If these walls were made from a material that absorbed the energy of the racquetball, such as carpet, the ball would lose energy upon impact and the return bounce would be of considerably less velocity. Not to mention, the game would not be nearly as fun.

Now, let's replace the racquetball with sound waves. By standing in the center of the racquetball court and clapping our hands together, we will send a sound wave toward the wall. The sound wave will strike the wall with a great amount of energy and bounce back in the opposite direction. The sound wave will strike the opposite wall with less energy than the first wall, but still with a great amount of energy. This will continue until the sound wave finally loses energy. Unlike a racquetball that moves in a single direction, sound waves move in a 360-degree radius from the sound source. Upon clapping our hands, we send the sound wave in every direction, including up and down. In a racquetball court, the flat surfaces allow the sound wave to continue to travel at a steady decline in amplitude until all of its energy is lost. In effect, the sound waves persist long after the sound event has occurred.

In short, sound is a messy, determined creature that wants to live as long as possible. To properly trap this animal, you need to use an *anechoic chamber*. These rooms are designed to eliminate any possible echoes, thus suffocating reverberation and successfully capturing the beast. Sound mixers, however, must capture sound without the use of this trap. Location sound work tasks the sound mixer with capturing sound in any given environment. It is therefore necessary to understand sound's properties and how it interacts with its environment. Herein lies the greatest challenge for the sound mixer: sound does not want to be tamed or captured. It wants to live on. In the next chapter, we'll discuss the microphone, our primary tool for capturing this creature.

CHAPTER EXERCISE Experiment with room acoustics to help familiarize yourself with how a room will sound in the recordings. Find a room and clap your hands together once. Next, say a few sentences at different volumes. Now, repeat these steps and record them. Play back the recording to see if the acoustical responses of the room match what you remember hearing. What are the differences between what your ears heard and what the microphone captured?

CHAPTER 3

MICROPHONE BASICS

The microphone converts acoustic energy into electric energy through a process called *transduction*. Sound waves enter the microphone's capsule and cause a diaphragm to move in direct relation to the change of air pressure. This works much in the same way as the human ear. Sound waves enter the ear and cause the eardrum to move in direct relation to the change of air pressure. The ear converts the acoustic energy into an electric energy known as nerve impulses. The brain understands these impulses as sound.

There are two main types of transducers for microphones: *dynamic* and *condenser*. They each use a different type of diaphragm that greatly affects the characteristics of the sounds they reproduce.

DYNAMIC MICROPHONES

Dynamic microphones use a moving coil wrapped around a magnet to convert sound waves into an electric signal. The moving coil is attached to a diaphragm. This is the same method in which a speaker converts electric signals into sound waves, but in reverse. Like speakers, they do not require external power to operate. Dynamic microphones are very rugged and can handle high SPL, making them an excellent tool for recording loud sounds such as drums, gunshots, and electric-guitar amplifiers. They require much more air movement than other microphone types, which helps reduce feedback and excessive background noise, but at the cost of having a lower *transient response* than that of condenser microphones. Transient response is the measurement of time it takes for the diaphragm to respond to air movement. The faster the response, the more accurately the signal is reproduced.

In television production, especially ENG work, reporters typically use dynamic handheld microphones during standups, man-on-the-street interviews, stage productions, and live events. For a dynamic microphone to capture speech, it needs to be very close to the mouth.

Dynamic mics are perfect solutions for ENG work where the talent is conducting interviews or reports in noisy environments (football stadiums, roadside reports, locker rooms of the World Series' winning team, etc.). These mics have a great rejection of background noise and tend to allow the reporter's voice to sit on top of any extraneous noise. Stage productions and live events with P.A. systems will often call for dynamic microphones because they have a high amount of feedback rejection.

Dynamic mics are seemingly indestructible. There is an incredible video on YouTube of Stockholm's Mats Stålbröst, who ran an extreme endurance test on a Shure SM58. This mic is arguably the most common stage microphone in the world. The video shows the SM58 being subjected to various tests to see how the microphone would hold up. After being used to hammer nails, dropped from six feet, submerged in water, placed in a freezer for an hour, having beer poured on it, put in a microwave on top of a slice of pizza, having a car drive over it twice and being buried in the ground for over a year to endure rain, snow, and a wide range of temperatures, the microphone still worked! This level of stamina is hard to find and I certainly wouldn't try this with a condenser microphone.

