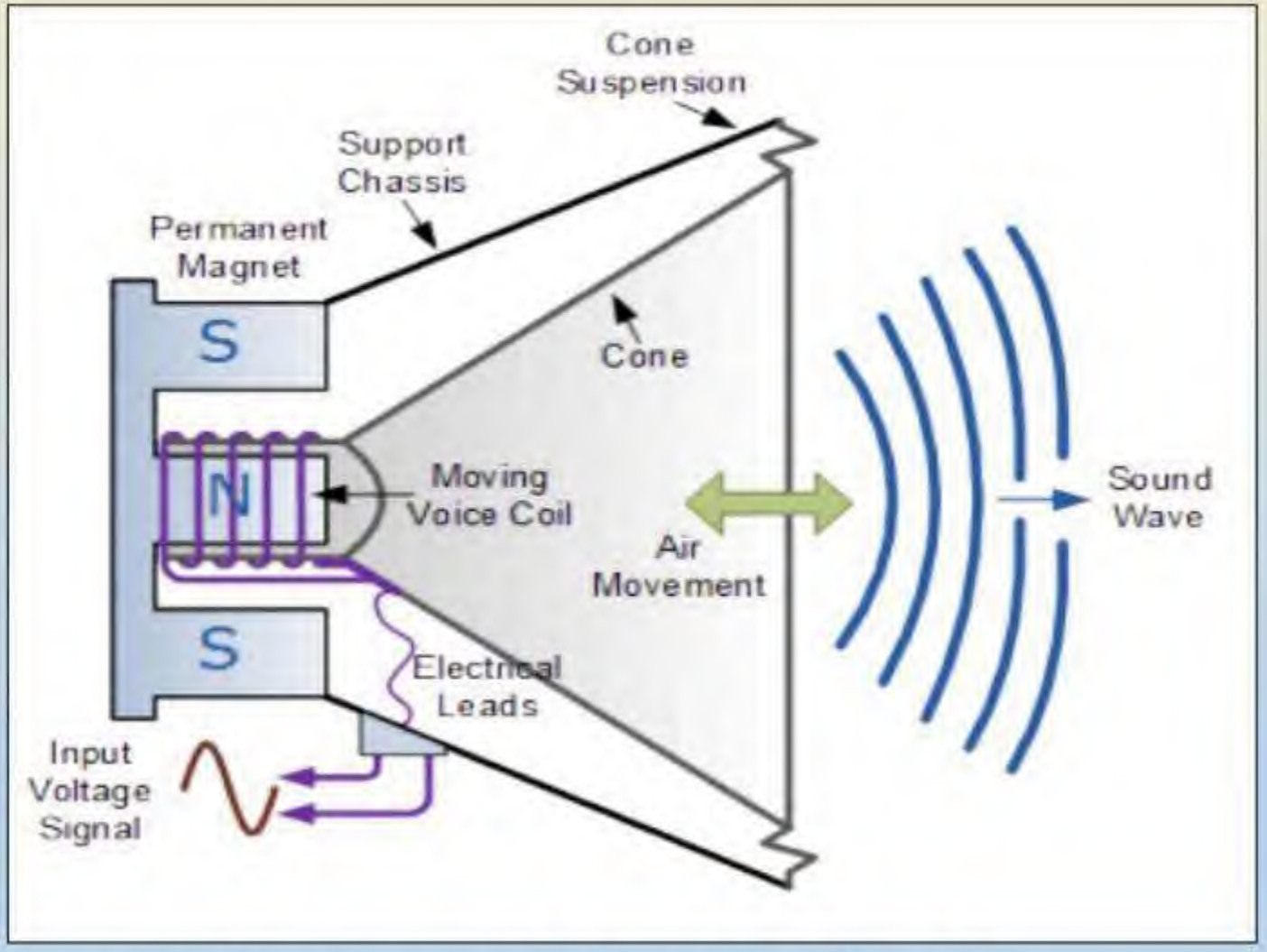


Fig. Construction of Moving Coil Type L.S.

