Part 4

in our beginner's series

BY ALEX CASE

Nuts & Bolts

Microphones 1—Transducer Designs

Selecting the right microphone is a constant part of the job. Band: The Has Beens. Song #5: The Hair I Used to Have. Overdub #16: ukulele. Which microphone should be used?

Depending on the studio, the engineer has to choose among maybe a dozen or maybe even a hundred microphones. They come from countless manufacturers, offering several model numbers.

What will a given microphone sound like on a particular instrument in a specific style of music in this unique recording space? Aaargh! There is no end to the possibilities.

One develops insight and intuition about which mic to try for a given situation through experience. But we can help our experience along by learning how they work.

It's helpful to break down the vast range of microphone possibilities into some subgroups. In the recording studio, the recording engineer typically chooses among three types of microphone designs: moving coil, ribbon, or condenser.

How do they work?

Unusual in our world of complicated gear (ever open up a digital 8-track?), the microphone is an elegantly simple, completely knowable technology. And knowing how the thing works gives us some insight into how to use it.

A fascinating parallel between electricity and magnetism exists and seems tailor-made for audio. Whenever an electrical conductor—like a wire—moves through a magnetic field, an electrical current is induced onto it.

Leveraging this principle, called electromagnetic induction, you can generate your own electricity if you want. Just persuade someone to hop onto a bicycle modified so that the rear tire is a coil of wire. Set it up so that the wire rotates through the gap of a magnet when he or she pedals. If he or she pedals hard enough and if the coil and magnet are big enough, you could power all your favorite equipment free (assuming you don't pay this person). We don't know people willing to do that, so instead we have power companies.

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Power companies use giant steam-powered turbines to spin generators that rely on this same fundamental physical property. And not only does a magnetic field induce a current on a wire that moves through it, but also a changing current on a wire creates a magnetic field around it. That is, electromagnetic induction also works in reverse.

Using electricity to create a magnetic field is a basic necessity when recording music on magnetic tape or playing music back through a loudspeaker. More on all that in future episodes of Nuts & Bolts; for now let's apply electromagnetic induction to microphones.

Microphones that rely on electromagnetic properties to convert an acoustic event into an electrical signal are called electrodynamic (more commonly 'dynamic') mics. There are two types of dynamic microphones used in the studio: moving coil and ribbon. And they both are appealingly straightforward devices.

The moving coil dynamic microphone converts sound into electricity with essentially three components: a diaphragm that moves with the air, a coil that is moved by the diaphragm, and a magnet that induces electrical current onto the coil when it moves.

This type of mic takes advantage of the motion of air particles during an acoustic sound to move a coil of wire through the magnetic field of a permanent magnet. The coil movement creates an electrical signal whose voltage changes as a direct result of the acoustic event. It's a satisfyingly simple process.

The ribbon microphone takes advantage of the same electrodynamic principle we've discussed. As a machine that converts acoustic energy into electrical energy, it is even simpler than the moving coil system. The ribbon microphone cleverly combines the diaphragm and the coil above into a single device: a ribbon. That is, the thing that moves in the air is also the conductor of electricity.

The ribbon is a piece of metal suspended between the poles of magnet.

When a musical instrument plays, air molecules move. The air molecules near the ribbon force it to move; the motion of the ribbon through the magnetic field induces electrical current onto the ribbon itself. Voltage changes that are a perfect analogy to the acoustic event are created.

A third microphone transducer technology employed in the studio doesn't rely on electromagnetic induction at all. The condenser microphone relies on the electrical property of capacitance instead. We know that if we hook up a voltage source (e.g. a battery) across a wire, electrical current will flow. If we cut that wire, the current stops.

Once upon a time this type of electrical component was called a condenser While the component is today generally called a capacitor instead, the microphone built around this technology hangs on to the name condenser.

A condenser microphone is nothing more than a variable capacitor driven by acoustic sound waves. One plate of the capacitor is the diaphragm whose motion is a result of the changing sound pressure around it. As the diaphragm moves, the capacitance changes. The electrical output of the microphone is a pattern of voltage changes derived from this change in capacitance.

