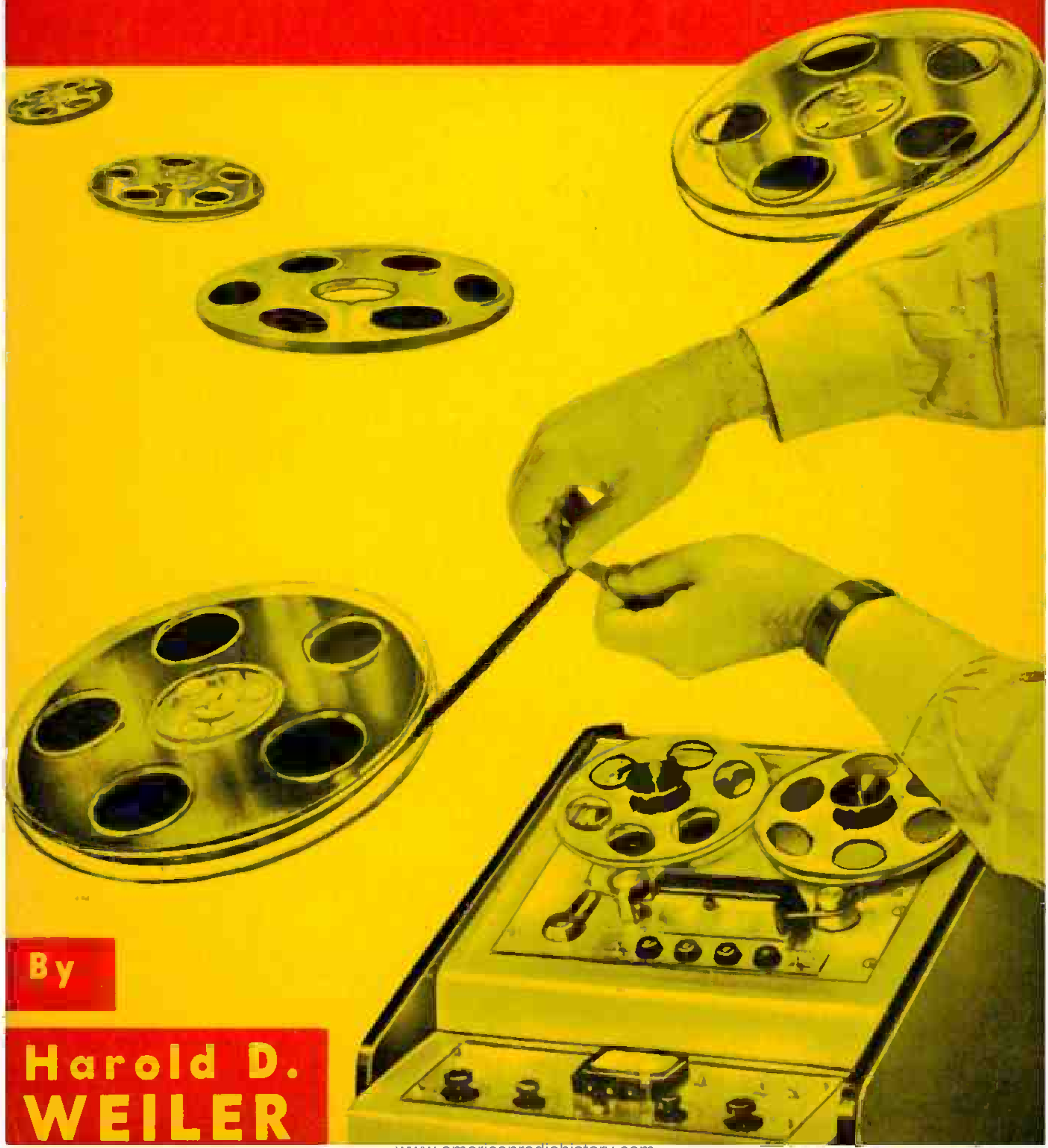
TAPE RECORDERS AND TAPE RECORDING



By

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Tape Recorders
and
Tape Recordings

By

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Introduction

THIS BOOK was written for the amateur and semi-professional recordist. It is presented as a source of practical information on all aspects of tape recording. It is dedicated to the millions of recorder owners who are sincere in their desire to obtain the finest reproduction of sound their recorders are capable of producing.

It is not a technical treatise written in the language of the engineer. On the other hand, it does cover those fundamental principles whose understanding is necessary if you are to realize the full potential of your tape recorder. But, while the subjects may be technical in nature, the explanations are couched in simple, every-day words. Not only does this apply to the tape recorder itself, but also to microphones, mixers, filters, and all the other accessories which will help you to make better recordings. Illustrations are used to add to the graphic quality of the text.

In preparing the manuscript the author has given full consideration to the extent to which the modern tape recorder has been integrated into our daily scheme of living. In the home the tape recorder has become an entertainment center. It is also an unequalled means for improving the speech habits of children. In schools and colleges tape recorders are rapidly finding their way into virtually every classroom where their value is almost without limit. Amateur musical organizations, such as choral groups and community symphony orchestras, are using tape recorders to preserve their performances with a degree of fidelity equal to that of the finest commercial phonograph record.

A recent compilation of uses for a tape recorder lists more than twelve hundred applications. You can build a library of fine music recorded off the air. The sounds of children's voices may be preserved as heirlooms. Treasured records may be re-recorded before they become worn or scratched. After-dinner speeches may be dictated and auditioned before the fateful moment of their delivery arrives. Children may be instructed in better diction by hearing themselves as others hear them. Synchronized sound may be added to your home movies. Cherished moments of family history, such as weddings, may be recorded and re-lived through the years. The list is virtually endless.

When you purchased your tape recorder, all these and many other fascinating experiences were placed at your command.

In a sense, your tape recorder might well be compared with your camera. Simple enough for a child to handle, nevertheless it will not take good pictures unless it is in the hands of one who is capable of operating it intelligently. With a tape recorder the overexposed picture becomes the distorted recording; the fuzzy picture has its analogy in the recording made with the microphone too far away from the performer. As in the case of the camera or any other piece of fine equipment, the results you obtain from your tape recorder will be governed entirely by your knowledge and experience as a recordist – in other words, your recording "know-how."

This "know-how" is yours in the pages which follow.

Harrie K. Richardson
Associate Editor, AUDIO
March, 1956

To Marie

The Most Patient Wife in the World

Chapter 1

Sound-What It Is

NINETEEN FIFTY-FOUR, which incidentally was the seventy-fifth anniversary of the first recording and reproduction of sound by Thomas Alva Edison, witnessed a tremendous revival of interest in this medium of entertainment. The primary reason for this renewal of interest is unquestionably due to the realism with which recorded and broadcast music can now be recreated in your own home. Records and radio, of course, have been available for many years. However it was not until recently that they could bring you more than the mere shadow of an original performance. Only since the end of World War II has the transmission and reproduction of sound progressed to a point where it is possible virtually to create an acoustic facsimile of the original performance of a favored concert or opera.

The same period of time which witnessed these improvements in transmission and reproduction also saw an equal number of important advances in the recording of sound. An outstanding example is the modern tape recorder. Because of these improvements, it is now possible to obtain recordings from an inexpensive home recorder that are superior to those which could be obtained from even the finest professional equipment of not too long ago. The superiority of tape recording becomes still more evident when we discover that today all of the record companies use tape exclusively for their original recordings. After the tape is made and carefully edited, the recorded sound is transferred to a disc master as shown in Fig. 1-1.

The modern tape recorder, an outstanding example of which is

Fig. 1-1. Transferring recorded sound from magnetic tape to a master disc. (Photo Courtesy of Columbia Records, Inc.)

illustrated in Fig. 1-2, has been so simplified that it is now easier to operate than many ordinary electrical appliances found in the home. All that is required to make high quality recordings, in addition to the recorder itself, is a little knowledge and some experience.

Unfortunately, since tape recording is a comparatively new field, information on the subject has appeared mostly in professional trade publications devoted to the electronic, broadcast, motion picture or commercial recording industries. The articles which have appeared, in addition to being highly technical, have usually been confined to some specific application in the fields covered by the various publications. In short, it has been rather difficult for anyone interested in tape recording to acquire more than a rudimentary knowledge without a great deal of research. We will attempt to rectify the situation with this book and try to provide the information necessary to obtain maximum efficacy and satisfaction from any tape recorder.

Experience is both simple and inexpensive to acquire. One of the many advantages of recording on tape is that it costs nothing to gain this experience. Rarely does any medium allow its users to correct errors, eliminate mistakes, add to or subtract from the orginal work or, if necessary, erase it completely and start over again using the original material.

When the user is armed with a little knowledge, which we hope to provide, and obtains some experience, a tape recorder can become much more than a toy or a novelty to be used for amusement at parties and stored in a closet until the next party. One tape recorder manufacturer recently listed over twelve hundred ways to use a recorder. A few of the most valuable and interesting follow.

A library can be built up of music recorded off the air. For those interested in serious music, unforgettable moments of the concert stage and the opera may be recorded and preserved. Rare perfor-

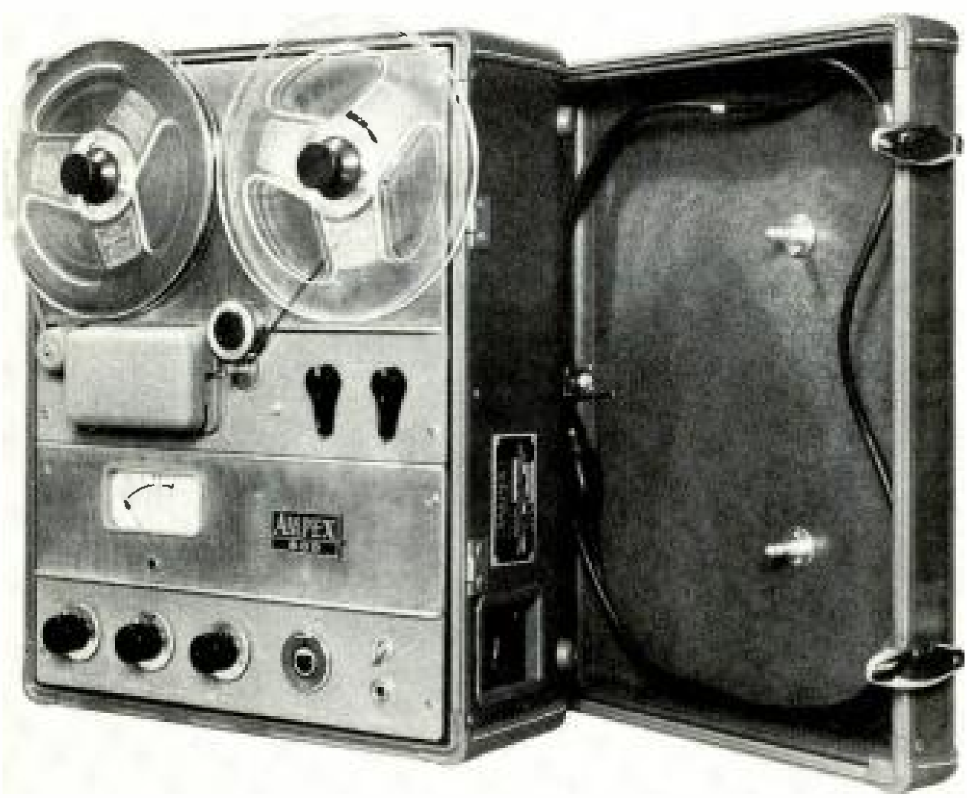


Fig. 1-2. Ampex Model 600 portable tape recorder.

mances of selections not otherwise available may be recorded. For those interested in regional music, a tape recorder can provide what is often the only method of collecting the finest in the field, since much of this music is not commercially available. The local radio station is an inexhaustable source of material and its program director will usually cooperate and advise you of impending broadcasts of special interest.

Popular music may also be recorded, and those selections which become boring thru constant repetition can easily be erased and that section of the tape reused for a later release. Any live performance from a good broadcast station may be recorded with a quality which rivals the finest commercial records.

Valuable phonograph records may be transcribed to tape before they become worn and scratched. In fact, damaged records may be recorded on tape and the annoying sounds due to cracks and gouges can be eliminated, restoring to listenability what may be an irreplaceable collectors' item. Older 78-rpm records may be recorded on tape and the annoying pauses between sides and records eliminated to provide an uninterruped program. Much of the noise on these early records, which may mar an otherwise perfect program, can also be eliminated while re-recording on tape.

Home sound movies, heretofore prohibitively expensive, are available to anyone owning a tape recorder. Sound effects, speech or music may be recorded simultaneously with the picture taking, or sound may be added to pictures taken previously. A tape recorder may also be used for narration and sound effects while showing color slides.

Tape recorders are utilized extensively as valuable tools for music teachers and students. A recording will allow the pupil to hear himself as others hear him. The author recently had an interesting experience regarding this particular application. A neighbor's boy who plays the guitar was recorded, and it was only natural that he perform a favorite number which he assumed he played well. He was flabbergasted when he heard exactly how he sounded. There is no question that this incident will be extremely helpful to both the pupil and his instructor.

Our previous paragraphs stressed the need for knowledge and experience on the part of the user if he is to obtain full satisfaction from his tape recorder; this point cannot be too strongly emphasized.

The author has taken part in many recording sessions in which the equipment used was the conventional home recorder, but during which the temporary guest operator was more familiar than the owner of the machine with the microphone technique and placement. The owner, upon hearing the results achieved, was invariably surprised and pleased to learn that his recorder could operate so well. Yet the only difference was in the knowledge and the experience of the guest operator.

THE NATURE OF SOUND

Since the function of any tape recorder is the recording and reproduction of sound we should begin by learning something of the nature of sound. Because it will be extremely helpful to acquire an elementary knowledge of the sounds we wish to record and reproduce the remainder of this chapter will be devoted to explaining in a simple manner just how sound is created, its method of travel and some of its other characteristics. This basic information will greatly simplify our future explanations.

The word *sound* has two definitions. It describes both a cause and an effect. Sound is the sensation which is produced when the ear stimulates the brain through the nervous sytem. Sound is also the physical effect which produces this stimulation through atmospheric disturbances. We are, for the moment, interested in the physical effects which create sound.

Sound is created when the atmosphere is set into motion by any means. Any vibrating body can produce sound by imparting a portion of its energy to the atmosphere surrounding it. The vibrating body may be a string as in a violin or a piano, a stretched membrane as in a drum, the reed in a clarinet, a tuning fork, a human vocal cord.

Since a piano is a common source of musical sound and readily available to almost everyone, this instrument will be used to illustrate the majority of the elementary principles of sound. We will use it as an analogy in many of our future discussions.

If you open a piano and pluck one of the strings, it will produce a sound. Should you look at the string after it has been plucked you will find that it appears blurred. This is because of its rapid to-and-fro, or vibrating motion. Holding a finger lightly against the string will enable you to feel the vibration. Should you stop the vibration the sound will cease.

The manner in which a vibrating body creates sound can easily by shown by analyzing just one to-and-fro motion of the surface of a simple vibrating body such as the membrane, or skin, on a drum after it has been struck. The outward motion of the membrane compresses a layer of air as shown in Fig. 1-3(A). This compression increases the atmospheric pressure of this layer of air to a point where it is above normal.

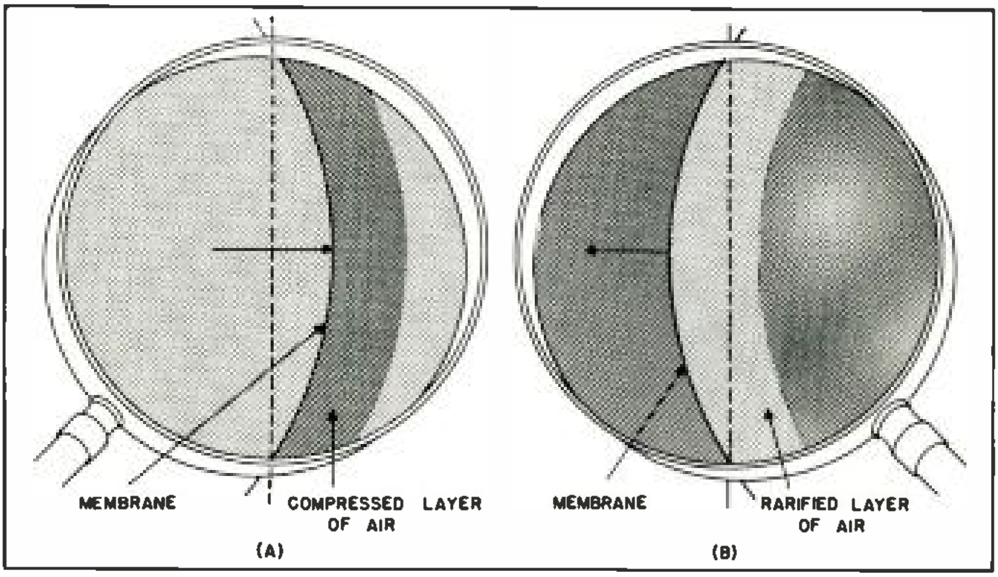


Fig. 1-3. (A) shows the compression of air caused by the outward motion of a simple vibrating body such as the skin of a drum. (B) illustrates the decrease in pressure caused by the vibrating body's return motion.

The return, or inward motion of the membrane has an equal but opposite effect, forming a slight vacuum which causes a decrease in the atmospheric pressure of the layer of air to a point where it is below normal, as shown in Fig. 1-3(B).

These disturbances of the atmosphere, consisting of a high-pressure layer of air, which is compressed, and a low-pressure layer of air, which is rarefied, constitute a simple sound wave. A sound wave which is created by a complete cycle (one to-and-fro motion of the vibrating body) is illustrated in Figure 1-4(A).

The variations of pressure which comprise a sound wave are imparted to successive layers of air and travel outward in the following manner. The compressed layer of air pushes outward imparting a portion of its energy to the surrounding atmosphere. This in turn compresses the adjoining air and creates what is in effect a second layer of compressed air still further from the source.

The low pressure layer of air, which we have found consists of a slight vacuum, pulls particles of air from the adjoining layer and thus reduces its pressure. This is the manner in which our original sound wave moves outward from its source. The speed at which this sound wave travels outward is approximately 1120 feet per second or 763 miles per hour.

A more complex sound wave is created when the vibrating body makes more than one to-and-fro motion, or complete cycle, per second. Each vibration imparts a portion of its energy to the surrounding atmosphere resulting in a series, or train, of individual waves such as are shown in Fig. 1-4(B), and which all move outward from the sound source.

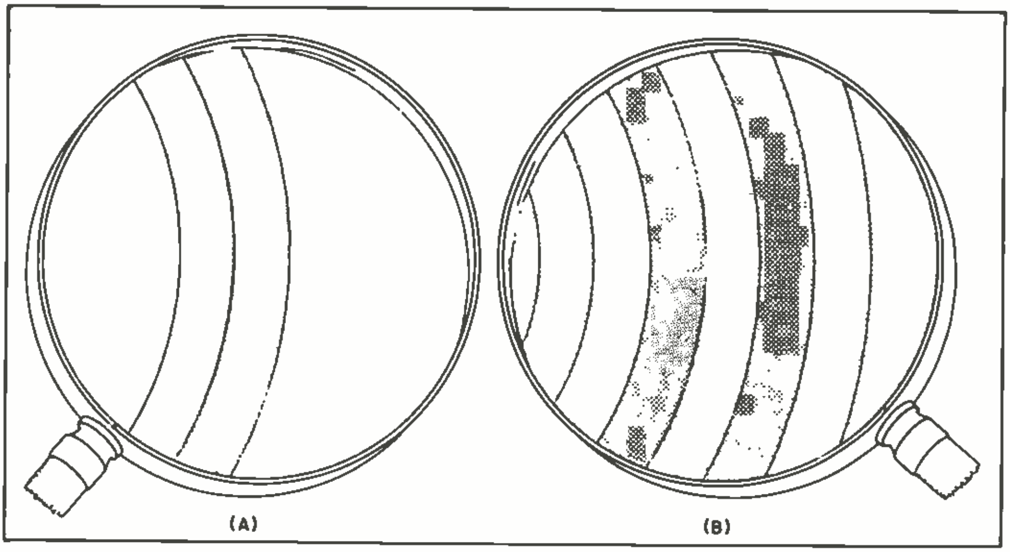


Fig. 1-4. (A) shows a simple sound wave. (B) shows how pressure variations which comprise a sound wave are imparted to successive layers of air.

Should we be able to see sound waves, their method of travel would appear similar to a water wave; in fact, a simple analogy generally used to explain the travel of a sound wave is the action of a water wave. Everyone has seen a body of water when a stone is dropped into it. From the point at which the stone enters the water a series, or train, of continuously expanding ripples moves outward in all directions. These water waves look exactly the same as the sound wave illustrated in Figure 1-5.

HOW PITCH IS DETERMINED

The number of complete cycles, or vibrations, per second which are made by the vibrating body determines the pitch of the tone the sound wave produces in the human ear. Pitch, to the musician, is that characteristic of a tone which enables him to place it in its proper position in the musical scale. The recording engineer on the other hand uses a term which describes this characteristic of sound in a purely physical manner. The number of vibrations, or the frequency with which the sound producing body vibrates, is used to describe the tone it produces.

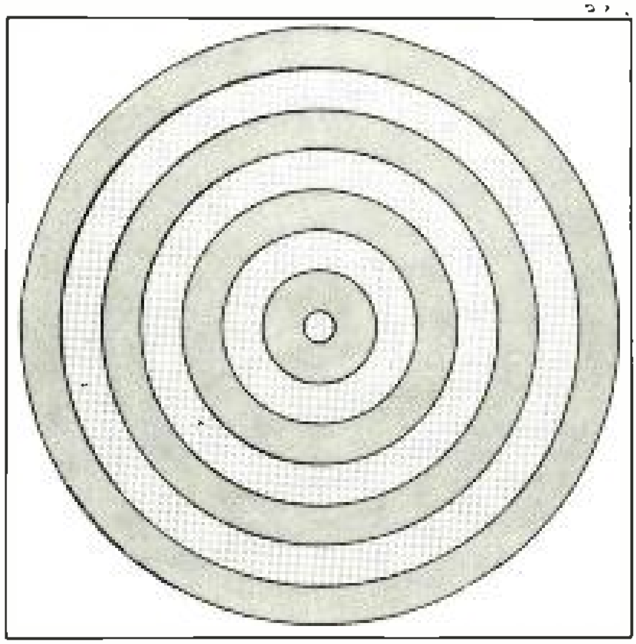


Fig. 1-5. Air waves travel outward from a source of sound as do water waves from a spot at which a stone is dropped in a pool.

A musician describes a tone as being of a certain pitch by notes, Middle A, Middle C, etc. A recording engineer would describe it as having a frequency of a specific number of cycles per second — abbreviated *cps*. For example, when the Middle A key on the piano is struck (see Fig. 1-6) it actuates the strings and causes them to vibrate at the rate of 440 times per second. Consequently this note is spoken of by the recording engineer as a 440-cycle tone.

Using the piano as an example, we find that each string creates a different number of vibrations per second, and as a consequence each note has a different tone. The difference in the tone, or frequency, of each piano note is due to the fact that the strings vary in length, tension and thickness. This can be seen from Fig. 1-7 which is a photograph of a Steinway piano.

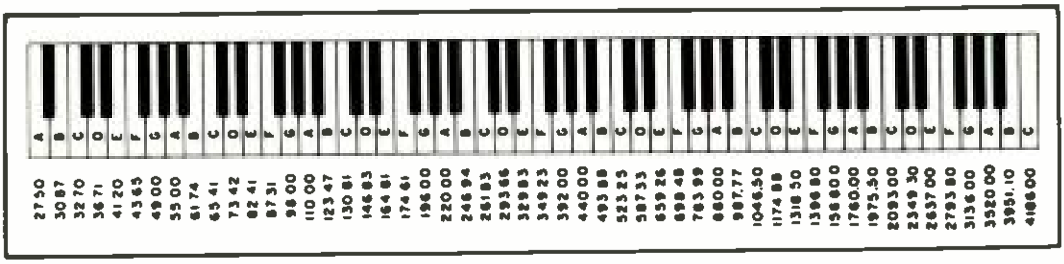


Fig. 1-6. Frequency range of the piano in cycles per second.

How these variations affect the tone can easily be demonstrated by attaching a rubber band to some stationary object, then stretching it a bit and plucking it. A tone will be heard. Stretching it a bit further and plucking it again will result in another, different tone. In stretching the rubber band we have reduced its thickness and increased its length and tension.

To return to the piano string; should we reduce its length by one-half, retaining the same tension and thickness, we find that it will when struck vibrate twice as many times per second as it did in its original length. This produces a tone which is twice the frequency of the original, or stated musically, the second tone is one octave higher in pitch. Conversely, if we should double the length of the string it would vibrate half as many times per second. This would create a tone one octave lower in pitch or exactly half the frequency.

Another simple demonstration of how the variation in the length of a vibrating string affects the tone can be obtained with a Hawaiian guitar. The continuous tonal glide characteristic of this instrument utilizes this principle and is produced by sliding a steel bar along the strings. This varies the length of the vibrating portion of the strings and consequently their frequency or tone.

Most sounds with which we are familiar have some specific frequency range. We can ascertain the frequency range of a sound or a sound-producing device by determining the lowest and highest number of vibrations it can create per second. These figures when stated together provide the frequency range or, as in the case of a device which responds to sound, the frequency response. The human ear for example, is capable of responding to, or hearing, sounds between 16 and 20,000 cps. This is known as the frequency response of the human ear.

As mentioned previously, striking the different keys of a piano produces sounds of different frequencies. Returning to Fig. 1-6 we find the piano will produce sounds ranging from 27½ to 4186 cps. This is called the fundamental frequency range of this instrument. Figure 1-8 illustrates this range in comparison with the frequency ranges of other musical instruments, sounds and voices.

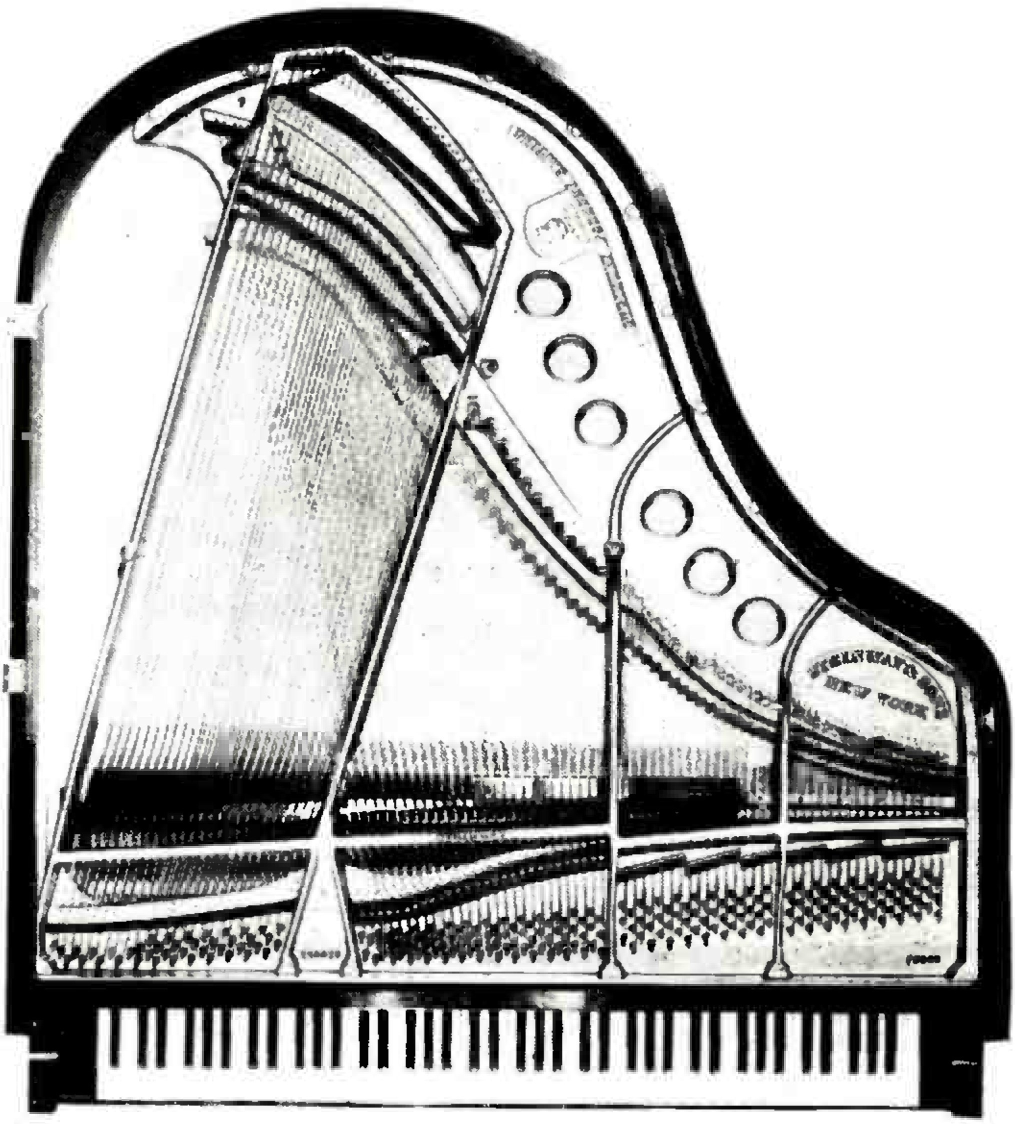


Fig. 1-7. Steinway piano with lid removed.

The lower portion of Fig. 1-8 shows a series of numbers, reading from left to right, 20 to 20,000. These numbers indicate the frequency range of the audio spectrum in cycles per second. The horizontal lines supply the frequency ranges of the various instruments and

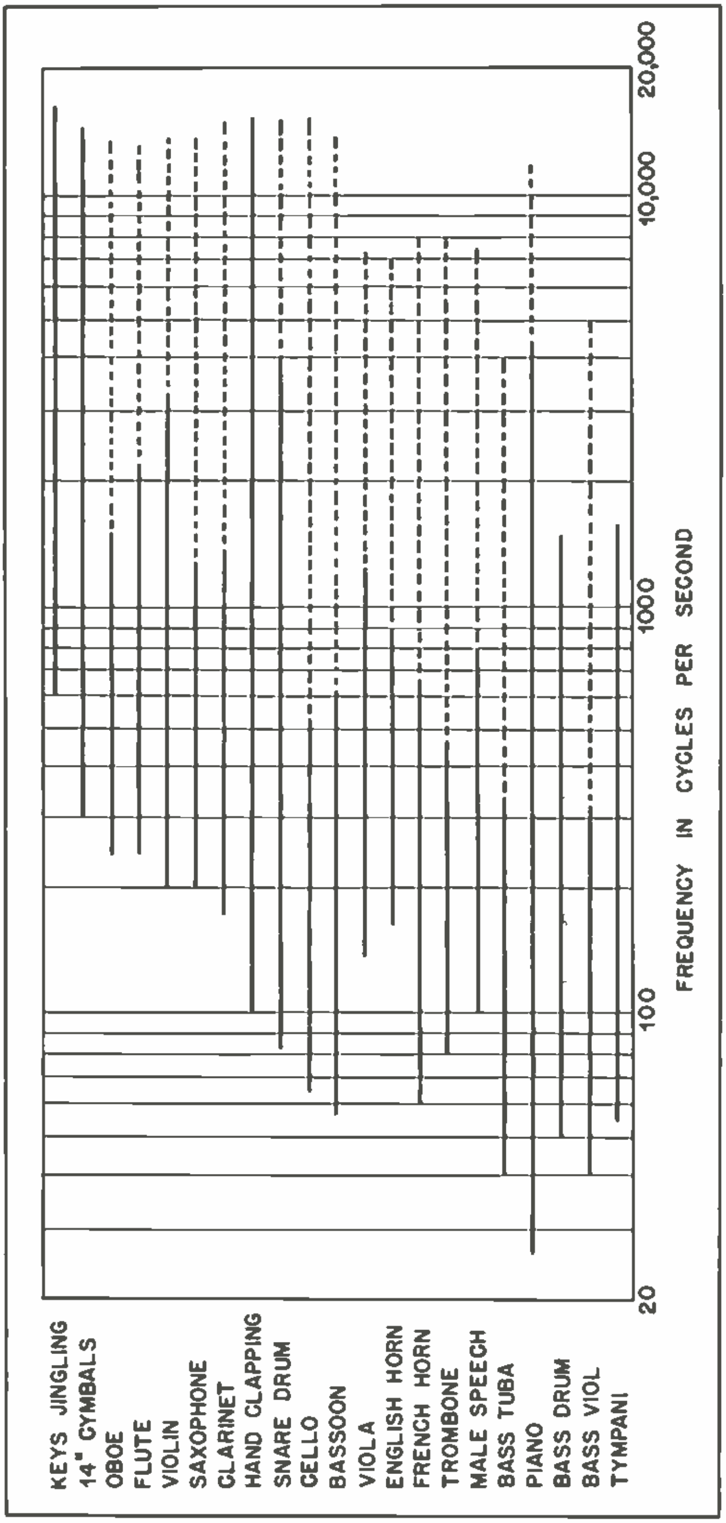


Fig. 1-8. Solid black lines indicate fundamental frequency range of the various instruments and sounds. Dotted lines indicate harmonics, or overtones, which give tones their identifying characteristics.

sounds. For example: The solid black line at the word trombone extends from roughly 85 to 520 cps. This is the fundamental frequency range of that instrument.

