# Section 10. Microphones

## 10.1 Methods of Transduction

*Microphone* is a generic term that is used to refer to any element which transforms acoustic energy (sound) into electrical energy (the audio signal). A microphone is therefore one type from a larger class of elements called transducers — devices which translate energy of one form into energy of another form.

The fidelity with which a microphone generates an electrical representation of a sound depends, in part, on the method by which it performs the energy conversion. Historically, a number of different methods have been developed for varying purposes, and today a wide variety of microphone types may be found in everyday use.

### 10.1.1 Dynamic

By far the most common type of microphone in contemporary sound work is the dynamic. The dynamic microphone is like a miniature loudspeaker — in fact, some dynamic elements serve dual functions as both loudspeaker and microphone (for example, in intercoms).

Figure 10-1 illustrates the basic construction of a dynamic microphone.

A flexibly-mounted diaphragm, Figure 10-1 (a), is coupled to a coil of fine wire (b). The coil is mounted in the air gap of a magnet (c) such that it is free to move back and forth within the gap.

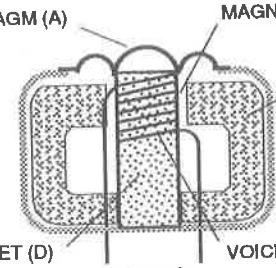


Figure 10-1. Construction of a dynamic microphone

When sound strikes the diaphragm, the diaphragm surface vibrates in response. The motion of the diaphragm couples directly to the coil, which moves back and forth in the field of the magnet. As the coil cuts through the lines of magnetic force in the gap, a small electrical current is induced in the wire. The magnitude and direction of that current is directly related to the motion of the coil, and the current thus is an electrical representation of the incident sound wave.

Dynamic microphones are highly dependable, rugged and reliable. For this reason, they are extremely common in stage use, where physical strength is very important. They are also reasonably insensitive to environmental factors, and thus find extensive use in outdoor paging applications. Finally, because moving-coil technology is fairly refined and is capable of very good sonic characteristics, dynamic microphones also are widely used in recording studios.

### 10.1.2 Condenser

Next to the dynamic, the most common microphone type is the condenser. Figure 10-2 illustrates the construction of a condenser element.

A gold-coated plastic diaphragm, Figure 10-2 (a), is mounted above a conductive back plate (b), which is often made of gold-plated ceramic. The diaphragm and back plate, separated by a small volume of air (c), form an electrical component called a capacitor (or condenser).

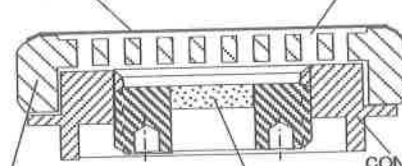


Figure 10-2. Construction of a condenser microphone

A polarizing voltage of between 9 and 48 volts is applied to the diaphragm by an external power supply, charging it with a fixed, static voltage. When the diaphragm vibrates in response to a sound, it moves closer to and farther from the back plate. As it does so, the electrical charge that it induces in the back plate changes proportionally. The fluctuating voltage on the back plate is therefore an electrical representation of the diaphragm motion.

Condenser microphone elements produce a signal voltage with almost no power. Thus they present a very high impedance. For these reasons, all condenser microphones incorporate an amplifier, which drives the microphone line. Its function is both to boost the signal level and to isolate the element from the lower impedance of the input to which the microphone is connected. Early condenser microphones employed tube amplifiers and thus were physically quite large. Modern condensers use transistor amplifiers, and can be made very small.

Because the diaphragm of a condenser is not loaded down with the mass of a coil, it can respond very quickly and accurately to an incident sound. Condensers therefore generally have excellent sonic characteristics, and are widely used in recording. Being somewhat more sensitive to physical shocks and environmental factors (humidity), however, classic condensers are less often used in sound reinforcement.

## 10.1.3 Electret Condenser

The electret is a special class of condenser microphone. Electrets incorporate diaphragms made of a unique plastic material that retains a static charge indefinitely. The manufacturer charges the diaphragm when the element is made (usually by irradiating it with an electron beam), and no external polarizing voltage is required.