CONDENSER MICROPHONES

Condenser microphones use the change of a stored charge called *capacitance* to convert acoustical energy into an electric signal. A constant voltage is sent to a front plate (the diaphragm) and to a back plate. Air movement causes the front plate to vibrate toward and away from the back plate resulting in a change of capacitance. This change becomes the electric signal.

Years ago, condenser mics were considered extremely fragile. While they are not as rugged as dynamic microphones, today's condensers are much more robust than their predecessors and can handle higher SPL than ever before. A better transient response makes the condenser microphone sound clearer than a dynamic microphone. Condensers can faithfully reproduce subtleties in the sound wave's dynamics and capture higher frequencies than dynamic microphones. If you can hear the sound with your ears then you can bet that the condenser microphone can also hear it. Many times, the microphone seems to hear the sound even "louder." If you can faintly hear a cricket in the distance, it's safe to say that the microphone can hear the cricket's heartbeat. Not really, but you get the idea.

There are two types of condenser microphones: *true condenser* and *electret.*

True Condenser Microphones

A *true condenser microphone* requires external power known as *phantom power* to

charge its capacitor. Phantom power is typically supplied through the same cable used to send audio from the microphone. Modern phantom power is 48 volts and indicated on microphones and other equipment by various abbreviations: PH, 48V, 48, P48, etc.

Phantom power requires a balanced cable to supply voltage. The power scheme is as follows: Pin 1 – Negative, Pin 2 and Pin 3 – Positive.

Since the voltage is consistent between Pin 2 and Pin 3, only the audio signal would be detected as sound, as this would be the only change in voltage down the cable; hence the name "phantom."

An older type of phantom power was called *T-Power* or *parallel powering* (usually indicated as 12T or 12 Volt T). This used the following powering scheme: Pin 1 – Ground/Neutral, Pin 2 – Positive, Pin 3 – Negative.

Some of the older microphones might have a red dot engraved on the side. The red dot indicates that their wiring is reversed. The reason for this dates back to the days of the old Nagra recorders that had positive grounds. Microphones were adapted to this odd standard to supply T-Power so that Pin 2 was negative and Pin 3 was positive. Normally, T-Power was configured so that Pin 2 was positive and Pin 3 was negative. For whatever reason, Nagra developed a system that went against this standard and so microphones featuring the red dot were developed to use with the Nagra.

Many manufacturers developed microphone models that came in either 12-volt T-Power or the now standard 48-volt phantom power. Examples are the Sennheiser MKH 416-P48 (phantom power) and the MKH 416T (T-Power). It is rare to come across T-powered microphones today; however, if you plan on using mics with a T-Power supply, you'll need to observe the polarity or your microphone will not work. In a pinch, you can simply reverse the polarity by soldering an XLR cable so that Pin 2 on one end connects to Pin 3 on the other end and vice versa. Beware that sending modern 48-volt phantom power to a T-Powered mic will damage the microphone.

Certain models of microphones can receive phantom power from an internal battery. You should never double-power a microphone (i.e., use an external phantom power supply in addition to a mixer's phantom power or internal batteries on the microphone in addition to a mixer's phantom power). On most mixers and recorders, if you are not using phantom power, choose the "dynamic" setting. This means that the microphone signal is accepted as is with no powering of any kind. Phantom power should be turned off when using a device that does not require phantom power. Dynamic microphones are pretty much immune to phantom power but devices, such as wireless receivers, recorders, and mixer outputs connected to the input of a device with phantom power, can be damaged or result in poor signal quality. The bottom line: if your device does not require phantom power or is already receiving phantom power, then turn the phantom power supply off.

The majority of the boom microphones used in the film and broadcast industries are true condenser microphones and will require phantom power. There are a few exceptions, but you will most certainly use phantom power every day.