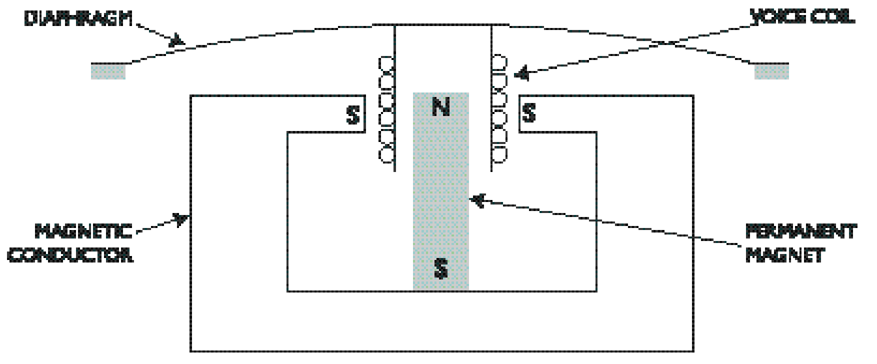

FIG 1: MOVING COIL DYNAMIC MICROPHONE

It turns out that there is something in between a closed circuit (the wire) and an open circuit (the severed wire). Imagine that after cutting the wire we bring the two ends of the wire really close to each other without touching. It's easy to imagine that, without current actually flowing across the gap we've made in the wire, the two ends would influence each other electrically.

A capacitor is a component that does this on purpose. Where the wire was broken, plates of metal are attached. And these two plates are brought up very close to each other, again without touching. The result is that an electrical charge builds up on the plates, pulled by the influence of the voltage source across the gap in between the plates.

The ability to store a charge, or capacitance(hence the name capacitor), is a function of the voltage across the plates, the size of the plates, and the distance between the two plates. As the plates separate, they become more like a fully broken circuit and the charge dissipates. As the plates converge, they have a stronger and stronger influence on each other and try to approach the behavior of a completed circuit—the charge on the plates then increases.

Mission accomplished: acoustic music in, electrical signal out.

Which one do I use?

Knowing the type of transducer technology a microphone employs gives the engineer some insight into how it might sound and what applications it is best suited for. But let me preface this discussion with some very important, really good news: we're lucky to be in the audio biz in 1999.

The quality of the design, materials, and manufacturing techniques used today is enabling all microphone technologies to converge toward a consistent,high-quality, high-durability product.Below I discuss some general properties of microphones based on the type of transducer used. This is a good starting point for deciding which mic to use in a given situation. And it's certainly helpful when using the ever-popular older microphones.

Take note, however, that some new microphones have addressed many of the historic design weaknesses cleverly, creating mics that are often appropriate in a broad range of recording situations.

So with the caveat that these generalities don't apply to all mics, consider the following.

Durability

Moving coil microphones are often considered to be the heartiest of the bunch. As a result they are often the transducer of choice for live sound applications, which are very tough on delicate equipment.

At the other end of the durability chain is the ribbon mic. The ribbon itself is pretty fragile—especially on the vintage (i.e. expensive) ribbon microphones available at some studios.

Remember, the job of the ribbon is to react instantly to any change in the air pressure around it. And if there is, say, a 10 kHz component to the music you are recording, then the ribbon has to be able to move back and forth ten thousand times a second. Physics asks it, therefore, to have as little weight as possible.

Unfortunately, as the ribbon loses mass it necessarily loses strength. Some ribbon microphones are still manufactured today, and the ribbon within those mics is certainly tougher than the ribbons in Granny's microphones.

But nobody dares stick a ribbon microphone in the high amplitude world of a rock and roll kick drum. Some new ribbons are designed to be tough enough for screaming vocals and thundrous electric guitar. But they all want a chance at the horns (not too close, thank you), the piano, and the acoustic guitar, among others.

Moving coil dynamic microphones are the largest mechanism used for converting acoustic waves into electrical ones. Not surprisingly, then, they generally have a natural high frequency roll-off as the ability of the device to transduce diminishes at higher frequencies.