Electrets still require a built-in amplifier, however, and this is normally a transistor unit. The amplifier often is powered with a battery — between 1.5 and 9 volts — housed in the microphone case. (In some designs, the amplifier and battery are housed in a small case that is connected to the element by a cable. Increasingly, phantom power is being used instead of a built-in battery on electret condenser models.) The purpose of the amplifier here is primarily to buffer the high impedance condenser capsule output from the relatively lower impedance of the mic input.

Electrets are increasingly common in both recording and reinforcement. Because they may be made very small, electrets make possible some unique close-miking techniques. The technology is also relatively inexpensive, so electret elements are often used in consumer products. Electrets can be of high quality, and some very fine electret microphones are available for professional recording and laboratory applications.

## 10.1.4 Ribbon

Ribbon microphones employ a transduction method that is similar to that of dynamics. Figure 10-3 illustrates the construction of a typical ribbon element.

A very light, thin, corrugated metal ribbon, Figure 10-3 (a), is stretched within the air gap of a powerful magnet (b). The ribbon is clamped at the ends, but is free to move throughout its length.

When sound strikes the ribbon, the ribbon vibrates in response. As is the case with the dynamic coil element, the moving ribbon cuts the magnetic lines of force in the air gap, and a voltage is thereby induced in the ribbon. The

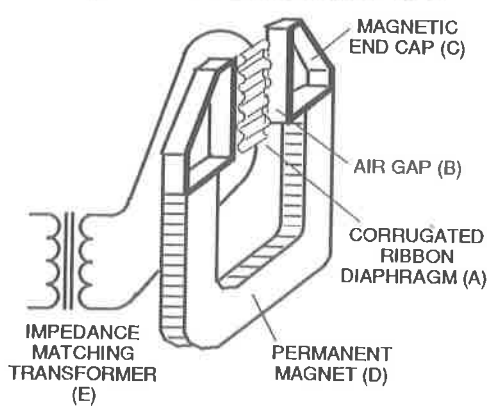


Figure 10-3. Construction of a ribbon microphone

voltage is very small and the ribbon impedance very low, so all ribbon microphones incorporate a built-in transformer. The transformer serves the dual functions of boosting the signal voltage and isolating the ribbon impedance from the load presented by the input to which the microphone is connected.

Early ribbon microphones were extremely fragile. The ribbon could be damaged simply by blowing or coughing into the microphone! Not many microphone manufacturers now make ribbon units, but those that are available are much more rugged than older units. All but a few modern ribbon mics remain more fragile than dynamic or condenser units, so they are used primarily in recording (a couple of notable exceptions are used for reinforcment).

Ribbon microphones usually have excellent sonic characteristics, with great warmth and gentle high-frequency response. They also have excellent transient response and very low self-noise. For these reasons, some ribbon mics are prized as vocal microphones, and are also very effective with acoustic instruments.

## 10.1.5 Carbon

The carbon type is among the earliest microphone elements ever developed. Figure 10-4 illustrates the construction of a typical carbon element.

A small cup, Figure 10-4 (a), is packed with pulverized carbon and enclosed at one end by a brass disk called a button (b), which is coupled to a circular metal diaphragm (c). The button and a back plate at the rear of the cylinder form the connection terminals. A battery (d) provides an activating voltage across the carbon.

When sound strikes the diaphragm, the carbon granules in the button vibrate, becoming alternately more and less dense as the diaphragm moves. The electrical resistance of the carbon thereby fluctuates, and converts the battery voltage into a corresponding fluctuating current that is an electrical representation of the sound. The current is stepped up by a transformer (e), which also serves to isolate the low

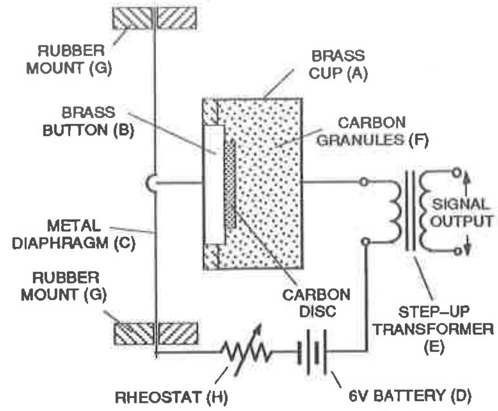


**Figure 10-4. Construction of a carbon microphone**

impedance of the element from that of the input to which it is connected, and to block the battery DC from the input.