HARMONICS

We have thus far, in order to simplify our discussions, confined our explanations to fundamental tones. Actually all musical and vocal sounds are slightly more complex. In addition to producing fundamental tones, musical instruments and the human voice also produce tones which are called harmonics by the recording engineer and overtones by the musician. These overtones, or harmonics as they will be referred to in the future, are extremely important, as we shall soon discover.

Should an instrument or a voice produce just fundamental tones

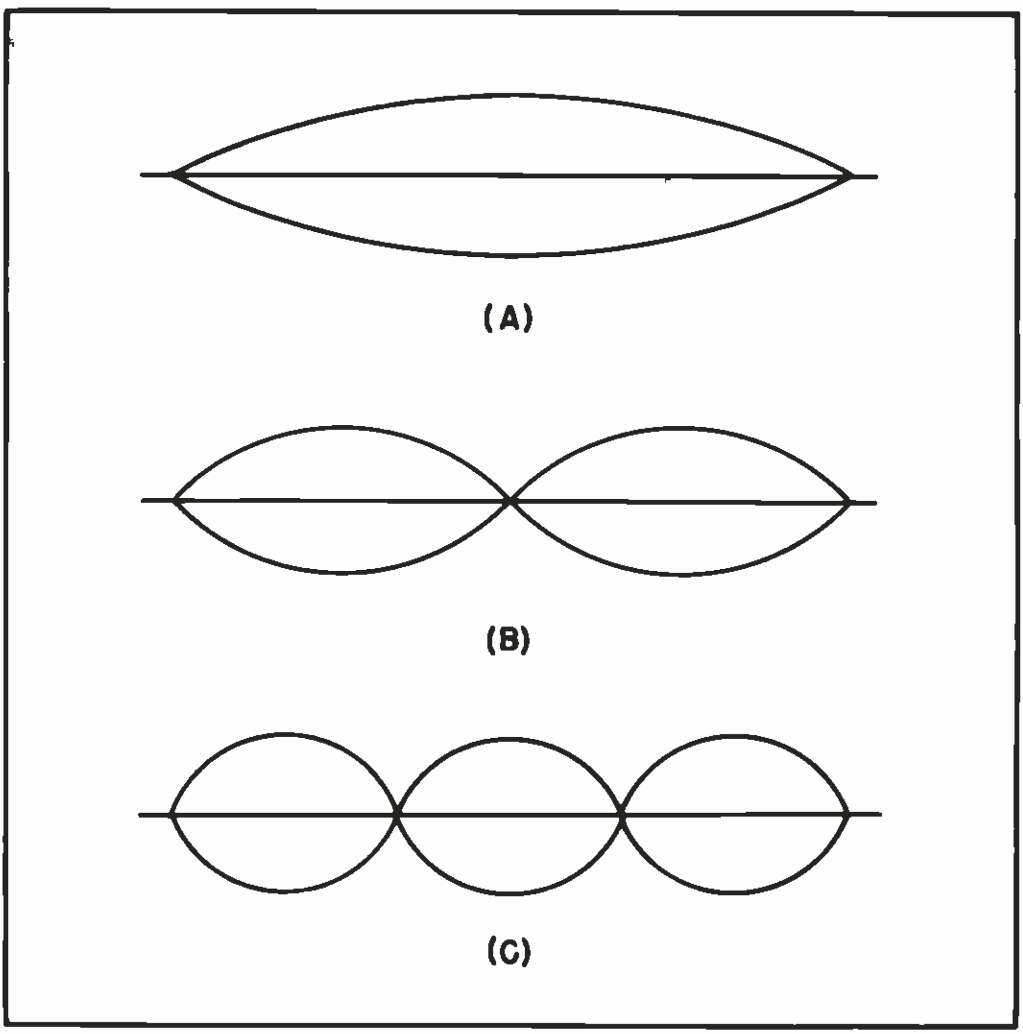


Fig. 1-9. (A) indicates a piano string vibrating at its fundamental frequency. (B) shows the same string vibrating in two sections to produce a second harmonic. Vibration of the string to produce a third harmonic is shown at (C).

without any harmonics, it would sound exactly the same as all other voices or instruments, unless the frequency range or volume was sufficiently different to aid in its identification. The importance of harmonics becomes quite obvious when we discover the primary difference between a Stradivarius and a ten-dollar fiddle lies primarily in the harmonics each creates.

Harmonics are produced in the following manner. A fundamental tone is, as we have learned, produced by a piano string vibrating as a whole, as shown in Fig. 1-9(A). However the string also vibrates in sections due to the reflected waves from its fixed ends, and in this manner produces secondary vibrations, or harmonics, which are exact multiples of the fundamental tone or frequency. For example, let us assume we have struck the Middle A key on a piano. We know that this will produce a tone with a fundamental frequency of 440 cps. In addition the string will also vibrate in two sections as shown in Fig. 1-9(B). This secondary vibration creates what is called the second harmonic, in this case a tone whose frequency is 880 cps. It is also possible for the string to vibrate in fourths, sixths, eighths, etc. Figure 1-9(C) illustrates a string vibrating at the third harmonic or 1320 cps.

Each of these sets of vibrations contributes a certain amount of energy to the total sound output, however the harmonics usually create less energy than the fundamental frequency. But it is the combination of all these vibrations which creates the particular sound which is characteristic of a specific instrument. We know that even if the same note is played on the piano and a violin there is a distinct difference in the resulting sound; we can easily tell which sound is produced by the piano and which is produced by the violin. This occurs despite the fact that the fundamental frequency produced is the same in both cases. The reason lies in the fact that distribution and the intensity of the harmonics are different because of the difference in the physical structure of the two instruments. Harmonics are responsible for the fact that musical instruments can produce higher frequencies than their fundamental ranges. The piano, for example, produces overtones above 8000 cps, despite the fact that its fundamental range only extends to 4186 cps. This extension of the frequency range of the various musical instruments is given in Fig. 1-8, where it is indicated by the dotted section at the high-frequency ends of the lines showing the frequency response of the various sounds.

Chapter 2

Sound and The Human Ear

Any discussion of sound must, in addition to pitch or frequency, include mention of the volume or loudness of the sound. We have explained previously just how sound is created, how it travels, and how the pitch or frequency is varied. We have not, as yet, explained what causes a sound to be louder or softer. In order to do so in a simple manner we must return to our earlier analogy of the water wave.

Dropping a pebble into a body of water creates wavelets of relatively small force. Dropping a large stone into the water creates larger wavelets of greater force. Sound acts in exactly the same manner; the greater the force that generates the sound, the more air pressure it will exert and the louder it will be. This can be shown quite easily by holding a sheet of paper as illustrated in Fig. 2-1 and speaking directly at it. The sheet of paper will vibrate due to the sound waves generated by the voice. Using more vocal force and shouting will cause the paper to vibrate more violently.

THE HUMAN EAR

The human ear intercepts and is affected by sound energy in essentially the same manner. The ear can be divided into three sections. The first section is the outer ear, which is the visible part, and which acts as the collector of sound waves. Intercepted by the outer ear, sound waves then pass through the auditory canal and affect the ear drum in the same manner as they did the sheet of paper, causing it to vibrate. The second section is the middle ear which is separated from the outer ear by the ear drum. This section transmits sound waves to the third section, the inner ear, which converts them into nervous or electrical energy which is transmitted to the brain and results in the sensation of sound.

Changes in sound intensity or volume affect the ear in the following manner. A loud sound, as we have discovered, creates a greater pressure or intensity than a softer sound, and therefore causes the ear drum to move more violently, just as it did the sheet of paper. This creates a greater impulse in the nervous system. A sound of lower volume causes the ear drum to move less violently thus creating a lesser impulse in the nervous system. From the foregoing we can understand how a sound can be so low in intensity that it does not

Fig. 2-1. Speaking directly at a sheet of paper will cause it to vibrate exactly as does the diaphragm of a microphone.

create any impulse at all in the nervous system and hence no sensation of sound is produced, or so high in intensity that it may actually cause physical pain.

Just as the frequency or pitch of a sound may be measured so can its intensity or loudness. However a special unit of measurement must be used since the loudness range of everyday sounds is truly enormous (over one trillion to one) and the use of ordinary numbers would be unwieldly. For example, the intensity of a quiet whisper would be 10,000. That created by normal conversation in the average city home would be 400,000. The intensity of the average city street noise would be about 50,000,000. The unit commonly used in measuring sound is called a decibel (abbreviated *db.*)

As with any other measuring scale we must start with some arbitrary figure which may be used as a reference point. The reference point, or "zero level," which has been chosen by acoustic engineers is a sound pressure or intensity which hardly affects the ear drum and consequently is barely perceptible to the average person. This zero reference point is called the *threshold of audibility* and is shown as 0 db in the table in Fig. 2-2.

Figure 2-2 illustrates the sound intensity or loudness level, in decibels, created by some common sounds. As may be seen from this chart, audible sound ranges from the threshold of audibility which is indicated by 0 db, to 135 db. Until recently the loudest sound measured by man reached what was called the *threshold of feeling*. A sound at this level was felt as well as heard since it displaced the ear drum to such an extent that it caused a tingling sensation. The advent of the jet plane increased the known sound level to what is now called the *threshold of pain*. This is a level at which sound causes a sensation of pain and may actually destroy human tissue. This sound level occurs about 25 feet from the rear of a jet plane as it is being warmed up for flight.

Figure 2-2 will also provide some idea of the relative levels of various sounds when we explain that a sound twice as loud as a reference sound is only 3 db higher in level. When a sound is four times louder than another, it is said to be 6 db higher in level. When it is eight times as loud, the intensity level is about 9 db higher. When one sound is ten times as loud as another it is 10 db higher in level. When a sound is one hundred times louder than another it is 20 db higher. From the foregoing figures it becomes obvious that the response of the human ear is not directly proportional to the intensity of a sound but rather to the logarithm of its intensity.

SOUND LEVEL IN DB	
0	Threshold of audibility
10	Rustle of leaves
15	Quiet whisper
20	Average whisper at 5 feet
23	Studio noise level
25	Noise around country house
30	Noise in suburban street
32	10th-floor apartment, window closed
38	10th-floor apartment, window open
48	Noise in fireproof storage warehouse
60	Noise in average restaurant
63	Average conversation
70	City street noise
78	Noise in factory (average)
80	Loud radio playing in a home
90	Noisy factory
95	Subway train noise
97	Symphony orchestra at 20 feet
120	Threshold of feeling
125	Threshold of pain

Fig. 2-2. Acoustic level of various sounds under average conditions.

Figure 2-2 illustrates a number of sound levels between the threshold of audibility and the threshold of pain. Since background noise is an extremely important factor in making tape recordings the majority of those shown refer to noise levels encountered in various typical locations.

NOISE

Noise is usually a combination of unrelated sounds which have no definite pitch and are usually inharmonious. For example, city street noise may consist of the shouting of children at play, the rumble of heavy trucks passing, the sound of adult voices in conversation, and the sound of an airplane overhead. All of these various sounds combine to create "city street noise." From the table in Fig. 2-2 we can see that its average sound intensity is about 70 db. This noise level is about ten thousand times as loud as that normally found on the average suburban street, which has an average noise level of only 30 db. There are fewer children and only occasional sounds created by automobiles and trucks. The rustle of leaves and the voices of children are the biggest contributors.

Very often the recordist is greatly surprised when he hears the results of his first recordings, since they usually contain many unwanted sounds that were not apparent at the time of the recording session. Automobile horns, traffic noises, birds and the murmur of voices are all picked up by the microphone and recorded. These extraneous sounds are quite annoying and often ruin what otherwise would have been an excellent recording.

The reason these extraneous sounds become so noticeable in a recording is that a microphone picks up sound monaurally – just as a person deaf in one ear would hear it; there is very little sense of discrimination and localization. Hearing is quite similar to sight in this respect. In order to obtain a sense of depth, in sight, two eyes are required. If you close one of your eyes, the effect on sight is quite noticeable.

Closing one ear with your finger has almost as pronounced an effect on hearing. The sense of depth and localization is lost. You will immediately notice that background sounds, which previously passed unnoticed, have seemingly become louder. They actually have not; your sense of discrimination is reduced. Distant sounds no longer seem so distant. A microphone responds to sound in the same manner. It cannot discriminate; it will pick up every sound which is capable of actuating its diaphragm.

Background sound or noise can be reduced at its source by eliminating most of its causes although this is not always feasible. Noise may also be reduced by artificial means. An example of this may be seen by comparing the noise level of a city street and that obtained within a quiet tenth-floor apartment on the same street. The noise on the street measures 70 db. The noise level within the apartment measures 38 db with the windows open. This difference is primarily due to the fact that a certain percentage of the street noise is reflected by the walls of the building and does not enter it. Some is absorbed by the walls as the sound strikes them and the remainder is heard within the building.

In order that we may understand just how this occurs we will explain something of the other characteristics of sound, its reflection, absorption and diffraction. Chapter 1 explained how sound traveled in open space. Very few recordings are made under these circumstances. The majority are made indoors or in the vicinity of buildings, trees, shrubs, etc. Sound acts in a slightly different manner under such circumstances.

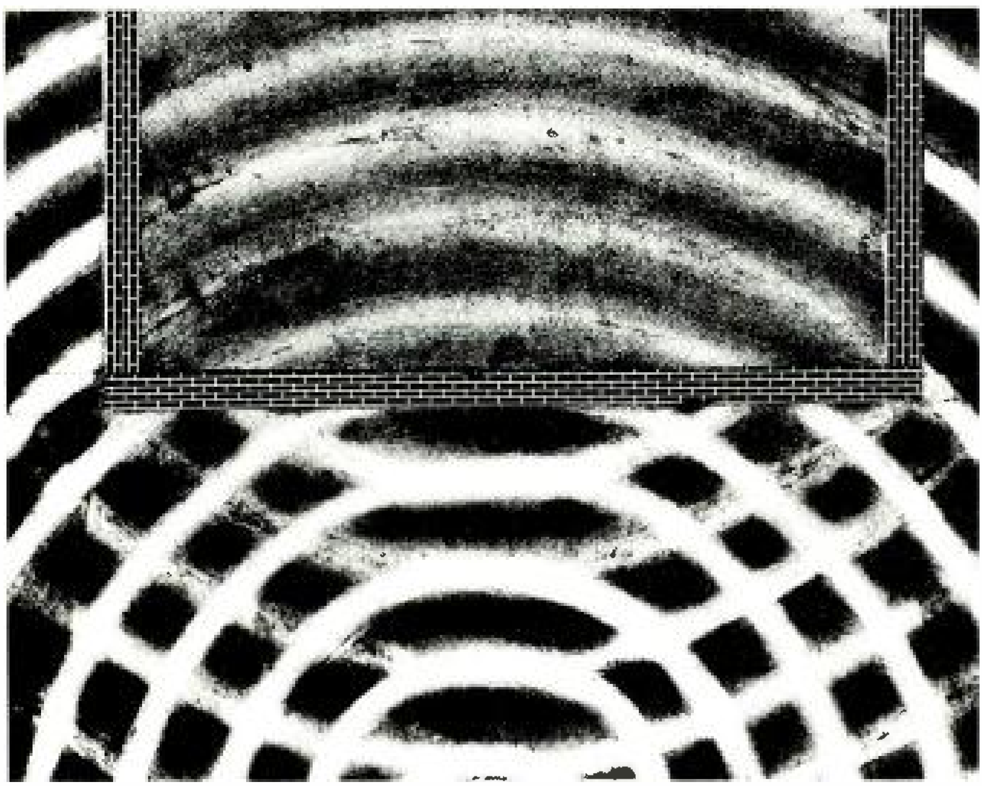


Fig. 2-3. Action of sound waves as they strike the outside wall of a windowless storage warehouse.

Figure 2-3 illustrates the reflection, absorption and transmission of sound when it encounters the wall of a storage warehouse, similar in construction to the walls of a conventional apartment building. The sound waves created by the street noise hit the wall as shown. Some are reflected back toward the source by the wall and some are absorbed by it. The amount of sound absorbed by the wall is dependent upon its construction and the materials of which it is built. In our example the particular wall of brick and plaster absorbed 30 db of the street noise. This, as may be seen from the table in Fig. 2-2 checks with our previous noise levels. As we may see, from this chart, the outside noise level was 70 db; the noise level within the room measured only 48 db. The sound waves hitting the wall cause it to vibrate in exactly the same manner as the sound waves created by the vocal cords caused the sheet of paper to vibrate in Fig. 2-1. These vibrations set up sound waves on the inside of the wall which are exact duplicates of the original waves which created them, but much lower in intensity. In this manner the original sound waves have created what in effect are new sound waves since, as we discovered earlier, any vibrating body creates sound.

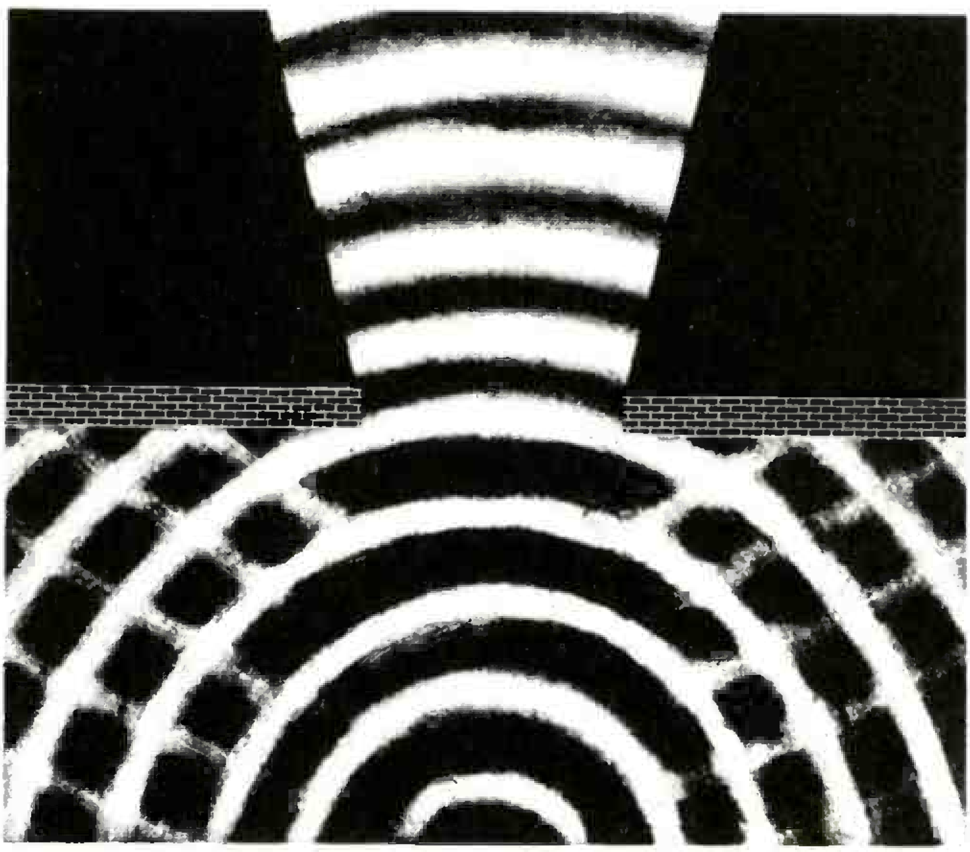


Fig. 2-4. Action of sound waves as they encounter a wall similar to the one shown in Fig. 2-3, except that a window has been added.

Very rarely do we encounter a completely enclosed room except in recording, broadcasting or movie studios, or in a storage warehouse, where these readings were taken. Most rooms in which the reader will record will have one or more openings – windows, doors etc.

The effects of the sound waves differ slightly under these circumstances as shown in Fig. 2-4. With the window open the greatest percentage of the sound waves act as previously explained, but those passing through the window or door opening itself are fairly directional and always result in a higher noise level in the area immediately in front of the opening. Closing the opening obviously reduces the noise level in this area but due to the fact that a glass window or a wooden door absorbs less sound than the wall, the directional effect is still noticeable. Drawing a drape across the window will reduce the noise level from this source still further due to its additional absorption of sound. Actual measurements made with a Scott Model 410-B Sound Level Meter indicate the noise level in the author's tenth-floor apartment with a window and drape open was 38 db. Just closing the window reduced the noise level to 34 db. Closing the drape, which is of unlined bark cloth, resulted in an additional reduction of 2 db, making the noise level with both the window and drape closed 32 db. A reduction of 6 db in the background noise on a recording provides a considerable and quite noticeable improvement.

Whenever possible all windows, doors, or other openings in a room should be kept closed while making a recording. If drapes which are movable are used, they should be kept in the closed position. It is always desirable to reduce the level of any outside or background sounds to an absolute minimum. When traffic noises, the sounds of birds, crickets, etc., are required for background effects they should be obtained through use of sound-effect records or "dubbed" in later, when their intensity and duration can be controlled by the recordist. The various methods of adding background sounds to establish locale or mood will be discussed in detail in Chapter 11 on sound effects.

When recording outdoors the diffraction and absorption of sound by large objects can, when properly utilized, be very helpful in obtaining recordings which are free of background noise. Figure 2-5 illustrates the effect of a house upon the sound waves caused by street noise. The plan shown is that of the Miami home of Mr. and Mrs. A. Gross, who incidently were extremely patient while the author prowled the premises at all hours of the day and night making recordings. Many bird songs were recorded in their garden using the house as a shield to reduce the intensity of traffic noises. The microphone was placed at position A and directed toward position B,

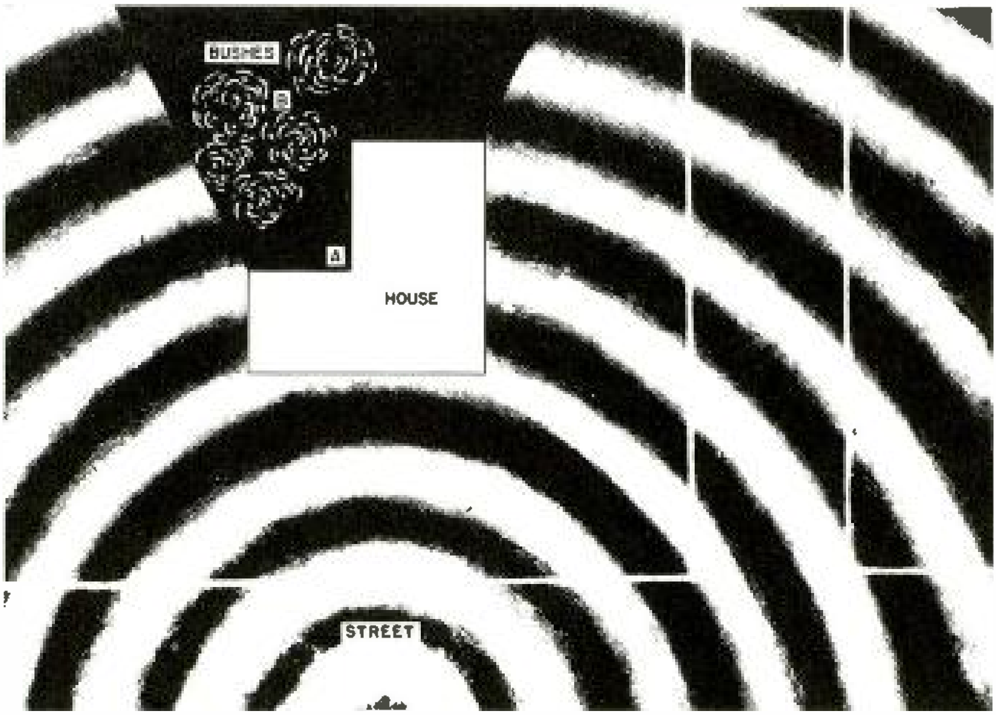


Fig. 2-5. Effect of a house upon sound waves caused by street noise.

the area in which the birds lighted on the lime and orange trees. As we can see from this illustration the sound waves created by the street noise strike the building, and some of them are reflected back toward the source, some are absorbed and the house diffracts the remainder from areas A and B. This same effect may be obtained to a lesser degree by utilizing any available dense shrubbery between the source of any unwanted sound and the microphone position. The shrubbery diffracts some of the sound and absorbs some, thus reducing the noise slightly on its far side.

SOUND INDOORS

Thus far our discussions have been primarily concerned with the characteristics of sound waves outdoors. Sound traveling in an enclosed space has other characteristics which affect the recordist. As previously explained and illustrated in Fig. 2-3, whenever sound waves strike a solid barrier such as a wall, part of their energy is reflected, another portion is absorbed by the wall itself, and a third portion is transmitted through the wall. When recording in an enclosed space the sound energy which is absorbed by walls and transmitted through them is lost but the amount of energy reflected back may under certain circumstances be added to the original sound energy, in this manner augmenting it. The sound waves created within a room are not reflected once or twice but many times. The number of times a sound wave is reflected is primarily dependent upon the position and amount of absorption of the reflecting surfaces such as walls, floors, ceilings, etc. A hard smooth surface will reflect more sound than a soft porous one.

We can see how the additional sound energy obtained in this way is not inconsiderable. Many churches, auditoria and concert halls are specifically designed to utilize these reflections to reinforce the original sound. This reinforcement of sound is the reason "singing in the bathtub" is so popular. In the tub or shower every person sounds like an opera singer because the tile surfaces of the floors, walls, and fixtures are almost perfect reflectors of sound. Reflections, as we have discovered, add to the original energy of the voice, making it sound more powerful. Reflected sound is not always this advantageous, in fact it can often be and usually is detrimental, since in large halls the reflections of music or voice may be sufficiently delayed to interfere with the next note played or the next syllable spoken.

The most commonly noticed reflection of sound waves results in a characteristic we all know as echo. An echo is created when a sound wave, traveling outward from its source, strikes a large obstacle, in our case a wall, and is reflected back to the ear of the listener or to a microphone. In order to obtain a noticeable echo there must be a lapse of at least one-twentieth of a second between the time the direct sound wave is heard and the reflected sound wave returns to the ear of the listener. He then actually hears the same sound twice.

Echo can be very easily demonstrated in a large empty auditorium or church by standing at one end of the room and clapping the hands once sharply. The sound created in this manner can usually be heard twice – once as it travels directly from the source to the ear of the listener, path A in Fig. 2-6, and again when another part of the same sound wave, which travels path B, strikes the far wall and is reflected back to the ear of the listener. In order to obtain this effect the reflected wave must travel a path which is at least 56.25 feet longer than that of the direct sound wave.

Under average circumstances there may be more than one echo since the original sound may be reflected more than once. However, multiple reflections do not usually manifest themselves as a series of individual echos but are most often heard as a prolongation of the original sound. This effect may be likened to the sound created by a piano when the *loud* pedal is used. The effect will vary with the size of the enclosed space, the absorption of its walls, ceiling, etc., and the intensity of the original sound. This form of multiple echo is called reverberation and is present to a greater or lesser degree in every enclosed space.

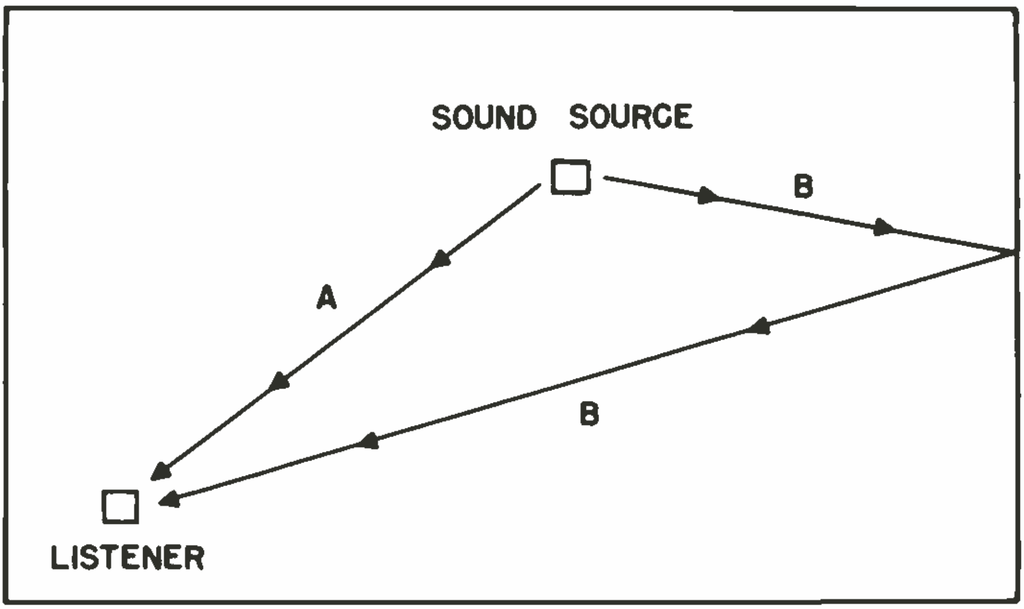


Fig. 2-6. Direct sound travels path A. Reflected sound travels path B.

Reverberation is of interest to us because of its effect on any recordings made in large enclosed spaces. The effect of continuing reflections, if their delay time is great enough, is more noticeable on the recordings of speech than music. For example, when a speaker is heard using conversational tones while standing near the listener, each successive syllable is distinct and is separated from the succeeding one. The speech is intelligible. If the same speaker should raise his voice in a large room, each syllable is prolonged by the multiple reflections of the sound and more or less runs into the succeeding syllable, with the result that there is a loss of intelligibility.

This characteristic of sound does not generally affect the average recordist to any great degree unless he records church sermons, weddings, speeches, or dramatic performances in large enclosed spaces.

The reverberation time in an enclosed space may be reduced or, in cases where special effects are required, it may be increased, by acoustical treatment which results in the absorption or reflection of more or less of the sound in the area. However, the average recordist, whether amateur or professional, is very rarely allowed to do anything which would change the acoustic conditions he may encounter in a specific location. This, incidentally, is the reason that some of the sound in most motion pictures is usually recorded or "dubbed in" after the picture has been taken, in a studio where the required acoustic conditions prevail. Reverberation time does, however, affect the teacher or others who are forced by circumstances when recording to use large rooms, halls, churches, or concert halls with poor acoustics. Methods of eliminating or reducing the effects of reverberation will be discussed in detail in Chapter 4.

Earlier we compared the action of a sound wave to the effect caused when a stone is dropped into a body of water and creates a series of continuously expanding ripples which moved outward in all directions. This method of sound propagation is true only of a non-directional sound source. Most of the sounds we wish to record, such as the human voice, musical instruments, etc., are directional, particularly at the higher frequencies. At these frequencies the sound waves act in a manner similar to a beam of light from an automobile headlight or a flashlight in which the area of greatest intensity of

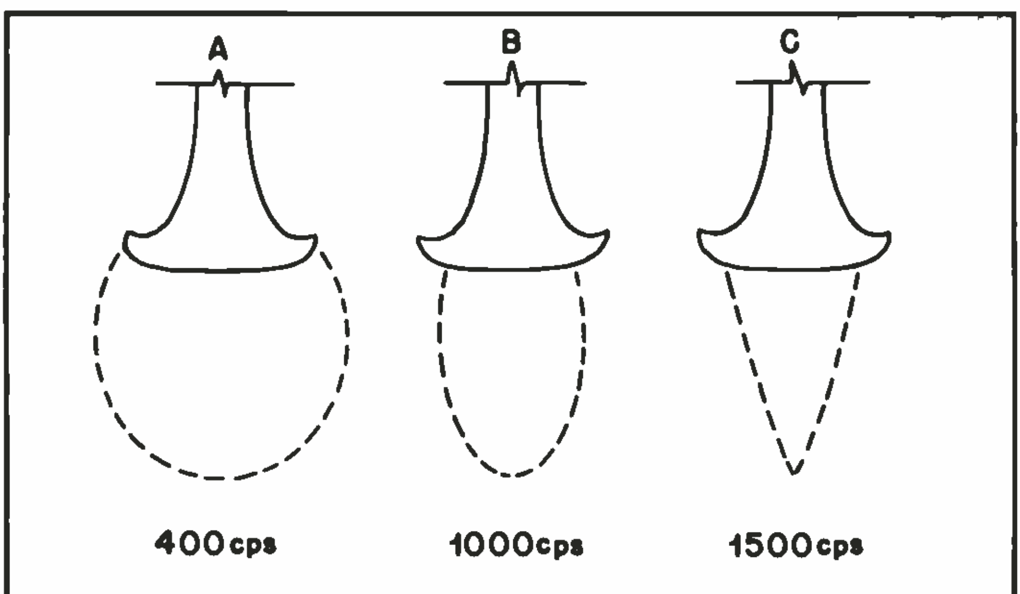


Fig. 2-7. Sound waves tend to beam as their frequency is increased.

light lies along the axis, gradually diminishing in intensity as the angle from the axis is increased.

Figure 2-7 illustrates this characteristic as it occurs with three different frequencies from a clarinet. The broken lines indicate the areas of greatest sound intensity. As may be seen from pattern A this area is quite large at 400 cps when compared with pattern B which shows the area of greatest sound intensity at 1000 cps. The area of greatest sound intensity becomes even smaller and takes the shape of a narrow beam at still higher frequencies as illustrated in pattern C. This directional characteristic is true of almost all musical instruments and is of great importance to the recordist, since if this factor is not considered in microphone placement the resultant recording will usually be characterized by poor high-frequency content which results in a loss of brilliance and "presence" effect.

