The Character of Sound

Extensive knowledge of sound and its reproduction is not necessary to make simple recordings, but the more complex the challenge, the more a lack of knowledge will cause inadequate sound. Therefore, some basics about the character and recording of sound are presented here.

Sound emanates from a source and becomes the vibration of elements in a transmission medium, usually molecules in the air. Sound is air molecules compressing and separating, generally represented as a wave. **SEE 11-3**

The frequency with which the signal fluctuates above and below normal air pressure is called cycles per second (cps) or, more common, hertz. Hertz (Hz) represents the pitch of the sound, that is, whether it is a low, midrange, or high tone. Sounds with rapid rates of fluctuation are higher, such as a soprano singer or a flute. Sounds with slow rates of frequency are low, such as a bass singer or a tuba.

**Frequency range** refers to the spectrum of audible and inaudible sound, represented in hertz. The average adult human ear hears from roughly 20 to 16,000 Hz. Sound exists above and below these parameters but it is inaudible. The distance of variance from normal air pressure represents **amplitude**—or the strength of the signal. The more the air is disturbed, the louder the sound.

Musical notes are at specific frequencies measured in hertz, with the audible spectrum easily divisible into octaves. Middle C is about 260 Hz. Someone singing bass would be in a range roughly from 60 to 200 Hz; a soprano would be around 2,000 to 3,500 Hz. Despite the general accuracy of these last two statements, wherever in the audible spectrum a particular human voice is, that voice has elements of other frequencies in it. Even if a person has a very low voice, that voice includes elements of high frequencies. Conversely, a high voice has elements of low frequencies. This is true of all sound, from distant thunder to the piccolo. When one starts manipulating sound with equalizers and other signal processors, this becomes a significant consideration.

**Frequency response** refers to how evenly and completely a specific recorder or playback format reproduces the audible range. High-quality recorders reproduce almost the entire spectrum of human hearing. Consumer recorders may record only within a relatively narrow range. Some recorders have poor low-frequency reproduction, whereas others fail on the high end. A recorder’s frequency response can be checked in the machine’s “specs,” a list of its technical specifications. Find a recorder that reproduces as much of the sound spectrum as possible.

Frequency response is based on technical considerations, most notably quality of electronic circuitry, tape speed, and area on the tape devoted to the signal. Quality of audiotape is also a contributing factor. Due to the nature of photographic reproduction, sound on 16mm films is notoriously poor—reproducing the range of frequencies from about 70 to 7,000 Hz. Sound for 35mm is significantly better, because it is running at a faster rate and has a larger area devoted to it.

The following terms and concepts are necessary to understanding some of the fundamentals of sound.
Decibels A **decibel (dB)** is an increment of measurement of the amplitude, or loudness, of sound. Decibels are logarithmically based and defy any simple explanation. Suffice it to say that most recorders represent decibels either as a unit of amplitude in the recording of an audio signal or as a percentage or increment away from an optimal recording.

**Mixing** There are generally two types of mixers available: the previously mentioned studio mixing console and the field mixer. A studio console is a large board with a varying number of channels for individual signals. A **field mixer**, also called a **mic mixer**, is a simple unit with a small number of mic inputs and, on some models, a few signal-processing options. A field mixer is not a requirement for location recording, but one is used when a particular setup requires more than the standard two mic inputs on most professional recorders. A field mixer converts the **mic signal**—the electric current—to a **line signal**, which is then fed to the recorder.

**Signal processing** The idea that an audio signal can be changed and shaped is important. When dealing with sound coming from a microphone, you are faced with an electrical, or possibly digital, signal that can be altered as desired. Signal processors such as equalizers are frequently used to “clean” or “brighten” sound that was recorded in less than optimal conditions. Other signal processors, such as reverb units and echo chambers, can add specific character to sound.

**Signal path** The route an audio signal travels—the **signal path**—is important to understand, both for troubleshooting and for determining what processes the signal is going through. The microphone converts sound into an electrical signal that is directed by the mic cord toward the record head. The signal goes into a mic input on the recorder, where the weak microphone signal is boosted by a **preamp**. In a simple recording system, the signal is then fed to the record head. In a complex recording system, the signal may be routed through a number of internal circuits.

