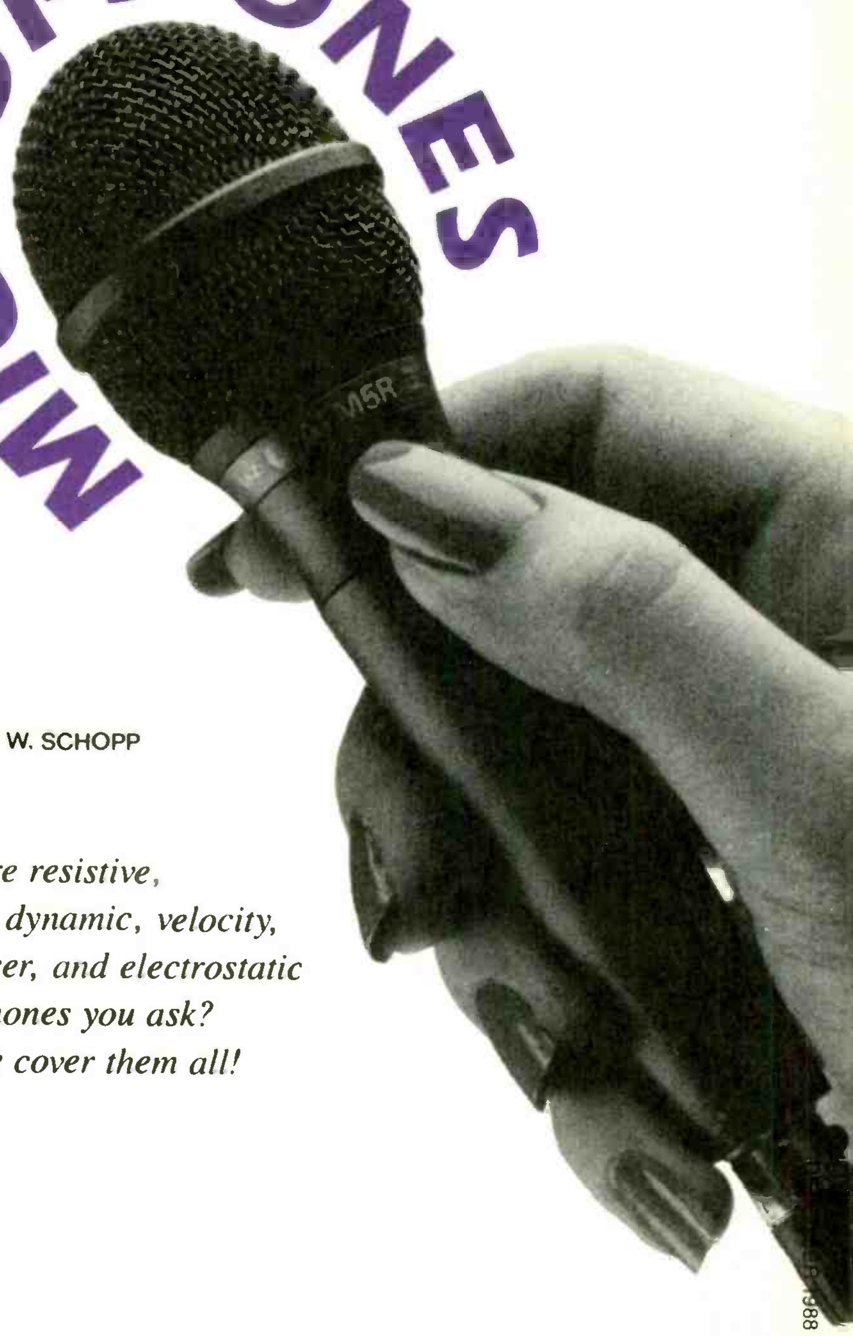
All About MICROPHONES



BY WALTER W. SCHOPP

What are resistive, crystal, dynamic, velocity, condenser, and electrostatic microphones you ask? Here we cover them all!

No matter how many times you have watched the news on TV, you may never have noticed the small microphone clipped to the tie or lapel of the newscaster. Those microphones are about the diameter of a pencil, and are less than an inch long. Often, two of the tiny microphones are worn side by side in case one fails during a broadcast. Fifty years ago, if you were even able to fit two high-quality microphones on your lapels the odds are that they would have ripped the lapels off your suit. Over the years, research has reduced the size and increased the performance of microphones, but the principles for converting sound waves to electrical signals have remained the same.

You can use the sound waves striking a thin diaphragm to alter inductance, capacitance, or resistance, or compress a crystal to accomplish that conversion. Further, there are enclosure-design modifications that will make the microphone directional or non-directional. And there are microphones with a variety of output impedances and output levels. Without getting bogged down in the technical aspects of all the variations, let's look at some of the basic methods used to convert sound waves into electrical signals.