Consider the following hypothetical expedition. Before the session begins, you go food shopping for the band you are working with, and the drummer helps. The shopping list consists solely of potato chips and beer, but in enough quantity to get the band through a two-week session.

You and the drummer go to the neighborhood Chomp 'n Gulp, get two shopping carts, and you fill one cart with chips while the drummer fills the other with beer. 'This has nothing to do with microphones,' you—and my editor—think to yourselves.

But consider these questions: Which cart is easier to drive? Which cart is easier to stop and start? The chip cart and the beer cart can go pretty much the same speed, but the beer cart needs a stronger shove to get going. Clever drummers start emptying (i.e. drinking) some cans for this very reason.

For our microphones, the moving coil is more like the beer cart. Quite simply, the diaphragm/coil assembly is too big to react quickly, as required by very high frequencies.

Unusual in our world of complicated gear (ever open up a digital 8-track?), the microphone is an elegantly simple, completely knowable technology.

In the durability category, condensers generally fall somewhere in between moving coil and ribbon designs. As a result, you'll certainly find some of them performing on stage or placed near the very loud instruments such as kick drum, trumpet, trombone, and so forth.

Sound quality

Though microphones of all types seem to be improving in capability, it is worth making some generalizations about how a microphone of a given transducer technology might sound.

The ribbon microphone is more like the chip cart. Consisting of a single moving part (the ribbon) it is a lighter mechanism. As a result the ribbon transducer is typically more agile than a moving coil, achieving more sensitivity at the high frequencies as a result.

The condenser microphone is generally lightest of all, behaving more like an empty shopping cart in the analogy above. The only moving part, the diaphragm, can be an extremely thin plastic membrane with just the lightest coating of a metal to make it

conduct electricity. As a result the condenser offers the best opportunity to capture the detail of a transient, or the very high frequency portion of a high hat.

pelling after the subtle reshaping of the transient that a moving coil microphone introduces.

As soon as a session permits, try using a moving coil and a condenser

The apparent transient response weakness in the moving coil design can in fact be quite a handy engineering tool.

The apparent transient response weakness in the moving coil design can in fact be quite a handy engineering tool. By reacting slowly to a sudden increase in amplitude, it acts mechanically as a compressor might act electrically. It reduces the amplitude of the peaks of a transient sound.

This is helpful for two major reasons. First, this reduction of peaks can help prevent the sort of distortion that comes from overloading your electronics. The true spike of amplitude that comes off a conga might easily distort the microphone preamplifier or overload the tape you are recording onto. The use of a dynamic mic might be just the right solution to capture the sound without distortion.

on the same instrument, placed as near to the same location as possible. Then listen critically to the different coloration of each mic. Most apparent will be the frequency response differences, with the condenser sounding a little brighter at the high end while the moving coil offers perhaps a presence peak in the upper mid-range.

But listen beyond this, to the character of the attack of the instrument. Depending on the application, you will often find that the moving coil dynamic microphone squashes the transients into a more exciting, more intense sound.

By the time the track you are recording gets combined with all the other tracks in the multitrack project, and after the signal makes its way

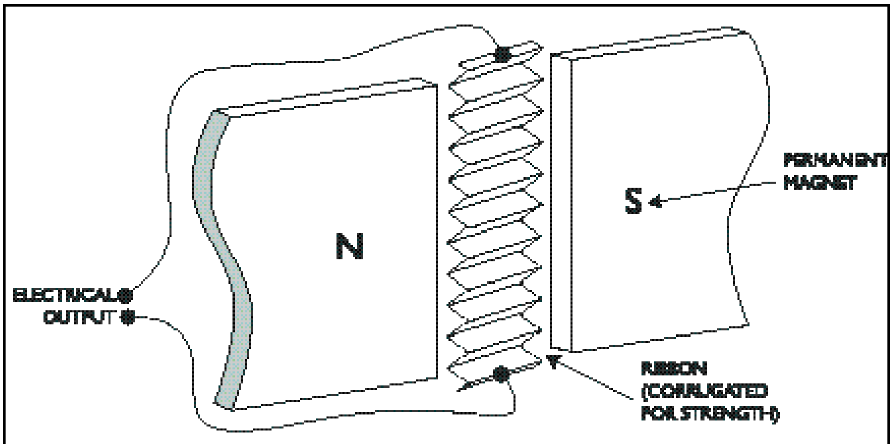

FIG 2: RIBBON DYNAMIC MICROPHONE

Beyond this issue of audio fidelity and the prevention of distortion, dynamic microphones with their natural lethargy are often used for creative reasons. The sound of a clave, snare, kick, dumbek, and many other instruments is often much more com-

