THE PA BIBLE

ADDITION NUMBER EIGHT
MICROPHONE TECHNIQUES

Electro-Voice receives many inquiries regarding the selection and application of microphones. These questions can be very specific, such as "what model microphone should I use with a B-flat clarinet", or very general as, "recommend a good vocal microphone". It is very difficult to adequately answer these questions in a letter or telephone conversation. We hope that the following information will fill in the blanks in our responses.

This addition is divided into two sections, moving from the general to the specific.

In Section I microphone technique is analyzed to establish a basis for making specific judgments, with emphasis on the live performance of a contemporary (pop/rock) music group.

In Section II some specific microphone setups are described and the techniques involved considered.

Throughout this addition we assume that the microphones selected are operating properly, and that they are correctly matched for level and impedance. Our discussion will concentrate on the decisions of selection, placement and quantity, choices the user can make to affect the quality of sound.

SECTION I

In PA Bible Addition No. 3 different types of microphones are discussed, and some guidelines for selection are suggested. (The material in Addition No. 3 relates closely to the subject of microphone technique and the reader may wish to reread No. 3 as an introduction to the present addition.)

While the information in Addition No. 3 is involved in the selection of a microphone, it is not sufficiently specific to a given application. To achieve the "right" sound we need to choose a microphone with a specific frequency response and a specific directional characteristic.

In any microphone application we are concerned with sounds that we want to "hear" and sounds that we do not want to "hear". For example, we may accentuate bass frequencies of the voice that we want to "hear'% while, in a different situation, we may reduce bass frequencies to eliminate acoustic noise and reverberation that we do not want to "hear". In a similar way we may use a directional microphone to favor the pickup of sound we want to "hear" and eliminate unwanted sounds.

Directional Microphones. As suggested above, a directional microphone can be used to avoid the pickup of distracting, undesirable noises. By reducing the pickup of off-axis sounds, a directional microphone reduces the amplitude of undesirable sounds such as noise, reverberation, or music from an adjacent instrument or a vocalist.

The most commonly used directional microphones belong to the general class referred to as cardioid microphones. This class includes microphones with cardioid, hyper-cardioid, and super-cardioid polar patterns. Plots of these patterns are shown in Figure 1. The super-cardioid and hyper-cardioid microphones have a broader rejection in the back hemisphere and a greater overall rejection of random sounds, but there is the penalty of a back lobe. The hyper-cardioid microphone, because it is only down 6 dB at 180 , is less widely used than the cardioid and super-cardioid microphone. In some applications it is desirable to reduce sounds that arrive from a specific, known direction. As the polar plots show, these microphones can be "pointed" so that the null rejects sounds from a specific direction. Thus, pickup of direct sounds from adjacent instruments can be reduced by aiming the microphone so that the angle of lowest sensitivity points towards these instruments.

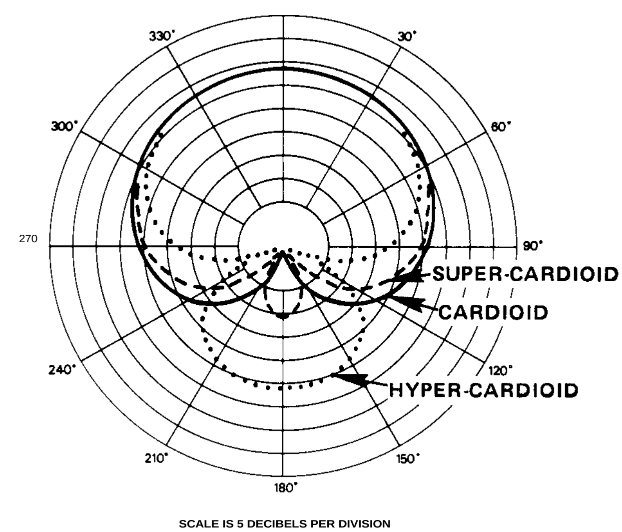

FIGURE 1 - Cardioid Polar Patterns

Directional microphones can also be used to reduce the pickup of sounds with a random directional character, such as noise and reverberation. This is especially true indoors where sounds are sustained, forming a reverberant field.

Thus, we can generalize that a directional microphone should be selected when it is necessary to isolate a sound source or to reduce room reverberation and ambient noise. It is also true that a directional microphone will allow a more distant placement. This is particularly true of a microphone with high directional characteristics, such as a line microphone.