As a practical matter, this means that a microphone should be placed so as to intercept the full frequency range of all the instruments possible. In making a recording of piano and clarinet, for instance, the microphone should be placed not only directly in the path of the piano sound – usually opposite the raised cover on a grand, but also directly in front of or "on the beam" of the clarinet.

Chapter 3

Microphones and Tape Recordings

THE FIRST STEP in the sound recording process is the conversion of the mechanical energy of sound waves into electrical energy. This is accomplished through the use of a microphone. The action of a sound wave upon a microphone is essentially the same as its action on the human ear.

A microphone of the crystal or ceramic type generally furnished with most home recorders has a diaphragm which is caused to vibrate by the fluctuations in air pressure which constitute a sound wave, in exactly the same manner as the sheet of paper illustrated in Fig 2-1, or the eardrum.

Figure 3-1 (A) illustrates a segment of a sound wave with the high-pressure layer of air just striking the diaphragm. This high-pressure layer of air, moving outward from the sound source, displaces the diaphragm from its normal position, as shown by the broken line, to the position indicated by the solid line. Figure 3-1 (B) illustrates the action of the same diaphragm immediately after the high-pressure layer of air has passed on. The diaphragm is now affected by the low-pressure layer of air which follows. Since there is now a lack of pressure, the diaphragm springs back, through equilibrium, to the outward position, as indicated by the solid line. At the conclusion of each cycle of the sound wave, the diaphragm returns to its normal position and is ready to be activated by the next cycle. When a sound with a frequency of 1000 cps strikes this diaphragm it is forced to vibrate one thousand times per second. A sound with a frequency of 5000 cps will force the diaphragm to vibrate five thousand times per second.

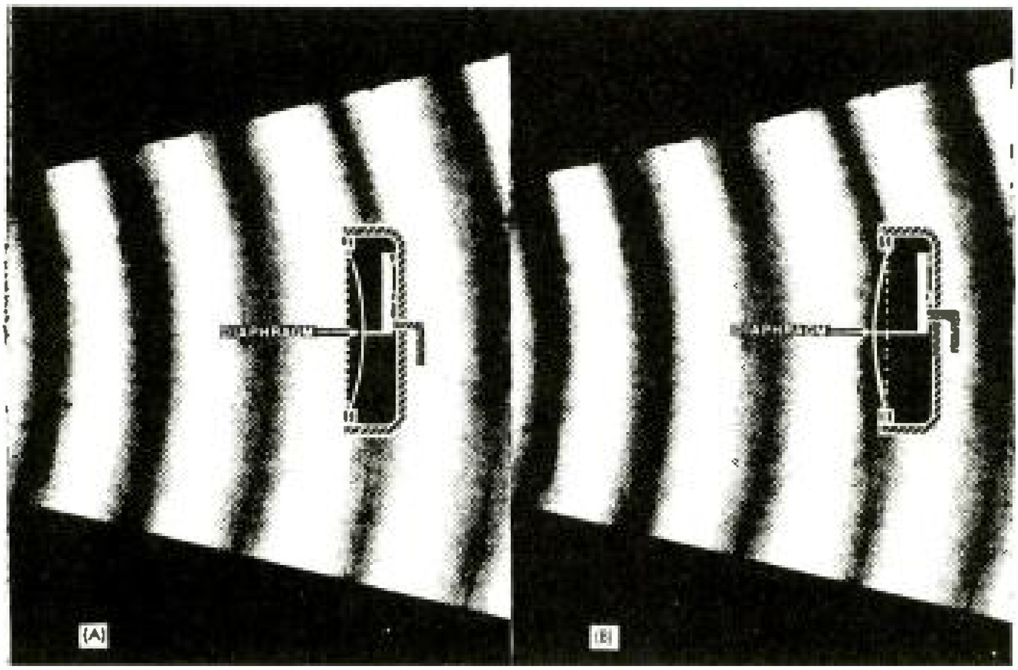


Fig. 3-1. Action of the diaphragm of a microphone as it is struck by a sound wave. In (A) the wave is striking. In (B) the wave has passed on and the diaphragm springs back due to the low-pressure layer of air which follows.

The similarity in action between a microphone and the human ear becomes even more evident when we discover that the movement of the diaphragm actuates a mechanism which translates the resultant mechanical energy into electrical energy, just as does the inner ear. The exact manner in which this conversion is accomplished varies with the different types of microphones available. These variations also affect the performance and the characteristics of the microphone in many ways.

There are a number of factors which influence the home recording and reproduction of sound. The most commonly known of these is the tonal range of the equipment. The tonal, or frequency range, as it is correctly called, reflects the ability of the equipment to record and reproduce with equal fidelity all of the tones in the musical scale from the highest treble to the lowest bass.

As explained in Chapter 1 the ability to record just the fundamental tones produced by an instrument or voice is insufficient. We must, in addition, be able to record the harmonics or overtones, which provide the *timbre* of the instruments or voice being recorded.

It is timbre which gives a musical instrument its individual color and enables us to recognize it. It is timbre which permits us to tell the difference between brass bass and string bass when both are playing the same note. It is timbre which permits us to distinguish one voice from another. This quality, as we have found, is to a large extent dependent upon the overtones generated by an instrument or voice; consequently when we wish to record in such a manner that the recording will provide a realistic reproduction of the original sound, the frequency response of the microphone must be sufficiently wide to include these overtones or harmonics.

In addition to providing the tones which supply timbre the higher frequencies also provide that intangible effect known as "presence."

We have illustrated our previous discussions on frequency range or response (Fig. 1-8) with a straight line drawn between the lowest and highest frequencies mentioned. This indicated that all frequencies within this range were being produced or reproduced at exactly the same intensity or volume level. This is the most desirable response or reproduction, no one portion or frequency is emphasized over another. However, this is a theoretically ideal response, not an actuality. The closest approach to this ideal is found in the higher-priced professional or semi-professional equipment. For various technical reasons there is always some variation within the frequency response of a microphone, but the smaller this variation is, the more desirable is the instrument from the standpoint of performance.

Figure 3-2 illustrates the frequency response of a good inexpensive crystal microphone. As may be seen line A on the chart is straight. This indicates that when the microphone is subjected to a source of sound which is equally loud over the entire frequency range the resultant electrical signals from the microphone are of equal intensity. This is the ideal response for a microphone since it displays no peaks or valleys within the audio range. Each frequency is reproduced with equal intensity. Line B on the other hand is uneven and does display the peaks and valleys which indicate that the microphone in question is more sensitive at certain frequencies (the peaks) and less sensitive at others (the valleys). Let us take one of the peaks, specifically the one shown at 440 cps, and analyze its effect upon a recording made with this microphone. Translating this

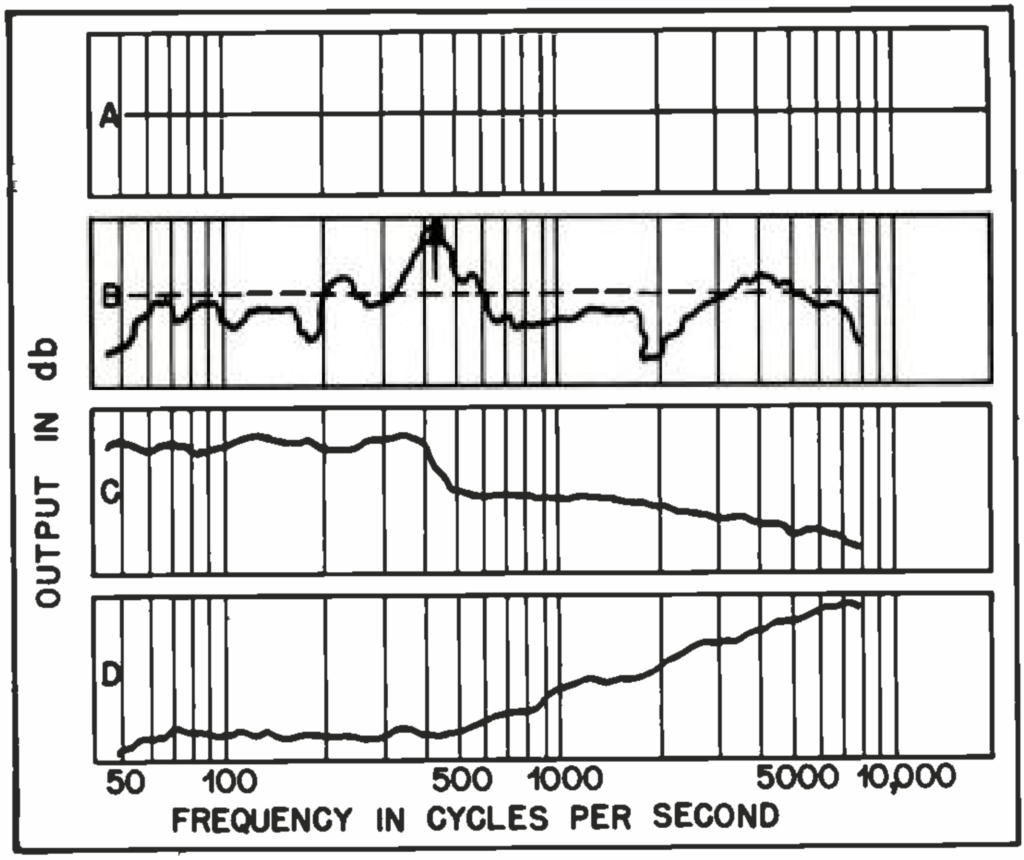


Fig. 3-2. Line A indicates flat frequency response. Lines B, C and D are response curves for typical inexpensive crystal microphones.

frequency into a musical tone we find that it corresponds to Middle A on the piano, as can be seen from Fig. 1-6. The response of the microphone at this particular frequency is approximately 6 db higher than its response at 110 cps, which is the frequency of the "A" two octaves below. This difference translated into terms of reproduction simply means that on a piano recording made with this microphone Middle A will be reproduced at four times the volume level of the "A" two octaves below it. This obviously results in a recording which insofar as volume level is concerned is not a facsimile of the original sound of the piano. Consequently, the reproduction would sound unnatural.

Should the microphone have a response as illustrated by line C which, as we can see, indicates that the instrument is more sensitive to the lower frequencies below 500 cps, the resultant recording would be characterized by a boomy, bassy tone, and would be weak in the important higher frequencies. On the other hand, should a microphone display a response such as is indicated by curve D a recording made with it would be sharp and shrill and be deficient in the important low frequencies which supply the rhythm to music.

The frequency response and the linearity of this response, which is the lack of variation within the frequency range of the microphone, are two of the factors which determine its quality. The wider the frequency response and the more linear it is, the higher is the price of the microphone.

The general purpose microphone usually furnished with home recorders is quite adequate for most of the applications for which the recorder will be employed. The average person usually confines his recording activities to the speaking voice. As we can see from Fig. 1-8 the frequency range of the human voice is approximately 100 to 7500 cps. The general purpose microphone will record this range of frequencies quite well. However, its limitations become quite noticeable when the user widens his activities and begins to record music. It is then that the advantages of a microphone with wider range and more linear response become obvious.

The first improvement which can be made in a home recorder is the acquisition of a second microphone with increased range and more linear response. A dynamic microphone of the type illustrated in Fig. 3-3 (A) has a frequency response of from 60 to 9000 cps, and has a more linear response than the unit usually acquired with the recorder. The improvement in quality which can be obtained with a microphone of this type is distinctly noticeable on recordings of a speaking voice; it manifests itself in the fact that the recorded voice becomes more of a facsimile of the original through better recording of the higher frequencies which provide timbre and "presence."

The microphone illustrated in Fig. 3-3 (B) has a still wider frequency range (60 to 13,000 cps), and is even more linear; consequently its use will result in even better recordings than the microphone shown at (A).

As we mentioned earlier, there are various types of microphones available to the recordist. Each has its own advantages and characteristics. In the author's opinion one of the most important of these characteristics to the home recordist is the directivity pattern of the microphone.

The directivity pattern of a microphone may be likened to the directional characteristics of musical instruments which were explained in Chapter 2. However, instead of this pattern referring to the area of most efficient propagation of sound, it refers to the area of most efficient reception of sound. Microphones are available in

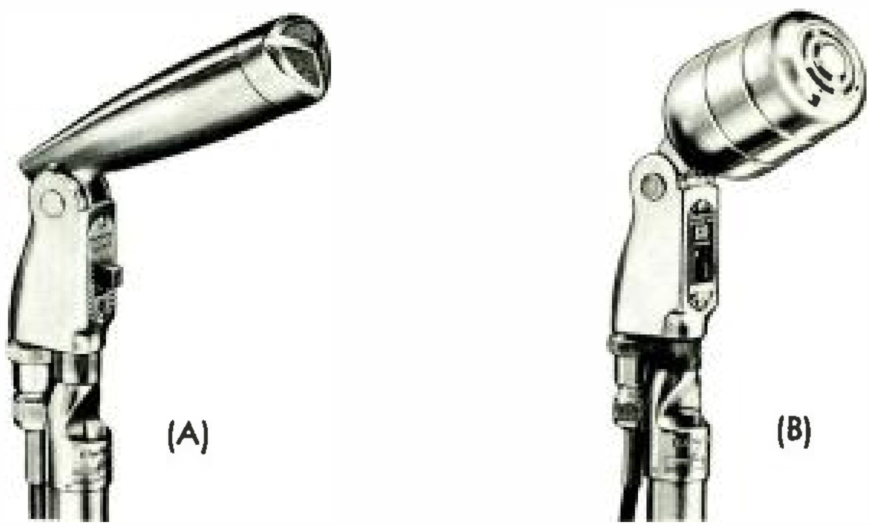


Fig. 3-3. Two high-quality dynamic microphones. The one at (A) has frequency range of 60 to 9000 cps. The one at (B) has frequency range of 60 to 13,000 cps and is more linear. (Photo Courtesy of Electro-Voice, Inc.)

unidirectional, omnidirectional, and bidirectional types, and also in variations and combinations of these directional patterns. Each of these types performs certain functions and provides certain advantages.

One of the primary uses of the differences in directional pattern can best be explained by a comparison with camera lenses. The crystal or ceramic microphone generally furnished with home recorders may be compared to the general-purpose lens furnished with a camera. Both of these, the microphone and the lens, have been chosen by the manufacturer to serve the majority of everyday applications for which the instrument is generally used. However a photographer may decide that he wishes to specialize in landscape photography and finds it desirable to obtain a wider angle of view from the same camera position. He acquires a wide-angle lens for this purpose. Another photographer may decide to specialize in wild life photography and be willing to accept a narrower angle of view than his general-purpose lens affords in order to obtain an enlarged image. He of course acquires a telephoto lens. If the same user is interested in both aspects of photography he purchases both lenses and uses them in addition to the general-purpose lens furnished with his camera. Since amateur photographers have discovered the tremendous advantages available thru the use of more than one lens their pictures have improved considerably. So it is with the recordist; the microphone is one of his most important tools. He can, through the proper choice and use of a microphone, greatly improve the quality of his recordings.

The directivity pattern of a microphone controls a number of

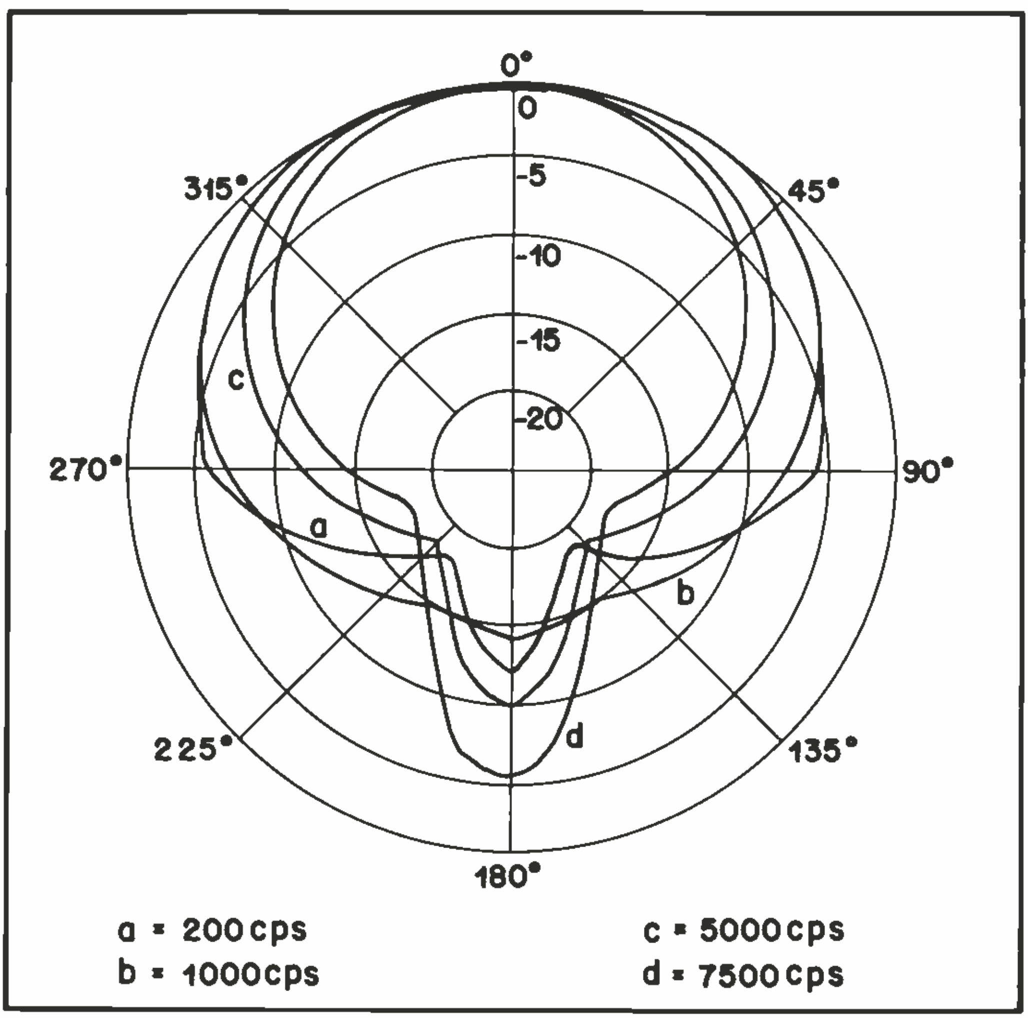


Fig. 3-4. Directivity patterns of an Electro-Voice Model 950 Cardex crystal microphone at various frequencies. (Photo Courtesy of Electro-Voice, Inc.)

factors which are responsible to a great degree for the quality of a recording. In our previous paragraphs on the frequency response of microphones we referred to the response on the axis of the microphone as shown in Fig. 3-4. The directional characteristics of the microphone also affect the frequency response. This important factor, while generally known, is not generally considered while recording, except by professionals.

Figure 3-4 illustrates the directivity pattern of an Electro-Voice Model 950 Cardex crystal microphone at various frequencies. From this pattern we can see that, despite the fact that this microphone will pick up sound over an arc of 180 degrees, this coverage does not apply at all frequencies. For example, the coverage is only 30 degrees at a frequency of 7500 cps. Any sound of this frequency, in order to be recorded at the same level as a sound of 1000 cps, must be picked up within a 30-degree angle.

Figure 3-5 illustrates this effect upon the frequency response of the same microphone. From line A in this illustration we find that

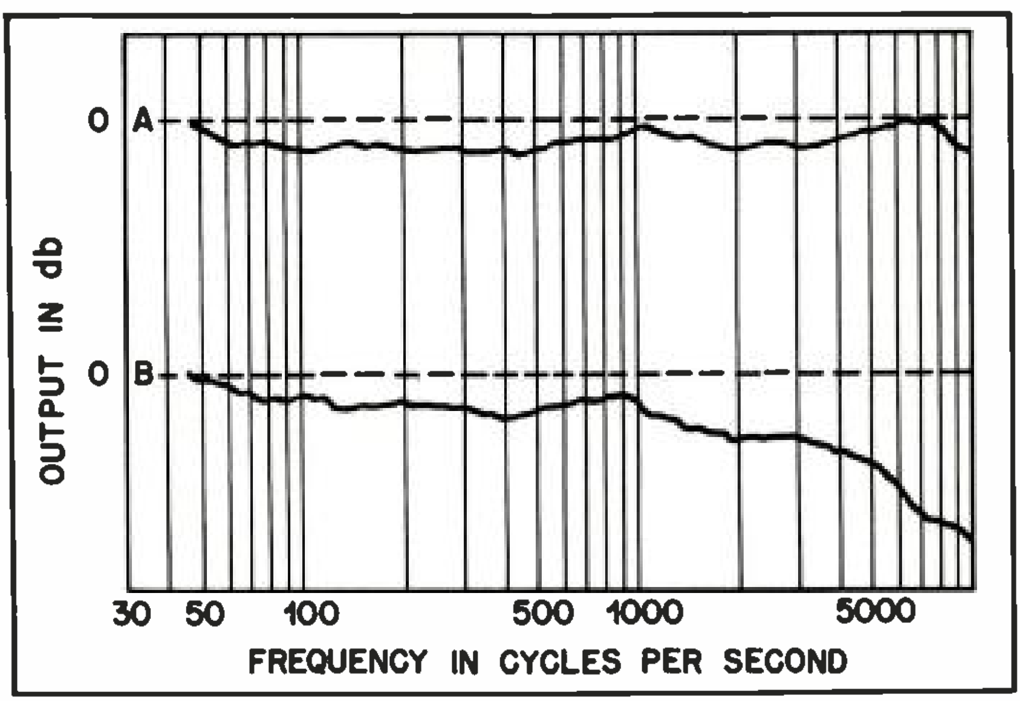


Fig. 3-5. Effect of directivity pattern on frequency response of Electro-Voice Model 950 microphone. Line A shows frequency response when sound originates within 30-degree angle directly in front of microphone. Line B shows response when pickup area is expanded to 67½ degree. (Photo Courtesy of Electro-Voice, Inc.)

the frequency response is essentially flat from 60 to 10,000 cps. Line B illustrates the response of the same microphone to sounds originating within an angle of 67½ degrees. From this curve we can see that the response to the higher frequencies has been reduced. These curves do not indicate that this microphone is a poor one but rather shows us the results of its directional characteristics. These characteristics, when properly employed, provide us with an advantage as we will eventually discover.

Before discussing the various directional characteristics available to the recordist, we should mention that they have one other effect which is as important as their effect upon the frequency response.

A microphone, as was explained in Chapter 2, is essentially a monaural device and as such is affected to a considerable degree by both the sounds we wish to record and those we would like to reject, such as noise, etc. As mentioned earlier a microphone cannot discriminate. The brain, through the human ear, is selective and automatically rejects unwanted sounds to a considerable degree. A microphone will not reject any sound of sufficient intensity to actuate its diaphragm. Both the desired and the unwanted sounds are picked up and consequently recorded. Were we able to control the pickup area of a microphone in such a manner that only the sounds in the area of interest were picked up, we could by its proper placement duplicate the selective function characteristic of human hearing. By choosing the correct microphone and placing it in a position which utilizes its directional characteristics to the fullest extent we can accomplish almost the same end. By choosing microphones with different directional characteristics we can obtain essentially the same advantages obtained by the photographer who uses different lenses.

From our preceding paragraphs it should be obvious to the reader just why the author considers the directional characteristics of a microphone so important. When properly employed these characteristics permit the recordist to control the frequency response, type, amount, and character of the recorded sound.

Figure 3-6 illustrates the four most important of various microphone directivity patterns available to the recordist. The directional pattern of a unidirectional microphone is shown at (A), of an omnidirectional microphone at (B) and a bidirectional microphone at (C). The directional characteristics of unidirectional microphones vary

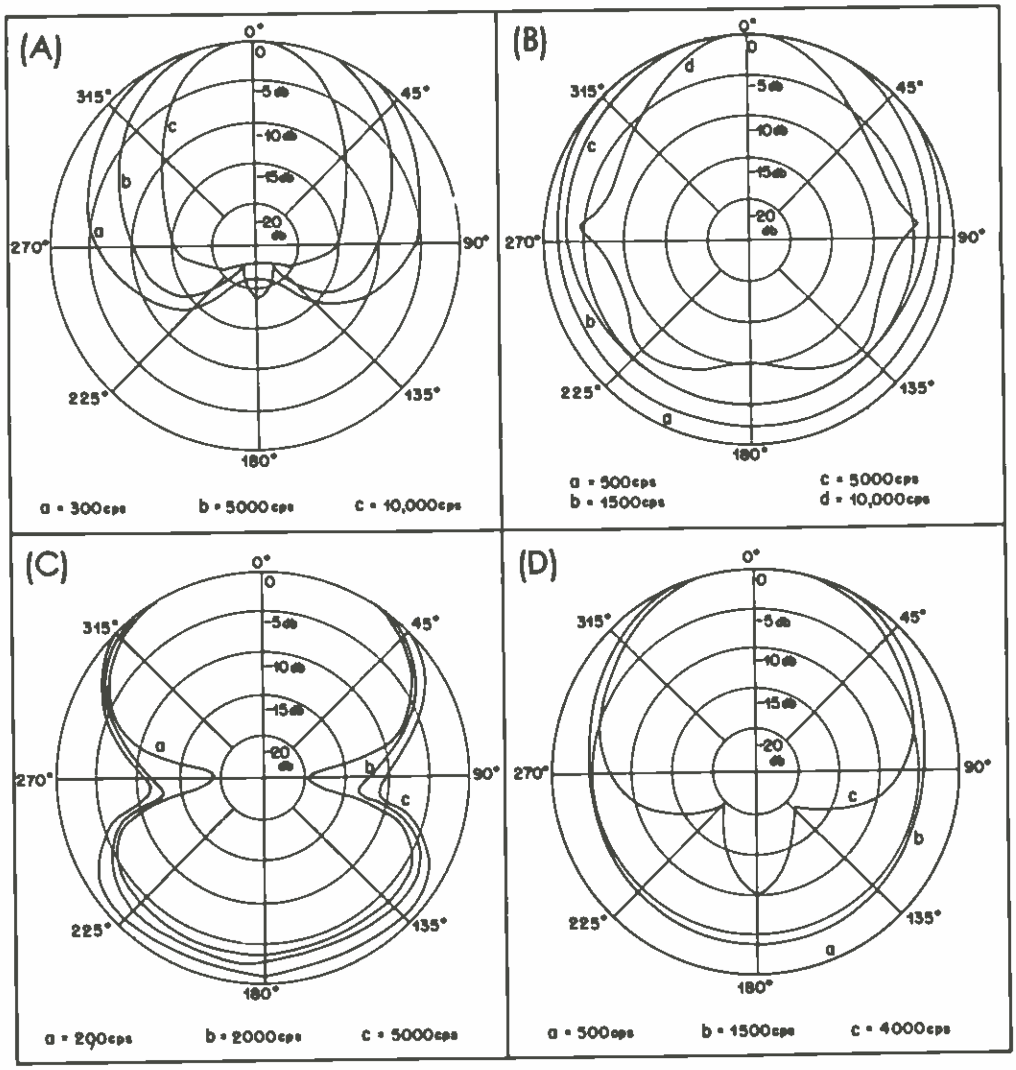


Fig. 3-6. The four most important microphone directivity patterns available to the recordist. (A) is unidirectional, (B) is omnidirectional, (C) is bidirectional, (D) is the pattern of the type of microphone supplied with most home tape recorders. (Photo Courtesy of Electro-Voice, Inc.)

within their type from the pattern shown at (D) to the pattern illustrated at (A). The microphone at (A) is called a cardoid type from its heart shaped pattern. The directional characteristics shown at (D) are those of the type of microphone usually furnished with home recorders.

One of the most important applications of the various directional patterns is the reduction of unwanted sounds in a recording. An earlier chapter explained that the average recordist was invariably quite surprised when he heard the results of his first recordings, since they usually contained many unwanted sounds which were not apparent at the time of the recording session. Through the proper choice of a microphone and use of reasonable care in its placement, the amount of unwanted sound picked up and recorded can be reduced by a considerable degree or in many cases it can be eliminated entirely.

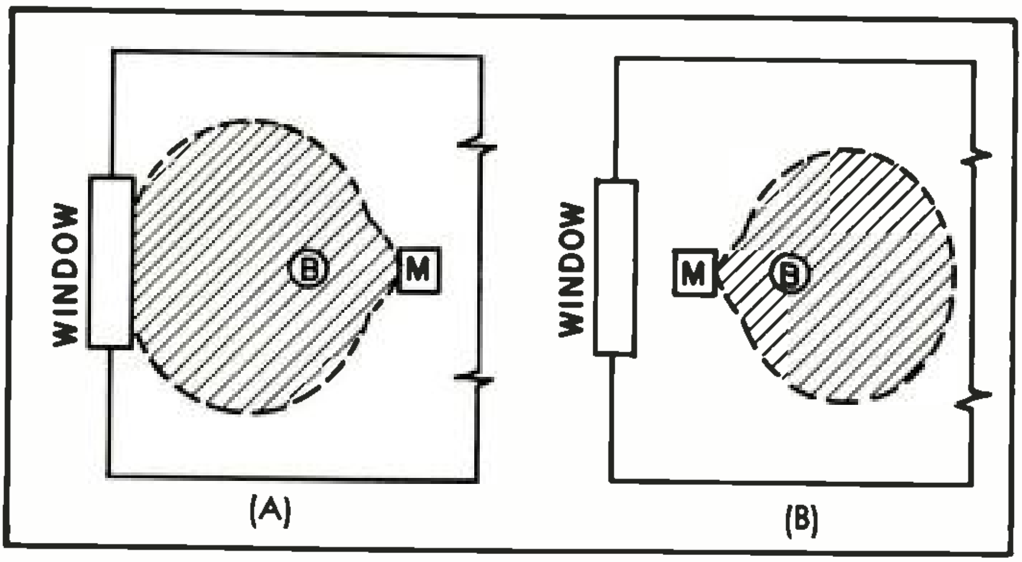


Fig. 3-7. Microphone placed as shown in (A) will result in higher noise level than if placed as shown in (B).

The simplest method of reducing the amount of unwanted sound is through the proper placement of the microphone. For example, Fig. 3-7 (A) shows a portion of a room with a window. Recording a person speaking in this room who is placed at position B and using the type of microphone usually furnished with a recorder, which is placed at position M, will result in a recording with high noise level, since the window which, in this case is the primary source of noise, lies within the area of most efficient pickup. This area is indicated by the broken line. Merely moving the microphone as illustrated in Fig 3-7 (B) places its area of greatest sensitivity away from the window and the source of noise. A slight change in the position of a microphone, when such a change is made with a knowledge of its directional characteristics, will often result in a considerable difference in the noise level of a recording. The noise level may be reduced still further by bringing the microphone closer to the performer, in this manner increasing the proportion of signal to the amount of noise picked up.

We can reduce the unwanted noise to an even greater degree by employing a microphone with a cardoid pickup pattern, such as is depicted in Fig. 3-6 (A). Its noise rejection to sounds from the rear is greater at all frequencies than the microphone generally supplied with the recorder. This type of microphone is fast becoming the standard as a general purpose microphone for home recording because of this feature. The latest model of this type is illustrated in Fig. 3-8.

Fig. 3-8. Electro-Voice Model 664 cardioid microphone.

The use of the omnidirectional microphone, whose pattern is illustrated in Fig. 3-6 (B) would provide results which were completely unsatisfactory for the particular application we are discussing, since it picks up sound and, in our case, noise, from all directions equally well as illustrated in Figure 3-9. A microphone of this type however has certain applications which are extremely important in recording, which will be discussed in later chapters.

Figure 2-5 in Chapter 2 illustrated a setup for the recording of birds. This particular group of recordings was made for ornithologists and others who were interested in bird songs and required the exclusion of most other sounds. At a later date other recordings were required for use as background sound to be used with a home movie of a barbecue party. The loud clear bird songs recorded previously were unsatisfactory for this application as they would have sounded unnatural, since we rarely if ever hear the songs of birds as loud or as clearly as they were recorded. What was required, in the interest

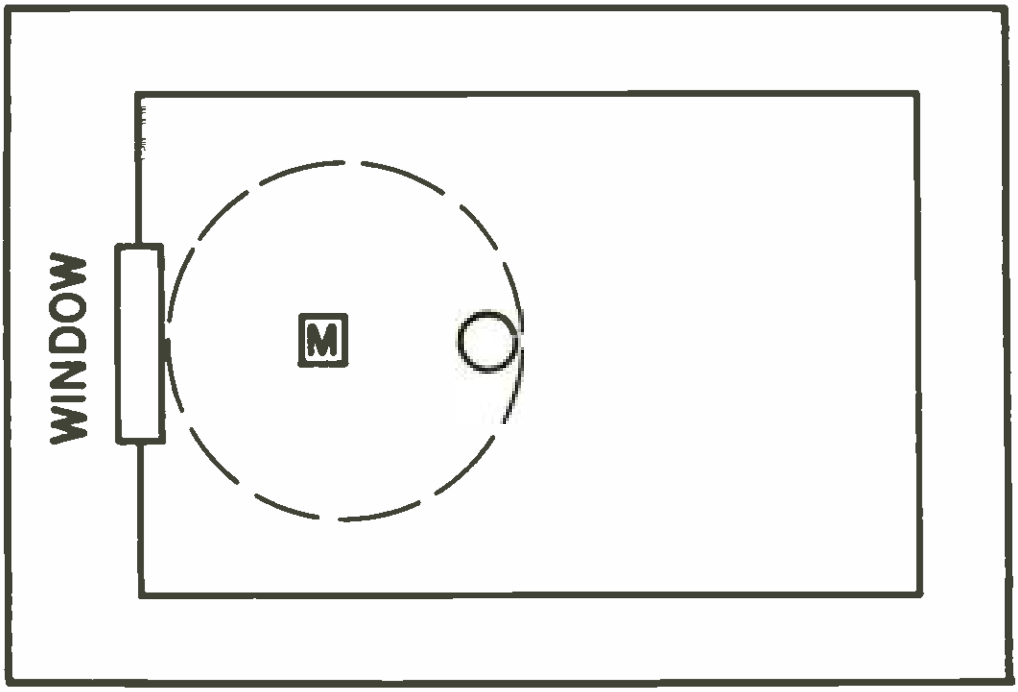


Fig. 3-9. An omnidirectional microphone is not suited for use where the pick-up pattern must be confined to a particular area.

