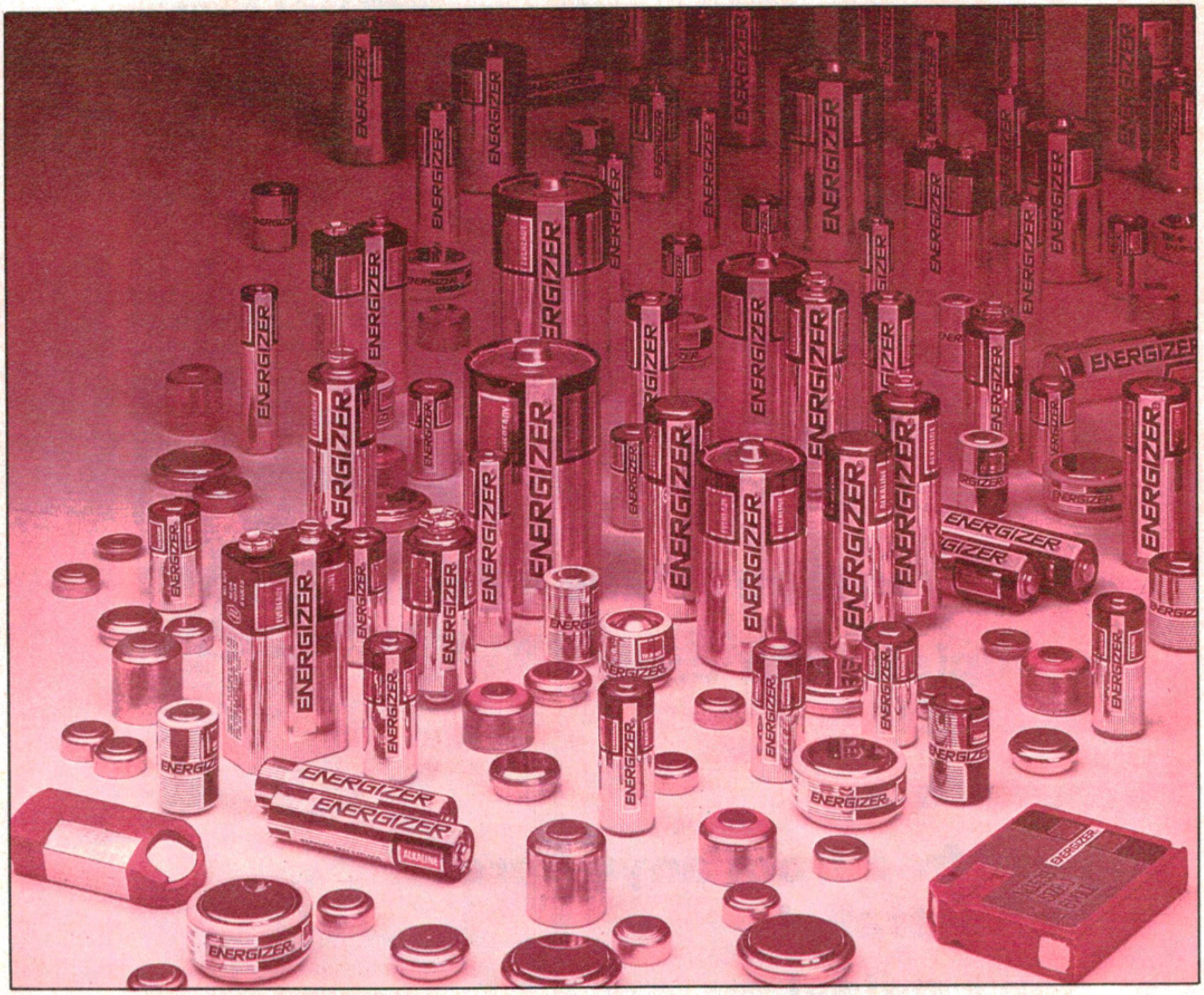
STARTING ELECTRONICS 7

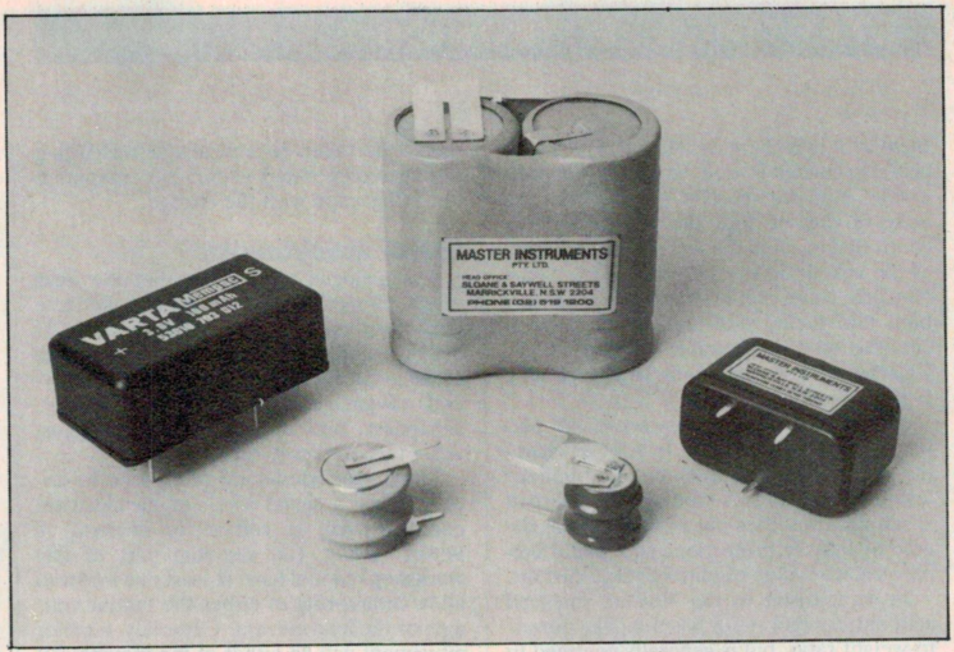
KNOW YOUR PASSIVE COMPONENTS

Part 2

What about transducers with a cardioid polar response? Perhaps you aren't quite certain which battery represents the best type for a given application. This article will answer these, and many other questions as we continue to examine more passive components that form the basis of electronics.

Peter Phillips





Various pc board mounting batteries (courtesy Master Instruments, Marrickville, NSW).

IN PART 6 of Starting Electronics the 'basic three' passive components were treated. We can now move into looking at more than this range. Passive components represent the majority of components in electronics, with batteries, meter movements, lamps, speakers, microphones, and a miscellany of things called transducers being covered in this article. We will also explain the meaning of the word "transducer". Included under the heading of transducers are speakers and microphones, and we will attempt to explain the plethora of 'technical terms' surrounding these items.

In future parts of the series, cabling and connectors, electronic 'hardware', transistors, etc will be presented. So, read on as the world of electronics spreads itself before you, with some of its secrets exposed.

Batteries

Very few electronic projects work without requiring a power source. (A mental teaser is to try and name a few . . .) Many circuits are designed for use with 'portable power', with some including a battery as a backup power source in case of power failure. The battery (or more correctly, the cell, a battery being a group of cells), is fundamentally a mixture of chemicals stored in a case. Different chemical systems produce different types. Basically, the chemical action within the cell will produce a voltage between the 'anode' or positive electrode, and the 'cathode' (negative electrode). The value of the developed voltage is a function of the type of chemicals employed, and the different compositions provide various characteristics which make different cells suitable for different tasks.