In this regard, it might seem logical to always select the most directional microphone, such as a line microphone. However, line microphones are limited to long pickup distances because of their large size, and variation in directional characteristics with frequency.

A related question is "why not always use a directional microphone?" The following discussion will lead us to the answer "that there are characteristics of non-directional microphones which are advantageous in certain applications".

Non-Directional Microphones. The reasons for using directional microphones relate to their cancellation of unwanted sounds and their proximity effect (discussed later). Unfortunately, certain problems unrelated to the pickup pattern result from the construction of directional microphones. For this reason non-directional microphones (often called omnidirectional) are recommended because they can offer the following advantages over a directional microphone:

1. Less mechanical noise.
2. Less wind noise.
3. Less breath noise.
4. Wider bandwidth.
5. A more accurate pickup of reverberant sounds.

Weighing these advantages against those of a directional microphone is difficult. It is the old story of "apples vs. oranges". Often the decision is one of finding the least objectionable choice, or selecting an onni-microphone because of its simplicity and lower cost.

Frequency Response. In selecting a microphone to give the "right" sound, it is important to choose a microphone with the proper frequency response.

To record a pipe organ it is essential that the microphone selected respond to the very low frequencies of the organ, that the bandwidth of the microphone match that of the source. However, using the widest bandwidth is not always correct. Limiting the bandwidth of the microphone discriminates against noise sources, such as air conditioner sounds and reverberation sounds in large enclosures. These sounds can often be reduced by the attenuation of low frequencies, without affecting the higher frequencies associated with the human voice. This attenuation can be a part of the microphone design.

Finally, adjustment of frequency response can be used to enhance certain frequencies, usually to give a special "artistic" effect. This enhancement is often characterized by a boost of the bass frequencies called proximity effect, as discussed below, or by a broad peak in the 5 kHz region which projects the upper range of the human voice.

Proximity Effect. Proximity effect is the microphone characteristic that results in a boost in bass frequencies for close microphone spacing.

All cardioid type microphones exhibit a proximity effect, but by vastly different degrees. Single-D cardioid microphones exhibit substantial low frequency boost, while Variable-D cardioid microphones minimize this effect.

Two positive benefits of proximity effect are: (1) an enhanced artistic effect resulting from the tonal coloration of the voice and the control of this coloration by the performer and/or operator; and, (2) an increase in "gain-before-feedback" in sound reinforcement use. The enhanced low-frequency response of Single-D microphones has become something of a standard for live-performance vocals, and is sometimes a desired effect in recording studios as well. Single-D microphones are often designed specifically to provide a balance of enhanced bass response coupled with enhanced response in the 5 to 10 kHz frequency range. There are precautions, however, which should be noted when using Single-D microphones.

1. The increased gain-before-feedback should be viewed as an increase in loudness that accentuates low frequencies, and the microphone should be used close to the source for maximum increase.
2. The low frequency boost at 1/4 inch is not the same as that at 1/2 inch; and, in fact, diminishes from lips to about eighteen inches. Proximity effect makes these microphones sensitive to position, and therefore, control of position is essential to achieve the desired sound quality.
3. Single-D microphones can be notorious noise makers in the wind, including the wind from the mouth.
4. The spectral characteristics of Single-D microphones can vary from one model to another, and because artistic results are usually involved, the selection of a specific model can be both significant and meaningful to the result.

As these precautions indicate, the Single-D microphone is not for everyone or every microphone; and that is why Electro-Voice invented the Variable-D microphone, a different tool.

Variable-D microphones have considerably less proximity effect than Single-D microphones. Variable-D microphones are used where proximity effect is not desirable, but rejection of sounds is desired. In P.A. uses, where the microphone is not used close to the source, the Variable-D microphone provides improved gain-before-feedback compared to Single-D and omnidirectional microphones. In recording, isolation of sources and reduction in reverberation pickup also make the Variable-D microphone a correct choice.

PLACEMENT

Having selected an appropriate microphone type, good technique requires the correct placement of the microphone. Correct placement involves finding the "right" angle and distance of the microphone position relative to the source.

Angle. Choosing a particular angle from the microphone to the source requires a knowledge of the radiating characteristics of the source; knowledge of the effects of objects near the source and microphone; and knowledge of the microphone polar characteristics. Musical instruments are usually composites of several sources, each with different spectral and radiation characteristics. This complexity needs to be recognized and taken into account. More on this in Section II.