Carbon microphones are not known for excellent sonic characteristics, but they are quite inexpensive, and rugged. For this reason, they are still widely used in utility sound applications. (The standard telephone mic element has long been a carbon type, although dynamic mics are used in many newer phones.) Carbon microphones can lose some efficiency and become noisy if the granules in the button become compacted, but simply tapping the element against a hard surface usually cures the problem.

## 10.1.6 Piezoelectric

Another very early microphone type is the piezoelectric. Figure 10-5 illustrates the principle of piezoelectric microphones.

A flexible diaphragm, Figure 10-5 (a) is coupled to a crystal element (b) by a drive pin (c). The crystal element is of a material that exhibits the piezoelectric (*pressure-electric*) effect. When it is physically deformed by pressure or torsion, the crystal generates an electrical voltage (potential) across its faces.

When sound strikes the diaphragm it vibrates, and the crystal is thereby deformed slightly. The crystal generates a voltage in response to this bending, and this varying voltage is an electrical representation of the sound.

Piezoelectric microphones (sometimes called *crystal* or *ceramic* types), like carbon types, are not generally known for their sound quality, but are quite inexpensive. Properly implemented, a crystal element can perform very well, and the principle is often used for contact-type pickups.

Piezo elements are high-impedance devices, and they produce substantial output levels. They can be damaged irreparably by physical abuse, and are susceptible to both heat and humidity.

In addition to the method of transduction and pickup pattern, microphones are further classified according to their functional design. Many different microphone designs are available, and each is optimized for a specific range of applications.

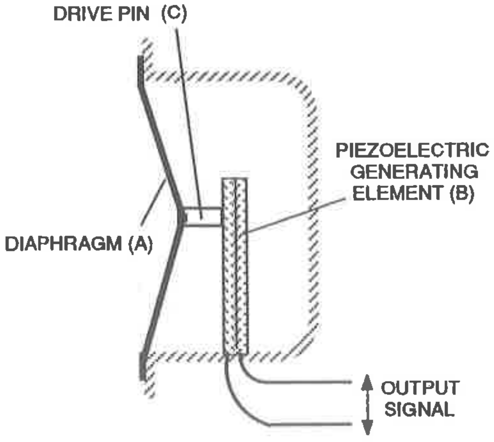


**Figure 10-5. Construction of a piezoelectric microphone**

# 10.2 Functional Design

## 10.2.1 Hand-Held

By far the most prominent microphone design is the hand-held type. Figure 10-6 shows a few typical hand-held microphones.

As the name implies, this microphone is designed so that it may be held in hand by a lecturer or singer. Of course, such microphones also are very often mounted on a stand using a threaded mounting clip.

**Figure 10-6. A few typical hand-held microphones**

The most common pattern in hand-held microphones is the cardioid, although other patterns are available. Whatever the pickup pattern or type of capsule (sound generating element), if it's in a hand-held mic, it must be well isolated from physical vibration to prevent handling noise, and the capsule must be protected from being dropped. Rubber shock mounts and protective screens are standard features of most hand-held mics.

## 10.2.2 Stand-Mounting

Some microphones are designed specifically for stand (or boom) mounting only; Figure 10-7 shows examples of such microphones.