from mic to tape, through the console and various effects processors to the loudspeakers, the recorded sound from a moving coil microphone often just seems to work better.

Meantime the ribbon microphone, offering more high frequency content

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than the typical moving coil microphone but less high frequency reach than most condensers, still finds its place in the recording studio.

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Many instruments have a rather painful amount of high end. Close-miking them, as we so often must do in the studio, only makes this worse. The natural high frequency attenuation of a ribbon is often just the right touch to make a trumpet, a cymbal, a tambourine, a triangle, and others become beautiful, airy, and sparkling, without being shrill, piercing, thin, or edgy.

In our next Nuts & Bolts episode we'll look at other microphone properties like directionality and proximity effect so that we can make more sense out of the vast range of options microphones offer. We can look forward to a career-long exploration of the beauty of applying different microphones in different musical situations.

Let the other engineers work their way through the microphone closet, randomly trying different microphones in different applications. We can organize our experiences based on what we know about how the microphone works.

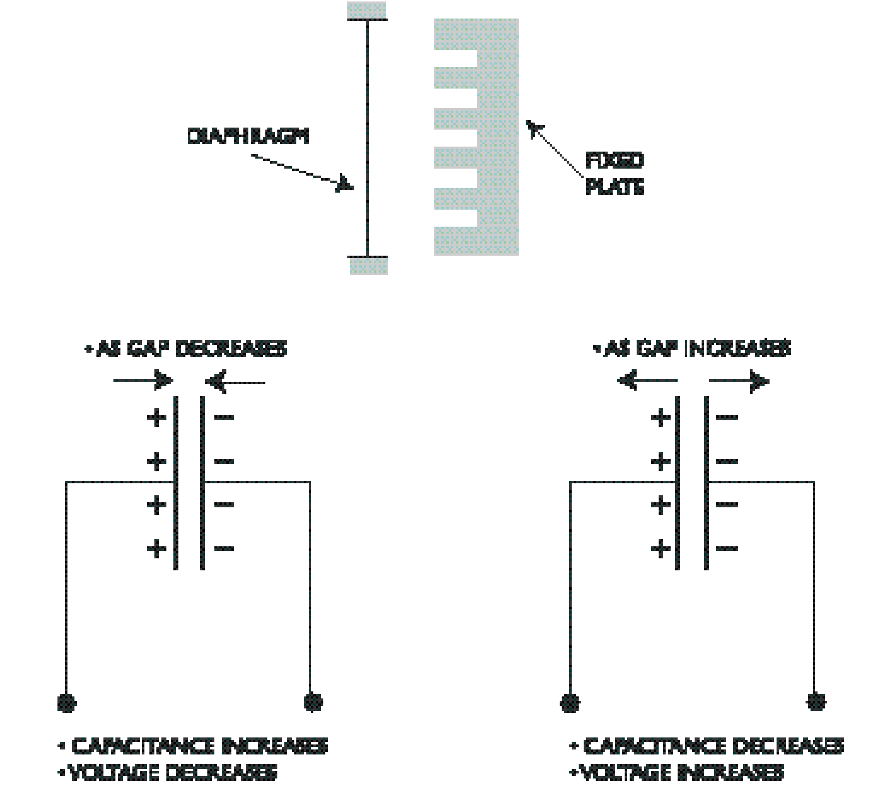

FIG 3: CONDENSER MICROPHONE

Try to rationalize what you actually hear with how you think it should sound, and you'll bring some order to an otherwise chaotic part of the recording gig.

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