It is obvious that objects between the source and microphone should be avoided. Most users recognize that a "shadow" effect results from such objects. Not as obvious is the effect of an object adjacent to either the source or microphone. Reflections from such objects "color" the sound in a complex relationship involving size, wavelength and transit time, and can result in creating both peaks and dips in the output of the microphone.

Distance. The distance from the microphone to the sound source is often a critical factor in determining sound quality.

As sound radiates outward from a source, it decreases in intensity, and with increasing distance there is a corresponding reduction in microphone output. A degradation in the ratio of desired sounds to unwanted sounds results as microphone spacing is increased. Thus, problems with reverberation, wind noises, mechanical noises and particularly feedback become more difficult. To avoid these problems, placing the microphone close to the sound source is a good starting procedure. The consequence is a good signal-to-noise ratio, excellent isolation, and the individual control of multiple microphones. These effects relate to the prevalence of "close miking" in the recording and sound reinforcement of popular music. The tight, isolated sounds resulting from this spacing permits the control and manipulation that is desired.

Close spacing is often only a starting procedure, however. As indicated in the discussion of angle, musical instruments often have multiple sources. Microphone placement too close to one of these sources can alter the perceived character of the instrument. Moving the microphone away results in a more balanced pickup by reducing the differences in distances from the various source locations to the microphone, i.e., close spacing requires control of the microphone position. Being close, small changes in spacing can cause large changes in microphone output. For moving sources such as a clarinet or saxophone, maintaining a fixed, close, position may not be possible.

The above factors tend to move the microphone placement away from the source. A factor that often mandates moving the microphone location is visual distraction. Some visually oriented activities, such as television and motion pictures, will not tolerate a microphone in the field of vision. The result is a reliance of specialized products, such as line microphones. In the extreme, no microphone position is adequate and "dubbing" results.

A common result of moving the microphone away from the source is the increase in reverberant content when "miking" indoors. When some reverberant sound is desired, microphone spacing can be adjusted for the desired content.

Feedback in public address applications is a complex subject involving many factors, one of which is microphone placement. In this regard, a rule that applies to microphone placement is that it should be located in the direct sound field of the performer, and in the reverberant sound field of the loudspeakers; i.e. the microphone is placed near the performer, but far from the loudspeakers.

One specialized placement that has found favor lately is to position the microphone close to a large reflective surface, especially in locations where such a surface cannot be avoided. An excellent example of this technique is the mounting of the microphone near the stage floor in miking stage plays. Elimination of the reflections of sounds off the floor results in a substantial improvement in the sound pickup quality. Spacing to the floor should be in the size range of one-half inch or less.

NUMBER OF MICROPHONES

Proper placement and correct selection may not be a sufficient microphone technique. More than one microphone may be required. Just when and where more than one microphone should be used is the subject of this section.

Redundancy is occasionally a requirement, as when separate house feeds and broadcast feeds are used. Placement in this case is no problem, and there are no restrictions in using separate microphones for each feed.

By contrast, where two microphones are connected additively, the microphones should be mounted very close to each other or spaced sufficiently apart to avoid phase cancellation. If the microphones are placed so that the sound arrives at both microphones with comparable amplitudes, and if the microphones are spaced at different distances from the source, then phase delay occurs. This phase delay introduces a noticeable degradation in the signal. A useful rule to reduce this effect is the three-to-one rule. By spacing the microphones apart three times the distance to the source, phasing will not be a problem.

Isolation and control of sound sources is a primary reason for using multiple microphones. The use of a separate microphone to pick up crowd noise is a good example. Another is the pickup of individual sources within a group. Common in recording, this technique permits balance and the use of special effects, and permits experimentation in obtaining a desired sound.

The pickup of instruments, such as the piano, often requires more than one microphone. The instrument may be large and have multiple polar patterns associated with different parts of the instrument, requiring separate physical locations for pickup.

A mix of a "tight" close sound and the reflected, "open" sound can readily be adjusted using two microphones. Phasing in this instance is not a problem because the microphones "hear" different sounds.