Variable Resistance. One of the earliest conversion methods used was to vary a resistance. That method was used in the design of the carbon microphone; see Fig. 1. Carbon microphones are very rugged, which is why they were used for telephone and military communications well into the 50's.

The theory of their operation is simple: As the sound waves impinge on the diaphragm, causing it to vibrate, the carbon granules behind the diaphragm are compressed. As the pressure on the carbon particles is increased and decreased, the resistance across the granules changes, and the current through the carbon varies with the audio.

One of the idiosyncrasies of that type of microphone is that occasionally the granules will compress and stick together. When that happens, the microphone suddenly becomes insensitive and can only be fixed by sharply rapping it against a solid object to jar the granules apart.

As a further inconvenience, since those microphone do not generate an electrical signal, they require a power

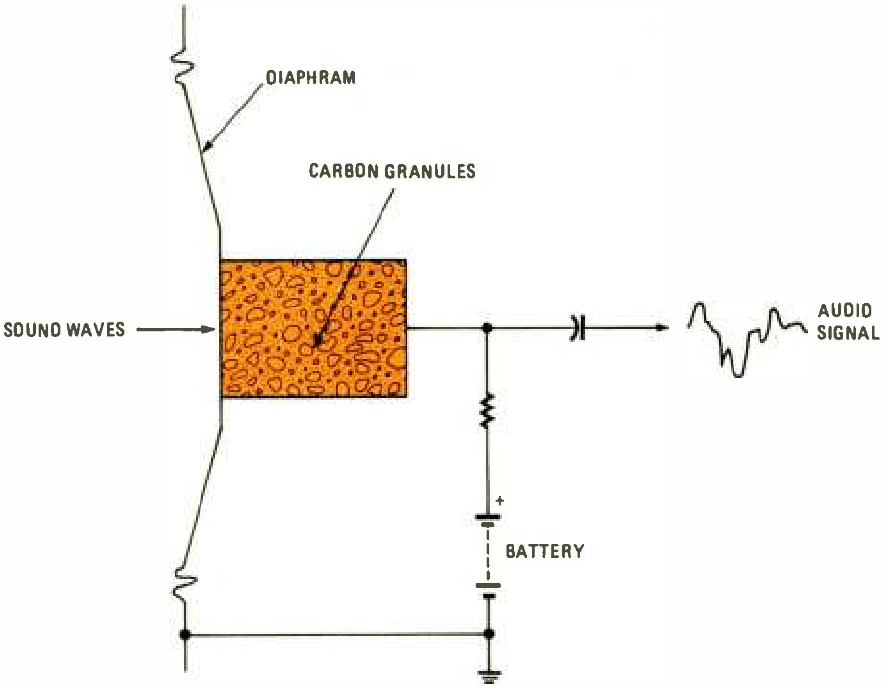


Fig. 1. The carbon microphone is one of the oldest audio-to-electric conversion devices around. It was developed by Thomas A. Edison.

source that they can modulate to produce an electrical signal.

Crystal Microphones. It has long been known that a Rochelle-salt crystal will change voltage into mechanical movement or mechanical movement into voltage. A microphone can be designed based on that *piezoelectric* effect of the crystal; see Fig. 2. As the sound waves cause the diaphragm to vibrate, pressure is applied to the crystal. An alternating output voltage is produced that follows the input sound waves. That type of microphone needs no external power supply and will produce a hefty output in the millivolt range. Crystals have a disadvantage because their output is affected by high temperature and moisture. However, research has found that certain types of ceramic materials also display the piezoelectric effect. Those can be used for making microphone elements that are not affected by temperature and humidity.

Dynamic Microphones. The dynamic microphone uses the same principle as the loudspeaker, but in reverse. A loudspeaker will not only change an audio voltage into sound, but it will also change sound into an audio voltage; see Fig. 3. As the sound waves strike the diaphragm of the microphone, the diaphragm moves in and out. A small coil located in a magnetic

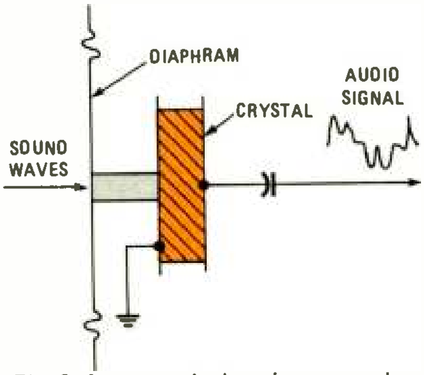


Fig. 2. In a crystal microphone, sound waves push the diaphragm into a piezoelectric crystal to produce voltage, which is then amplified.

field is attached to the diaphragm. As the coil moves in the magnetic field, it cuts through magnetic lines of force, inducing a voltage in the coil winding. The alternating voltage induced in the coil follows the sound waves in both intensity and direction (forward movement/positive current; reverse movement/negative current). When built with the proper materials, that type of microphone is fairly rugged and insensitive to heat and humidity. Dynamic microphones are inherently low-impedance devices, but their output impedance can be matched to any desired impedance by using a matching amplifier or transformer.