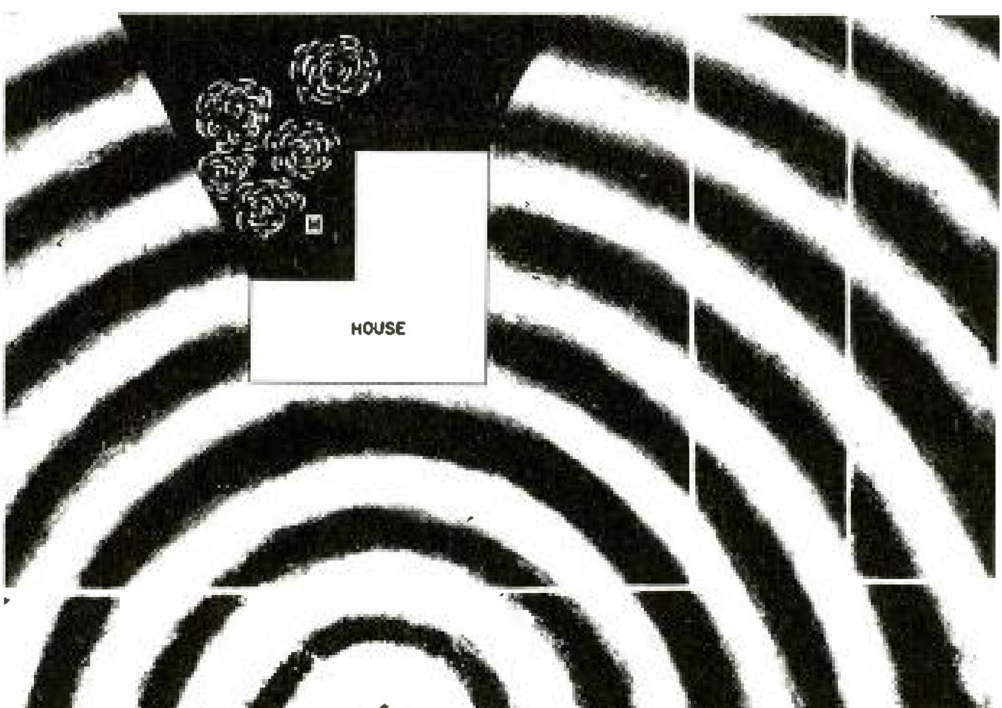


Fig. 3-10. An omnidirectional microphone placed at position "M" responds to all sounds in the general area.

of realism, was the songs of birds accompanied by the other natural background sounds such as the rustle of leaves, the swish of the palm trees, the sound of crickets and other insects and the low hum of conversation.

As may be seen from Fig. 3-10 an omnidirectional microphone placed at position M is ideal for this purpose since it responds to all sounds in the general area. This particular recording will be referred to again in Chapter 10 on sound effects and also in Chapter 13 on adding sound to home movies.

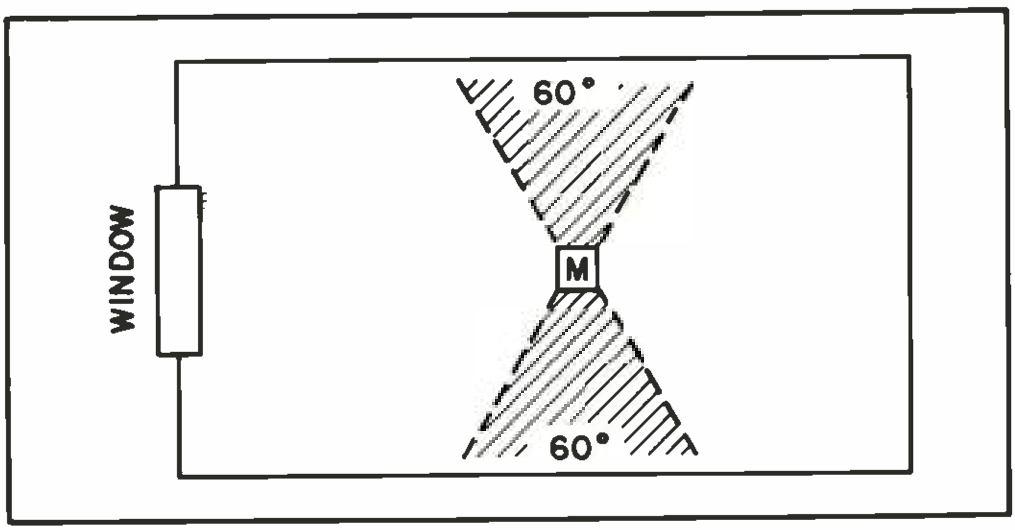


Fig. 3-11. The pickup area of a bidirectional microphone.

The bidirectional type of microphone, whose directivity pattern is illustrated in Fig. 3-6 (C) picks up sound principally from the front and rear. Until recently, this was the most popular microphone with professional recordists. However due to the remarkable advances made in the directional and other characteristics of the unidirectional type it is fast replacing the bidirectional microphone. However the bidirectional microphone is still regarded as useful for certain applications. Its pickup area is quite narrow, as may be seen from Fig. 3-11. As we can see there is little pickup at the sides and if this microphone is placed as shown its noise rejection to sound from the sides is greater than any type previously mentioned.

There are a number of other advantages which can be obtained through the use of microphones with different directional characteristics in addition to the reduction and possible elimination of unwanted sounds. The proper choice of a microphone and its placement are also useful in controlling the acoustic conditions in the recording location, in this manner changing the tone color and the character of the recorded sound. The proper choice and placement of a microphone also permits the user to change the tonal balance of a musical group. Both of these applications will be discussed in detail in Chapter 4.

In this chapter we have discovered how sound waves affect a microphone, the importance and the effect of a microphone's frequency response and the linearity of this response upon a recording. We have found how the directional characteristics of the microphone affect its frequency response and how they also affect the proportion of wanted to unwanted sound recorded, in this manner allowing us to reduce background noise. Chapter 4 will explain exactly how to change the character of the recorded sound and how to compensate for the various acoustic conditions encountered in recording.

Chapter 4

Tape Recording and Room Acoustics

In chapter 2 we discussed the echo and reverberation created in enclosed spaces as a result of reflected sound and explained that in the average size living room they were rarely a problem. We mentioned, however, that there was one other manifestation of reflected sound which did affect the home recordist.

Whenever sound waves created in an enclosed space strike a solid barrier such as a wall, part of their energy is reflected, part absorbed and another part is transmitted through the wall and lost. These sound waves are not reflected only once but many times. The number of times they are reflected is primarily dependent upon the room acoustics, *i.e.*, the position and absorptive qualities of the reflecting surfaces — walls, floors, furnishings, etc.

From the foregoing, we can see that a microphone placed in a room will receive sound energy directly from the sound source as well as sound energy which has been reflected from various surfaces. The proportion of direct to reflected sound picked up by a microphone is primarily dependent upon the acoustics of the room.

Any change in the proportion of direct to reflected sound causes a corresponding change in the character of the sounds being recorded.

This change has a vital effect upon the liveness, timbre and presence illusion of the recorded instruments or voices.

We mentioned in Chapter 1 that the distribution and the intensity of the harmonics created by musical instruments or voices were mainly responsible for their timbre, and that this factor was of considerable importance when we wished to obtain a recording which would provide an accurate facsimile of the original sound. Any change in the proportion of direct to reflected sound changes the over-all intensity of the harmonics or overtones; and because certain frequencies are absorbed to a greater extent than others, reflections may also change and redistribute the relative intensities of the harmonics.

This change in the character of the recorded sound caused by changes in the acoustics of a room may be demonstrated in the home by comparing recordings obtained under three different sets of acoustic conditions. The microphone is placed at the same distance from the source of sound (30 inches) for all three recordings. When an average living room is heavily draped, has rugs with rug pads and contains pieces of overstuffed furniture, the proportion of direct to reflected sound affecting the microphone is high since the majority of the reflected sound is absorbed by the furnishings. A recording made in a room of this type is comparatively "dead," the duration of each individual syllable or note is very short, and sound seems clipped, precise, and well defined. This is the type of sound which we have come to associate with a small room. At the other extreme a recording made in a room of the same size which is completely devoid of furnishings (an attic or cellar, for example) is very much alive and bouncy; in fact it may be too much so. The reflected sound picked up by the microphone may be equal in intensity to or may even exceed the intensity of the direct sound. In a recording made under these conditions, each note or syllable has a slightly greater duration. The sound has a hollow, reverberant character, which is usually associated with a room of much larger size. When a recording is made in a room with characteristics midway between these two extremes it will be crisp and have sparkle and the desired brilliance without the hollow sound. The proportion of direct to reflected sound has been changed again, the amount of reflected sound is not quite as great as it was in the "live" room nor as little as in the "dead" room.

These changes in the character of the sound caused by room acoustics are considerably more noticeable when the sound is picked up by a microphone than they would be to a listener in the same room. As explained earlier the microphone is essentially a monaural device and as such will not reject the reflected sound to the same extent as do the ears of the listener. Consequently the room in which a recording is made sounds more "live" than it will to the listener.

The simplest method of demonstrating changes in the character of recorded sound caused by the differences in the acoustics of the three types of rooms is by means of a piano note. Strike the Middle – C key, holding the key down after it has been struck. The note will have a comparatively long duration which could be illustrated

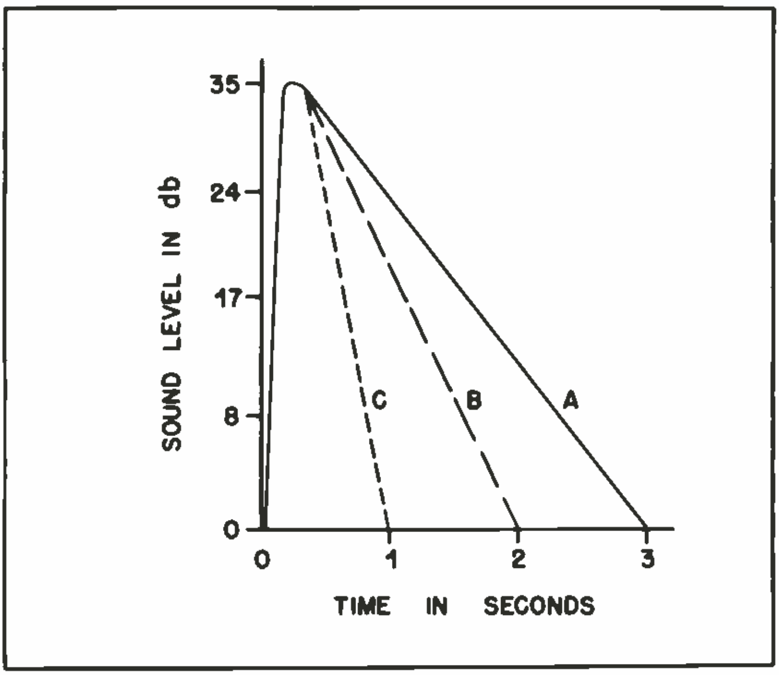


Fig. 4-1. Reverberation time of a given tone at a given level varies with the "liveness" or "deadness" of the room in which the tone is generated.

roughly as shown in line A of Fig. 4-1. This is the type of sound and duration which is characteristic of the live room. Striking the same key again, this time releasing it immediately after it has been struck, creates a tone of shorter duration similar to the sound created in our third room as shown by line B in Fig. 4-1. Strike the same key a third time, this time while pressing the left pedal, and release the key as soon as it has been struck. This action produces a tone characteristic of the dead room, as illustrated in Fig. 4-1 by line C.

Unfortunately, the average recordist cannot usually choose or correct acoustic conditions he encounters in various locations he must use. However, there are methods which may be used to change the *apparent* acoustics and achieve almost the same end. It is fortunate that the proportion of direct to reflected sound picked up by a microphone is only *partly* controlled by the acoustic conditions of the location. Two other factors which affect this proportion are the directional characteristics of the microphone and the distance between it and the sound source. These factors are important to the recordist since when they are properly utilized they permit him to alter the apparent acoustics of the room, in this manner changing the character of the recorded sound. For example, in a room of given size with a microphone six inches from the sound source, reflected sound may account for only three per cent of the total sound energy recorded. Under the same conditions, with the microphone placed at a distance of six feet, the proportion of reflected sound may rise to sixty per cent of the total sound energy recorded.

Thus, by merely changing the distance between the microphone and the sound source we are able to change the proportion of direct to reflected sound and the character of the recording. This change can be demonstrated by making a special recording of your own voice reading a part of this text. Before making the test recordings be sure that the room you use (preferably a fairly dead room such as a typical living room) is as quiet as possible. The procedure is as follows.

Select one paragraph which contains at least four sentences. Read the first sentence with the microphone about one foot from your mouth, the second with the microphone at three feet, and the third and fourth with the microphone at six and nine feet, respectively. Leave as little empty tape as possible between the sentences. Be sure that the recorded level is the same with all four sentences; this will undoubtedly mean that the volume or record level control will have to be advanced each time the distance increases. Make the test for level without running the tape if possible, so that when you do start the tape the control will be set correctly.

After this test is completed, you should have one continuous strip of tape consisting of four individual recordings made at different distances from the microphone, all at approximately the same level. Play this strip back and carefully notice the difference in the character of the sound of each individual recording as compared with the ones preceding and following it. The differences will be quite startling to anyone who has never made a comparison of this nature. You will notice that as the distance between the microphone and the sound source is increased the sound becomes more "alive", reverberant and fuller; it takes on the characteristics of sound recorded in the empty room mentioned earlier. You will also find that the greater the distance between the microphone and the sound source the more noticeable becomes the effect of the room acoustics upon the recording. One other noticeable difference is the apparent increase in the room size as the distance between the microphone and the sound source is increased. The further from the microphone the particular section of tape was recorded, the larger will seem the room.

Listening to the same person in the same room in which we made our tests, as he changes the distance between himself and the listener will not reveal the differences we can hear in the recording. The differences will be very slight and barely noticeable. A comparison of this nature will illustrate the importance of proper microphone placement.

Assuming we have made our previous recording in the living room of an average home, which we have found is comparitively dead, we can choose a room for our next test which has opposite characteristics and repeat the same procedure. Instead of the living room we can use a bare cellar or attic. When this test tape is played back we will find the results are similar to those obtained on our first tape, however the effects created by increasing the distance between the microphone and the sound source are greatly intensified due to the fact that the amount of reflected sound is much greater in the empty room to start with. Splicing this tape to the one made previously will provide a direct and very dramatic comparison between the two sets of recordings. This comparison will reveal that one microphone position in the bare room provides results which are comparable to those obtained in a different position in the room which is furnished. The exact comparison is, of course, dependent upon the individual acoustics in both rooms. We find that the three-foot position in the bare live room provides results which are quite similar to the nine-foot position in the comparativly dead room.

From these tests we have discovered how to change the apparent acoustics of an area in which a recording is made and consequently their effect upon the character of the recorded sound, without changing the physical characteristics of the room. This effect increases as the intensity of the sound is increased. For example the effect becomes more noticeable with a quartet than it is with a solo and it it is more pronounced at the higher levels produced by musical instruments than on speech.

In addition to changing the character of the sound, any change in the microphone position in relation to the source of the sound also changes the aural perspective of the sound. This factor may also be utilized to change the apparent position of the speaker in relation to the ultimate listener, particularly important in a presentation of a dramatic performance or in home sound movies when the illusion of a large space with performers at different distances must be created in a small room.

To illustrate this effect we must make a third set of recordings in the same room in which the second group was made. This time, however, we will not increase the recording level each time the microphone position is changed. When this third group of recordings is completed it is spliced into our two previous groups in the following manner.

The first sentence of the second group is spliced to the first sentence of the first group. The first sentence of the third group is then spliced to these two. The second sentences of the first, second and third groups are spliced in this order and joined to the first three. This procedure is continued in this fashion until the three sets of recordings are combined into one master test tape which contains each sentence three times in succession, recorded at the same distances from the microphone but under different conditions.

If instructions were followed carefully, the listener will be quite surprised, as he plays this combination of recordings back, to hear the subtle differences in tone color and to hear that each sentence in a group sounds as though it were recorded at a different distance from the microphone. The first sentence of each group will sound as though it was closest; the second, despite the fact that it was recorded at the same distance, sounds as though it was further away because of the increase in the amount of reflected sound picked up by the microphone, and the third sentence sounds still further away, because in addition to the increase in the amount of reflected sound picked up, the sound level is successively lower at each step.

We have now found that we are able to create the illusion of increased space and/or distance by either increasing the proportion of reflected to direct sound picked up by a microphone or by reducing the intensity of the sound recorded. We have also found that by combining these two factors we are able to increase this illusion to an even greater degree.

While this space-distance illusion is of interest to the recordist it was not our primary reason for asking the reader to make the test tape. The principle reason for this series of recordings was to demonstrate both the effect of the acoustics of the room in which a recording is made and the effect of microphone placement upon the character of the recorded sound. Listening to this test tape carefully will reveal the differences in the fullness of the sound as recording conditions are changed. Listen to the three recordings made at a distance of six feet. Despite the fact that the voice, the microphone and its distance from the speaker are the same the differences in the tone color are quite pronounced. The differences caused by room acoustics are quite obvious since the proportion of reflected to direct sound is high. On the other hand, comparing the three recordings made at a distance of one foot does not reveal so obvious a difference since the proportion of reflected to direct sound is low.

We have discovered just how we can change the character of the recorded sound, compensate for room acoustics, change the aural perspective, and also change the apparent size of a room, all by simply varying the distance between the source of sound and the microphone. These effects should be used sparingly like salt and pepper — a pinch will enhance the flavor while too much will spoil the taste.

The characteristics of sound, the human ear and the microphone which we have just discussed are those which make microphone placement a creative art and which, when properly employed, permit the recordist to add a new dimension to his recordings. It is the correct use of these characteristics which transports the ultimate listener into the presence of the performer despite the fact that they are separated in time and space.

When the recordist is forced by circumstances to use a room larger in volume than 5000 cubic feet, which is usually the maximum ever encountered in the home, he meets with the same problems; however they become slightly more difficult to cope with. Rooms of this size are usually more sparsely furnished than a living room and consequently have very little sound absorption.

The teacher or anyone else forced to use comparatively large, bare rooms for recordings can compensate for and change the apparent acoustics of the room to almost the same degree as the home recordist, despite the fact that most rooms of this size and type are quite live. The average classroom, for example, usually has one complete wall of windows which are highly reflective to sound when closed, no rugs, no drapes and no furniture which absorbs sound. Most of these rooms, in fact are so live that the recordist may encounter actual echo, or at least sufficient reverberation to interfere with the definition of speech and degrade the quality of music. Methods of reducing these extreme effects will be discussed in detail in Chapter 5.

Instead of the living room in which we made our first section of tape, the teacher must use the classroom and increase its absorption with the materials at hand. Fill each seat with a pupil. When the closets which contain the pupils' outdoor clothing are in the same room they should be opened, exposing the clothing to view. The pupils and their outdoor clothing are used in this manner to deaden the room by increasing its absorption of sound. The degree of absorption may be increased still further by having each pupil lay his outdoor clothing on his desk. The pupils must be cautioned to remain very quiet during the recording. A recording is now made following the procedure outlined at the beginning of this chapter. The ideal time to make this recording, for obvious reasons, is just before school is dismissed for the day. After school is dismissed a second recording should be made in exactly the same manner in the same room in its empty state.

Listening to the first of these two recordings will reveal the same differences we encountered in the tests made in the home; as the distance between the microphone and the sound source is increased the sound becomes more live and reverberant, and the effect of the room acoustics becomes more noticeable. Listening to the second recording made in the classroom reveals the same conditions, however the effects become much more noticeable since now very little of the sound in the room is absorbed and the reflections have a greater intensity.

A comparison of the two classroom recordings discloses the same differences we encountered in the recordings made in the home, and shows that by proper microphone placement we can compensate to some degree for the acoustic conditions encountered. If the teacher cares to pursue the matter further and make a set of recordings in his home in the manner outlined earlier, and then compares these with the two sets made in the classrooms, he will find that even under the comparatively dead conditions obtained with the pupils in their seats and their outdoor clothing exposed to absorb sound, the classroom is still much more live than even the empty attic or cellar in the home. This additional liveness, which, as we have found, is even more intensified in a recording, is the primary reason for the difficulties encountered when recording in large rooms such as the classroom of our example. However there is a solution.

Earlier in this chapter we mentioned that there are two factors which affect the proportion of direct to reflected sound picked up by a microphone, aside from the acoustics of the room. These are the distance between the microphone and the sound source, and the directional characteristics of the microphone itself.

During the latter part of Chapter 3 we explained how the directivity pattern of a microphone affects the amount of unwanted noise picked up and how a specific pattern could be utilized to reduce it. The directional characteristics of a microphone may also be used to control the amount of reflected sound picked up.

When using the semi-directional microphone furnished with the recorder, as illustrated in Fig. 4-2, the reflected sound may account for 60 per cent or more of the total sound energy recorded. When a more directional microphone, such as one of the velocity or cardiod type is utilized in the same position, under the same conditions, the reflected sound picked up will drop to possibly 20 or 30 per cent of the total sound energy recorded. The use of a cardiod microphone, such as that shown in Fig. 3-8, will increase the working distance about two-and-one-half times without any change in the ratio of direct to reflected sound picked up. We are thus able to affect the apparent acoustics of a room merely by a change in the type of microphone used. The liveness now may be reduced or increased still further by varying the distance between the microphone and the sound source, as explained earlier.

In this chapter we have discovered the effect of room acoustics upon the character of the recorded sound and how to compensate for and vary this effect. We have found how we can create aural

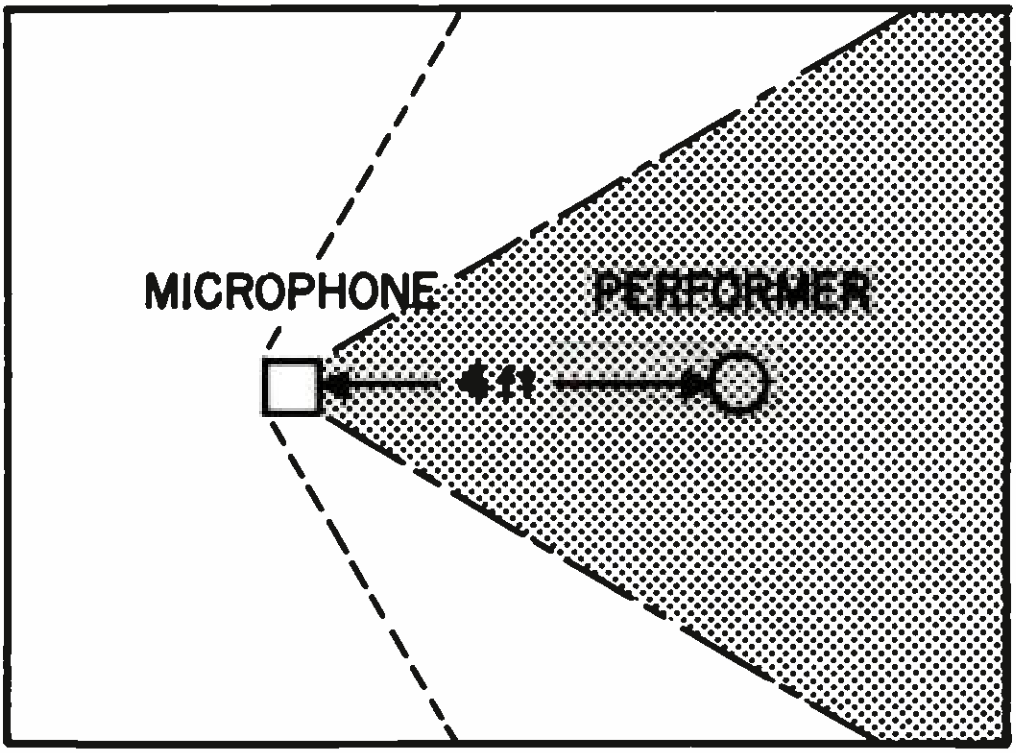


Fig. 4-2. With a semi-directional microphone, reflected sound may account for as much as 60 per cent or more of the total sound energy recorded.

perspective in a recording and how to alter it. We have discussed the problems encountered in recording in large rooms and how to cope with them. Our next chapter will explain how the knowledge we have thus far acquired may be applied toward making better recordings.

Chapter 5

Recording with a Microphone

THE READER has now arrived at a point where he is familiar with the various types of microphones available, most of their characteristics, and the characteristics of the sound waves which actuate them. This knowledge can now be applied toward obtaining recordings which are an acoustic facsimile of the original performance, with its mood, aural perspective, and emotional impact.

Our first step will be to explain and solve the most common problems encountered by the average recordist. For the sake of discussion we will assume that our examples are to be recorded in the average size living room (under five thousand cubic feet) with the microphone generally furnished with the recorder, unless otherwise mentioned. All of the microphone distances suggested are given for average conditions and are basic figures.

Tape recordings may be roughly grouped into four categories: (1) the speaking voice, (2) solo musical instruments, (3) singing voice with musical accompaniment, and (4) larger instrumental or vocal groups. The category most often encountered is the recording of a single speaking voice. This, incidentally is also the simplest recording to make. In recording the speaking voice intelligibility and definition are of paramount importance, consequently the proportion of direct to indirect sound picked up by the microphone should be high unless special effects are required. This means that the microphone should be placed fairly close to the performer. A distance of between one and three feet is usually correct for average conditions. The exact distance is, of course, dependent upon the acoustics of the room. In a comparatively dead room the microphone should be placed closer to the three-foot position to avoid the artificial, too intimate sound characteristic of a room of this type. In a larger or more live room the microphone should be placed closer to the one-foot point to reduce the proportion of reflected to direct sound. The microphone placement is of course also subject to the volume of the performer's voice. A loud, powerful voice requires more distant placement (closer to the maximum figure) than does a comparatively weak voice.

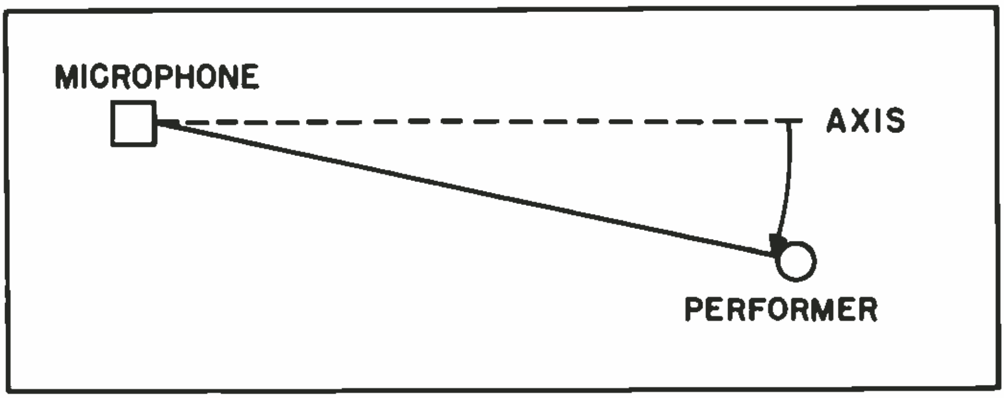


Fig. 5-1. High-frequency content of a recorded voice may be reduced by placing a performer at an angle off the axis of the microphone.

There are some variations which may be obtained in the quaility of the recorded sound. The high-frequency content of the recorded voice may be reduced by placing the speaker at some angle off the axis of the microphone, as shown in Fig. 5-1. The greater the angle off the axis the greater will be the reduction in the high frequency response, as illustrated in Fig. 3-6. The use of this directional characteristic is extremely valuable in obtaining a flattering recording of harsh, high-pitched voices and voices with too noticeable sibilants. The character of the voice may also be changed, as explained in Chaper 4, by varying the distance between the performer from the basic distance given.

When a room is too dead and the more distant placement of the microphone does not provide sufficient fullness and resonance, the microphone and the performer may be arranged as shown in Fig. 5-2(A). With this arrangement the axis of the microphone is parallel to the length of the room and the proportion of reflected to direct sound picked up by the microphone is higher. When the room is

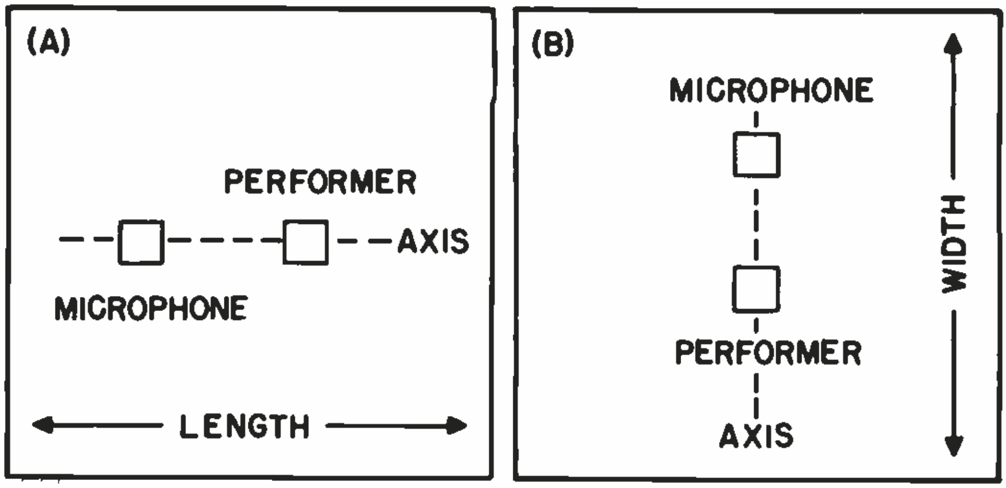


Fig. 5-2. (A) depicts the axis of a microphone arranged parallel to the length of a room to increase proportion of reflected to direct sound. (B) indicates the preferred arrangement where reflected sound must be subdued to reduce the apparent liveness of the room.

too live, as may be the case in rooms of more than five thousand cubic feet in volume, or in bare empty rooms, the arrangement illustrated in Fig. 5-2(B) should be used since it reduces the amount of sound reflected into the microphone, and in this manner reduces the apparent liveness of the room.

Recording more than one person, as in a dramatic performance or when adding sound to home movies, may be made much more realistic by introducing aural perspective. The position of the lead or most important voice is obtained as outlined in our previous paragraphs. This position is then used as the key for the placement of the remaining performers. For example, recording the sounds of an anniversary dinner party we would place the host at a distance of about three feet from the microphone. This will produce a slightly less intimate recording than the one-foot position and yet will provide the illusion of placing the ultimate listener at the dinner table. When adding sound at home to a movie taken of the family while visiting a museum, we would place the microphone at a distance of ten to twelve feet from the lead voice, which would be the person imitating a guide or the father explaining the various exhibits. This microphone placement will provide the distant, hollow, reverberant sound which we normally associate with large enclosed spaces and add realism to the recording.

Once the position of the key figure is determined for the over-all effect required, the subordinate figures are placed in positions which indicate their relative importance or their distance from the key figure. For the dinner recording, the wife and children are placed slightly "off mike" and at a slightly greater distance from it. The distance should not be greater than four feet from the lead voice, since any greater distance will remove the speaker from the dinner table completely. As mentioned earlier, the relative loudness of the various voices must also be taken into consideration, since a comparatively weak child's voice may be overshadowed by an adult's voice at the same or greater distance. The child's voice may be given more prominence by placing the adult slightly off mike or at a slightly greater distance from the microphone. If the child is very young and his voice is quite shrill and high-pitched a better method is to place the child slightly off mike and increase the adult's distance. This will cut down the shrillness and yet give the child's voice prominence. The over-all effect achieved in recording a group is dictated by the placement of the key figure. This effect is then enhanced by the correct grouping of the other performers in relation to the key figure. This method is utilized quite frequently in professional movies, radio and television to feature a specific character.

The type of recording next in popularity is that of solo musical instruments. Recording musical instruments is no more difficult than recording a speaking voice, however it is important that you familiarize yourself with the instrument you wish to record. How does it work? Where does the sound come from? These characteristics are important if you are to obtain a realistic recording. The first of the factors which must be considered is the frequency response of the microphone. It must be sufficiently wide to respond to all of the fundamental tones and overtones created by the instrument. A check of Fig. 1-8 and a comparison with the response of your microphone will indicate this. Second, the directional characteristics of both the instrument and the microphone must be considered when the microphone position is chosen. Third, the dynamic or loudness range of the instrument must be considered.