A stereo signal is an obvious source for the requirement for two or more microphones. Several stereo recording systems use coincident microphone pairs, such as the MS and XY systems. The ORTF system uses a pair of cardioid microphones, separated by 17 cm and angled 110 °. Other systems use microphone pairs, special microphones, and spaced microphones to produce the stereo signal. Each of these systems have well defined requirements for the number and type of microphones used in the basic system.

HINTS AND OTHER MISCELLANY

There are some additional subjects bearing on microphone technique that need mentioning.

Elimination of Distracting Signals. Air movement past a microphone, whether it be caused by motion of the microphone or by breath blasts or wind, can cause distracting, noise-like microphone outputs. Windscreens are provided for such problems and should be used as they are very effective.

Mechanical excitation is a frequent source of unwanted microphone signals. Tapping the case of a microphone can produce an electrical output, as, for example, the "click" of a performer's ring while holding a microphone. Shock mounts, both internal and external to the microphone, are available to the user. The user should be aware of the available accessory shock mounts and the sensitivity to mechanical shock of the microphones he owns. In general, omnidirectional microphones are less shock sensitive than directional types; and condenser microphones are less shock sensitive than moving coil (dynamic) microphones.

Special Microphones. Certain special microphones are available to the user to improve microphone technique.

Microphones that have special spectral characteristics for the human voice, such as the 635A, are available.

Lavalier microphones permit the fixing of microphone distance where movement is a factor, and these microphones have special spectral characteristics to match their position near the user's chest.

Line microphones, such as Electro-Voice Cardiline® microphones, have polar patterns narrower than cardioids, and are especially useful for pickup of sounds at greater than optimal distances, as in boom mounts in TV and motion pictures.

Some General Guidelines. There are some characteristics of microphone sources and environments that allow general guidelines to be stated for some applications.

For use out-of-doors, where the microphone is handheld, the non-directional microphone is an excellent choice. The non-directional microphone does not color the sound, and has low sensitivity to wind and mechanical shock.

In sound reinforcement applications, especially for handheld uses, the Single-D microphone can offer significant gain-before-feedback amplification. This result, however, includes the bass boost that is associated with Single-D microphones, and the specific microphone and user should be tested in the intended environment.

In extremely noisy environments, noise cancelling, close talking microphones can improve communications. These are special microphones, designed for voice communications. They are subject to breath noises and spacing control is essential; but they do work well in very noisy environments, as in a helicopter.

The microphone, as a tool to assist in the recording or reproduction of an artistic performance, poses a challenge to microphone technique. Appreciation of classical music in live performances is dependent upon receiving reflected sounds, and in recording classical music the inclusion of reflected sound is essential. For this reason symphonic orchestras are usually not miked close; but, rather, with microphone placements that achieve a balanced pickup, including reflected sound. Therefore, multiple microphones are often required to achieve the correct balance for the complete orchestra. It is essential that phase interference resulting from a source that is "heard" at two different microphone locations, not equally spaced, be avoided. Since the bandwidth of the microphones should match the spectrum of the instruments, very wide bandwidth microphones should be used.

The recording and reproduction of popular music tends to be creative, as opposed to the realism sought in classical recording. Balance is achieved in the "mix". Reverberation can be added artificially or with separate microphones. Close miking is used extensively to provide separation of instruments and allow control of the balance. Close miking allows the use of more than one microphone on an instrument to control the "sound" of the instrument. Microphone selection and placement under these conditions permits more selection and variety. The microphone can be a part of the performance in the sense that it can be selective in its pickup due to placement, directionality, bandwidth, and proximity effect.

A potential problem with close miking is the change in level with microphone position. Since the microphone is close, small changes in the distance to the source can cause large level changes.

A technique that is used to avoid this problem is to mount the microphone on the instrument. Two precautions should be observed when doing this: the microphone pickup will be selective in the sound that it picks up, and the microphone may need to be shock mounted to eliminate mechanical drive from the body of instrument to the case of the microphone.

For general guidance in selecting microphones, the guide shown in Figure 2 can be useful.