Generally, batteries can be grouped into one of two types, these being either primary or secondary cells. A primary cell is one that cannot be recharged, and, you guessed it, a secondary cell is one that can. Primary cells vary from the common zinc-carbon variety, the longer lasting alkaline types, through to the many miniature watch type cells available. Different sizes of these basic types, allowing different currents and voltages make up the large range of primary cells available. Miniature cells, such as those used in watches and calculators, use various chemicals, including lithium, silver oxide or mercury, and are usually used where very low currents are required. These cells are sometimes employed as backup power supplies for the memory system in computers and are available for direct placement on a pc board.

Testing the voltage of these cells, (normally around 1.35 V for mercury, 1.5 V for silver oxide) should be done with a high impedance voltmeter, like a DVM. An important point about primary cells is that they have, depending on their size and age, a fairly high internal resistance, which increases with age. This can sometimes cause erratic behaviour, particularly when the circuit uses power in a pulse form, as some digital circuits do. The average current may be small, but the individual bursts can be high enough to create severe voltage variations only visible on a cathode ray oscilloscope (CRO). Alkaline cells have a much lower, and more constant internal resistance, and are more suited to digital type circuits. A primary cell has a shelf life which would embarrass the corner store operator although very large cells can last for many years, and are often employed in burglar alarms as a backup supply.