Virtually all audio equipment—recorders, mixers, signal processors, and so on—come equipped with **line inputs** and **outputs**. The audio signal can be routed through a **line out** of one machine to the **line in** of another. You might choose to route the signal through a variety of sideboard signal processors. If you send it to an equalizer, it has to come out again. If you send it to a field mixer, you should be able to find out where it is and how to send it where it needs to go. With some basic knowledge of how signals travel, you should be able to route a signal wherever you want.

As a sound person, you should also be able to follow the often labyrinthine path of virtually any signal in any setup, including the path of a video signal. When the path of the audio signal for a specific setup is understood, the various things that affect the signal become less mysterious. There are also many points in the chain where the signal can get waylaid, and understanding the concept of how a path works can be helpful in audio troubleshooting, a skill all too frequently needed on the set.

**Ambience** The quality and character of the underlying sound in any given location is called **ambience**. The **acoustics**—or total effect of sound—of any space give the sound a distinct character, whether it is the muted sound in a plush bedroom, an echo-filled school gymnasium, or the cavernous sound of Grand Central Station. This ambience colors the dialogue and effects you are recording as well and will have a specific character in even the briefest silent stretches in a scene. Even if there is no discernible audio occurring, every space has distinct acoustic characteristics. One generally attempts to exclude as much ambient sound as possible. Ambience is distinguished from **background noise**, such as distant traffic, heaters, fans, and similar interfering sources—all of which must also be addressed (both concerns are discussed later in this chapter).
DAT is a relatively new technology that combines digital information encoding and linear analog storage. These recorders record digital information consecutively on a tape that is in many ways similar to a standard audiocassette. The shortcoming of conventional analog recording that the Nagra addressed with its revolutionary internal tone is that you cannot produce a perfect-speed analog recording. The DAT has finally overcome that inability; it is a perfect-speed recorder that, barring significant anomalies, will reproduce its speed every time it is played back. There is some question as to whether this former problem was really significant. The Nagra did, and still does, its job extremely well, but the analog world is fading fast and newer technologies will come to the fore by sheer momentum.

The key distinguishing feature of the DAT, and digital recording in general, is the near absence of any noise in the recording system. Analog recorders have inherent system noise, usually referred to as hiss, and digital all but eliminates this unwanted presence. DATs provide an exceptionally clean recording, however there are critics who have said it is too clean, lacking the warmth and ambient character of analog. Despite this, most sound mixers have opted for the security that less trouble-free signal provides. Another positive—one that relates to system noise—is that digital recording is not subject to generation loss. Although some limitations are being discovered, digital information can be copied many times without degradation of the signal. This is a particularly good feature because, as stated, sound is rerecorded a number of times in postproduction. DAT has also won wide acceptance because it is one more digital component in an increasingly digital postproduction landscape.

The downside of DAT recorders has been their tendency to respond poorly to climate extremes and other environmental factors. Extreme humidity has been known to render machines inoperable, and dust, cold, and heat have been problems as well. The newer DATs have addressed some of these shortcomings, but reliability remains an issue.

Beyond sync recording there is usually an extensive campaign for recording effects and music. This can be as simple as someone recording a local band or whipping up funky effects in the kitchen with a cassette recorder and mic, or it can be highly sophisticated audio studios recording a full orchestra or producing complex effects in a Foley studio. This phase can also involve narration sessions and the replacement of bad or inadequate dialogue. (See chapter 17 for a discussion of effects creation and automated dialogue replacement.)

**Microphones**

Microphones are classed by their *pickup*, or *polar pattern*, which refers to how a mic picks up sound from different directions in relationship to where the mic is pointing. The two types of mics that are generally available to students are omnidirectional and cardioid.

**Omnidirectional mics** pick up sound in a spherical pattern, that is, equally in all directions. See 11-8.

This approach is not particularly useful because of the more focused recordings required for sound in motion pictures. These mics do, however, have occasional applications. They can be useful for picking up the general sound, the ambience, of a scene or location. When held close to the mouth, they can also be used for voice in a reporting or interview situation. The ElectroVoice (EV) 635a is a typical example of an exceptionally durable omnidirectional mic used in field recording.
Cardioid, or unidirectional, mics pick up sound in a heart-shaped pattern, hence the name. They pick up sources in front of the microphone to the general exclusion of sources behind. See 11-9 in the familiar “shotgun” variation, cardioids are designed to pick up sound in a narrow angle. Because of the need to focus on specific sound, these short cardioids (short shotguns) and supercardioids (super shotguns) tend to be the mics of choice for location recording. See 11-10 Sennheiser, AKG, and a number of other companies make high-quality shotguns that are in common use.