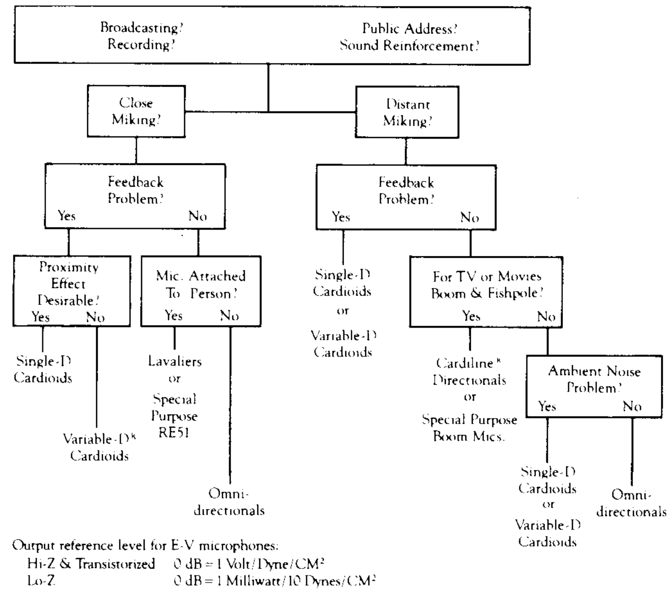

FIGURE 2

Microphone Application/Recommendation Chart

SECTION II

In Section 1 the elements of technique were analyzed without reference to a specific application. In this section a specific microphone installation will be discussed.

Figure 3 shows a hypothetical stage setup for a small music group consisting of a drum, electric/bass guitar, piano, vocalists, and acoustic guitar. The particular microphone installation shown consists of eight microphones: two for vocals, one for the electric/bass guitar, one on the piano and acoustic guitar, and four on the drums.

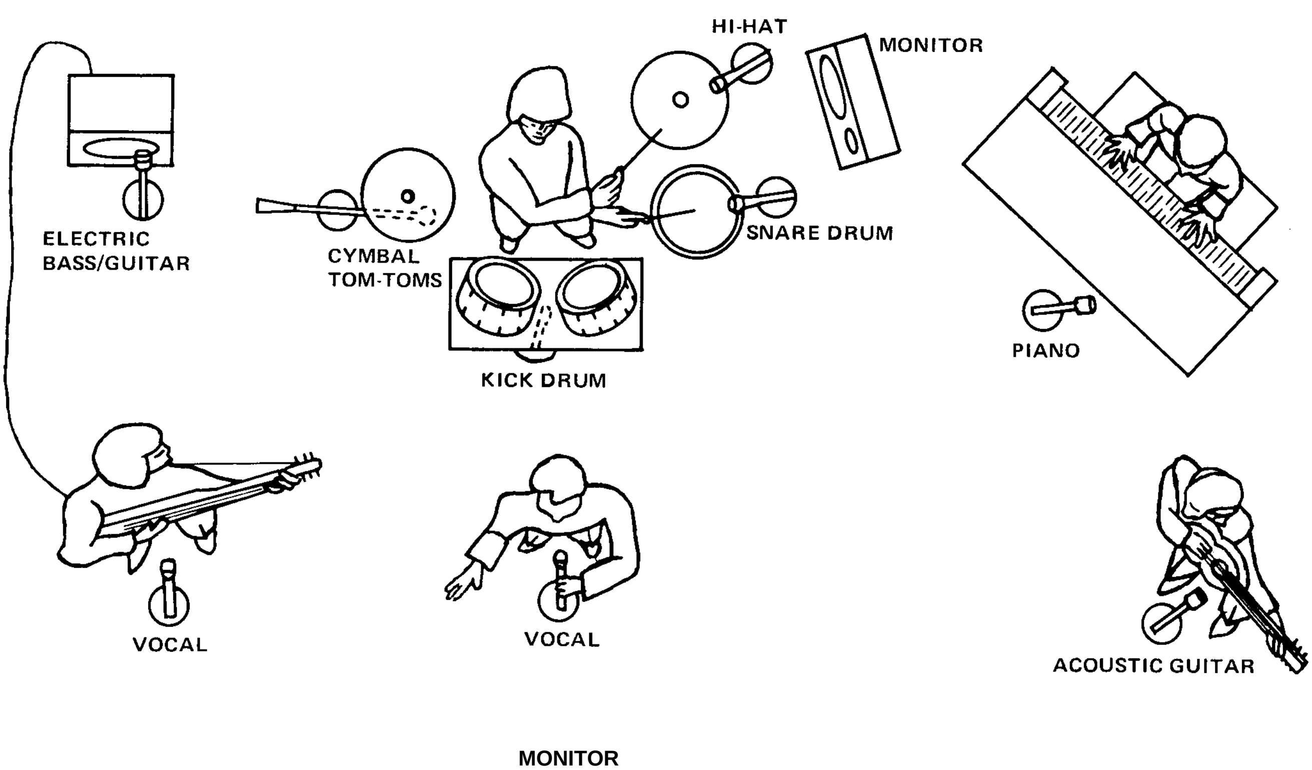

FIGURE 3 - Musical Group Layout

The grouping of the instruments follows standard practice, with the drummer at the rear center and main vocalist center front. The lower volume instruments have been placed together, away from the amplified instrument.