Rechargeable batteries

Rechargeable batteries, (or secondary cells), are now extremely common, and represent better value for use in portable equipment. The two most common types are the lead acid, (as in motor cars), and the nickel-cadmium chemical systems. A third variety, using a nickel-iron chemical system (NiFe cell) is occasionally found, but has been largely superseded by the lead-acid battery.

The lead acid type is now available in the so called gel type, in which the electrolyte is stored in a gel form, and any gas that is produced during charging is recombined within the electrolyte, allowing the battery to be sealed and preventing leaks. However, like any sealed rechargeable battery, a safety valve is incorporated in case of accidents.

The lead acid gel cell has several advantages over the popular Ni-Cad variety, and as it is 'mess free' (unlike a car battery), it provides an excellent power source for burglar alarms, emergency lighting, or for computer backup supplies. Like most rechargeables, the gel cell comes in various ampere-hour (Ah) ratings. The Ah rating of a battery is generally the value of current the battery can deliver over a 20 hour period. Thus, a 2.6 Ah rating means a current of 130 mA for 20 hours, with temperature affecting this rating almost proportionally. The battery can deliver higher currents, but for a shorter period than the amps x hours relationship gives for the 20 hour rating.

Ni-Cads, as the nickel-cadmium rechargeables have become known, are available in the same sizes as the zinc-carbon batteries, although they have a lower output voltage (1.2 V per cell, as compared to 1.5 V per cell). An advantage of the Ni-Cad is its low output resistance, and its virtually constant voltage, almost to the end. (When they die, however, they die!) A disadvantage is the so called 'memory effect'. This means that they 'remember' how many times they have been charged and recharged, with an eventual reduction in capacity.

Ni-Cads should be charged with some care. If charged with a 'float' or trickle charge it becomes nearly impossible to hurt ▶

them with overcharging. However, if a high charging current is used, which is often preferable, both for the Ni-Cad and from the point of view of time, the current must be controlled to avoid the internal temperature of the cell rising to explosion levels. Some Ni-Cads come with temperature sensors built into them, allowing fast charging in conjunction with a suitable charging circuit. Clearly, their replacement with the same type is essential.

Some recharging circuits sense the battery's voltage, and switch to a lower charging current when a predetermined voltage level is reached. This type of charge circuit is simpler, but does not offer the same degree of battery protection, and would employ a lower value of initial charge current.

In comparison to the Ni-Cad, the lead acid battery (gel type) has a higher power-to-weight ratio, but is generally confined to fixed, and semi-portable equipment, due to its larger physical size and the fact that it's usually only available in 6 V or 12 V types. Should you wish to replace, say, a 12 V Ni-Cad system with a 12 V gel battery, care should be taken to ensure the recharging system incorporated within the equipment can safely cope with the change.

Meter movements

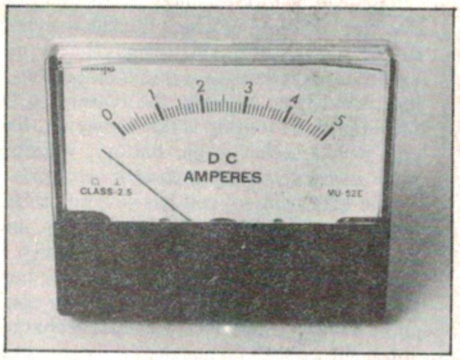
The analogue meter movement now finds direct competition in a range of solid state indicators using bar-graph displays, LCD displays, and digital displays. However, the moving-coil meter movement still has several advantages, including its simplicity, cheapness, and the fact that a changing value is more easily seen.