The dynamic or loudness range of a musical instrument or a singing voice is the difference in the volume level between the loudest and softest sounds it can produce. This is the one important factor in recording which we have not as yet mentioned, since in our previous discussions it has not been a factor. The volume level of a human voice speaking in normal conversational tones remains comparatively constant throughout normal speech unless the speaker becomes excited. The sound level of a musical instrument or a singing voice, on the other hand, varies considerably during the rendition of a musical selection. Some passages are soft, others are loud. These changes in volume level are one of the means by which the musician creates variations in mood and expression.

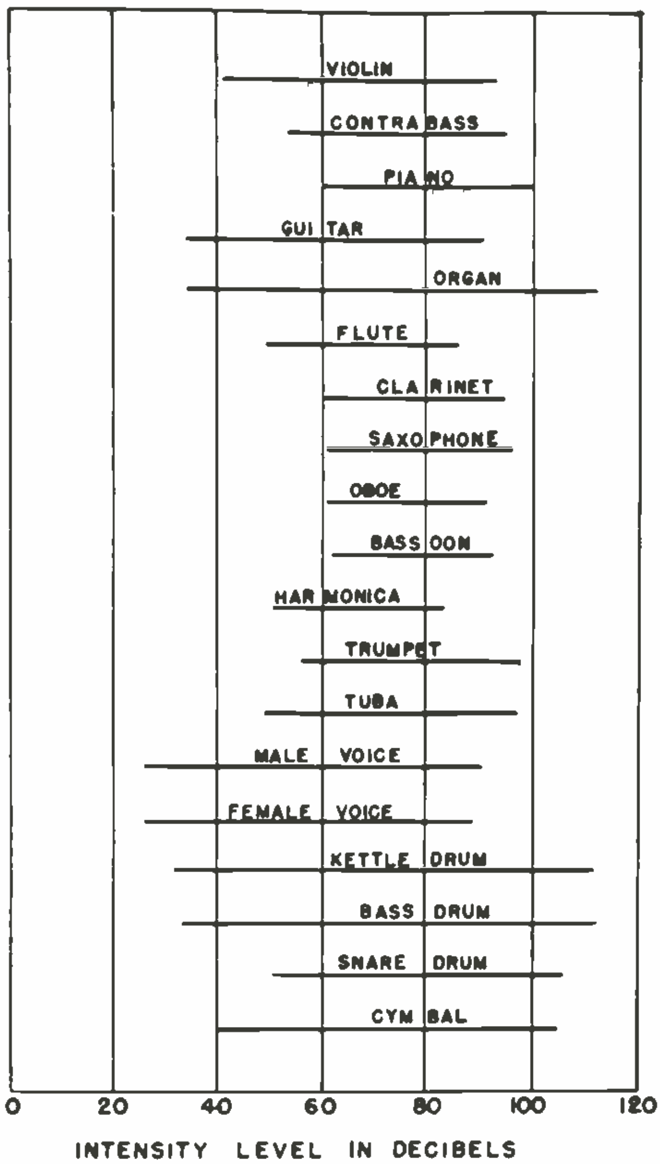
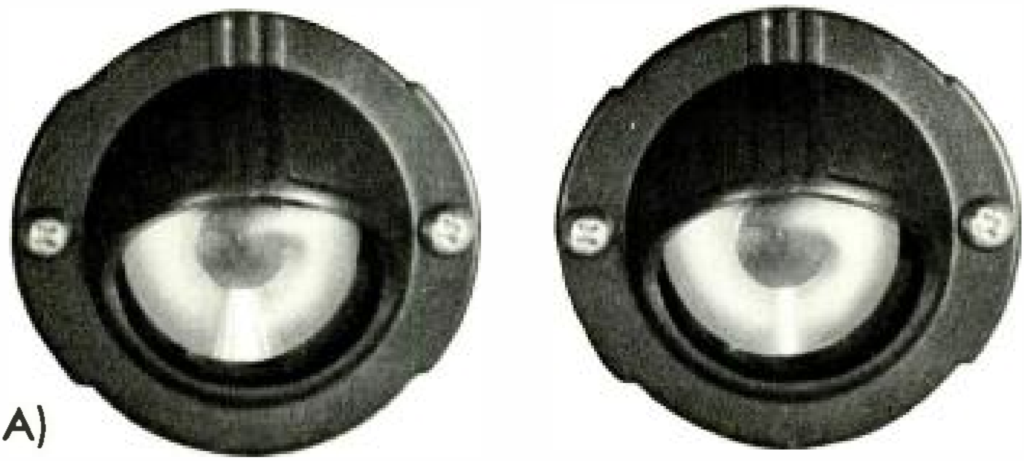
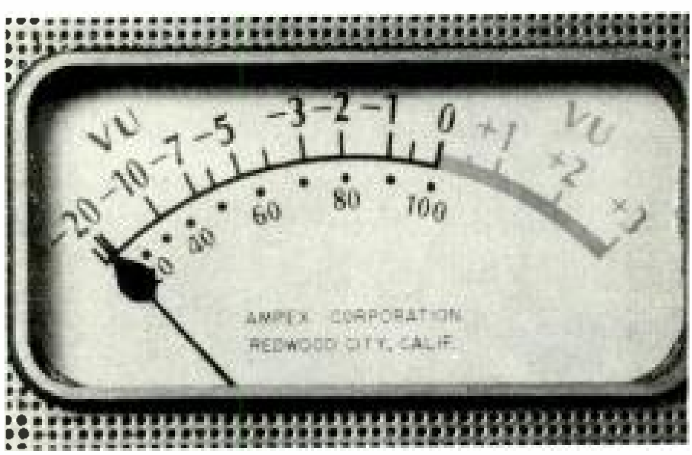


Fig. 5.3. Here is shown the dynamic range of various instruments and voices.

Figure 5-3 depicts the dynamic or loudness range of the various musical instruments and voices which we are apt to encounter in recording. From this illustration we can see that the instrument which produces the greatest sound intensity and has the widest dynamic range is the organ. Next are the drums and the cymbals, followed by the piano.



(A)



(B)

Fig. 5-4. (A) shows the "magic-eye" volume-level indicator used in many home recorders. (B) shows the VU meter used in semi-professional and professional machines.

Dynamic range is important in recording because there is a maximum level which can be handled by the recording equipment without introducing objectionable and noticeable distortion. Any level above this specific level results in a recording which is noticeably distorted. The maximum level which can be handled without distortion is shown on your recorder by one of three types of record level indicators. The most common is the neon indicator, in which one or two lamps may be utilized. Another is the magic eye as illustrated in Fig. 5-4 (A). A third is the VU meter often seen on professional equipment, illustrated in Fig. 5-4 (B).

Detailed instructions for the use of the record level indicator are usually provided in the operation manual furnished with your recorder. However we may say briefly that the simplest of these is the single-bulb neon indicator. The maximum recording level, hereafter referred to as zero level, is the point at which this bulb glows intermittently on loud peaks of sound. Some recorders use two neon lamps, one of which should glow intermittently and is marked *normal* and the other which is labeled *distorted* and should not glow at all during recording. Other recorders use a magic eye as shown in Fig. 5-4 (A). The distortion point or zero level on this type is indicated when the eye is completely closed. At very high level the sides of the eye overlap. The third type, usually seen only on professional or semi-professional equipment is the meter illustrated in Fig. 5-4 (B). The zero mark on the meter indicates the zero level over which excessive distortion occurs.

The most commonly used musical instrument is the piano. Unfortunately this is also the most difficult instrument to record properly, as many commercial recording companies will testify. The first problem encountered in making a piano recording is usually distortion. The sound produced by a piano occurs in sharp bursts as it is a struck-string instrument. Loud sound in sharp bursts tends to cause overloading quite easily. Overloading, as explained previously, results in distortion. Proper microphone placement and careful adjustment of the recording level can reduce distortion to a negligible factor.

An earlier paragraph said, "learn the characteristics of the instruments you wish to record." As an example of the variations you will encounter in recording musical instruments we will explain in detail the various methods employed to record the piano in its various forms. There are two general types of piano, the upright with its smaller version known as the spinet, and the grand piano with its undersized counterpart, the baby grand. Since the upright and the spinet are most frequently encountered we will discuss the recording of these instruments first.

It is not usually convenient to move a piano of any type so we must assume it occupies the conventional position against the wall as illustrated in Fig. 5-5 (A). The microphone should be placed four to five feet from the piano as illustrated. The microphone should be pointed between Low A and Middle A for good tonal balance with the average microphone furnished with a home recorder. Vary-

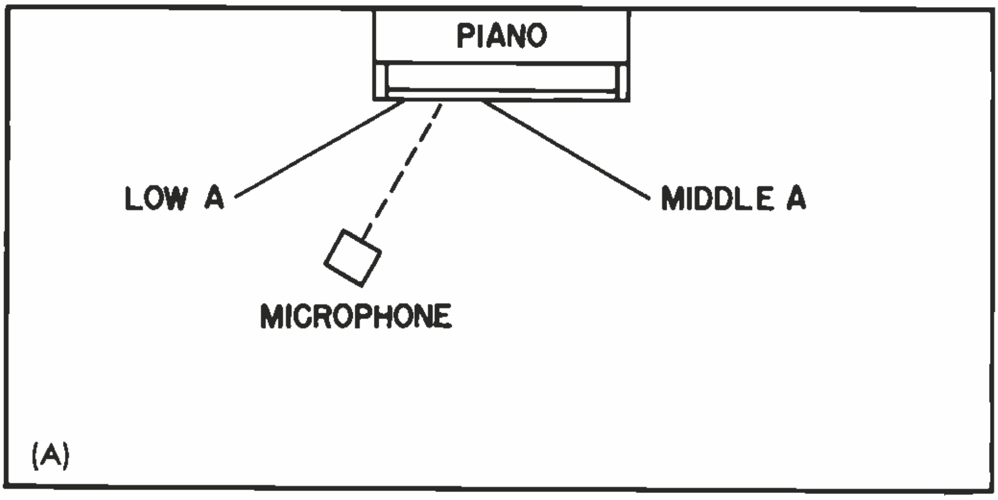
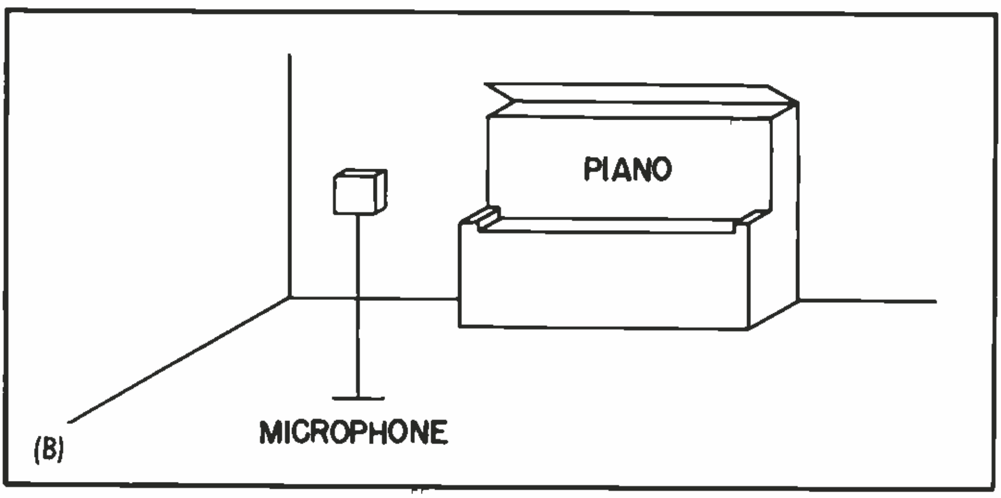


Fig. 5-5. These views indicate proper microphone placement for recording an upright piano when the instrument is placed against a wall.



ing the position of the axis of the microphone in relation to the keyboard will vary the tonal balance between the low and high frequencies to a slight extent at this distance. Though this position is best for an intimate pickup of both the upright and the spinet it may give rise to another problem – the mechanical noise created by the keys, pedals and hammers may be picked up and recorded. To avoid this the microphone should be placed on a stand at least two feet above the keyboard. This positioning will minimize and often eliminate these mechanical sounds.. When the piano is a conventional upright with a hinged top the noise problem is even more simple to solve; merely place the microphone at a point about six inches above the height of the piano and raise the top as illustrated in Fig. 5-5 (B). Due to the slightly greater volume of sound obtained in this manner the microphone should be moved about six inches further from the instrument making the total distance between five and six feet.

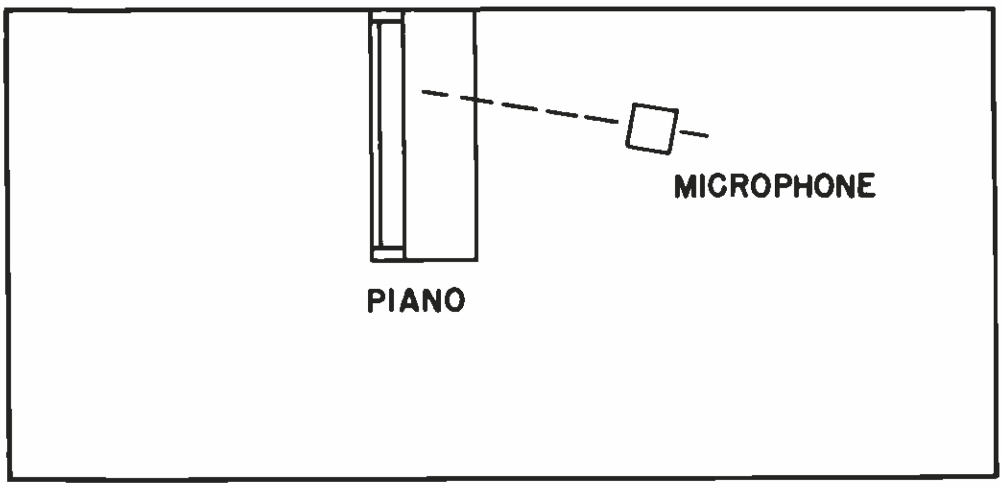


Fig. 5-6. A spinet is best recorded when placed at a right angle to a wall.

Should the mechanical noise be noticeable when making an intimate recording of a spinet the simplest solution is to move the piano (it is much lighter than the upright) at right angles to the wall as illustrated in Fig. 5-6. The microphone is then placed as shown, facing the rear of the instrument and twisted slightly toward the player's left side if the conventional crystal or ceramic microphone is used.

The baby grand is next in popularity in the home. The methods used to record this instrument also apply to the standard-size grand piano since, for recording purposes, they are quite similar.

With both types the sound issues from the side of the instrument when the top is open, consequently we must consider the open side as our sound source. The microphone should be placed as illustrated in Fig. 5-7. Due to the fact that the intensity of the sound radiated from a grand is greater than that from an upright the microphone should be placed at a correspondingly greater distance. For the baby grand a distance of five to six feet seems to provide the most satisfactory results. For the standard-size grand with its

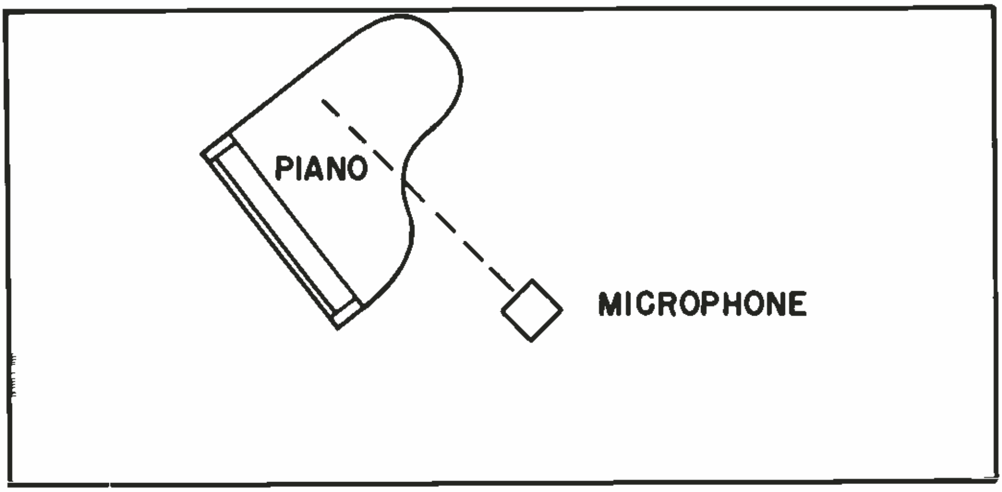


Fig. 5-7. Ideal microphone placement for recording a grand piano.

still greater volume a distance of seven to eight feet is more satisfactory.

The microphone distances we have given will provide what is called an intimate pickup. The proportion of direct to reflected sound is high, consequently the recording will sound just as it sounds in your living room; each note will be sharply defined, crisp and clean. When the recordist wishes to create the illusion of increased space and obtain a tone quality less crisp the recommended distances should be doubled. To obtain the illusion of concert-hall sound the distance between the instrument and the microphone should again be doubled. Changing the distance, as we have found, also changes the character of the recorded sound; consequently the correct microphone position is the one which makes the recording sound most nearly like the original performance.

The bowed-string instruments are next in popularity to the piano. The most popular of these is the violin. Unlike the piano, the maximum loudness the violin produces is not the controlling factor in making a recording. In recording a violin the most important factor is the *minimum* loudness. Just as there is a maximum loudness level which can be recorded without excessive distortion there is a minimum loudness level which is controlled by the background noise in the recording room and the residual noise level of the recorder. Any sound below this level is masked by the extraneous noise. In order to obtain the maximum quality in a violin recording the microphone should be placed as closely as possible to the instrument without interfering with the performer. This distance will usually be two to three feet. Another limiting factor is the microphone position at which the surface noise of bowing becomes noticeable. When this sound does become objectionable the microphone distance should be increased until it disappears. The violinist should always be placed on the axis of the microphone despite the fact that this instrument is almost nondirectional, as the overtones it creates are quite weak and any loss in their intensity is quite noticeable. The foregoing remarks apply equally to all bowed-string instruments such as the viola, violin cello, and the double bass.

As closely as the author could determine the instruments next in popularity are the guitar and its smaller counterpart the ukulele. When recording a guitar it should be placed from three to four feet from the microphone. When the guitar is used as a solo instrument it should be placed directly on the axis of the microphone to insure good high-frequency response. The ukulele has about half the output of the guitar and therefore requires a closer microphone placement.

The banjo and the mandolin, while they are not as popular as the instruments previously mentioned, should be included in this group. The banjo has a volume level considerably higher than that of a guitar. The volume level of the mandolin is about the same as that of the ukulele. Generally speaking, plucked-string instruments produce more volume than bowed-string instruments and require more distant microphone placement.

The next group we will discuss comprises the wood-wind and wind instruments. The most popular of the wood-winds are the saxophone and the clarinet. These instruments are highly directional in their propagation of sound at the higher frequencies, consequently they require exceptionally proper microphone placement.

For solo recording, a saxophone or clarinet should be placed on the axis of the microphone, at a distance of from five to six feet. When a particularly loud passage of the selection to be recorded is encountered the performer may turn his instrument no more than ten degrees off the axis, as illustrated in Fig. 5-8, to reduce the level slightly. But this movement should not be carried to an extreme since it may result in a complete drop out of the higher frequencies. The directional characteristics of the trombone and other solo brass instruments are similar to those of the saxophone and clarinet.

Since the drums produce a greater volume of sound than any

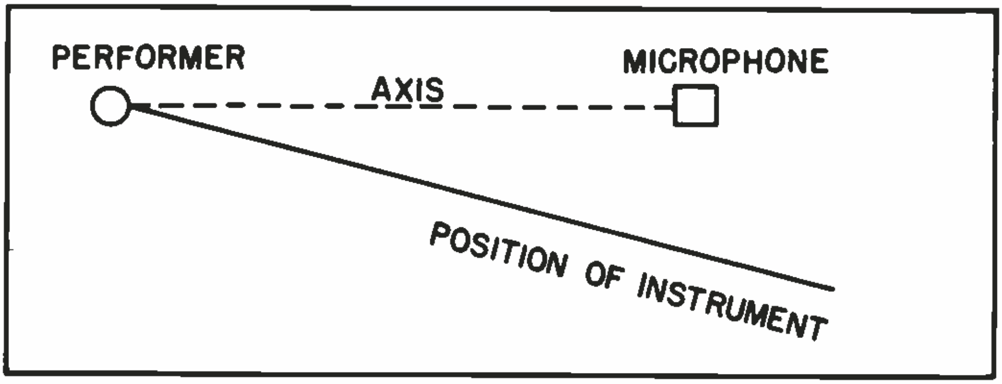


Fig. 5-8. On particularly loud passages an instrumental soloist may turn his instrument slightly off the microphone axis to reduce the recording level.

other instrument with the exception of the organ, they may be placed at almost any desired distance from the microphone for solo recording. Drums are also nondirectional, consequently they may be placed at almost any angle.

As we explained earlier, recording a solo musical instrument is no more difficult than recording a speaking voice once the directional, frequency and intensity characteristics of the instrument are known. The figures provided for microphone distance may be varied as explained in Chapter 4 to alter the character of the recorded sound and compensate for room acoustics.

We have assumed in all of the examples given in this chapter that the background noise in the recording room was low, consequently the information related only to the microphone and the sound source. When the noise level of a room is high enough to be objectionable it may be reduced by proper placement of the microphone and the performer with relation to the source of the noise as explained in Chapter 3, or through the use of a cardioid microphone placed at the recommended distances.

Chapter 6

Microphone Techniques

RECORDING a vocalist is quite similar to recording a musical instrument in that we encounter practically the same problems. The volume level of a singing voice, unlike that of a speaking voice, does not remain constant. The vocalist may at first sing loudly, then more softly, then loud again. We must, as we did with musical instruments, allow for this variation in volume level, since if the record level control is adjusted for the high-level passages the softer passages may be lost in the background noises.

The most practical method of determining the proper distance between the vocalist and the microphone is to have the singer take a position about eighteen inches from the microphone, and then set the record level control at a position slightly lower than the one which has been previously determined to be the proper one for a speaking voice. Ask the vocalist to render the loudest portion of the selection you are about to record. Watch the record level indicator. If it shows overload have the vocalist move back from the microphone until the loudest passage does not exceed the maximum recording level on the indicator. This position will usually be between eighteen and forty-eight inches, depending upon the power of the singer's voice. A crooner will work closer to the microphone. This type of singer will be discussed separately in later paragraphs.

Overloading caused by the use of too high a recording level is responsible for more poor recordings than all other factors combined. However, there is one other factor to be considered. There is a lower limit which is the minimum recording level, below which the recordings may be obscured by background noises of various kinds. This factor is particularly important when recording classical music with its wide dynamic range.

During professional recording sessions the artist compensates to some extent for the variations of sound level during the rendition of a selection by microphone technique. He varies the distance or the angle, or both, between himself and the microphone, coming closer at particularly low-level passages to increase the level slightly and moving back slightly at the higher-level passages to decrease the level. The recording level may be further decreased when required by moving slightly "off mike."

Whenever possible, the microphone-technique method of compensation for wide volume level variations should be utilized. The difference in the distance or the angle off mike is not great; six inches will suffice for most voices. Very loud singers performing operatic selections require a slightly greater change in distance and angle but neither should be so great as to cause the performer to actually change his standing position. Inclining the head or body slightly is usually sufficient. Any movement by the performer should be made gradually; if it is not, it will create a sudden change in level rather than one which is unnoticeable.

Unfortunately, it is not always possible for the recordist to obtain this valuable assistance from the performer, since most amateur performers are too preoccupied with the recording itself to provide any cooperation. Consequently it is left to the recordist. When confronted with this rather common situation the recordist must employ the record level control, raising the level very slightly at the softer passages and then returning it to its original position when the singer's level is again increased. Extreme care should be used not to overcompensate by excessive control twiddling, since this can destroy the musical expression of a recording by reducing its dynamic range. Any variation of the record level control should be made very gradually.

You may find that while recording bass and baritone voices the microphone furnished with your recorder will perform to your complete satisfaction. However when you begin to record tenor, alto and soprano voices you may notice that they do not sound quite natural. A microphone with a wider frequency range will solve this problem since these voices are all higher pitched and have important overtones in the higher register.

Occasionally a singer may be encountered whose speech has excessive sibilance, a hissing sound most noticeable in words with the letter *s*. These people should be placed at some angle off the axis of the microphone, the exact angle to be determined by the amount of sibilance. Such placement will greatly reduce or even eliminate this annoying characteristic.

A crooner is the easiest singer to record since his voice is usually quite low-pitched and has a very narrow dynamic range. Crooners must be placed very close to the microphone since their volume level is usually very low. A crooner may be placed as close as four to six inches from the microphone unless a velocity microphone is employed. With this type of microphone the performer should be placed from twelve to eighteen inches from it or the resultant recording will sound bassy and boomy.

Our next problem in recording a vocalist is due to the fact that there is usually some form of musical accompaniment. A piano is most frequently employed. The problem is caused by the fact that the average sound level of a singing voice is 68 db. and the level created by a piano is about 78 db.; consequently, the microphone placement which is correct for the singer is not correct for the piano, and *vice versa*. For example, if the vocalist stands in the conventional singing position in relation to the piano and the microphone is placed for an intimate pickup of a baby grand, as illustrated in Fig. 6-1 (A), the vocalist will be drowned out by the piano. This is due to the higher sound level created by the instrument.

The correct microphone placement is illustrated in Fig. 6-1 (B). Due to the fact that sound loses its intensity as the distance between the source and the microphone is increased, we need merely place the microphone in the correct position for the piano pickup and bring the vocalist closer to the microphone until a position is reached where the correct volume balance is obtained. In our case it was a distance of between two and three feet.

When a less intimate recording is required or when the room in which the recording is being made is too dead, the microphone should be placed six to twelve feet from the piano. When the distance between the microphone and the piano is increased, the distance between the vocalist and the microphone must also be changed. In our example, the vocalist should now be placed at a distance of from four to six feet. Unless these distances are changed proportionately

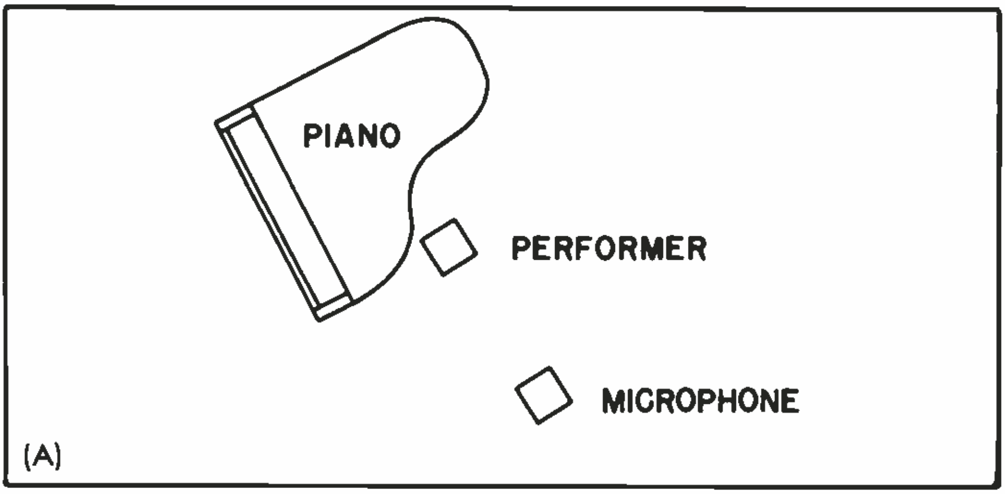
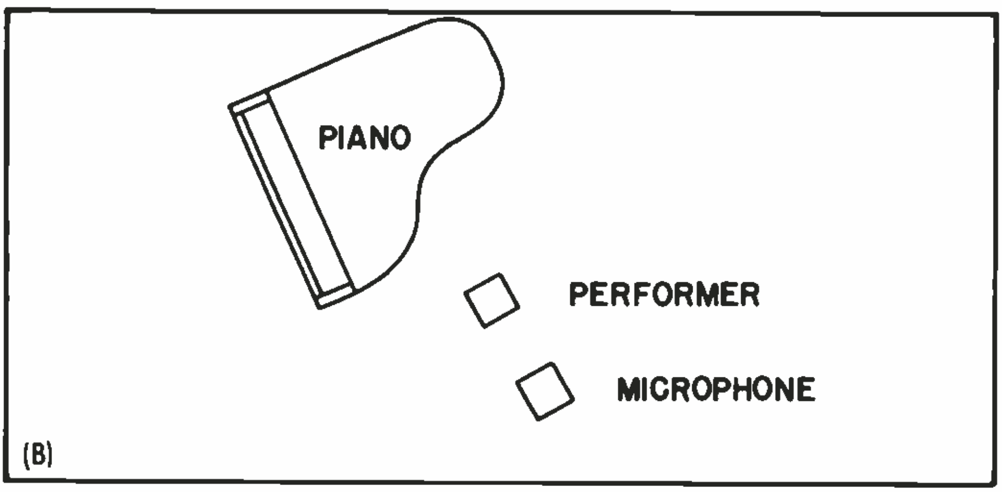


Fig. 6-1. (A) indicates improper placement of a vocalist singing with piano accompaniment. The piano would be much too loud. (B) indicates proper placement with the singer closer to the microphone.



the aural perspective will not be correct; the piano will sound as though it were widely separated from the vocalist. In fact, it may sound almost as though it were placed at the other side of the room.

When a vocalist provides his own accompaniment on a piano, the microphone placement becomes slightly more critical. The average amateur recordist usually employs the arrangement shown in Fig. 6-2 (A), with the microphone equidistant from the performer and the piano. When employing this arrangement, the sound from the piano is recorded at a higher level than that from the vocalist. This provides a recording which is unbalanced insofar as the volume

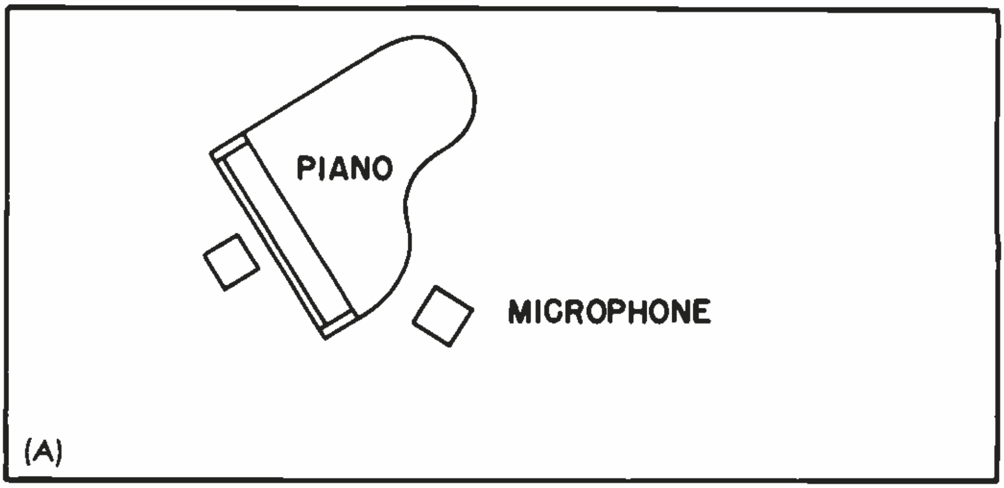
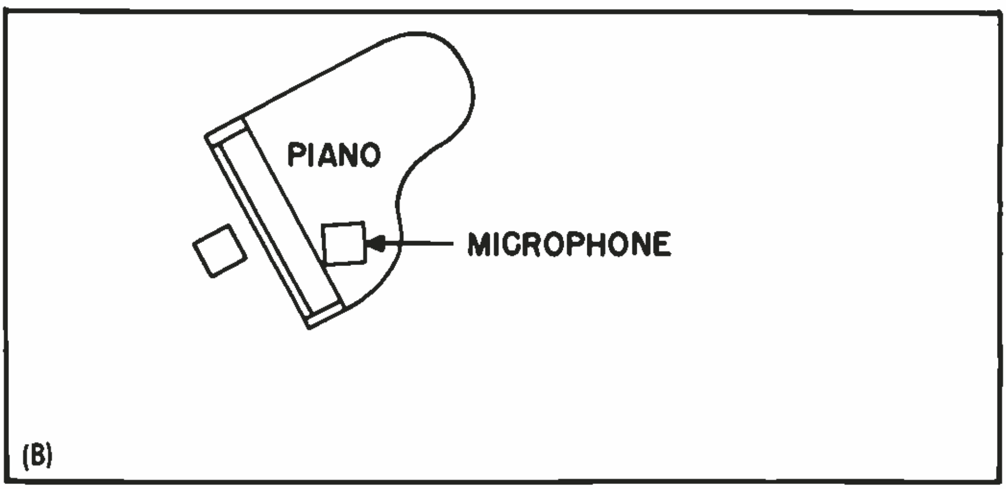


Fig. 6-2. (A) indicates improper placement of microphone for pickup of self-accompanied soloist. (B) shows proper placement.



level is concerned; the voice, unless it is extremely powerful will be drowned out by the piano.

A much more satisfactory arrangement is illustrated in Fig. 6-2 (B), in which the microphone is placed six to twelve inches from the singer's face. This placement increases the pickup from the singer and reduces the amount of sound picked up from the piano. If the piano is still too loud in comparison to the voice the level may be reduced still further, if the piano is a grand, by merely closing the top.