Because this is a P.A. setup with high sound levels involved, close microphone spacing is used throughout. **Wherever possible, cardioid microphones have been placed so that the "dead" spot is pointed towards the nearest stage monitor,** or other instrument. The P.A. speakers should be placed out front and to the sides of the group, taking care to avoid directing them toward close reflecting surfaces.

Vocalist Microphones. Single-D, cardioid microphones are recommended for vocal use. The microphone should be stand-mounted, as shown in Figure 4, or handheld, so that the cardioid dead spot is pointed towards the stage monitor, which would normally be placed in front of the vocalist. Recommended Flectro-Voice microphones include the PL80 (preferred), PL91 A, PL76A, and PL77A, with the PL95 being considered for maximum gain-before-feedback. Both microphones should be the same model to avoid the need for level and equalization compensation at the mixer.

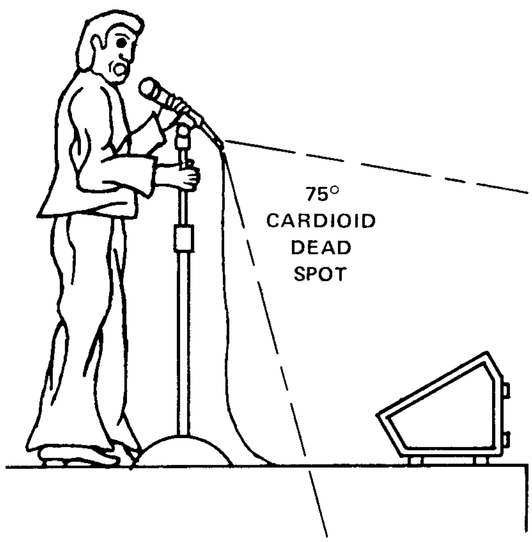

FIGURE 4 - Vocal Microphone Use

For the out-of-doors installations, the Model 376 windscreen should be available.

Electric/Bass Guitar Pickup. Place the microphone very close to the guitar loudspeaker at a point midway between the center and edge of the cone. (See Figure 5.) Select one speaker out of a cluster of identical speakers. A Variable-D cardioid microphone. such as the PL6, or PL11, has been selected fur its excellent polar response and smooth, flat frequency response.

Piano Microphone. A single, Variable-D cardioid is shown mounted oil a floor stand close to the soundboard (Figure 6). A second microphone, if **available, could improve the balance by allowin**g separate microphones for bass and treble, Variable-D cardioids arc recommended.

Acoustic Guitar. Because of the low amplitude of this instrument, pickup is difficult. The microphone, a cardioid Variable-D is floor-mounted below **the** band **upwards** toward the hole. (Sec Figure 7 meat is essential, but realistically must allow, for f the instrument. \, previously suggested po the **microphones** tward the nearest stage ()Use 1'. \ . if closer)