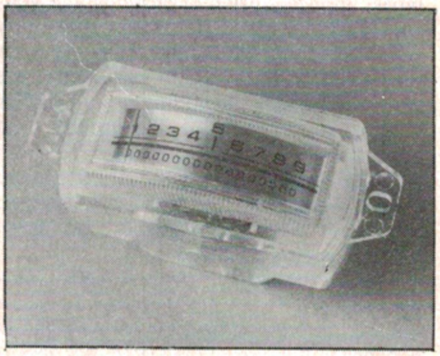
Meter movements are often used to display either a signal level, or an electrical quantity such as voltage or current. A power supply, (an essential part of any workshop) should have at least one meter to allow monitoring of either the output voltage, or the load current. Generally, a meter movement will be either of the moving-coil variety, in which a coil, suspended in a magnetic field deflects in proportion to the current flowing in the coil, or a moving-iron type, which has the coil fixed, and a metal disc that is attracted by the coil, again in proportion to the coil's current. The moving-coil is by far the most common, and is the only one we will consider here.

The main thing to know about a meter movement is how much dc current is required to cause the meter to reach full scale. This is known as the full scale deflection (FSD) current, and can be as low as 10 μA; less sensitive types might require up to 10 mA. A moving-coil meter movement cannot respond to ac (although a moving-iron one can), and a rectifier is required to convert the ac to dc if you need to measure an ac quantity. A meter movement becomes a meter if extra components are added, usually inside the case, with a scale also attached showing appropriate calibrations. For example, a 0-20 V panel meter can use the same meter movement as a 0-5 amp panel meter, it's only a matter of how to adapt it. Basically, a voltmeter has a resistor in series with the movement, and the ammeter has a resistor in parallel to limit the current in the meter movement to its full scale deflection value. The calculations to determine the size of the particular resistor are not difficult, and can be found in most text books on the subject.

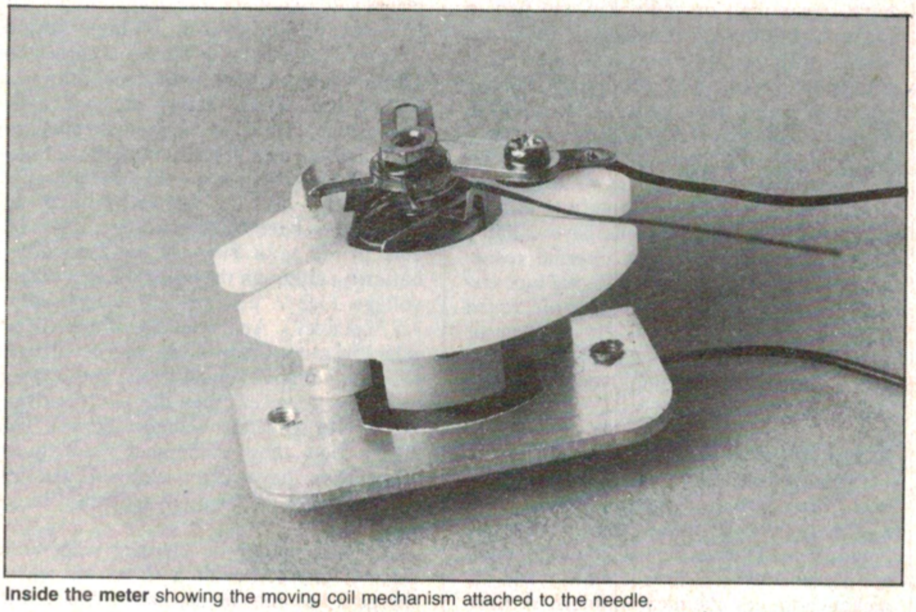
Generally, meter movements employ a pivot and jewel suspension. The torque for the movement is generated against two oppositely wound spiral springs, with one spring being used to adjust the 'zero' of the pointer. The balancing of the movement is critical, and many movements are only accurate in one particular plane. More sophisticated movements employ a 'taut' band suspension, with two non-hygroscopic bands at either end of the coil assembly being pulled taut, with the movement suspended within the magnetic field by the two bands.

Meter movements are available in various forms, including edge reading, panel mount, and centre zero types. The main point to consider is the FSD current, which should be matched to the design specifications. It is possible to adapt a movement with a lower FSD current than that specified, but changes in component values will be necessary.





Above left. Panel mount meter. **Above right.** Edge reading meter.



Inside the meter showing the moving coil mechanism attached to the needle.

Indicator lamps

Indicator lamps serve the purpose of providing information. Mostly, they are characterized by being small and requiring only a small amount of power to operate. The three main varieties are LED (light emitting diode) indicators, filament lamps, and neon lamps. The neon indicator is generally only used to indicate a high voltage, such as the 240 V mains, and is usually made up of an assembly containing a neon tube and a series resistor, (around 220k ohms). The assembly will have a coloured bezel, and allow the unit to be mounted in a panel. The important thing to know is that you must *never* connect a neon bulb across the voltage it is to indicate, unless the series resistor is present. Otherwise you'll blow just about every fuse between it and the power station. (Or almost!!)