Many different types of microphones are used in film production, but mics with narrow pickup patterns have obvious advantages. Traditional voice mics, such as the ones used by rock bands, are not suitable for film applications. They are meant to be put close to the mouth, which is unfeasible in most filming situations. The long shotguns, though physically impressive, are usually too much for interiors, their weight and size making them difficult to use in the often tight quarters of locations. Using a short shotgun indoors and a long shotgun outdoors is a common approach.

Shotgun mics are also used because their narrow pickup pattern excludes some amount of unwanted ambience or background noise. This has led to certain misunderstandings, however. Just because a sound originates from behind a microphone does not mean that it does not exist in some form in front of the mic. Sound is like water—or light for that matter: It flows into any area it is not completely blocked out of. If a sound is emanating from behind a microphone position, elements of it will be recorded no matter how dissipated. Shotgun mics do not eliminate unwanted sound, they simply lessen the impact.

Lavalier mics (lavs) are small clip-on mics that are frequently used for interviews, although they have a wide variety of applications in film. Lavs are not truly a class of mics, as they can be omnidirectional or cardioid, although most of them pick up in a cardioid pattern. One complication of using lavs in many film applications is that they have to be hidden. Many filmmakers leave them in plain sight in interview or documentary situations, but they must be concealed in other circumstances. This can lead to problems of muffling and the rustling of clothes.

Wireless mics, also called radio mics, have become increasingly popular in recent years. This mic is usually a lavalier plugged into a radio transmitter, which is clipped onto the back of the performer’s waistband, taped to the body, or placed in a pocket. The radio signal is sent to a receiver that feeds it to the recorder, usually into a mic input. These mics can be handy for long shots where effective conventional mixing is impossible or when the subjects are moving through tightly confined spaces.
Radio mics are useful for many applications, but their convenience must be balanced against their recording capabilities. The quality of the signal they produce is arguably lower than that produced by a conventional mic, mostly because of muffling and clothes rustle. Their use is also complicated by the interference of other radio signals. Many locations are so saturated with radio frequencies (RFs) that other signals, such as radio stations, CBs, and cordless phones, can get thrown into the mix. The higher-end mics have many of the bugs worked out, but the rental costs of these may be beyond the means of many independents and students.

Though there are a number of other approaches, dynamic and condenser microphones are the two most common types found in schools and arts centers. In a dynamic mic, the current—the mic signal—is produced by air movement within a magnetic field. The moving air created by sound hits a membrane in the head of the mic, and the resulting vibration generates the signal. Condenser mics, also called capacitor mics, require a source of power, usually a battery, that supplies the microphone head with a consistent electrical signal. In this case the consistent electrical signal is altered by the movement of air against a similar membrane.

A common method of powering condenser mics, as well as several other types, is the phantom powering system. Phantom mics are powered by the batteries in the recorder rather than an internal battery. In many applications mic cords have to be specially wired with the polarity reversed for the current to reach the mic. The phantom design is one you will encounter frequently.

Sound people tend to find a small number of mics with which they are comfortable and they can be very opinionated, with arguments about what constitutes the best mic getting emotional and vehement. You need to get past the hype to pick the right mic for a given situation. Try out as many mics as you can. Listen to mics side by side to get a sense of which one produces the cleanest and highest-quality signal. Remember that the recording chain is only as strong as its weakest link, and a good microphone is essential to a high-quality recording.

**Audio Connectors and Microphone Cords**

There are four basic types of audio connectors used in the United States: quarter-inch, mini, RCA, and XLR. You will occasionally find others, such as the banana plug, but they are generally associated with foreign-made, mostly European, equipment or specific brands. Japanese and American recorders tend to conform to the same standards.