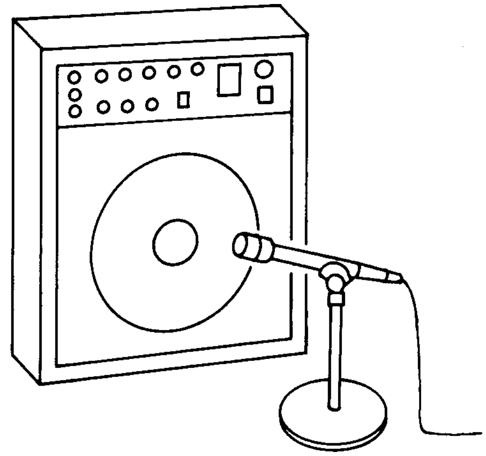

FIGURE 5 - Amplified Guitar Microphone Placement

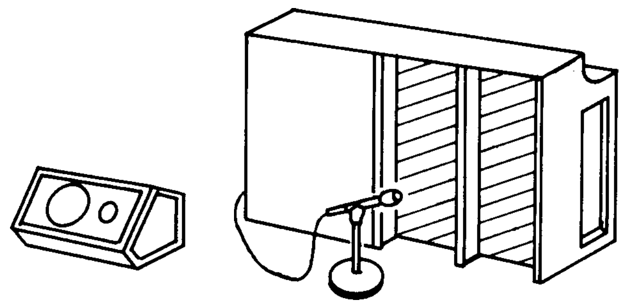

FIGURE 6 - Piano Microphone Placement

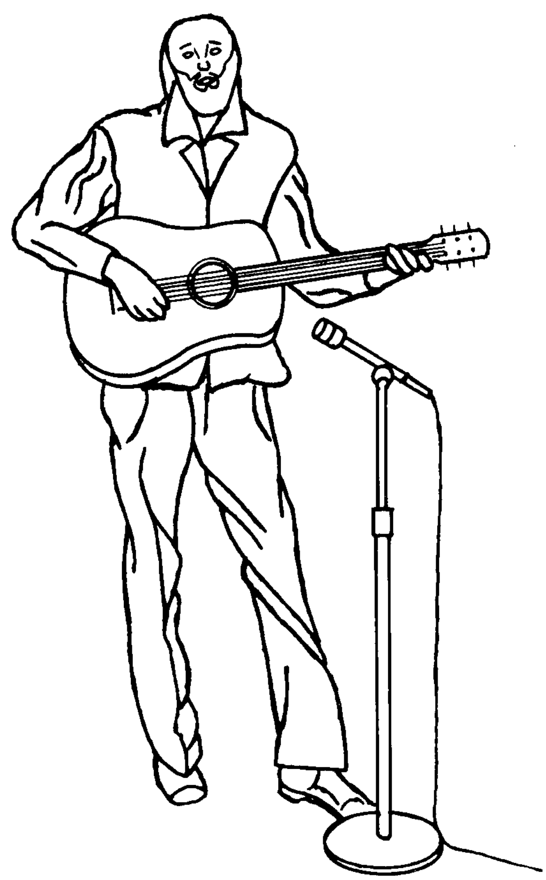

FIGURE 7 - Acoustic Guitar Microphone Placement

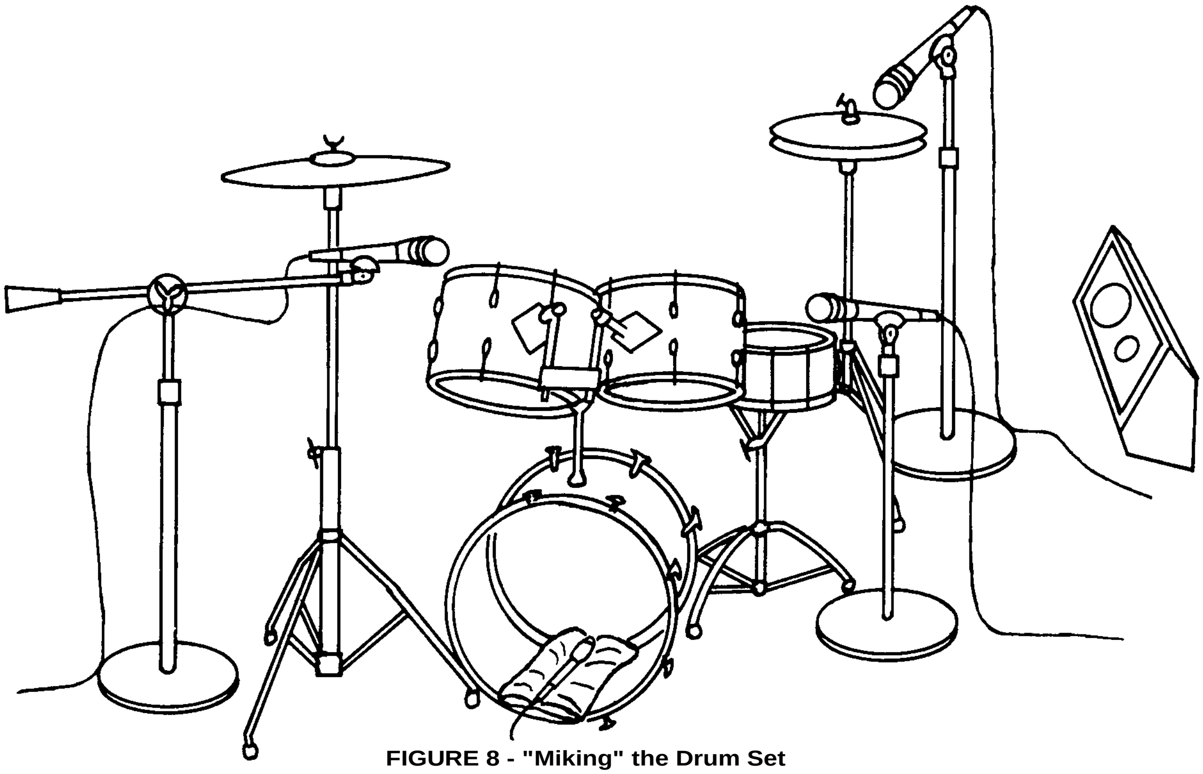

FIGURE 8 - "Miking" the Drum Set

Drum Microphones. Considerable variation in the number and placement' is possible in miking drums. In the setup shown in Figure 8, four microphones are used; one for "kick" drum, one for hi-hat, one for snare drum, and one for tom-toms and cymbal.

The "kick" drum microphone, an omnidirectional dynamic such as a PL9 or PL5, is placed on a pillow inside the open end of the drum. A variation that is sometimes used is a PL20 (Variable-D cardioid) on a floor stand pointed into the open end.

Because of high frequencies generated by the hi-hat, cymbals and snare drum, a condenser cardioid microphone is recommended. The Electro-Voice PL77A, and CS15P, are good choices.

The snare drum microphone is mounted above the drum, opposite the strike area, with the front of the microphone protruding over the edge of the drum. A technique which is very effective, if an additional microphone is available, is to place a second mike below the snare drum just inside the rear plane.

The hi-hat microphone is mounted opposite the strike area, above and to the side of the top cymbal.

The microphone used with the cymbals and tom-toms is mounted below the cymbals, pointed towards the tom-toms, using a 90° pickup for the cymbals.

CONCLUSION

Not all readers will find **the specific microphone placements** in our example applicable to their own requirements. For those readers we recommend experimenting with different techniques, following the guidelines listed in Section I. One precaution for our technically oriented readers: involvement of someone responsible for an artistic result is essential.