Filament lamp indicators have the advantage of producing a fairly high light output, and a wide range of globes is available for the purpose. The main classification of such lamps is the voltage, the current, and the type of connection. Voltages can be as low as 1 V, but 6 V and 12 V varieties are the most common. The filament current requirements also differ, with around 100 mA being typical. The type of connection also varies enormously, with various sizes of Edison screw, bayonet cap, or slide base types being common. Some globes even come with only two wires protruding from the glass envelope, allowing pc board mounting.

Fittings are also available for the different types of globes, so naturally you would select one to match the other. The main thing to be aware of is that the replacement globe should have the same voltage, and approximately the same current requirements as its predecessor. It is also worth noting that incandescent indicator lamps require more power than, say, LED indicators, and their use in battery operated equipment is not recommended.

The LED is very commonly used as an indicator lamp, due to its longevity, (100,000 hours), cheapness and small power requirements. Typically, LEDs require around 2 volts at 10-20 mA, and are available in a wide range of shapes, including the common 5 mm and 3 mm round types, as well as rectangular or pin types. Colours are usually restricted to red, green, orange and yellow. (Orange and yellow can sometimes be hard to differentiate between.) Recent developments include a blue LED, but its low light output may make it a poor choice for an indicator.

Other LED types include infrared varieties, which give no visible illumination, (no good as an indicator, great for an infrared remote control), as well as LED packages containing two LEDs of different colours in the one white translucent encapsulation. This latter variety usually comes mounted in a chrome plated bezel, and has three wires, enabling the indicator to be used as a dual function device. Yet other types include the 'flashing' LED, which has an IC built in to produce a flash rate of around 1 to 5 Hz, when a 5 volt charge is applied.

An LED is essentially a dc operated device, and requires the correct polarity of applied voltage to operate. The reverse voltage capability of an LED is low, being around 5 volts. Special circuits allow an LED to be used with ac, and these should be consulted if necessary. Excessive current through an LED will cause its demise, and usually a series resistor is required.

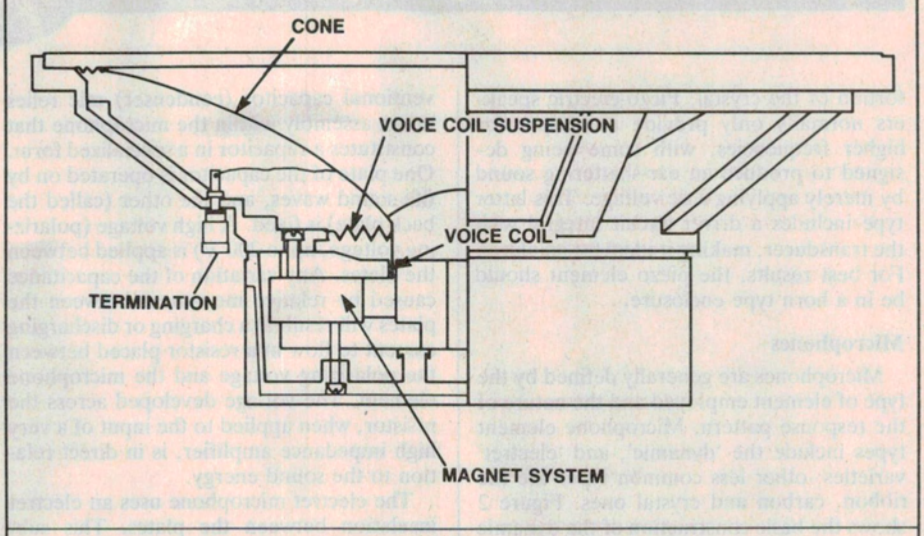


Figure 1. Cross-sectional view typical of a moving coil speaker.