Electret Condenser Microphones

The *electret condenser* has a permanently charged back plate. Phantom power is not required for the capsule to operate; however, most electret microphones use phantom power to power a preamplifier that amplifies the weaker audio signal produced by these types of capsules. This preamplifier can be powered by an internal battery or directly from phantom power supplied through the microphone cable.

Electret microphones are probably the most popular and widely used in the world. These mics can be found in nearly every cell phone, telephone, headset, and handheld recorder. While the consumer market uses relatively low-cost and low-quality electret microphones, there is a place for higher-grade electret microphones that are priced much lower than true condenser mics, but still deliver great quality. ENG-grade shotguns use electret capsules that are a low-cost solution for ENG work; however, their quality isn't high enough to meet the standards for feature films. In the film and broadcast world, the most popular use for electret microphones is *lavalier mics*. Nearly all lavaliers are electret microphones, with the exception of some that are dynamic, which are not useful for production sound.

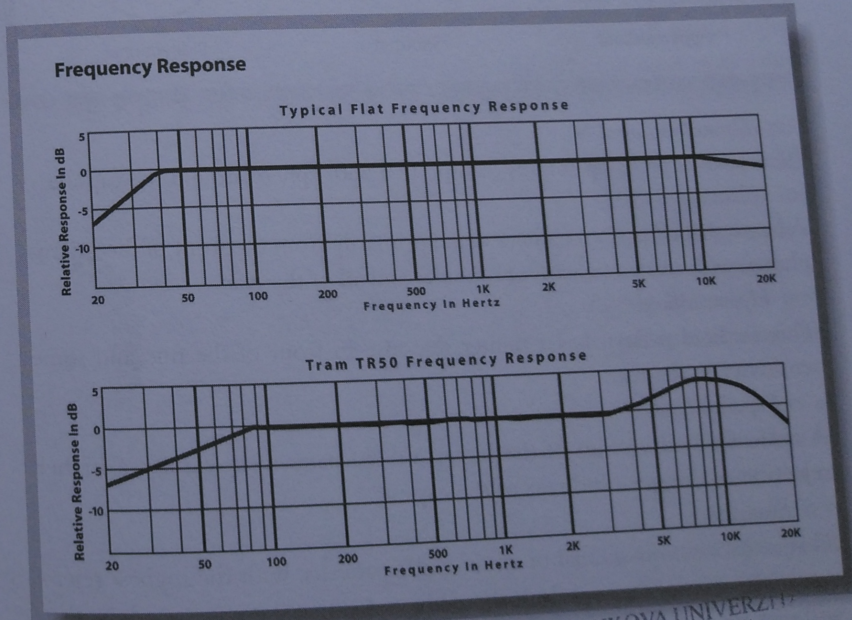
FREQUENCY RESPONSE

The range of frequencies that a microphone can reproduce is known as the microphone's *frequency response*. In general, the wider the spectrum of frequencies reproduced, the more accurate the sound will be. If frequencies are reproduced at amplitudes different from that of the original sound, the sound is considered "colored." Audio engineers often use the term "color" to describe different frequencies within the frequency spectrum. In the

light spectrum, different frequencies of light waves appear as colors. Lower-light frequencies like reds and oranges are described as warm. Higher-light frequencies like blues and greens are known to be cold. Similarly, lower-frequency sounds are described as warmer and higher-frequency ones are described as colder.

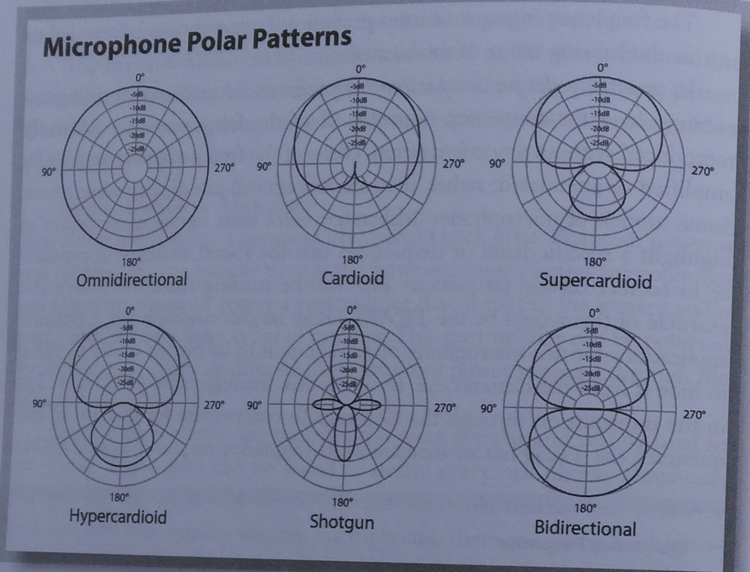
The frequency response of most professional microphones is intended to mirror the hearing range of the human ear: 20Hz – 20KHz.