Recording a small choral group of three to four voices with a piano accompaniment is quite similar to recording a single vocalist. Because the combined volume output of the singers is greater than

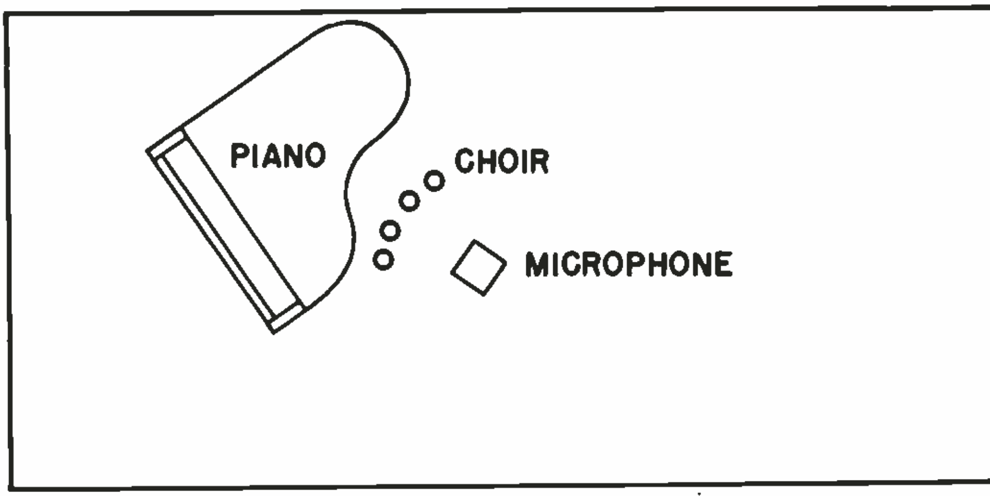


Fig. 6-3. Proper microphone placement for recording a small vocal group with piano accompaniment.

that of a single vocalist, we can obtain a volume balance more easily since the level of sound from the piano and that from the voices are more nearly equal.

Figure 6-3 illustrates the arrangement generally employed. The singers are grouped in an arc as close together as possible. The distance of the singers from the microphone is determined by the power of the lead voice. This distance is obtained in exactly the same manner as it was with a single vocalist and will usually be from two to five feet. A test recording should be made to determine tonal

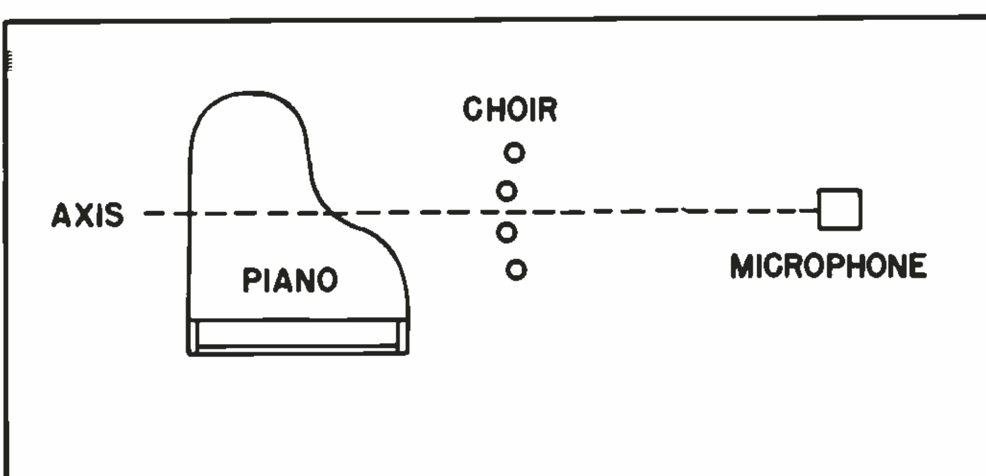


Fig. 6-4. This arrangement will make a small group sound larger and more resonant than the one shown in Fig. 6-3.

balance and the singer or singers whose voices are too loud should be moved back slightly. A change in distance of six to twelve inches should suffice. When one voice must be accented for special effects, that performer should be moved closer to the microphone. Bringing the lead voice closer to the microphone will automatically raise the level of his voice above that of the remainder of the group. In the event an even greater accentuation is required the others in the group should be asked to sing more softly as the featured singer moves toward the microphone.

Fig. 6-5. An omnidirectional microphone. (Photo Courtesy of Electro-Voice, Inc.)

A small choral group may be made to sound larger and its fulness and resonance increased by employing the arrangement illustrated in Fig. 6-4. As may be seen the axis of the microphone is parallel to the longest dimension of the room and the distance between the microphone and the performer is almost doubled. This distance will now be between three and eight feet. The increase in the distance between the microphone and the performers necessitates raising the record level control setting to obtain the same recording level. The use of this arrangement increases the proportion of reflected to direct sound picked up by the microphone, which results in an increase in the apparent reverberation. The apparent reverberation may be increased still further when required by the substitution of an omnidirectional microphone such as is illustrated in Fig. 6-5.

Increasing the distance between a singing group and the microphone will also result in better blending of the individual voices.

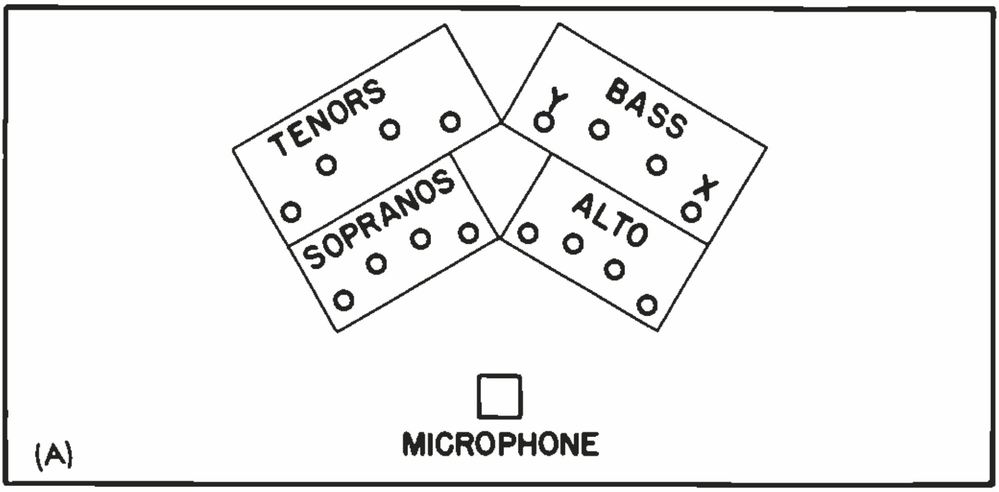
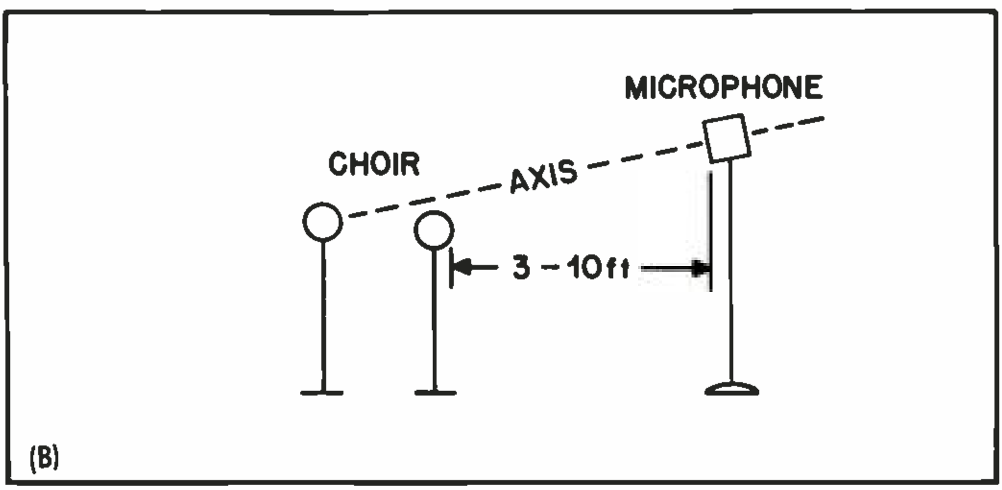


Fig. 6-6. Proper microphone placement for recording a group of twelve to twenty voices.



When greater definition is required for special effects, the distance between the microphone and the singers should be reduced.

When a choral group consists of more than four or five voices we encounter a new factor which affects the placement of the performers and the microphone. We must consider tonal balance in addition to the volume balance.

A small choral group of twelve to twenty voices with three to five voices per part is recorded by arranging the performers in two rows, as illustrated in Fig. 6-6 (A), with the sopranos at the left side of the first row. The alto voices are placed at their right. The tenors are arranged at the left side of the second row with the bass voices on their right. The microphone is placed at a level of about seven feet as shown in Fig. 6-6 (B), with its axis pointed between the first and second rows. The distance between the microphone and the first row of singers is between three and ten feet, dependent upon the power of the singers' voices and the particular selection to be recorded. The more distant pickup will usually produce a better recording with a group of this size due to the additional reverberation and better blending obtained.

After the microphone and the performers are placed as suggested, the alto group is asked to sing its part. The individual voices within the group are balanced by moving them backward and forward slightly. When one particular voice in a group is exceptionally loud, its prominence may be further reduced by moving its owner further off the microphone axis to position x in Fig. 6-6 (A). Conversely, when one voice in the group is too low, its volume level may be increased by moving the singer to position y.

After the altos are balanced within themselves, the same procedure is followed with the sopranos, tenors and basses. When the four groups have been balanced in this manner a test is made with all of the groups singing together. Listen to the chorus from the microphone position or, if the recorder has provision for monitor headphones, they are preferable for this test. While listening watch the record level indicator as it will help in determining if any group is unduly loud. When one particular group is too loud the level of that group may be altered by moving the entire group in the same manner that we moved an individual singer.

A larger choral group of more than twenty voices is handled in exactly the same manner as the group we have just discussed. The biggest problem in handling a large choral group is not caused by the chorus itself but is usually due to the fact that a group of this size is recorded in auditoria, churches and large concert halls. All of these rooms are usually quite large and consequently very live, in fact often so much so that the recordist is apt to encounter echo.

When the recording room is large and is highly reverberant the only method of recording a large choral group is to crowd the chorus into as compact a mass as possible and use a unidirectional microphone placed as illustrated in Fig. 6-7, at a height of ten to twelve feet above a point three to five feet forward of the first row of singers. The microphone is pointed at the exact center of the group. When this particular microphone placement is employed the percentage of

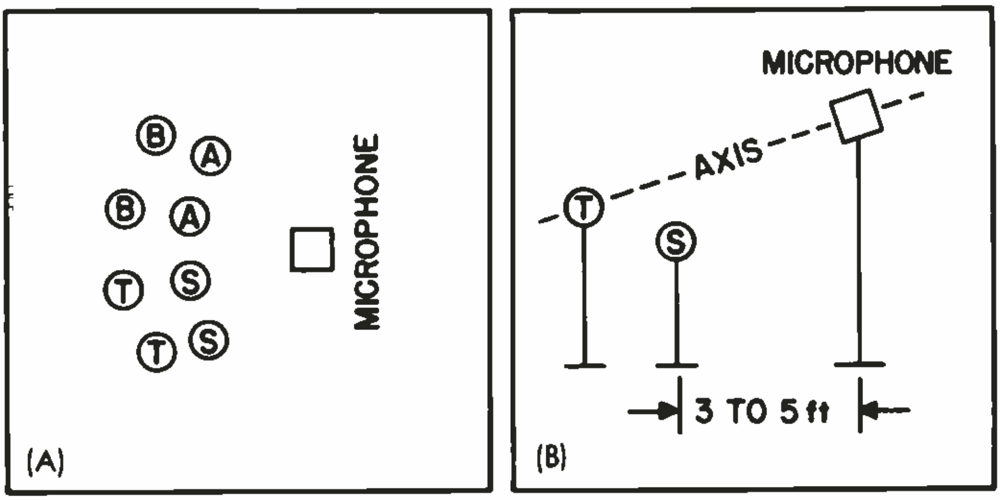


Fig. 6-7. When a recording room is large and highly reverberant, the only satisfactory method of recording a choral group is to crowd the singers into a compact mass and use a unidirectional microphone.

reflected to direct sound picked up by the microphone is reduced to a minimum.

A comparatively close microphone placement of this nature has one disadvantage in recording choral groups in that it increases the definition of the individual voices. The blending of the voices may be enhanced by increasing the microphone distance, however this will also increase the apparent reverberation. A satisfactory compromise can usually be made even under the most adverse conditions.

Recording an instrumental solo is, as we have found, quite simple when we consider the frequency range of the instrument, its dynamic or loudness range, and its directional characteristics. We have also discovered that most musical instruments differ in one or more of these characteristics from other instruments.

The differences between instruments become quite obvious when we attempt to record a group of them at the same time; for example, a small concert orchestra consisting of six to eight violins, two cellos, two violas, two basses, a flute, an oboe, two clarinets, two horns, a bassoon, three trumpets, a trombone, a piano and drums.

The first requirement in recording a group of this type is that the frequency response of the microphone be sufficiently wide to record the lowest frequency of the lowest pitched instrument and the highest harmonic of the highest pitched instrument in the orchestra. The second problem is due to the differences in the volume level created by the various instruments. These differences were illustrated in Fig. 5-3 and described in Chapter Five. From this information we find that the instruments producing the lowest sound level are the strings. Consequently they should be placed closest to the microphone. An excellent pickup arrangement for a small orchestra is shown in Fig. 6-8.

When a number of strings are employed in a musical group the violins are placed in such a manner that they form a close arc about four to six feet in front of the microphone. The first violinist is placed in the exact center of the group, on the axis of the microphone, so that the sound from his instrument produces a slightly higher level than the balance of the group.

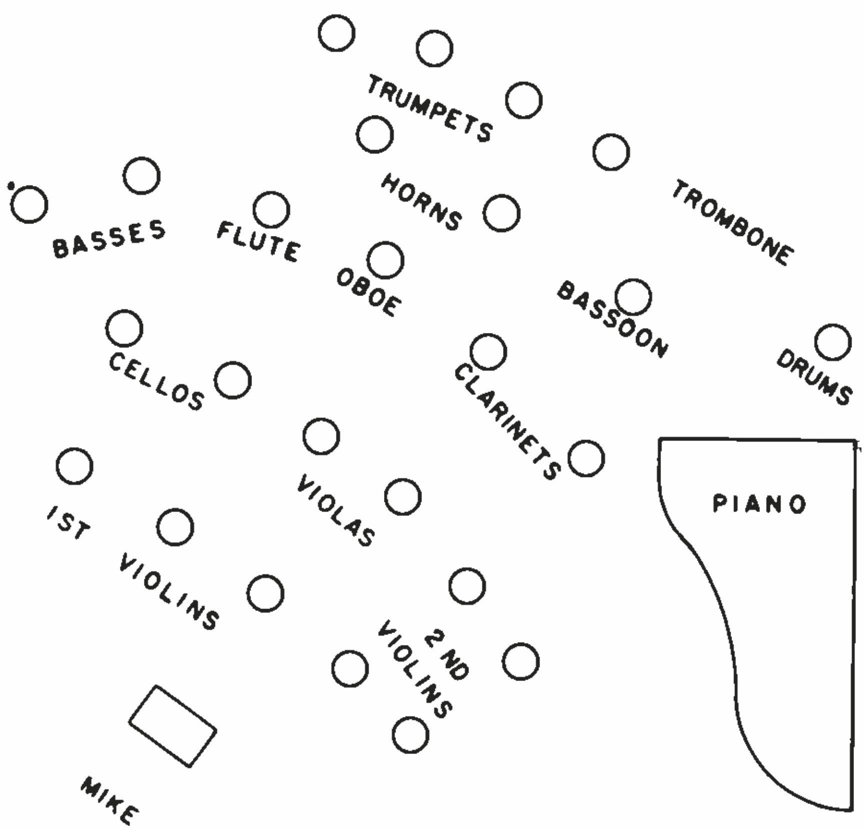


Fig. 6-8. An excellent arrangement for recording a small concert orchestra.

The distance of four to six feet which we have provided as the average placement for the violins is dependent upon the acoustics of the room and its noise level. Proper placement of the microphone can be obtained by having the violin section play the softest passage in the selection to be recorded, and gradually move the microphone closer until the sound overrides the noise level and has expression even in the softest passages.

All of the factors mentioned regarding the violins also apply to the viola, the cellos and the bass viols. The viola and the cellos should be as well defined as the violins at the softest passages. These instruments should be grouped in a second arc immediately behind the violins and as close to them as possible since the level they create is only slightly higher. The bass viols are usually placed at the outside of the second row because of their size, however they should not merely rumble somewhere in the distance. They must also make a well-defined contribution to the string section.

Since the sound output of most of the woodwinds, such as the clarinet, the bassoon, the oboe, and the English horn are quite similar they present little difficulty. They should be placed in a wide arc three to six feet behind the second string section. This brings the woodwinds to within ten feet of the microphone. The woodwinds should be seated on a low platform (about twelve inches high) in such a manner that they are not blocked from the microphone by the strings.

The brass section, which includes the trumpet, trombone and French horn, should be placed as far from the microphone as the dimensions of the room will allow. A distance of sixteen to twenty feet is suggested. This group should be seated on a platform about twelve inches higher than the woodwinds.

The piano should be placed at the right side of the orchestra at a distance of about twelve feet from the microphone, with its lid on full stick and its open side facing the microphone.

The percussion instruments, the drums, should be placed to the rear of the piano alongside the woodwinds, and when possible they should be placed on a platform about three feet above the floor.

We have now arrived at the point at which we can make our first listening test to determine whether we have achieved true volume balance for the conditions under which we are recording. Have the orchestra play the selection which it is about to record and listen carefully through the monitor earphones. In the event your recorder is not equipped for headphone monitoring, hold your hand over one ear and listen from the position in which the microphone is placed. From this position each instrument should be well-defined and heard clearly.

When one specific instrument or group seems lost and does not make a noticeable contribution to the over-all sound it should be moved forward slightly or closer to the axis of the microphone. For example, if the flute, which is shown to the left of the oboe in Fig. 6-8, produces too low a sound level, it can be given greater prominence by changing its position with that of the oboe, in this manner bringing it closer to the axis of the microphone.

The cello and the bass viol should provide a foundation for the string section. Too often these instruments merely snore and roar in the distance. When properly placed they should greatly enhance the sound of the strings, especially balancing the sound from the higher pitched violins.

When listening to a musical group it is not always possible to determine by ear alone which particular instrument or group is too loud. This is primarily due to the fact that the loudness of a sound is dependent to a large extent upon its frequency and harmonic content. Very often some particular instrument, while it does not sound unduly loud, will produce enough sound energy to cause overloading. The offending instrument can be very easily detected by employing the same method we used in determining overly loud voices in the choir, the record level indicator on the recorder. Set the recorder to the recording position without starting the tape transport mechanism. Watch the indicator as you listen, noting the sound which causes the indicator to show overload. When this method is employed the offending instrument can be very easily detected and the necessary corrections made.

The distance indicated between the orchestra and the microphone is for close pickup, since the type of room large enough to house a group of this size is usually highly reverberant unless it is a broadcast or recording studio. Increasing the distance between the microphone and the orchestra will, as with a choir, increase the blending of the various instruments. Once the tonal and volume balance have been obtained the group may be handled as we did an individual, with aural perspective and apparent acoustics of the room alterable as explained in Chapter 4.

A standard band, which is typified by the average school band, differs from a small concert orchestra in the fact that it includes tubas, saxophones and perhaps sarrusophones. It has no string section. Unlike the concert orchestra the main body of the tone is provided by the woodwinds and the brass instruments. When the band is not used for marching it may also include kettledrums, xylophone, etc.

Since the sound level created by a band of this type is greater than that of a concert orchestra with the same number of instruments the microphone is placed at a distance of approximately ten feet from the first row of musicians. The physical arrangement of a band is quite similar to that of a concert orchestra without the string section.

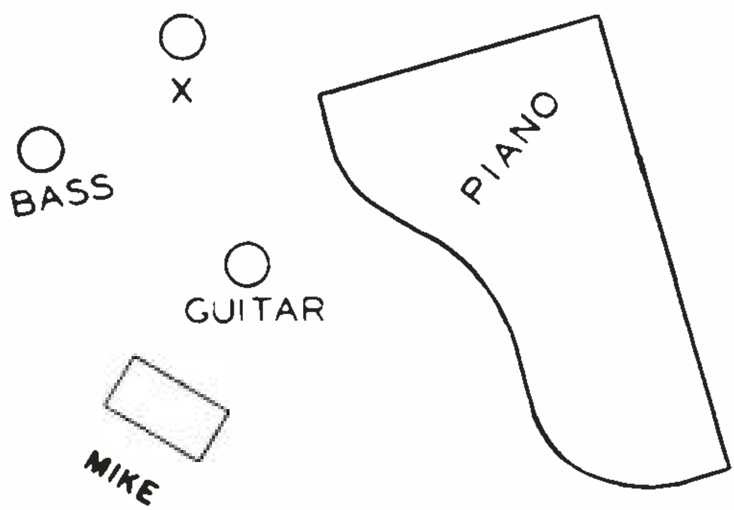


Fig. 6-9. Proper pickup arrangement for a small instrumental group.

The musical groups most often recorded by the average person are the three- and four-piece combinations generally employed for small dances, weddings, etc. The three-piece combination usually consists of a piano, guitar and a bass fiddle which are arranged as illustrated in Fig. 6-9. The guitar is placed on the axis of the microphone at a distance of two-and-a-half feet. When a baby grand piano is used it is placed at an angle of forty-five degrees off the axis and five feet from the microphone. A grand piano, due to its greater sound output is placed at a distance of from seven to eight feet. The bass fiddle is placed at a distance of from four to five feet and at a forty-five-degree angle on the left side of the microphone axis. A group of this type is comparatively simple to record.

A four-piece combination is usually created by the addition of a saxophone which is placed in position *X* in Fig. 6-9 at a distance of six feet. Very often small groups of this type employ an accordion instead of the piano. This instrument should be placed at a distance of six feet from the microphone in the position normally occupied by the piano. The distances we have given for the three- and four-piece combinations provide an intimate pickup.

All of our previous examples have employed a single microphone for recording. There are often instances where the use of two microphones can greatly simplify placement, permit greater flexibility of pickup technique, and allow special effects which can add immeasur-

(A)

Fig. 6-10. Two different types of mixers. The one shown at (A) is the smallest and least expensive available. It will mix the output of two microphones. The one shown at (B) will handle up to four microphones. (Photos Courtesy of Switchcraft, Inc., and Masco Sound Systems.)

(B)

ably to the quality of the recording. For example, the recording of a self-accompanied vocalist can be greatly improved by the use of two microphones, one to pick up the singing voice and the second to pick up the piano. The output of the two microphones is fed into a device called a *mixer* which feeds the combined output of the two units into the microphone input of the tape recorder. The mixer allows the recordist to regulate the amount of sound from each microphone separately.

Fig. 6-11. Two electronic mixers which can be used to mix and fade microphone, radio tuner, phonograph, and the like. (Photos Courtesy of Pentron Recording Corporation and Masco Sound Systems.)

The regulation of individual level from two or more microphones allows the user to obtain more exact volume balance from sound sources which create different levels. The use of a mixer also permits the recordist to obtain the interesting effects so often employed in commercial broadcasting, such as slowly fading a voice onto a musical background, highlighting the lead voice in a choir, or spotlighting an instrumental solo with an orchestral background.

There are available small inexpensive units designed to perform the function of "mixing" for the owner of a tape recorder. The smallest and least expensive (under ten dollars) is illustrated in Fig. 6-10 (A). This unit is no larger than a package of cigarettes; it may be kept in the same compartment as the microphone. It is simple to install and may be used to mix the output of two microphones. The mixer illustrated in Fig. 6-10 (B) is larger and more versatile; it will mix and fade up to four microphones.

Figure 6-11 illustrates two electronic mixers which can be used to mix microphones, radio, phonograph and the output from one of the new tape playback units. Neither of these is expensive and both are extremely compact.

Earlier in this chapter (Fig. 6-2 (B)) we illustrated what in effect was a compromise placement for recording a self-accompanied vocalist. This arrangement was due to the fact that we had limited ourselves to the use of a single microphone. A much better recording could be obtained by employing two microphones placed as illustrated

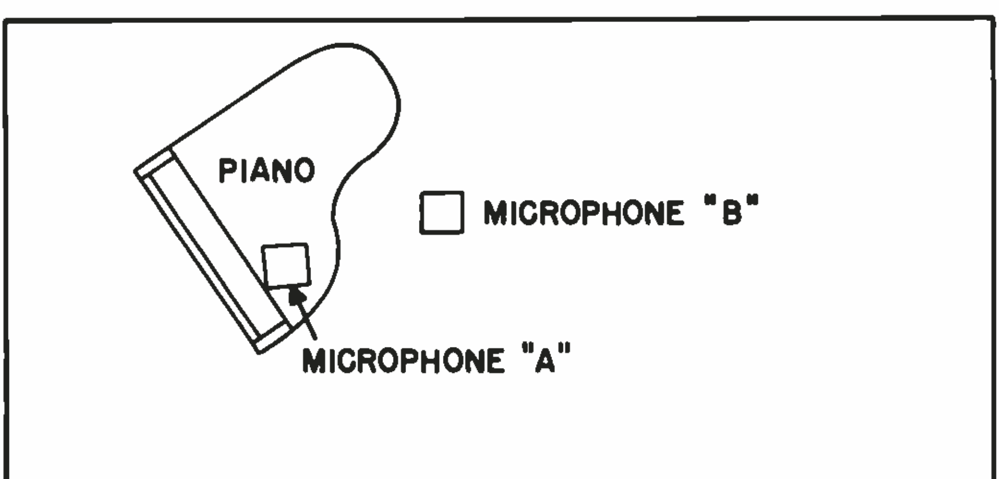


Fig. 6-12. Two-microphone arrangement for recording a self-accompanied vocalist.

in Fig. 6-12. Microphone "A" is the cardioid type and picks up the singing voice, at the same time discriminating against the piano. Microphone "B," also of the cardioid type, is arranged to pick up the piano but to discriminate against the voice. The outputs of the two microphones are fed separately into the mixer, where their relative levels are individually adjusted to provide proper balance, and then fed into the recorder.

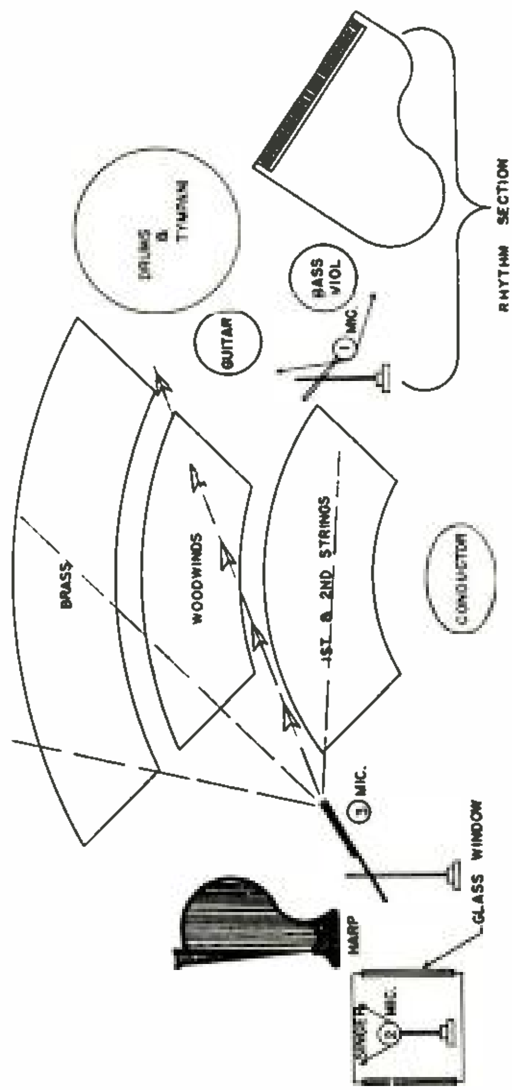


Fig. 6-13. A typical arrangement for recording a large orchestra and soloist. Note the "accent" microphone for lending emphasis to the rhythm section.

Through the use of one additional microphone and a mixer we have been able to achieve the desired aural perspective and at the same time compensate for the different levels created by the two sound sources.

Whenever a vocalist is to be recorded with orchestral accompaniment the use of a second microphone is almost always necessary to prevent the background music from overshadowing the soloist. The "solo" microphone is usually of the cardioid type and is placed in such a manner that it discriminates against all sound created by the orchestra.

A third, or "accent," microphone is often employed to emphasize certain sections of an orchestra. Both solo and accent microphones are placed as illustrated in Fig. 6-13. Still another microphone is often employed when there are special effects to be picked up.

Chapter 7

Recording From Records, Radio and TV

THE ABILITY to do a good job of re-recording on tape the music from commercial records can add immeasurably to the pleasure you can obtain from a tape recorder. Through the use of long-playing tapes you can obtain up to two hours of music on a 7-inch reel at 7½ ips, uninterrupted by the necessity for changing records or by the annoying pause between records which often occurs in the middle of a selection when a record changer is used. Music "dubbed" from commercial records may also be utilized to create mood, provide a background, and supply a bridge between scenes when recording for the sound track of home movies, exactly as it is done in broadcasting, TV and professional motion pictures.

A tape recorder becomes almost a necessity for collectors of the world's great music by renowned artists and orchestras. Much of this music was recorded on the earlier 78-rpm records. These recordings are usually marred by excessive "needle scratch" and the clicks and pops which are due to nicks and scratches on the record itself. These extraneous noises can usually be eliminated or greatly reduced when you make a tape from a record of this type. The resultant tape recording, when properly made, will provide reproduction which is far superior and quite startling in its quality when compared with the original record.

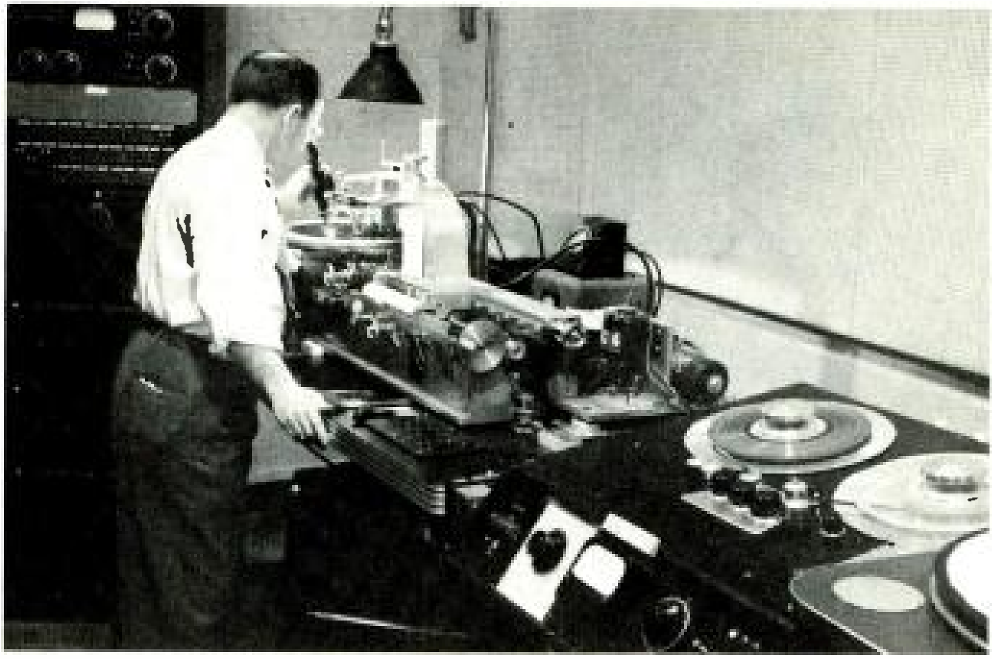


Fig. 7-1. Transferring recorded sound from magnetic tape to a master disc. (Photo Courtesy of Columbia Records, Inc.)

There are three primary factors which must be considered when dubbing sound from records onto tape. The first is the distortion created by worn phonograph needles, or *styli* as they are properly called. The second is the surface noise caused by dirt and grit lodged in the record grooves. The third is the snap, crackle, and pop characteristic of certain plastic records due to the electrostatic charges built up on the record as it is played. All of these factors are present when you play records on your phonograph and only constant care can reduce their effects. However when re-recording on tape, all may be eliminated permanently, and the resultant tape will be noise-free and never require attention to keep it in this condition.

When these factors are taken into consideration anyone can make recordings on tape which compare in quality with the finest commercial records made today. In order that we understand exactly how these three factors affect the re-recording of commercial records on tape we will explain briefly just how a record is made and some of the problems involved in its reproduction.

When a commercial recording company makes a record the music is first recorded on tape and is then transferred onto a lacquer disc as illustrated in Fig. 7-1. This disc is known as the "original" and acts as a master die. The transfer of the music from tape to disc is accomplished in the following manner.

The music recorded on the tape is amplified and fed into the cutting head of a disc recorder, which transforms the amplified electrical energy into mechanical energy. This mechanical energy forces a cutting stylus to move from side to side and engrave impressions onto the rotating lacquer disc. The cutting head functions in a manner similar to the action which occurs in your loudspeaker, but instead of the back-and-forth motion of the loudspeaker cone there is a side-to-side or lateral motion of the cutting stylus.