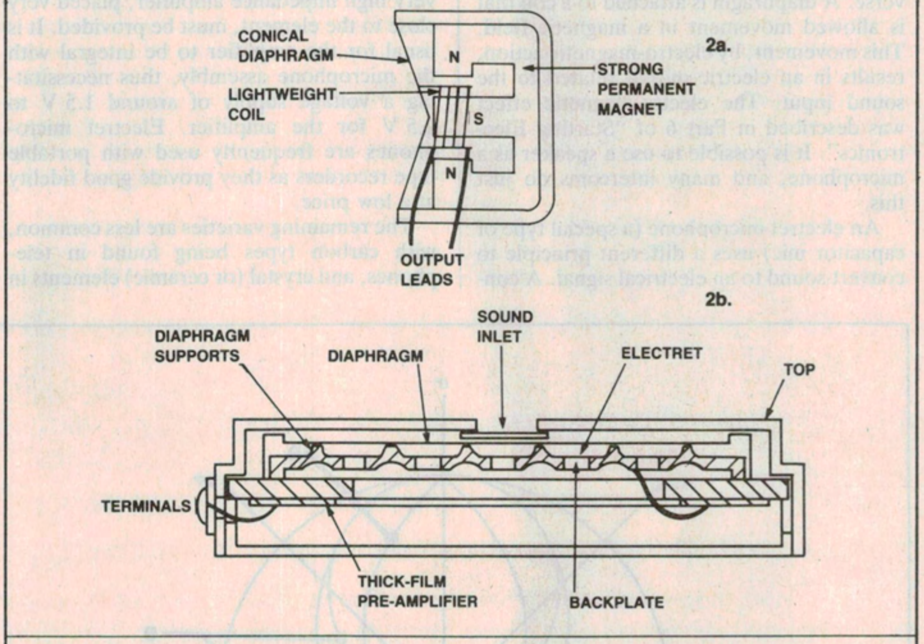


Figure 2a. A dynamic microphone and **2b**, an electret microphone.

Transducers

A transducer is essentially anything that receives energy in one form, and outputs energy in another form. In electronics, the only transducers of interest are those that have either an electrical input or output. A loudspeaker is a typical example. A speaker is, in fact a two way device, in that it will convert electrical energy to sound energy, and vice versa. For the purposes of this article, any dissertation on transducers must necessarily be scant, as herein lies a huge topic.

Speakers

Conventional speakers, designed for audio applications are usually rated by their nominal impedance (usually in the range of 4 to 40 ohms), power handling capability, frequency response, and physical size. Often one terminal will be marked "+", or something similar, which is an indication of the 'phasing' of the speaker.

Phasing refers to the direction of cone movement relative to the polarity of the applied voltage, and becomes important when two or more speakers are being employed. A speaker is best operated in a suitable enclosure, and the power rating of the speaker should be at least equal to that available from the driving source.

Speakers are normally of the moving-coil type, although other operating mechanisms are available. One variation is the piezo transducer. The piezo-electric effect results when the application of a voltage to a certain type of crystal causes a mechanical dis-

tortion of the crystal. Piezo-electric speakers normally only provide an output for higher frequencies, with some being designed to produce an ear-shattering sound by merely applying a dc voltage. This latter type includes a driver circuit integral with the transducer, making it ideal for an alarm. For best results, the piezo element should be in a horn type enclosure.

Microphones

Microphones are generally defined by the type of element employed and the nature of the response pattern. Microphone element types include the 'dynamic', and 'electret' varieties; other less common types are the ribbon, carbon and crystal ones. Figure 2 shows the basic construction of the dynamic and electret microphones. A dynamic microphone operates using essentially, the same principle as a loudspeaker, but in reverse. A diaphragm is attached to a coil that is allowed movement in a magnetic field. This movement, by electro-magnetic action, results in an electric output related to the sound input. The electro-magnetic effect was described in Part 6 of "Starting Electronics". It is possible to use a speaker as a microphone, and many intercoms do just this.

An electret microphone (a special type of capacitor mic) uses a different principle to convert sound to an electrical signal. A conventional capacitor (condenser) mic relies on an assembly within the microphone that constitutes a capacitor in a specialized form. One plate of the capacitor is operated on by the sound waves, and the other (called the back plate) is fixed. A high voltage (polarizing voltage, up to 200 V) is applied between the plates. Any variation of the capacitance caused by relative movement between the plates will result in a charging or discharging current to flow in a resistor placed between the polarizing voltage and the microphone element. The voltage developed across the resistor, when applied to the input of a very high impedance amplifier, is in direct relation to the sound energy.