Audio connectors and cords are all based on a simple connection. Most connectors have simple positive-to-positive and negative-to-negative contacts. On the standard plug-style connector, the tip of the pin is the positive, or “hot,” contact and the shaft is the negative, or ground, contact. **SEE 11-11** Microphone cords are equally straightforward. A simple cable has a single conductor surrounded by shielding—a metal mesh that encases the conductors for the length of the cable. The single conductor is connected from one hot contact to the other, and the shield is used to connect the grounds. All connections are soldered. The plug end of a connector is traditionally referred to as the male end, and the input end is referred to as female. Though some may find this usage of language peculiar or uncomfortable, it nevertheless remains the terminology of choice among audio people.

There are two types of audio inputs in general use in filmmaking applications: microphone and line. Mic inputs, of course, accept the signal from the mic. A line signal is of higher voltage and is exchanged either internally or between two machines. All the connections among recorders, mixers, and signal processors are line connections.

Mic and line connections are differentiated by the voltage level of their signal. Inputs are rated by their impedance, which refers to the designed resistance to voltage in the line. Low-impedance microphones and thus inputs are standard. Line inputs
Quarter-inch, or phone, plug The durable and heavy quarter-inch plug receives extensive use as both a mic connection and a line connection. Professional headphones are also usually equipped with a quarter-inch plug, also called a phone.
plug. The input requires quite a bit of dedicated space in the interior of the record deck, a possible reason why phone plugs are not as popular as they might be in consumer equipment.

**Mini plug** A *mini plug* looks like a smaller version of the quarter-inch plug. It is generally used as a microphone input on consumer cassette recorders and video cameras. Its major drawback is that it is not very durable, particularly on the input end, which is on the recorder or camera. The mini plug is also prone to being accidentally pulled out of the recorder. It is also a common headphone jack, though rarely found on professional equipment.

**RCA plug** The *RCA plug* is used almost exclusively as a line connection and is probably the most common type. It is found on everything from consumer stereos to VCRs. The center pin is the positive connection, and the sleeve is the negative connection. The sleeve also allows for a tight fit on the line input.

**XLR or Canon** The *XLR plug* has a three-pin configuration and is the standard mic connection on most professional equipment. Also known as the *Canon plug*, it is used for line connections in high-end studio gear as well. The XLR is the norm because the three-pin configuration incorporates a second conductor to connect the grounds and uses the shield to protect the signal from electronic interference. The hot contact carries the signal, and the ground carries its opposite.

**Banana plugs** These are used more frequently on European-produced equipment, particularly the Nagra. In a *banana plug*, the two leads are separated out into individual plugs. The plug has a flexible sleeve that contracts when inserted into the line input, thus holding it in place. The banana configuration is one of the key connectors used with the Nagra, although it does not show up that frequently on other equipment.

There are a number of other specialized pins, Tuchel pins and DIN pins to name two. *Tuchel pins* are used with the Nagra and often come with a threaded sleeve—a loose-fitting sleeve on the connector that screws into the body of the recorder. The *DIN pin* is a European connector found on older equipment, including the Ulter recorder, which was used extensively in sync recording.

*Adapters* convert one type of plug to another, from a male mini to a female RCA for instance. Anticipating all needs is always the goal, and having a good selection of adapters on hand can get you out of many tight situations.

Stereo and monaural (mono) are also important issues. The separate channel configuration of stereo, which consists of two separately recorded tracks on the same tape played back simultaneously, has become such a standard in home audio systems that the old single-signal mono has almost been forgotten by consumers. Until recently, recorders designed for films recorded in mono, because all individual sounds are treated separately in editing and the final product is usually mono. Advanced theatrical sound systems and transfers to video have complicated this issue, and sound for film is still frequently recorded in mono. Given that so much audio equipment is set up for stereo, this can cause problems in matching equipment so that the signal is both transferred and monitored properly.

In line connections, the stereo signal is handled by two separate conductors, particularly the familiar, paired *stereo RCA* cords. There are single cords designed to carry the stereo signal, particularly quarter-inch and mini headphone plugs. As with a mono connector, the tip carries one channel; the shaft of the connector has a band just below the tip which is the contact for the second channel. The stereo cable has a separate conductor connected to this second contact. Stereo headphones plugged into a mono headphone jack will produce sound in only one ear. Adapters that convert the mono signal so that it can be heard on stereo headphones are handy to have when different pieces of equipment are being used.