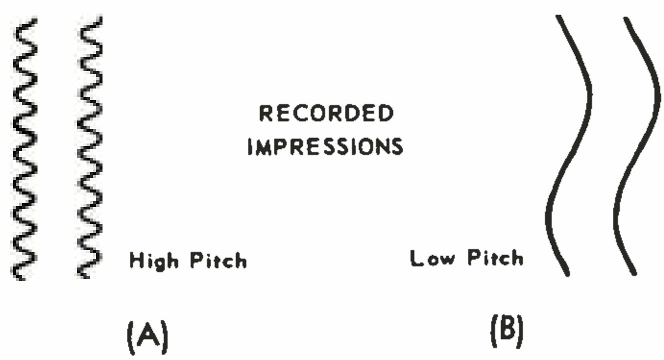


Fig. 7-2. A high-frequency tone will create an impression in a recorded disc as shown at (A), while a low-frequency tone will create an impression as shown at (B).

The shape and size of the impressions engraved in the rotating disc are determined by the particular frequency and the volume level of the signal being recorded. A high-frequency sound will create an impression such as is depicted in Fig. 7-2 (A), while a low-frequency sound will create an impression such as is illustrated in Fig. 7-2 (B). The higher the frequency of the sound the greater the number of times per second the cutting stylus will vibrate from side to side. The volume level of the sound also affects the impressions engraved upon the disc as shown in Fig. 7-3. Figure 7-3 (B) depicts the impressions made by normal volume level. Increasing the volume level causes the cutting stylus to engrave deeper impressions into the groove walls as shown in Fig. 7-3 (C). Conversely, a reduction in volume causes a reduction in the distance the cutting stylus swings from left to right, causing it to engrave shallower impressions, as shown in Fig. 7-3 (A). These impressions are actually microscopic three-dimensional duplicates of the sound wave pattern.

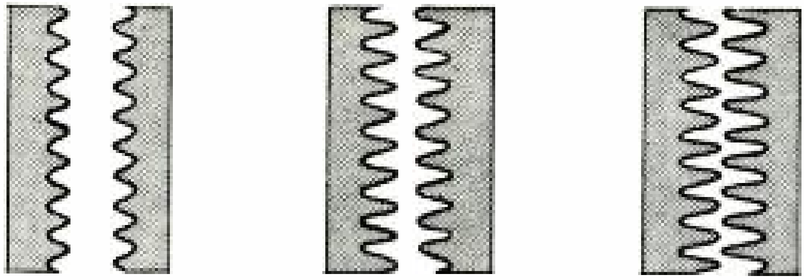


Fig. 7-3. Here are shown the effects of varying the level of sound on a recorded disc.

When the cutting of the original lacquer disc is completed the disc is put through a number of processes until a duplicate called a "stamper" is obtained. This stamper becomes the moulding die which makes the records you buy.

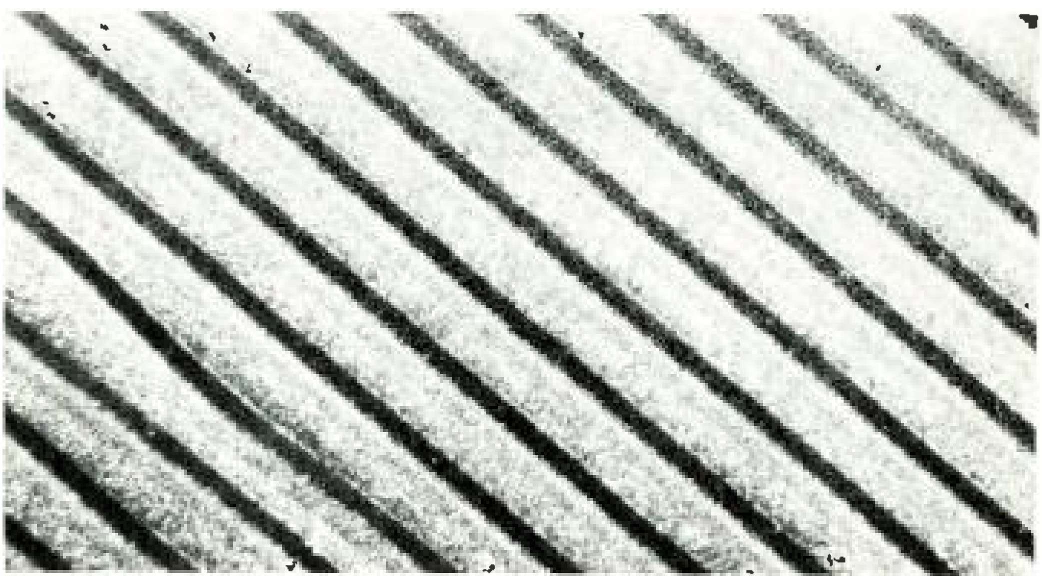


Fig. 7-4. Photomicrograph of a portion of a record.

We now have a basic knowledge of just how the impressions are created on the walls of the record groove. Figure 7-4 is a photomicrograph of a portion of a record. It clearly shows the grooves and the space between them called "land." Figure 7-5 is an even greater enlargement of the recorded grooves; (A) is a view from directly above the record as it was shown in the previous illustration; (B) is a view of the same section from a 45-degree angle, and (C) is a

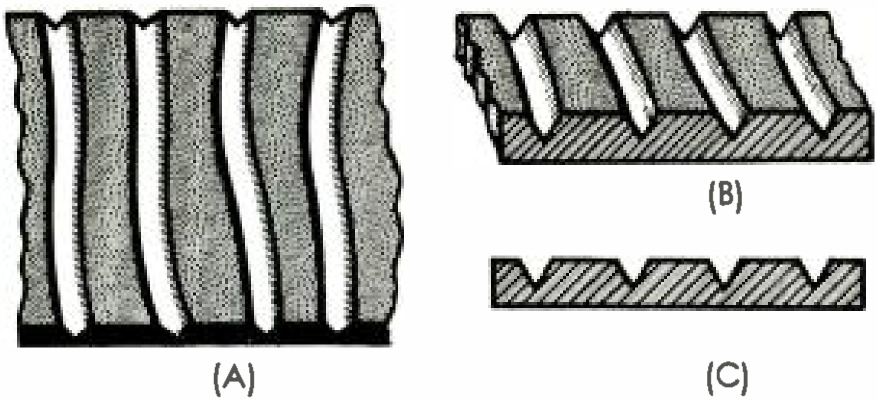


Fig. 7-5. Enlarged drawing of the recorded grooves of a phonograph record. (A) is a view from directly above the record, (B) is a view from a 45-degree angle, and (C) is a cross-sectional view.

cross-sectional view of the same portion. Figure 7-6 shows just one of the grooves depicted in Fig. 7-5 but still more greatly enlarged. Here we see the reproducing tip in the playing position. It becomes apparent from this illustration that the stylus tip, when in good condition, touches the groove walls at only two points. As can be seen the entire weight of the stylus and the structure which holds it is concentrated at these two microscopically small points.

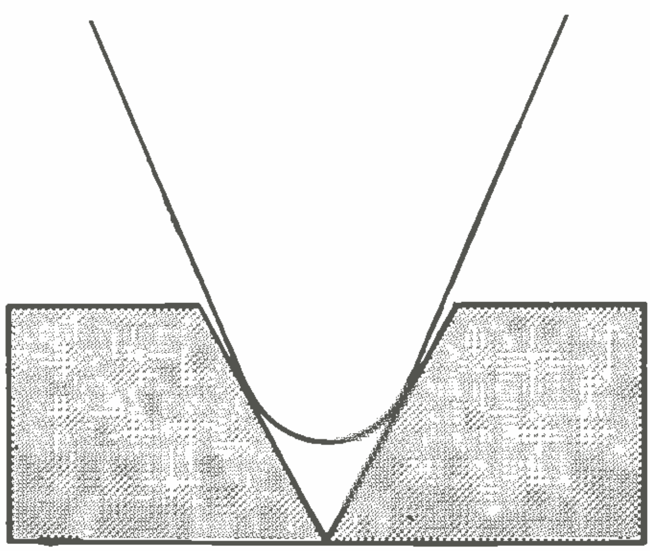
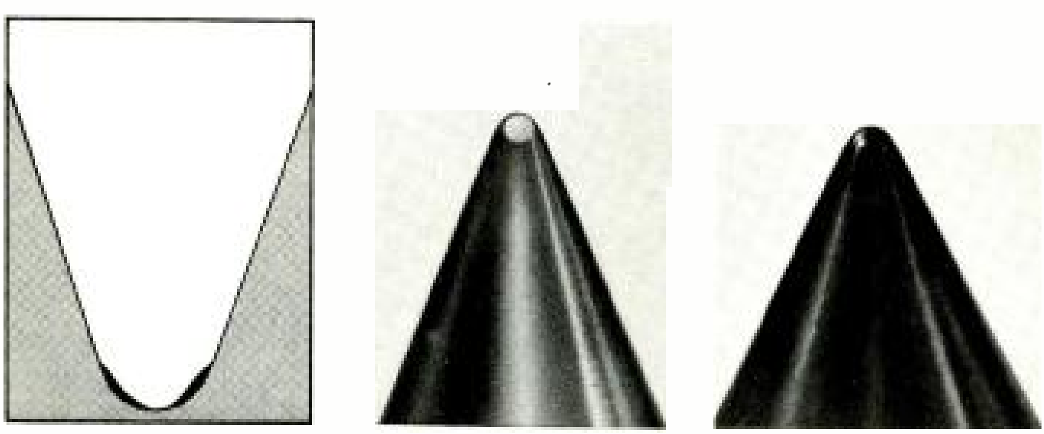


Fig. 7-6. An enlarged view of a single groove of a record with playing stylus in place.

When playing a record the reproducer stylus tip follows the impressions engraved upon the walls of the record groove. These impressions, depending upon the frequency of the recorded sound, force the stylus tip to vibrate from side to side as rapidly as 10,000 times per second. This side-to-side or lateral motion is illustrated in Fig. 7-7 which is a view of the record groove and the stylus tip from directly above; it shows just one of the grooves and a cross-section of the stylus tip at the point of contact. The stylus tip in the record groove follows a path in much the same manner as your automobile tires would follow the ruts in a country road.

Fig. 7-7. View of record groove and stylus tip from directly above.

As previously mentioned, the stylus tip touches the groove walls at only two microscopically small points. Any friction and the resulting wear is consequently concentrated at these points. This friction causes the gradual wearing away of the stylus material at these two points and eventually creates what are called flats. Figure 7-8 (A) is a front view of a stylus tip showing these flats. The shaded portions are the areas where the stylus material has been worn. The amount of wear is more apparent when the tip is viewed from the side, as



(A) (B) (C)

Fig. 7-8. (A) is a front-view drawing of a stylus showing flats due to wear. (B) is a side-view photograph of the same stylus. (C) is a photograph of a new stylus.

illustrated in Fig. 7-8 (B). This is a microphotograph of a microgroove stylus tip which is worn. It may be compared with the new tip shown in Fig. 7-8 (C).

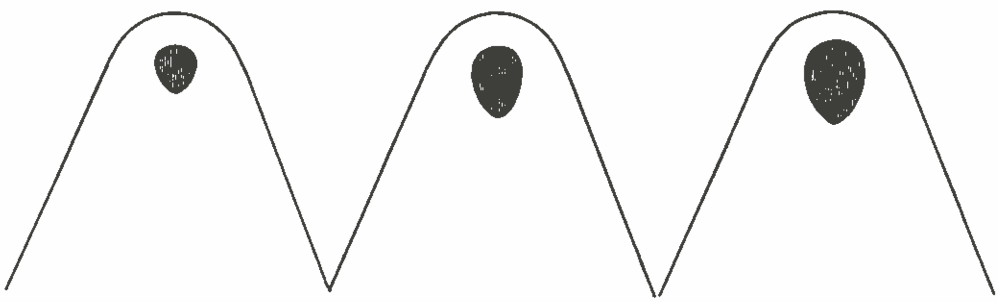


Fig. 7-9. This drawing shows the progressive wear of a sapphire stylus tip. (A) shows the wear created by 3½ hours use. (B) represents the wear caused by 5 hours use. (C) depicts the amount of wear caused by 7 hours of playing.

Figure 7-9 consists of three drawings illustrating the progressive wear of a sapphire stylus tip. (A) shows the amount of wear created by 3½ hours of use, (B) represents the size of the flat created by 5 hours of use and (C) depicts the size of a flat caused by 7½ hours of use. The gradual increase in the size of the flat is obvious. It is these flats which are the direct cause of the distortion and reduced tonal range usually encountered when the uninformed layman attempts to record the contents of commercial records onto tape.

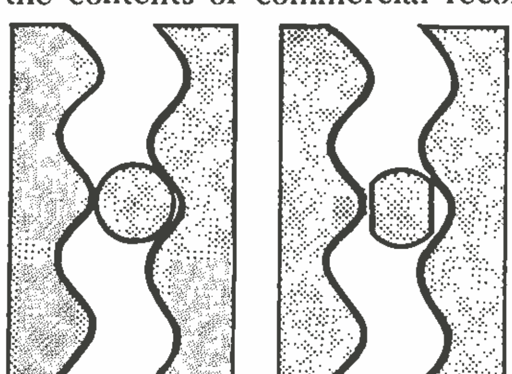
(A)  (B)

Fig. 7-10. Cross-section of two stylus tips at point of contact with groove walls. (A) is the cross-section of a new tip, (B) is that of a worn one.

The amount of distortion and the reduction of tonal range due to worn styli increases in direct proportion to the size of the flats on the stylus tip. Figure 7-10 shows the cross-section of two stylus tips at the point of contact with the groove walls. (A) is the cross-section of a new tip; (B) is that of a worn tip. We can see that (B) is no longer the perfect circle required.

Figure 7-11 (A) shows exactly how a new stylus tip fits into and can follow perfectly all of the variations engraved onto the walls of the groove. Note that the surface of the stylus tip, at the point of contact, is a perfect circle, and can thus enter any of the engraved depressions or pass around any of the engraved wave creats. Figure 7-11 (B) depicts a worn stylus tip. The old proverb of fitting a square peg into a round hole might well have been conceived to perfectly describe this condition. As can be seen, the worn stylus tip will no longer fit into the engraved depressions since the flat on the tip is now wider than the opening of the depression. Theoretically this fact should result in a complete loss of signal but in actual practice the worn tip is forced into the depression. Since the stylus tip now cannot follow with extreme exactitude the variations in the groove the resultant signal is not a perfect replica of the original recorded sound wave.

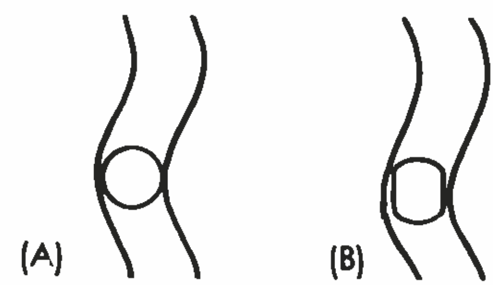


Fig. 7-11. Here is shown in (A) exactly how a new stylus fits into and can follow all of the variations engraved in the wall of a recorded groove. (B) depicts a worn stylus tip.

The distortion or fuzziness created by a worn stylus first manifests itself on the high frequencies at the inside grooves toward the center of the record. For this reason the recordist may notice that his tape recording sounds well at its beginning but finds the distortion increases as the stylus tip approaches the end of the record being re-recorded. This is the first sign of a worn stylus tip. As the flat becomes larger the distortion it creates becomes noticeable further and further toward the outside of the record, also at lower and lower frequencies, until the time when it has become so large that even sound in the middle register is distorted over the entire recorded surface. A stylus employed for re-recording long-playing records onto tape should not be used for more than 3½ hours if it is sapphire or more than 325 hours if it is diamond. When re-recording 78-rpm records the time given may be safely doubled.

Before we leave the subject of styli we might mention that there is one other factor which is quite important when re-recording very old (before 1927) 78-rpm records. A great number of these records were made to be used with a stylus having a radius of 2.5 mils at the tip. When these records are used with the 3-mil tip employed for modern 78's the noise level is increased considerably. The only method of ascertaining the correct stylus is by trial. Make a test recording if the date of the record is unknown, using both sizes of styli. The one which produces the least surface noise is the correct size.

The second cause of unsatisfactory tape recordings dubbed from commercial records is due to the dust and grit which becomes lodged in the record grooves. Dust which accumulates on a record falls into three categories – the airborne dust which falls on a record through gravity; the dust which is attracted to the surface of the record by static electricity, and the dust which is worn from the stylus tip itself. Dust and grit are primarily responsible for the hissing sound commonly known as "needle scratch." The effect of dust and grit on the noise level of a record can be easily understood when we stop to realize that even the granular structure of the record material itself affects the surface noise. This, incidentally, is one of the reasons why the older shellac-base records are noisier than modern vinylite records, even when they are in "like new" condition. The shellac base material is not uniform in structure, being built up of small grains. These grains press against the stylus tip as the record rotates and create random impulses which are translated as noise. Dust, grit and the particles worn from the stylus tip are often many times as large as the grains of shellac, and consequently affect reproduction to an even greater extent.

Cleaning dust-laden records has been a highly controversial subject since the invention of the phonograph. Many methods have been devised to accomplish this important function, but completely removing dust and grit from record grooves is not a simple matter. A number of factors must be considered. First, the cleaner must completely penetrate the engraved depressions in the groove (some are as small as ½ thousandth of an inch) and remove particles of stylus dust which are sub-microscopic in size. Second, it must not contain any fatty or gummy substances which would tend to remain in the record grooves and harden. Third, the cleaner must not adversely affect the record material itself.

The author, while doing the research for his book *The Wear and Care of Records and Styli,* discovered one commercially available cleaner which exhaustive tests showed cleaned records thoroughly. This product which is worthy of recommendation is called K-33 and is manufactured by the Sonafax Company. Its use results in a tremendous reduction of surface noise.

The third cause of noisy tape recordings from records is due to the electrostatic charges which are built up as the record revolves. It is this static electricity which causes the snap, crackle and pop heard on vinylite and styrene records. Most plastics are insulators and tend to retain a static charge. The friction created between the stylus tip and the groove accelerates the generation of this static electricity. Even the friction caused by slipping the record in and out of its jacket causes an increase in the static charge. This static electricity builds up to a point at which it must discharge. The electrostatic discharge is the same as that which causes lightning and thunder; on a record it results in a miniature version of thunder which manifests itself audibly as the crackling sound which is so annoying in record reproduction.

There are a number of methods available which eliminate or reduce static electricity, the latest and most practical of which is the use of an alpha ray emitter such as is illustrated in Fig. 7-12. The emitter is simply fastened to the underside of the pickup arm by an adhesive material. The alpha ray emission of the radioactive element provides a path for the discharge of the accumulated static electricity through the pickup arm itself. This constant discharge path prevents the static charge from ever building up to the point at which it creates a sound which can be impressed on the tape. The unit illustrated is called a *Negastat* and is manufactured by Sonafax.

The first step in the actual re-recording of a commercial record on tape is to determine the correct setting of the recording level control for the disc being copied. This setting will vary from record to record. This is easily accomplished by playing the record in its entirety with the phonograph pickup connected to the tape recorder in accord with the manufacturer's instructions. Advance the level control on the tape recorder to the half-way position and watch the level indicator as the record is playing. Reduce this setting slightly each time the level indicator on the recorder shows overload. After you have determined the setting on the record level control which does not result in overload during even the loudest portions of the music, mark the position carefully in pencil.

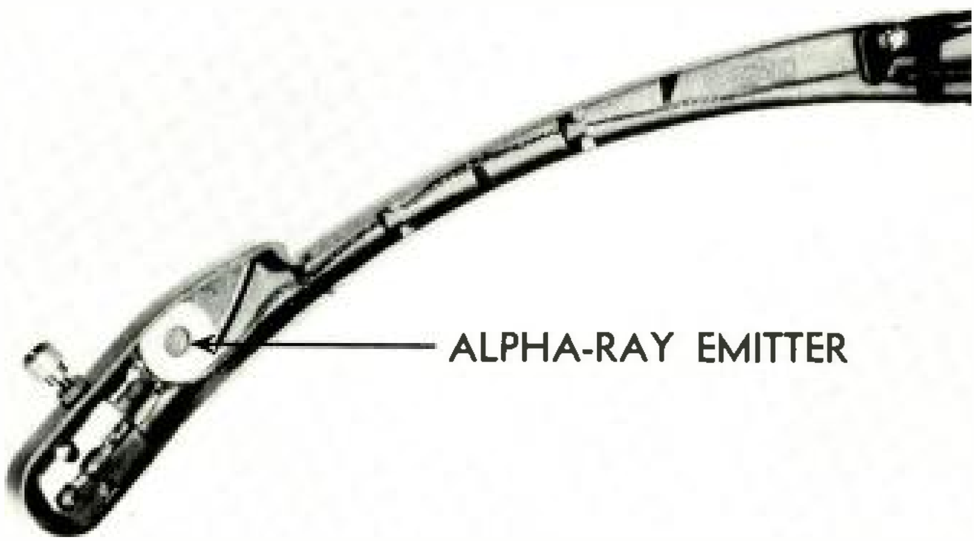


Fig. 7-12. A tone arm with an alpha-ray emitter mounted in place to provide a discharge path for static generated in records.

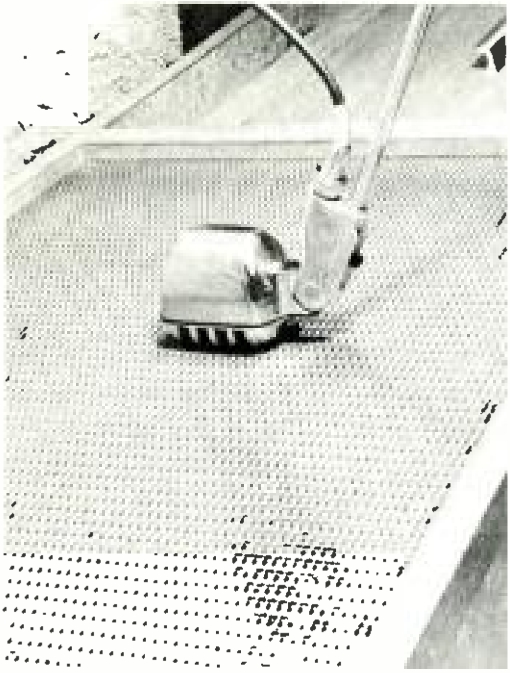
After the position has been marked the entire procedure should be repeated since the average person has a tendency to overcompensate, which results in a reduction of the dynamic range on the recorded tape. Advance the record level control slightly for the second test. If, during the second playing, the record level indicator does not show overload erase the first marking and mark the new setting. Should the second playing of the record cause the record level indicator to show overload, return the record level control to its original setting which was apparently the correct one. This method of copying commercial records on tape will insure recording at the maximum undistorted level and provide the full dynamic range.

One of the most rewarding aspects of tape recording and the least expensive method of obtaining a library of the world's great music as performed by famous orchestras and artists is to tape the music which is being broadcast by "good-music" stations throughout the country. Through the use of your radio receiver and tape recorder you can obtain recordings of once-in-a-lifetime broadcasts by famous artists. You also have at your disposal the vast record libraries which the majority of these stations possess and broadcast regularly. Purchasing a subscription to the weekly or monthly programs which are available from many FM stations will ease your selection of the particular music you wish to record and add to your collection.

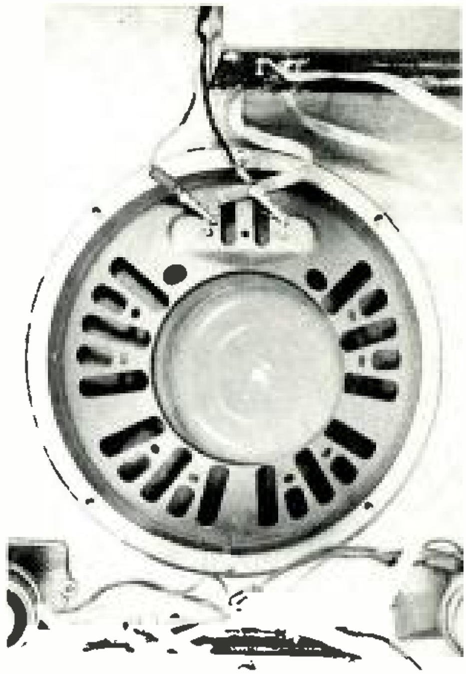
There are three different methods which can be employed to record "off the air." The most common for beginners, but far from the best from the standpoint of quality, consists of simply placing the microphone in front of the radio receiver. When this method of recording off the air is employed the microphone should be mounted on a stand and placed as close to the loudspeaker as possible, as illustrated in Fig. 7-13 (A), and directly in front of it. This method of recording should be avoided whenever possible because the distortion created by the radio loudspeaker and amplifier, which may be considerable in less expensive receivers, is also recorded. It should be utilized only in emergencies and then only when the tone quality of the recording is not particularly important. The room in which the recording is made should be extremely quiet since any noise will be picked up and recorded by the microphone along with the broadcast.

A much more satisfactory method of recording off the air is illustrated in Fig. 7-13 (B). It is advantageous in that it eliminates the distortion created by the loudspeaker. The amount of noise in the room in which the recording is made is no longer of any consequence since no microphone is utilized. This method uses a shielded cable with two alligator clips which are attached to the loudspeaker terminals as illustrated. The other end of the cable is plugged into the radio/phono input of your recorder in accord with the manufacturer's instructions.

By far the best method of recording off the air is to have your local radio-TV dealer or serviceman install a shielded connection from the output of the "detector" tube of your receiver to a jack, in such a manner that you can simply plug the recorder into it when desired. When this connection is properly made it will not affect the reception from the receiver in any manner. This method of recording off the air is the preferred one, since it does not employ either the receiver's amplifier or loudspeaker, and consequently eliminates the distortion they usually create.



(A)



(B)

Fig. 7-13. Recording off the air. (A) indicates proper placement when a microphone is used to pick up sound from the loudspeaker. (B) depicts a preferable method, with recorder input fed directly from speaker voice-coil terminals.

The first step in making a recording off the air is to tune the radio receiver to the station broadcasting the desired program, about fifteen minutes before this program is broadcast. Next make a test recording of whatever music is being broadcast at the moment. While making this test tape watch the record level indicator closely and adjust the record level control so that the indicator does not show overload on any peak passages. After you have recorded about two minutes mark the setting of the record level control, switch the recorder to the playback position and listen to the test. If the recording is distorted it was made at too high a level. The test should then be repeated, this time reducing the record level setting slightly.

The level setting obtained in the manner outlined above is arbitary since there is no exact method of anticipating the peaks on a live broadcast. For those seriously interested, the use of a musical score will help considerably. After the average level has been determined the recordings should be monitored and very slight adjustments made in the level when required. Under no circumstances should the recordist attempt to compensate to too great a degree since excessive curtailment of volume variations will destroy the musical expression of the selection being recorded.

Unless the program to be recorded is a particularly long one and all of the tape length is required, do not attempt to conserve tape by cutting out the commercials or other unwanted sections, since this can be accomplished in a more thorough and professional manner by editing and splicing after the recording is completed.

Just as in re-recording from records, the quality of the finished tape is dependent to a great degree upon the proper editing of the recorded material. This aspect of recording off the air will be discussed in detail in Chapter 9.

Chapter 8

Tape Recorders-Theory and Practice

SINCE MAGNETISM and magnets of various types are utilized in tape recording to preserve the sounds we hear, an elementary knowledge of this subject will greatly simplify our future explanations.

The dictionary describes a magnet as "a body with that peculiar form of polarity found in nature in the lodestone; a body capable of exciting and being acted on by magnetic force, and attracting to itself magnetizable substances such as iron or steel. Magnets are either natural, when found already magnetized, or artificial, when magnetism has been imparted to them by placing them in the field of another magnet."

A magnet such as described above, in bar form, when suspended in a manner that allows it to rotate about a vertical axis, will come to rest so that one end always points to the north pole and the other end to the south pole. This is the simplest form of compass. It is because of these opposite characteristics that one end of a magnet is described as the north pole and the other end as the south pole.

When the north pole of one magnet is brought in proximity to the south pole of another magnet they will attract each other; when the two north poles or the two south poles are brought together the magnets will repel each other. The area within which these forces of attraction and repulsion are effective is called the *field* of the magnet or simply the magnetic field.

We can actually see this magnetic field by placing a bar magnet underneath a blank sheet of paper and sprinkling it lightly with iron powder. This powder will form a pattern of curved lines joining the north and south poles, as illustrated in Fig. 8-1. As we can see, the lines are comparatively dense in the neighborhood of the poles and relatively sparse near the center. This is the magnetic field of our particular magnet.

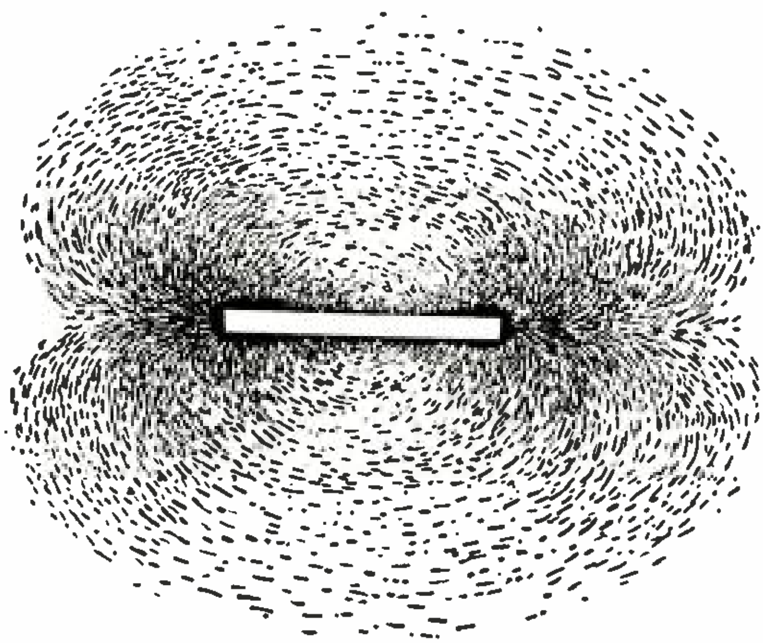


Fig. 8-1. Areas of greatest force in a magnetic field lie closest to the magnet creating the field.

The number of these lines of force, as they are correctly called, at any point in the magnetic field indicates the intensity of the field at that point. The more closely spaced lines in Fig. 8-1 indicate the areas of greater magnetic force; the more widely spaced lines show the areas of lesser magnetic force. As can be seen, the areas of greatest force lie closest to the poles of the magnet. As the distance from the poles is increased, the magnetic force decreases.

The individual molecules of any magnetic material are in themselves magnets. This is shown in Fig. 8-2 which is a greatly simplified illustration of the magnetic structure within a simple iron bar. As can be seen, these molecular magnets are oriented in various directions forming closed groups so that their magnetic effects neutralize or cancel one another. For this reason, the bar as a whole displays no magnetic properties.

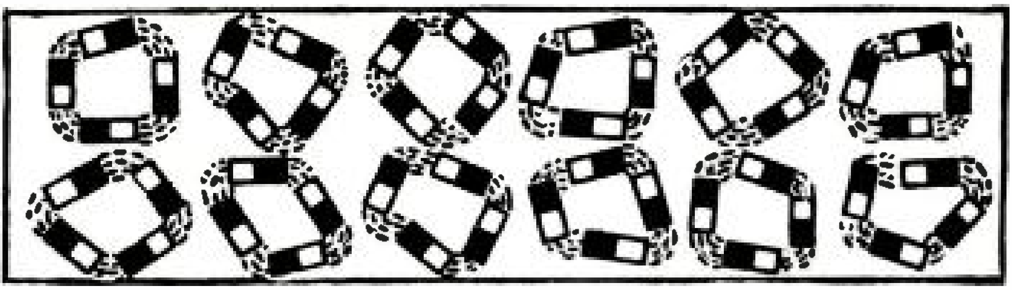


Fig. 8-2. Simplified drawing of the magnetic structure within a simple iron bar.