The electret microphone uses an electret insulation between the plates. This substance has a polarizing voltage present within it as a result of its manufacture. However, like the capacitor microphone, a very high impedance amplifier, placed very close to the element, must be provided. It is usual for the amplifier to be integral with the microphone assembly, thus necessitating a voltage supply of around 1.5 V to 4.5 V for the amplifier. Electret microphones are frequently used with portable tape recorders as they provide good fidelity at a low price.

The remaining varieties are less common, with carbon types being found in telephones, and crystal (or ceramic) elements in cheap microphones. Ribbon mics are primarily used in professional applications, and are generally more expensive than the other varieties.

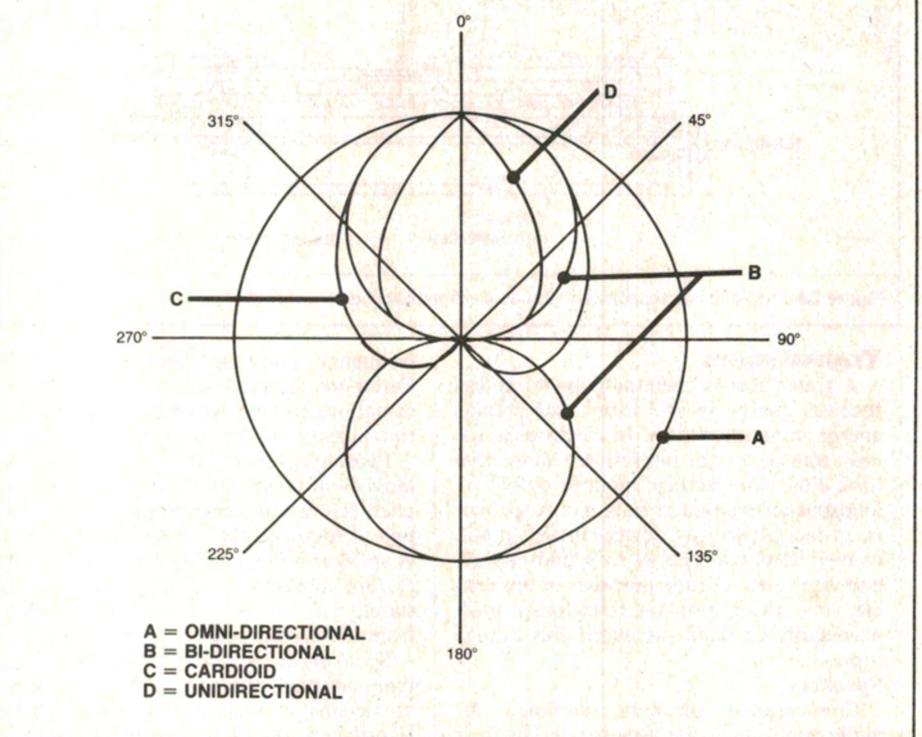


Figure 3. Polar response curves for microphones.

The response of a microphone to sounds from different directions is referred to as its 'polar' response pattern. Basically, a mic is either omni-directional, bi-directional, or uni-directional. Figure 3 shows the shape of the response curves for these three patterns. The term 'cardioid' is often used in place of, or in conjunction with the word uni-directional. The response curve of a mic identifies it to a specific application, with, for example, a highly directional (uni-directional) type being employed in conjunction with a video camera, and an omni-directional mic being most suited to a general purpose tape recorder application.

Other microphone characteristics include impedance, sensitivity and frequency response. Impedance can range from as low as 10 ohms right up to 50k ohms, and even into megohms for the crystal varieties. It is important to match the impedance of the mic to that of the device it must operate into, and sometimes an impedance matching transformer is required. Frequency response and sensitivity give an indication of the quality of the unit, and again should be matched to the application.

Other transducers in electronics include things like ultrasonic receivers and transmitters, record player pickups, tape heads, in fact anything that is, well . . . a transducer. A solar cell is a transducer that could also have been mentioned under batteries. A solar cell is a panel of material that will produce a voltage, around 0.43 V at a specified current, (usually around 20-30 mA), when exposed to sunlight. Applications are generally restricted to battery charging circuits, and various arrangements of solar cells are available that provide specified voltages and currents.

We wish to thank Dick Smith Electronics for the resistor and capacitor colour code artwork which appeared in last month's issue. Our apologies for losing August's acknowledgement.