CONSTRUCTION

- Because of use of permanent magnet it also called "permanent magnet type speaker"
- Voice coil – single layer winding of fine enameled wire – wound on cardboard or fiber cylinder
- Paper Cone – conical diaphragm – made of paper or parchment

CHARACTERISTICS

- Efficiency : Quite low – due to fact that it acts as a direct radiator – complete mismatch between the low acoustic load of large volume of air and high mechanical load of coil and cone assembly
- SNR : 30 dB (approx.)
- Freq. Resp. : Restricted to mid freq only – 200 Hz to 5000 Hz – woofer (up to 40 Hz), tweeter (up to 10 kHz)
- Distortion : Non-linear due to non-uniformity of magnetic field – about 10%
- Directivity : Basically Omni-directional – less behind baffles and enclosures
- Impedance and Power : Varies from 2 to 32 ohm about 25 watt

ELECTRODYNAMIC L.S.

- To provide very strong magnetic field for high wattage speakers – Electro Magnet is used instead of permanent magnet
- Working principle is same as that of permanent magnet type

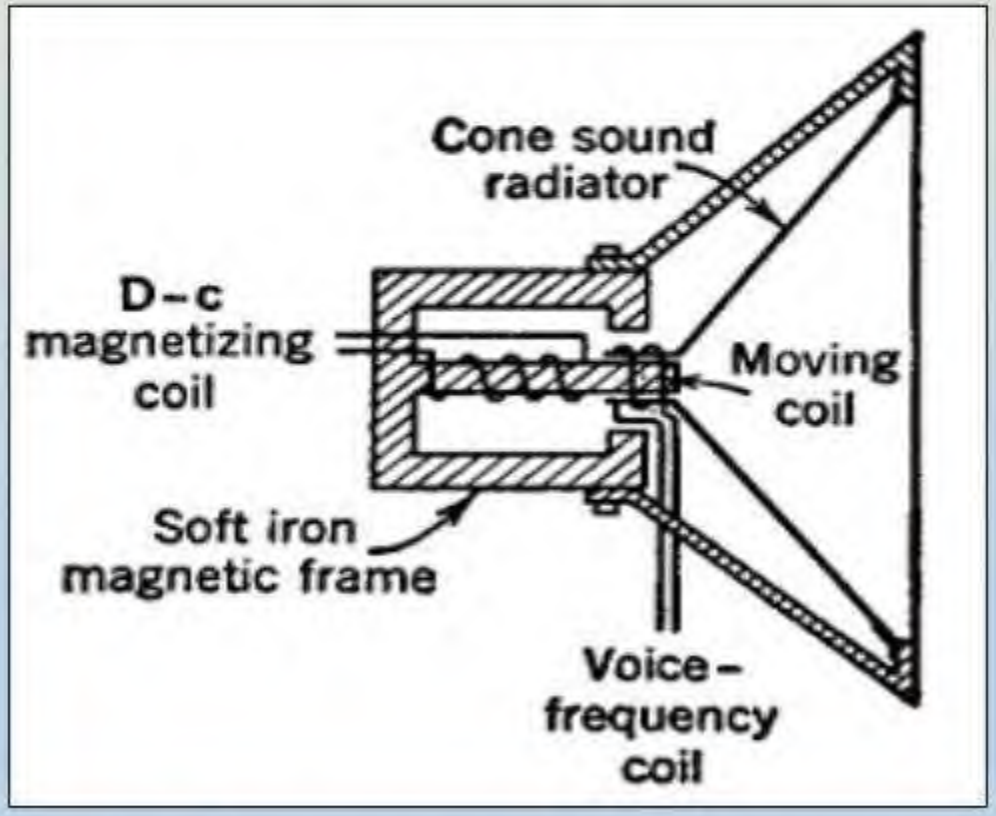


Fig. Construction of Electrodynamic L.S.

ELECTRODYNAMIC L.S.

- Advantages
  - Higher power
  - Better freq response

- Disadvantages
  - Power supply needed for field coil
  - Heavier in weight
  - Costlier

HORN TYPE L.S.