Trying different microphones, altering placement and critically evaluating the resulting sound is the heart of microphone technique, and the development of a critical "ear" an essential element. Knowledge, experience, experimentation and a critical ear will result in judgments that comprise good microphone technique.

For readers wishing more information, the following publications are recommended:

1. Lou Burroughs, "Microphones: Design and Application", Sagamore Publishing Company, Plainview, New York, 1974.
2. Alec Nisbett, "The Use of Microphones", Focal/ Hastings House, New York, 1974.
3. Bruce Bartlett, db, December 1980, p. 32.
4. John M. Eargle, db, December 1980, p. 38.
5. Electro-Voice, Inc., PA Bible, Addition No. 3.
6. Carson C. Taylor, Journal of the Audio Engineering Society, September 1979, Vol. 27, No. 9, p. 677.
7. John M. Eargle, "Sound Recording", Van Nostrand Reinhold Co., 1976, p. 129-137.
8. John Woram, "The Recording Studio Handbook", Sagamore Publishing Company, Plainview, New York, 1979, Ch. 4.
9. Bruce Bartlett, Recording Engineer/Producer, June 1980, p. 82.
10. Bruce Swedien, Modern Recording, August 1978, p. 50.
11. Wieslaw V.R. Woszczyk, Recording Engineer/ Producer, October 1979, p. 78.

We would appreciate receiving your comments about this addition or about topics for future additions. Please send your response to:

PA Bible
Electro-Voice, Inc.
600 Cecil Street
Buchanan, Michigan 49107

Elecfrol/oice®- company

600 Cecil Street, Buchanan, Michigan 49107

8234 Doe Avenue, Visalia, California 93277
Electro-Voice Div., 345 Herbert Street,
Gananoque, Ontario - Electro-Voice, S.A.,
Romerstrasse 3, 2560 Nidau, Switzerland