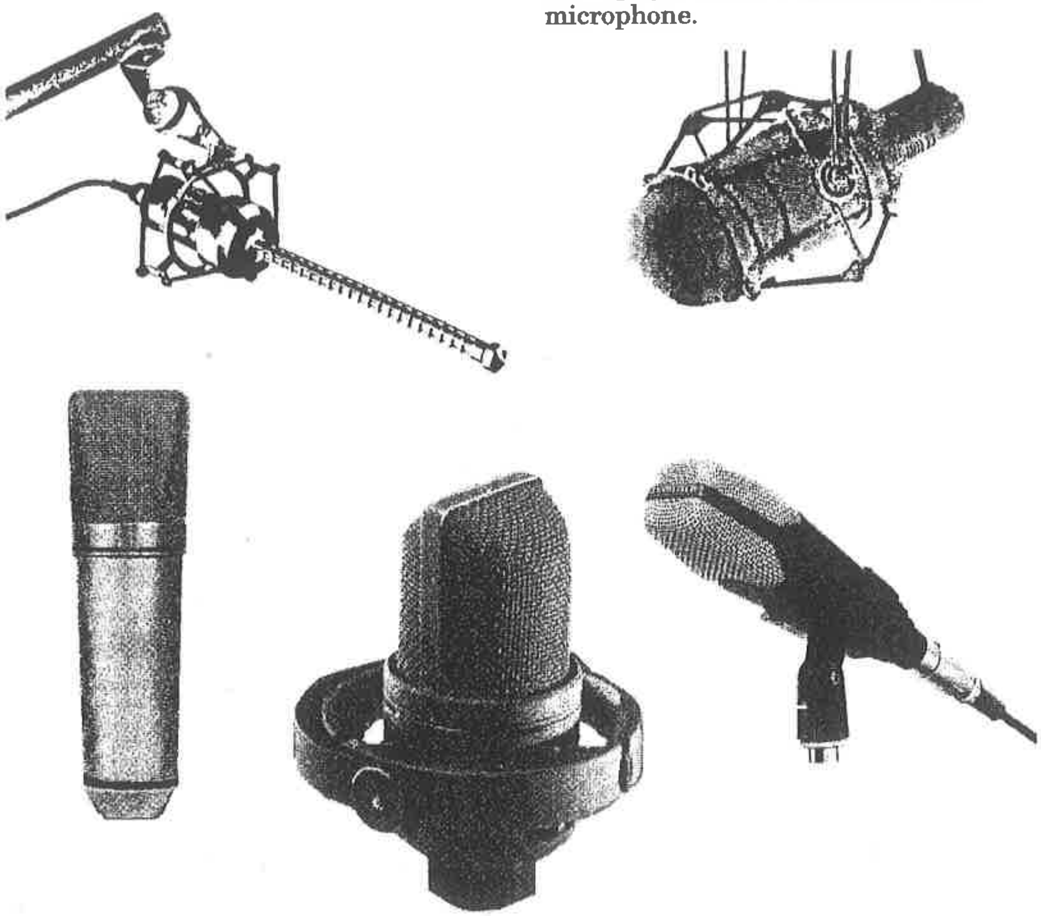

**Figure 10-7. Stand mount microphones**

Microphones like this are most commonly made for recording. Typically, older tube-type condensers were made for stand-mounting only, being too large for convenient hand-held use. Even the most modern mics, however, may be designed for stand mount in the studio because more elaborate external shock and vibration isolation is then possible. Video and motion picture production mics, mounted on booms, are often elaborately shock mounted to keep vibration out of the mic. Smaller, very unobtrusive modern stand-mounting microphones are usually electret types, and are designed specifically for reinforcement and broadcasting applications where appearance is a primary consideration.

## 10.2.3 Lavalier

Lavalier microphones are very small elements that are designed to pin directly to clothing or to be hung on a lanyard around the neck. Figure 10-8 (next page) shows a typical lavalier microphone.

It used to be that lavaliers were nearly always dynamics, since they were much less costly to build in the required small package. Modern lavalier microphones are almost always electret condenser types, since electret elements now can be made very small in size, offering excellent top-end response and sensitivity for a reasonable cost. The most common pattern for lavaliers is omnidirectional, although recently some cardioid and hypercardioid types have been introduced. The omni pattern has several advantages in this application. It does not emphasize the already resonant chest cavity because it does not have proximity effect, and it can be clipped in different orientations without its sound quality changing. This is crucial if the sound is to remain consistent.