- Instead of radiating acoustic power directly in open space of listeners area, power is first delivered to the air trapped in fixed non-vibrating tapered or flared horn and from here to the air in the listeners area
- Indirect Radiating Loudspeaker
- Horn does acoustically what the cone does mechanically
- Horn acts as an acoustic transformer
- Allows better impedance matching
- Results in increased efficiency – 30-50%

HORN TYPE L.S.

- Air chamber is lined with sound absorbing material
- Cross sectional area increases logarithmically
- Horn acts as a high pass filter
- Cut-off Frequency

$$fc = \frac{CA}{2\pi V}$$

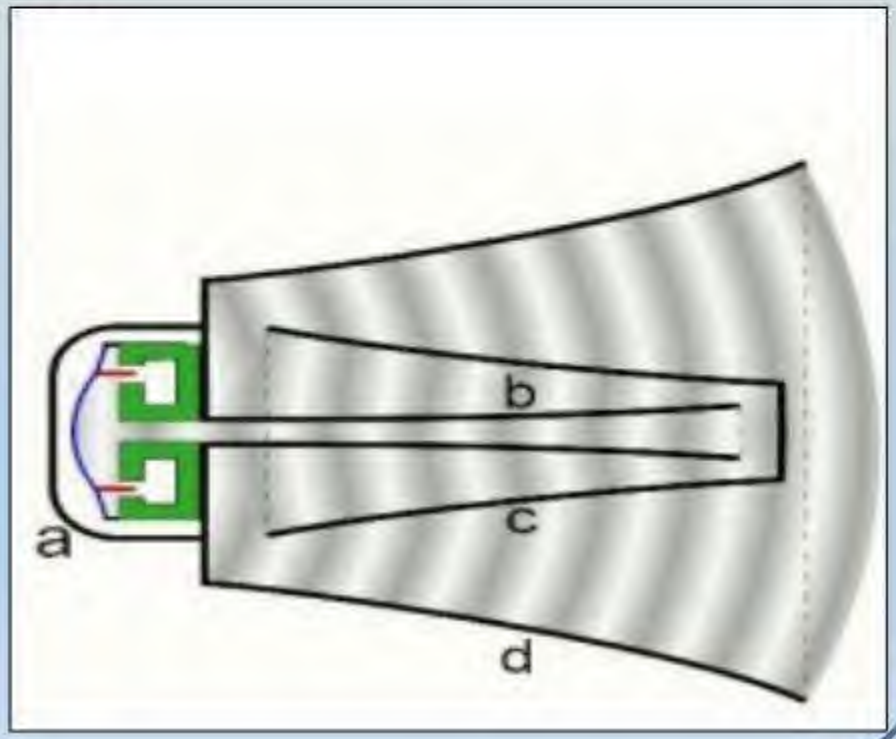
Where as C = velocity of sound
A= Area of cross section of throat
V = Volume of air chamber

- In terms of diameter of mouth, lowest frequency can be produced by horn is

f = (170/d) , d = diameter of mouth in meter

HORN TYPE L.S.

- Low freq. response is improved by wide mouth and high freq. response is improved by small throat
- To improve low freq. response – large size horn – unwieldy
- Horn structure is folded back in itself to conserve physical space
- Contains cone loudspeaker with a horn
- Horn for high fidelity



CHARACTERISTICS

- Efficiency : 30-50%
- SNR : 40 dB
- Freq. Response : 30-10KHz
- Distortion : low, less than 5%
- Directivity : about 90o – differs from low freq to high freq (concentrated in a narrow cone about axis of the horn)
- Impedance : 16 ohms
- Power : about 100 watts

MULTI-WAY SPEAKER SYSTEM

- Single loudspeaker – cannot have flat response for whole audio frequency range
- single speaker cannot produce both, the good solid bass and the smooth crisp treble
- Solution – spectrum is divided into at least 2 and preferably 3 parts
- Lower audio freq. – 16 Hz to 1000 Hz – Woofers
- Higher audio freq. – Tweeters
- Mid audio freq. – 500 to 5K Hz – Squawker – in this case woofer covers up to 500 Hz and tweeter from 5KHz