In general, a *flat frequency response* is preferred for professional dialog recording. In a flat frequency response, all of the frequencies are faithfully reproduced without any colorization. None of the frequencies are artificially amplified or attenuated; rather, they are reproduced just as they were heard. Some models of microphones deliberately color their frequency response to highlight a specific band of frequencies that the sound source will produce or to correct certain frequencies that will be missing from the source. An example of this would be the TRAM TR50 lavalier microphone. Common applications for this microphone often require it to be buried under clothing to hide it from the camera's eye. In doing this, the higher frequencies are lost in the transmission through the clothing. To compensate for this loss of frequencies, the TR50 has an increase in its frequency response around 8KHz.



MICROPHONE POLAR PATTERNS

The directionality of a microphone is called its polar pattern. Different polar patterns will "pick up" sound from different directions. There are six polar patterns:



Omnidirectional

This pattern picks up sounds coming in a 360° sphere around the capsule.

Cardioid

A heart-shaped pattern gathers sound primarily from the front of the microphone, with some rejection of the sides and all of the rear.

Hypercardioid

This cardioid pattern has a tighter response in front of the mic and some sensitivity in the rear.

Supercardioid

A more focused version of the hypercardioid pattern, it features a higher rejection of the sides and rear of the capsule.

Shotgun

This is the most directional of all the polar patterns, with the highest rejection of the sides of the capsule. It should be noted that there is a rear lobe that will pick up sounds coming from directly behind the microphone.

Figure Eight or Bidirectional

This is a dual cardioid pattern that picks up sound from both sides of the microphone. Other than in the use of MS microphones, this polar pattern is not used in location sound work.

ON-AXIS/OFF-AXIS RESPONSE

When a sound occurs within the primary area of the microphone's polar pattern, it is considered *on-axis*. This is also called the "sweet spot." When a sound occurs outside of the polar pattern, it is considered *off-axis*. The off-axis part of a polar pattern is sometimes referred to as the "rejection zone" (which is also the nickname I gave my high school). On-axis sounds are bright and crisp, while off-axis sounds are more flat with less high end.

Some microphones have better off-axis sounds than others. In these mics, sounds that occur off-axis sound quieter than those on-axis. Others tend to color off-axis sounds because of a frequency-response difference between the on-axis and off-axis part of the pattern. Not only will the sound appear quieter, but will also typically sound duller as fewer higher frequencies are picked up. When using these types of microphones, it is very important to keep the sound consistently inside the polar pattern to avoid coloring the sound. A sound that drifts between on-axis and off-axis will sound weird and unnatural. The listener will realize that something doesn't sound right. This is less noticeable with wider patterns like cardioids and more noticeable with shotgun patterns.

Sometimes the background noise is so intrusive that you'll need to position the mic so that it gives the maximum rejection of the background. This might be at the expense of optimal positioning for dialog pickup, but remember, the audience needs to hear the dialog so that they can understand what is said. If you put the mic in a position that rejects the majority of the excessive background noise with the dialog slightly off-axis, it will sound better than on-axis dialog that is difficult to understand over the background noise.

During a sound effects recording expedition, I recorded fighter jets at an air show in Cocoa Beach, Florida, with my good friend, Colin Hart of Hart FX. The air show took place on the edge of the ocean, which put us close to the jets. They were so close I could've probably thrown my car keys and hit them. I might have tried, but then I would have to fish my keys out of the water.