Velocity Types. The ribbon or velocity microphone was originally introduced

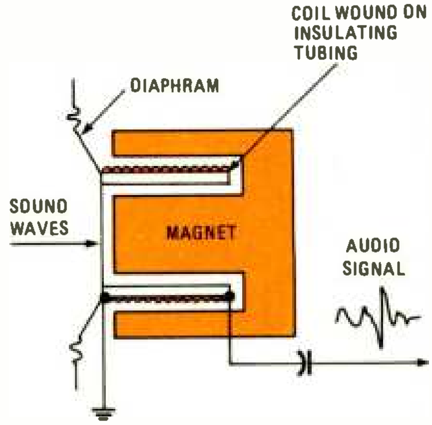


Fig. 3. A dynamic microphone works by inducing a current in a vibrating coil around a stationary magnet.

in 1934 and represented a great improvement in frequency response over other microphones of that era. The microphone uses a thin, corrugated-aluminum ribbon suspended between the two poles of a magnet, see Fig. 4. When sound waves cause the ribbon to vibrate, the ribbon cuts through the magnetic field, causing a small current to be induced in the ribbon.

The physical arrangement of the parts making up the microphone element only allow sound to directly impinge on the ribbon from the front or back side. That makes the element bidirectional

The output impedance of the ribbon is very low and must be raised by using a step-up transformer. The voltage produced by it is very small and must be amplified to a usable value.

Condenser Microphones. Another type of high-fidelity microphone is the condenser or capacitor type. That microphone uses a diaphragm as one plate of a capacitor. Sound waves striking the diaphragm change the geometry of the plates, and hence the capacitance. See Fig. 5. The diaphragm is a tightly stretched metal or metalized plastic film. Behind the diaphragm is a metalic "button" that acts as the other capacitor plate.

The capacitor is polarized by applying 100–200 volts DC through a very-high resistance. As the diaphragm vibrates, capacitance changes appear as voltage changes when taken from the top of the load resistor in Fig. 5. Used with that circuit configuration, the microphone will directly convert capacitance variations into a varying audio-signal voltage.

The polarizing voltage can be re-

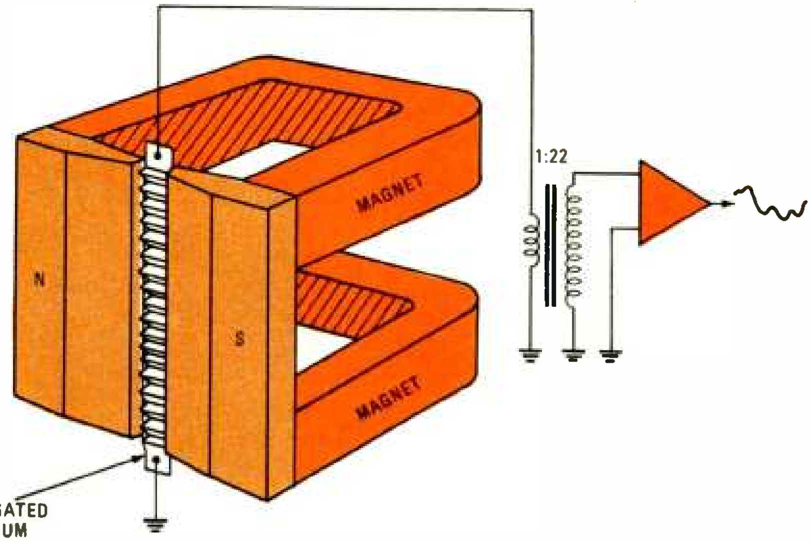


Fig. 4. Velocity microphones are rather interesting devices that are somewhat similar to dynamic microphones. However, the voltage is induced in a vibrating corrugated strip of aluminum instead of the windings of a moving coil.

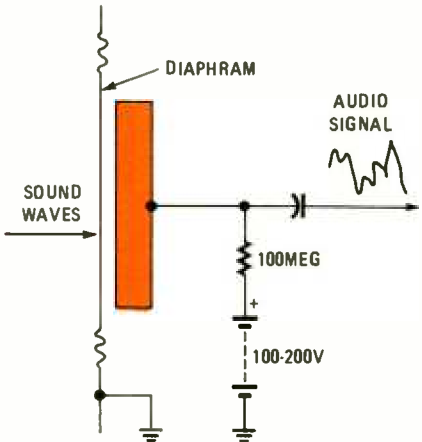


Fig. 5. The condenser microphone has a diaphragm that is one plate of a capacitor whose value varies with the sound waves striking it.

moved and the element connected as one of the resonant LC components of an oscillator circuit (see Fig. 6). That type of circuit will produce a frequency-modulated output that will deviate with the sound wave input. When used in such a configuration, frequency drift must be minimized to prevent changes in sensitivity.

Electrostatic Units. Originally developed in 1935, the electrostatic capacitive microphone is not new. But it gained popularity slowly due to technical problems and production costs. Today, modern plastics and solid-state developments have made it a very economical choice.

The plastic film used for the diaphragm has a thickness of .0025 to .005 inches. A gold conductive surface around 200-angstroms thick is evaporated onto one side of the plastic film. An angstrom is one-hundred millionths of a centimeter, and a centimeter is .3937 of an inch. It is obvious that the metallic coating is very thin.

The plastic film is then sandwiched between two metal plates charged with high voltage. Those plates are heated to a temperature just less than the melting temperature of the plastic and then cooled. When the plastic is cooled, the molecules in the plastic are permanently rearranged so that the plastic film retains a static charge. That makes a polarizing high voltage becomes unnecessary.

In operation, the capacitive changes are introduced between the charged film and a field-effect transistor gate (see Fig. 7) just as they are in the conventional condenser microphone. The output is taken from the top of a source resistor. That configuration lowers the high impedance of the capacitor element to a usable value determined by the value of the source resistance. The diaphragm can be made quite small in diameter and the FET can be an intricate part of the element housing. That method of construction accounts for the small physical size of that microphone.

Future microphone research may or may not turn up any radically new methods of converting sound into voltage. Research will surely continue to improve frequency responses, develop more predictable directional traits, and reduce susceptibility to adverse conditions. ■

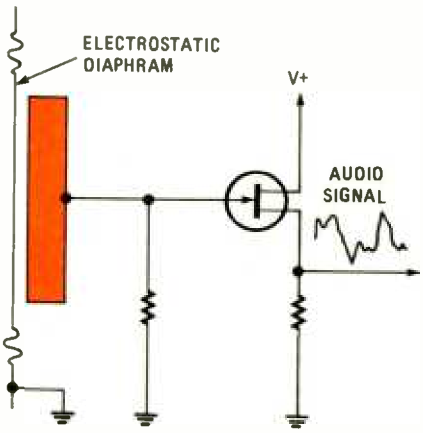


Fig. 7. Electrostatic microphones are really hi-tech condenser microphones with one capacitor plate made of a metalized plastic sheet.

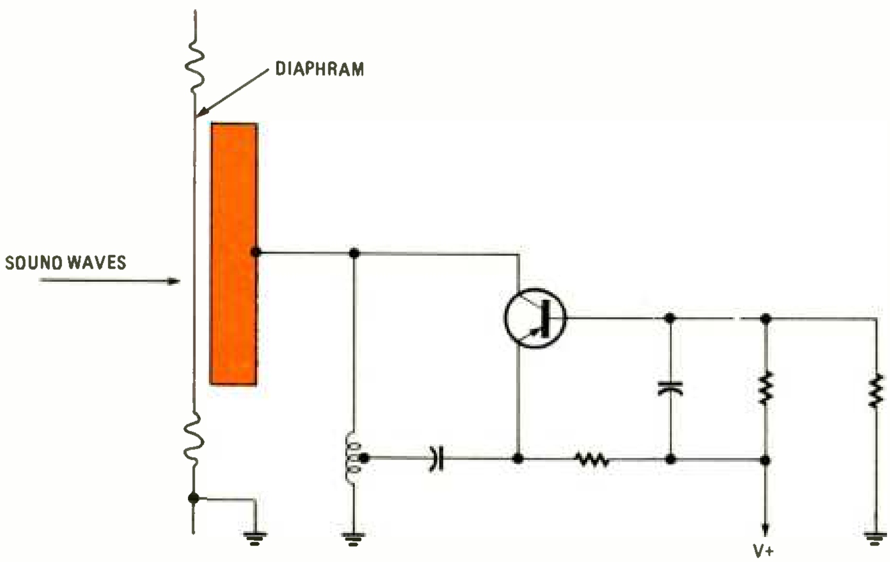


Fig. 6. When a condenser microphone is used as part of a tank circuit, it can use audio signals to frequency modulate a carrier directly.