When this unmagnetized iron bar is brought under the influence of a magnetic field created by a magnet, this condition of equilibrium is disturbed and the individual molecular magnets in the iron bar are forced to form new groupings, as shown in Fig. 8-3. As can be

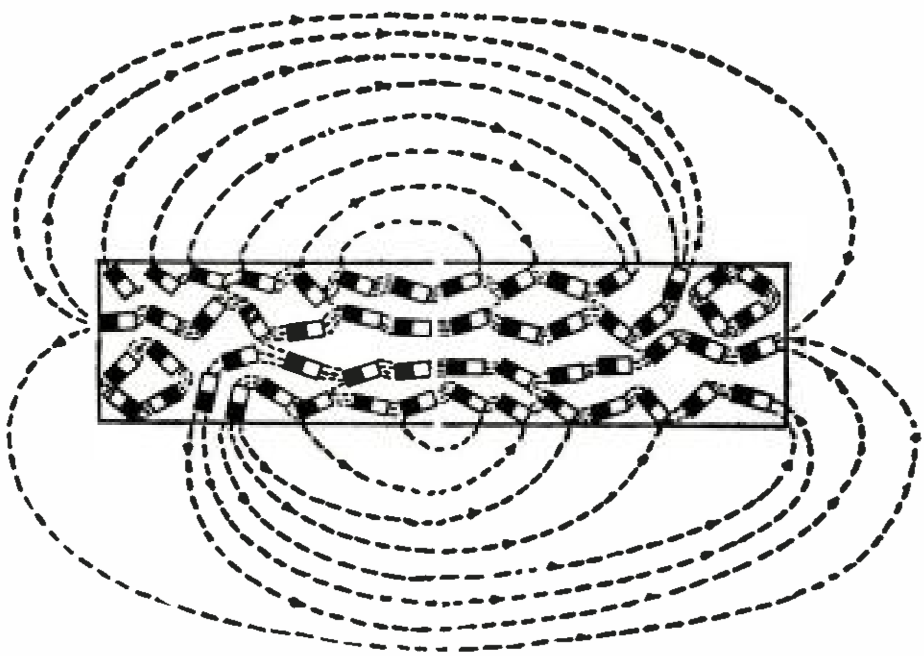


Fig. 8-3. Magnetic structure of the simple iron bar shown in Fig. 8-2 adjusts itself to the influence of an external magnetic force.

seen from this illustration the alignment of the molecular magnets is not perfect; some of the closed molecular groups illustrated in Fig. 8-2 still exist. When the magnetic field to which the iron bar is subjected is more intense, the alignment of the molecular magnets becomes perfect, as shown in Fig. 8-4.

Since the magnetic energy of the individual molecular magnets is additive when they are correctly aligned, just as adding batteries in series provides more voltage, we can easily see that the more perfect their alignment the more powerful is the magnet we have created.

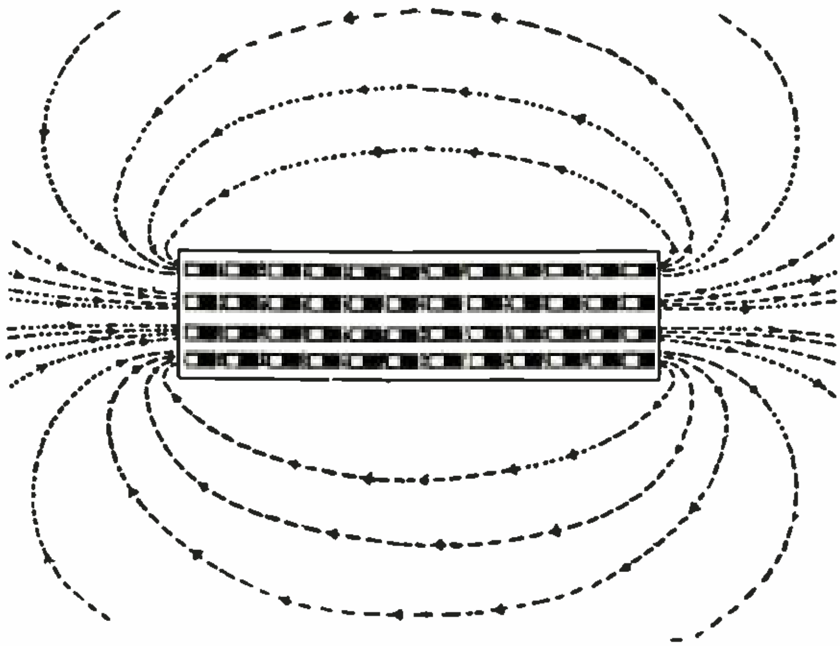


Fig. 8-4. A magnetic field more intense than the one depicted in Fig. 8-3 causes perfect alignment of the molecular magnets in a simple iron bar.

When the iron bar is removed from the influence of the magnetic field some of the molecular magnets revert to their original orientation and reform in the closed groups shown in Fig. 8-2, thus reducing the magnetic force. However a certain percentage of them remains in the direction to which they have been aligned by the external field. The actual percentage which remains in alignment is dependent upon the material used for the bar, since the ability to acquire and retain magnetism varies with different materials.

If the bar is of soft iron, it will not retain its magnetism for any length of time after it has been removed from the influence of the magnetic field. On the other hand, it is easily affected by the magnetic field and therefore is not difficult to magnetize. However, if the bar is made of hard steel, a more intense field is required to produce the initial magnetism, but when this bar is withdrawn from the magnetic field a great number of the molecular magnets remain in alignment, thus creating what is called a permanent magnet. This characteristic of magnetic materials is called retentivity.

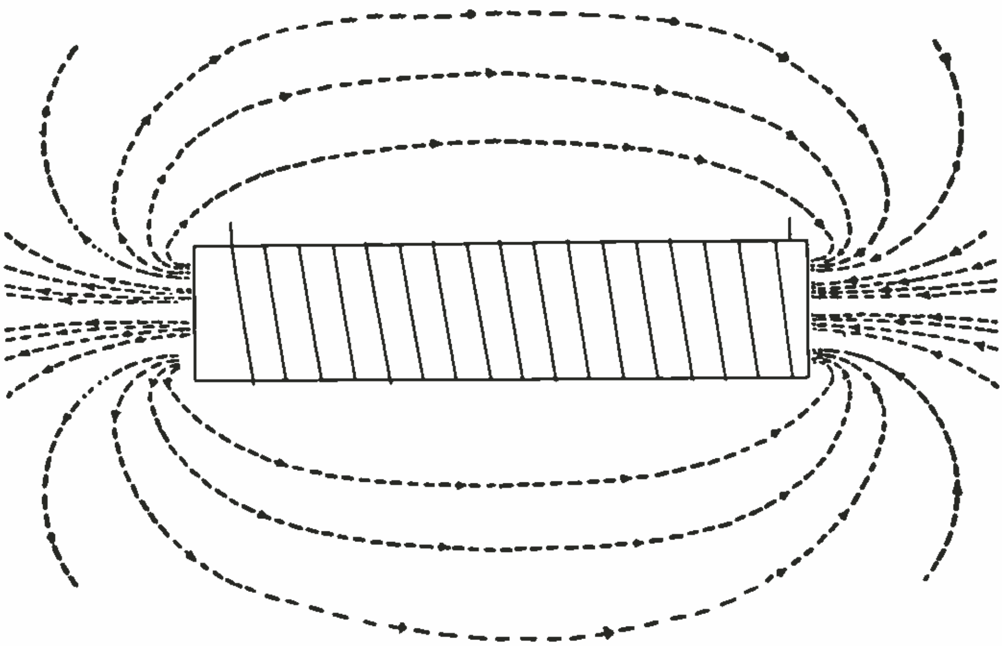


Fig. 8-5. A magnetic field created by electric current flowing through a coil of wire.

A magnetic field may also be created by an electric current flowing through a coil of wire, as shown in Fig. 8-5. As we can see, the magnetic field created by the coil of wire is similar to the field created by the magnet, illustrated in Fig. 8-4. The intensity of the field created in this manner, varies with the amount of current flowing through the coil of wire, i.e., a small amount of current flowing through the coil will create a comparatively weak field, a greater amount of current flowing through the coil will create a stronger magnetic field.

We may also use this type of magnetic field to magnetize an iron bar by inserting it into the center of the coil. The bar then becomes magnetized in exactly the same fashion as when it was exposed to the field of the permanent magnet. The ability to retain this magnetism is dependent upon the material used for the bar. If a soft iron bar is used and left in the coil, we have what is called an electro-magnet, since the bar displays magnetic properties only when current is flowing through the coil. At other times, due to the low retentivity of the soft iron bar, it is not magnetized.

This electro-magnet, when current is flowing through its coil, provides us with the means of magnetizing other magnetic materials, just as we were able to do with the permanent magnet. In addition, by merely varying the amount of current flowing through its coil, we can vary the degree of magnetism in the magnets we create. For example, with an electro-magnet we could magnetize a number of hard steel nails with varying degrees of magnetism. If we were to allow these nails to attach themselves to each other lengthwise, and then laid a blank sheet of paper over them and sprinkled iron powder over the paper, our magnetic fields would appear as shown in Fig. 8-6, which is a series of magnetic fields of varying intensity. In fact, if we were to use a strip of magnetically "hard" steel instead of the nails and place one section after another in the field of the electro-magnet, at the same time varying the amount of current flowing through the coil, we would achieve the same effect.

Fig. 8-6. A magnetic field as it appears when iron powder is sprinkled on a sheet of paper under which there are magnetized nails.

A recording head is nothing more than an electro-magnet of the type we have been discussing. The bar, however, is bent into a circular shape, such as the horseshoe magnet illustrated in Fig. 8-7. This head is made of magnetically "soft" material, and as explained earlier it becomes magnetized easily and instantly when an electrical current flows through its coil. However, as we have also explained, when a soft magnetic material is employed the electro-magnet loses its magnetism just as quickly and easily when the current ceases. Too, we have previously found that by bringing any object made of a magnetic material into proximity with a magnet, we can transfer magnetic energy to the object itself, thereby creating another magnet.

For the best method of illustrating the transfer of magnetic energy, we may use a toy similar to the one shown in Fig. 8-8. When a metal clown is brought within the field of the magnet it is attracted and becomes a magnet itself, with the power to attract and suspend another clown.

In Chapter 3, we explained how sound energy was converted

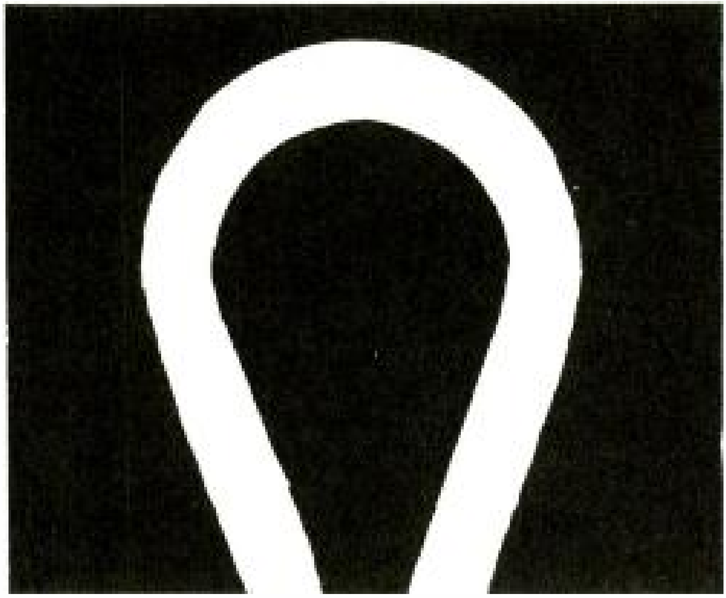


Fig. 8-7. A recording head is an electro magnet bent to resemble a common horse shoe magnet.

into electrical energy by a microphone. We found that when a sound wave with a frequency of 5000 cps strikes a microphone it causes its diaphragm to vibrate 5000 times per second. This mechanical energy is then converted into electrical energy and each complete vibration of the diaphragm results in the generation of a tiny electrical impulse. A 5000-cycle tone therefore creates 5000 individual impulses.

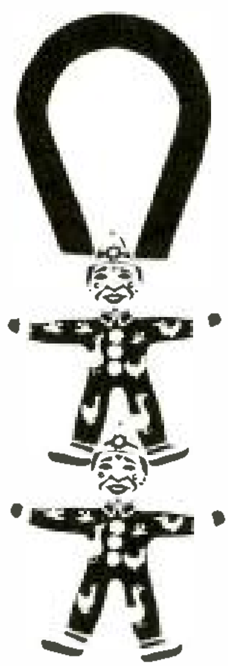


Fig. 8-8. Magnetic energy may be transmitted from one object to another.

We also discovered that the intensity or loudness of the sound wave affects these impulses, a louder sound causing a greater impulse, a softer sound causing a lesser impulse.

These electrical impulses created by the microphone are all, however, very minute. In order to increase them to a point where they will actuate the electro-magnet which is the recording head, they must be amplified. These amplified electrical signals are then fed into the recording head.

Earlier, we explained how we could transfer magnetic energy to a strip of steel tape. We also found that by moving this tape across an electro-magnet (recording head) we could create a series of individual magnets. The number of magnets we could create would be primarily dependent upon the number of times per second current flowed through the magnet.

If the current were made to flow 5000 times per second, we would create 5000 individual magnets on the tape. If a strip of steel tape were to travel across the recording head at the rate of 7½ inches per second (ips), we would have 5000 individual magnets impressed upon 7½ inches of tape.

Thus it is seen how a tone of 5000 cps, which causes the microphone diaphragm to vibrate 5000 times per second, also creates 5000 tiny electrical impulses. If the tone affecting the microphone was 1000 cps, the recording head would impress 1000 tiny magnets on the moving tape.

Should the intensity of the sound wave be increased or reduced, it would result in an increase or reduction of the electrical signal obtained from the microphone. This, of course, would result in a corresponding variation in the strength of the individual magnets created on the moving tape.

We have thus far discovered how we can create magnetic impulses which can be varied in intensity and in frequency. The magnets we have created and stored on the steel tape can be used to create sound by simply reversing the entire process. Just as electrical impulses can create magnetism, so can magnetism create electrical impulses.

A surge of electrical current can be created by moving a magnet (or its magnetic field) through a coil. By moving a series of magnets (or their magnetic fields) through a coil, a series of minute electrical impulses will be produced. This series of tiny electrical impulses can then be amplified to a point at which they will actuate a loudspeaker. Operating in a manner directly opposite to that of a microphone, the speaker converts electrical energy into sound.

To-day, instead of steel tape we employ a plastic tape for recording purposes. There are three basic ingredients which are combined to make modern recording tape. They are: iron oxide particles, a liquid binder, and an extremely thin and smooth cellulose acetate film. The oxide particles must be extremely tiny and uniform. In fact, in modern magnetic tapes they measure one micron or less – so small that many millions of them are on each inch of tape.

Even dispersion of the iron oxide particles in the binder, and smooth application to the plastic backing to which they are permanently bonded, are also of crucial importance to a quality tape. Laying the coating evenly to insure uniform response and output is the central problem in the manufacture of recording tape, and specifications for good tape are several times more exacting than anything previously known in mass-produced coatings.

When the coated tape is dry, it is cut into strips one-quarter of an inch in width. It has the appearance of a thin, brown plastic ribbon, which is shiny on one side and dull on the other. The tape is then wound onto plastic reels which are available in a variety of sizes. The two sizes most generally employed on non-professional recorders are the five- and seven-inch reels which hold respectively, 600 and 1200 feet of standard-thickness (0.0015 inch) tape. For extended playing time there is available at higher cost a thinner (0.001 inch) tape which increases the capacity of standard reels by fifty percent. Figure 8-9 provides the recording times for both types on the various sized reels available.

At the extreme right side of Fig. 8-9 the reader will notice two columns which are headed "Dual Track Time." These figures refer to those recorders in which the record-playback and erase heads are designed to uitilize only one-half the width of the standard ¼-inch tape, as illustrated in Fig. 8-10. In this manner it becomes possible to make a recording on one-half of the entire length of tape. After one recording has been made the reel is reversed and a second recording made on the remaining one-half of tape width. This results in doubling the recording time with the same length of tape.

Dual-track recording, while improving economy, makes editing slightly more complicated since, when the recordist wishes to edit either track, he is forced to cut out a portion of the remaining one. The proper method of editing dual-track recordings is provided in Chapter 9.

TAPE TIMING TABLE

Uninterrupted Recording Time for Various Tape Speeds and Tape Lengths (Tape Speed — inches per second)

		Single Track Time						Dual Track Time	
Reel Size	Tape Length	15/16 ips	1⅞ ips	3¾ ips	7½ ips	15 ips	30 ips	3¾ ips	7½ ips
3"	150'	½ hr.	15 min.	7½ min.	3¾ min.			15 min.	7½ min.
4"	300'	1 hr.	30 min.	15 min.	7½ min.	3¾ min.	1⅞ min.	30 min.	15 min.
5"	600'	2 hrs.	1 hr.	30 min.	15 min.	7½ min.	3¾ min.	1 hr.	30 min.
5"	900'	3 hrs.	90 min.	45 min.	22½ min.	11¼ min.	5⅝ min.	1½ hrs.	45 min.
7"	1200'	4 hrs.	2 hrs.	1 hr.	30 min.	15 min.	7½ min.	2 hrs.	1 hr.
7"	1800'	6 hrs.	3 hrs.	90 min.	45 min.	22½ min.	11¼ min.	3 hrs.	1½ hrs.
10½"	2400'	8 hrs.	4 hrs.	2 hrs.	1 hr.	30 min.	15 min.	4 hrs.	2 hrs.
10½"	3600'	12 hrs.	6 hrs.	3 hrs.	90 min.	45 min.	22½ min.	6 hrs.	3 hrs.
14"	4800'	16 hrs.	8 hrs.	4 hrs.	2 hrs.	1 hr.	30 min.		
14"	7200'	24 hrs.	12 hrs.	6 hrs.	3 hrs.	90 min.	45 min.		

Fig. 8-9. This chart shows maximum recording time for various sizes of reels and thicknesses of tape, both single- and double-track.

One of the most important advantages of tape recording is that any signal which has been recorded may be completely erased and the tape reused. The recording tape which is magnetically "hard," and therefore retains any magnetism imparted to it, is erased by an ultrasonic signal which is applied to an electro-magnet called an *erase head*. The magnetic field created by this head rearranges the molecular magnets on the tape so that they again become oriented in various directions and form closed groups, as illustrated in Fig. 8-2. Their magnetic effects then neutralize or cancel one another and the tape no longer displays any magnetic properties.

Since we are now aware of how sound is recorded, stored and reproduced from tape we should understand something of the mechanical nature of a tape recorder. The tape-transport mechanism of a recorder is the means by which the tape is moved past the erase,

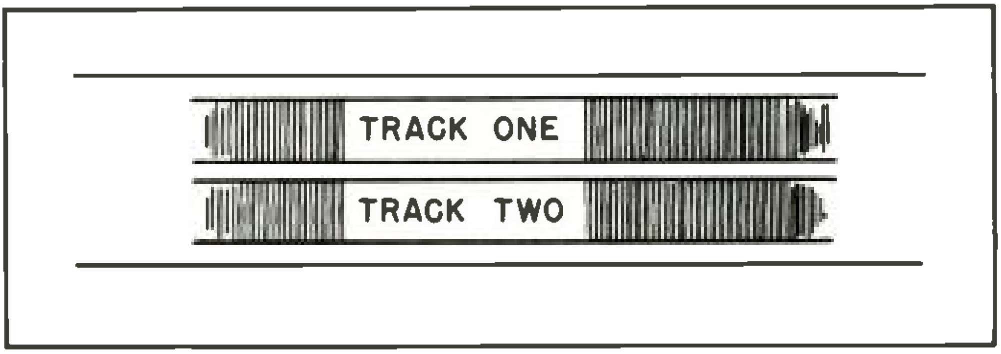


Fig. 8-10. With dual-track recorders, only one-half of the tape width is utilized for each recording.

record and playback heads. The rate at which the tape moves past the head is standardized at certain speeds and is regulated by the tape-handling mechanism. Its job is to feed the tape from the supply reel, as shown in Fig. 8-11, to the take-up reel, at a constant speed.

Fig. 8-11. Tape is fed from the supply reel (left) to the take-up reel (right) at a constant speed past the recording head. (Photo Courtesy of Ampex Corporation.)

The tape travels past the record head in a lineal direction so its speed is measured in inches per second. The speeds most commonly used are 3¾, 7½ and 15 inches per second. Many recorders incorporate two of these speeds on a single machine. To a great extent the frequency response of a tape recorder is determined by the rate at which the tape travels past the recording head. The greater the speed the higher the frequency response will extend. A rule of thumb is that the upper frequency response limit in thousands of cps is about 1½ times the tape speed in inches per second. When the tape speed is 7½ ips the upper frequency limit is around 12,000 cps. When the tape speed is 3¾ ips the upper limit is usually around 6000 cps.

The constancy of the speed of a tape-transport mechanism is determined by the motor and the capstan drive — a small cylinder at the end of the motor shaft which pulls the tape from the supply reel past the heads. The reason that constancy of speed is important is quite simple to understand when we realize that is has an important bearing on the fidelity of the recorded or reproduced sound.

Let us assume we have recorded a 2000-cps signal on a tape at a speed of 3¾ ips. This means that the tape contains 2000 magnets in a space of 3¾ inches. If this tape, when it is reproduced, moves past the playback head at the exact speed at which it was recorded it will result in the generation of 2000 impulses per second and produce a 2000-cycle tone. If, on the other hand, it is reproduced at twice the speed, or 7½ ips, the 2000 magnets will move past the playback head in one-half the time, resulting in the generation of a tone twice the recorded frequency or 4000 cps. We have provided an extreme example in order to illustrate exactly what occurs when there is variation in the speed at which the tape moves past the head. A momentary change in the speed will cause a corresponding change in the pitch of the recorded or reproduced sound. The degree of pitch change is determined by the amount of deviation from the normal operating speed.

The most noticeable speed variations are those which are periodic and result in cyclic variations in the pitch of the reproduced sound. Pitch variations may occur at a relatively slow rate, less than ten times per second, in which case they are described as "wow." Variations which occur at a higher rate of speed (more than ten times per second) are described with the term "flutter." Changes in pitch are particularly noticeable in the reproduction of the higher-pitched sounds such as are made by a violin, clarinet, etc., and on struck-string instruments at all frequencies.

When your recorder is operating properly you should not notice any pitch changes. The most common causes of wow and flutter are sticky splices, warped tape reels, and improper maintenance of the tape-transport mechanism.

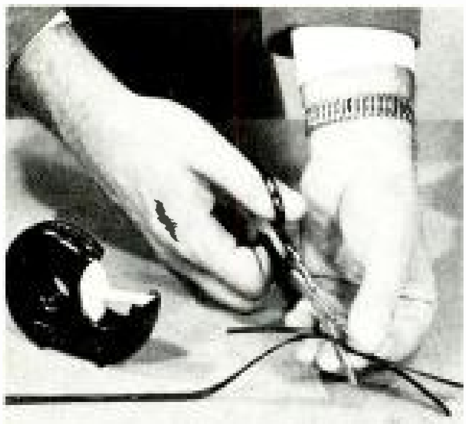
Chapter 9

Editing and Splicing

As we record sound, accidents often occur; a vocalist may go off key, an instrumentalist may hit a wrong note, a crash of static may mar an off-the-air recording, a previously unnoticed scratch or nick on a phonograph record may cause an audible click. All of these unwanted sounds are recorded along with the desired sound.

Before the advent of tape recording any unwanted sound of this nature could ruin an entire recording. Many educators and professional musicians remember well the days, not so long ago, when recording a musical selection or a dramatic performance meant the cutting of a master record on wax or acetate. Once this master was cut there was no method of eliminating mistakes except by cutting an entirely new master. They will undoubtedly also remember just how aggravating it was to record a performance almost to the very end, only to have some musician hit a wrong note or have a pupil fluff a line. This one slight error often ruined what otherwise was a perfect recording. Today, with tape, the conductor merely goes back a few bars from the place at which the mistake occurred, and starts over from that point. He knows that the editor can eliminate the section on which the mistake occurred and join the two good sections in such a manner that the joint defies aural detection.

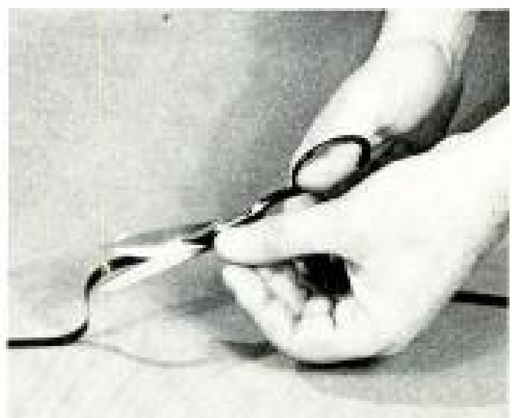
The first step in editing is to learn the correct method of joining or splicing two pieces of tape so that the splice cannot be detected aurally. The only tools really essential for splicing are a pair of scissors and a roll of splicing tape. It is extremely important that



(A)

(B)

(C)



(D)

Fig: 9-1. The four steps in splicing magnetic recording tape. (A) depicts cutting tape at a 60-degree angle with an overlap so ends line up. (B) shows how to align tape, uncoated side up. (C) illustrates how to cover aligned ends with splicing tape. The last step is to trim off excess tape as shown in (D). (Photos Courtesy of Minnesota Mining and Manufacturing Company.)

the scissors not be magnetized, since when they are they will cause erasure at the spot on the tape where the splice is made. The scissors you use can be checked for magnetism by bringing them close to some steel straight pins. If the scissors do not attract the pins they are safe to use.

The second factor of importance in joining tape is to use only splicing tape expressly designed for this purpose. The adhesive on this type of tape will not ooze out under pressure and cause a sticky splice as do other types of tape. A sticky splice causes the layers of tape adjacent to the splice to stick to it and cause a momentary slowdown of the tape transport mechanism, resulting in an audible "wow" on playback.

Figure 9-1 illustrates the four steps in making a simple splice on tape. First cut the tape diagonally at a 60-degree angle with some overlap, as shown, so that the ends will line up. Cutting the tape diagonally will eliminate aural detection of the splice on playback. Step two is to lay both ends of cut tape, uncoated side up, on a piece of corrugated cardboard. The uncoated side is the shiny side on plastic tape and the tan side on paper tape. The two ends, which should be placed in perfect alignment, are then covered with splicing tape as illustrated. This tape should be pressed on firmly to secure the ends evenly. Any excess splicing tape is then removed as illustrated. The possibility of a sticky splice may be further reduced by cutting into the tape backing very slightly.

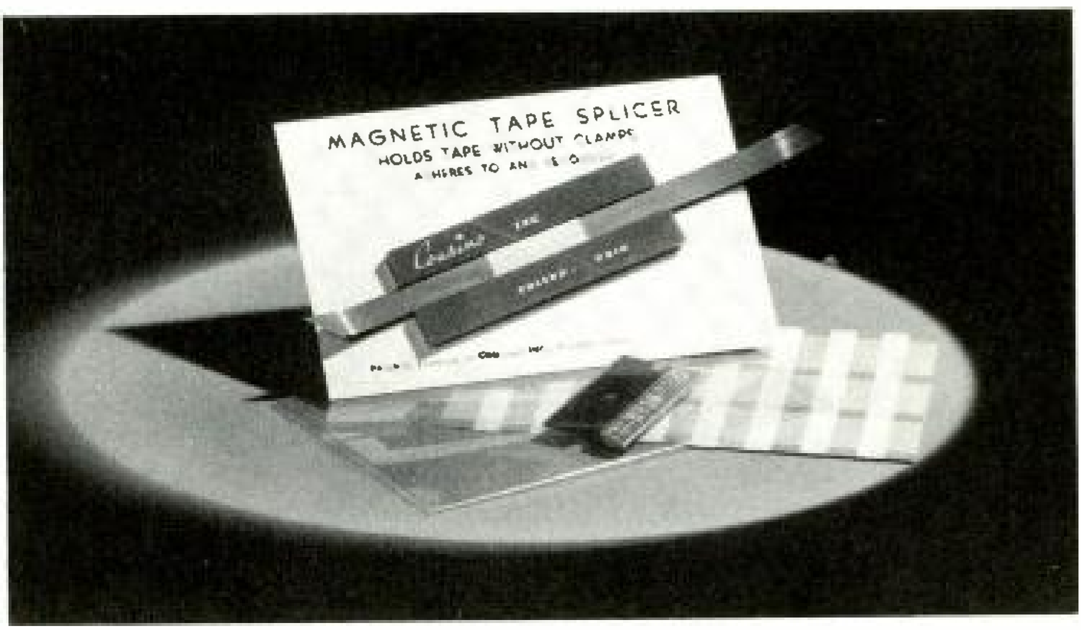


Fig. 9-2. An inexpensive tape splicer. (Photo Courtesy of Cousino, Inc.)

Figure 9-2 illustrates one of the variety of tape splicers available to the recordist to make the splicing operation even simpler. The razor blade for cutting the tape employed with this type of unit, like the scissors, must not be magnetized.

The simplest form of joining two tapes occurs when editing a series of tape recordings made from a group of unrelated records. The tape, if it has been recorded by putting a stack of records on an automatic record changer, will have spaces between each record of up to ten seconds. These sections of unrecorded tape are often too long and may be marred by the recorded clicks created by some changer mechanisms. When a manual record player is employed, the pause between selections is often even longer because of the time it takes to remove one record and put another on the turntable. It is not advisable to stop the tape-transport mechanism between selections since this may also create clicks.

The primary reason for splicing and editing the tape between selections recorded from phonograph records is to shorten the lapse of time between the two pieces of music. The simplest method of accomplishing this is to play the tape recording back until the end of the first selection is heard. At this point the tape-transport mechanism is shut off and the tape rewound by hand until the first sound is heard. This will be the last note of the selection. Do not move the tape any further. With an orange china-marking pencil mark the tape at this point. The spot to be marked is always exactly over the gap on the head at the extreme right side where more than one head is used, or the gap at the extreme right where only one head is employed.

On many tape recorders the head covers are not always removable as shown in Fig. 9-3, consequently another method of locating

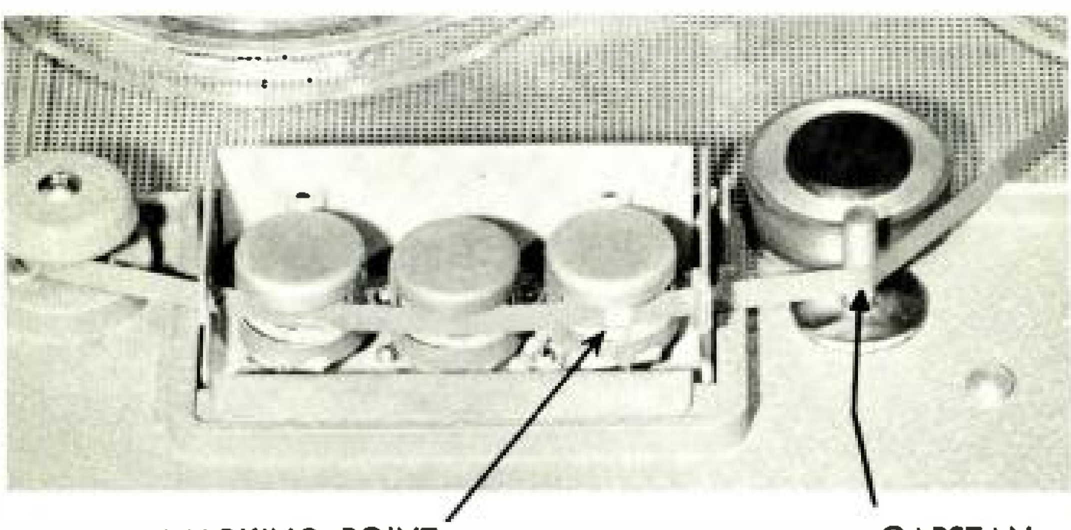


Fig. 9-3. For editing, the exact distance between the gap in the playback head and some external reference point, in this case the capstan, is measured. In this manner the precise point on the tape to be cut and spliced may easily be determined.

the marking point must be employed. Some accessible point is found outside the cover. This may be the capstan, as illustrated by the arrow in Fig. 9-3, or the point at which the recorded tape appears from under or behind the cover. The distance from the chosen point to the gap on the playback head, or the playback section of a single head, is accurately measured. Let us assume it is 1¾ inches as on the recorder illustrated.

The tape is rewound by hand, as previously described, until the first sound is heard. The tape is now marked at the point previously chosen, in the present case the capstan to which the arrow points. Do not cut the tape at this point! Measure off 1¾ inches of tape to the left of the point marked – this is the exact spot at which the selection ends. Next, wind the tape forward by hand until the start of the music on the next recorded section is heard. Mark this position as previously explained. You now have a visual indication of the points at which one musical number ends and the next begins. With some record changers the average time lapse between the end of one record and the start of the next is as great as ten or twelve seconds. When using a tape speed of 7½ ips this time lapse represents up to 90 inches of tape between the end of the record and the start of the next. The length of tape on which there is no music will also vary with the length of the run-on and run-off grooves on the phonograph records themselves. A splice may be made anywhere between the two marked points, leaving a total of 37½ inches of tape between them. At a speed of 7½ ips this length reduces the pause to five seconds which is an acceptable time.

While on the subject of pauses between records we might explain that when re-recording complete albums, operas or symphonies, the recordist is likely to encounter different types of transitions from one side of a record to another or from one record to another. These affect the re-recording of such a group particularly when the recordist wishes to obtain an uninterrupted version of the music being recorded. The most simple type of transition to re-record is the type which takes advantage of a pause in the musical score, usually a rest or some other type of break. In this type of transition the music on one record or side ends at the beginning of the rest, and begins again on the next record or other side at the end of the rest. The tape is merely cut at the end of the sound made by the run-off groove, which is measured, and at the beginning of the sound of the run-on groove of the next record or side, which is also measured. The two cut ends are then trimmed to the length which provides the exact time of the pause as it would occur in the original music.

The only difficulty which may be encountered in editing this type of transition is found when the recording studio in which the original recording was made was a large one and the reverberation time is high. This condition sometimes results in the last note having a duration of up to two or three seconds, depending upon the size and acoustics of the studio.

When a record displaying this characteristic is reproduced on a record changer or player the excessive length of the last note is not noticeable because of the time lapse between the playing of one record and the next. However when the recordist wishes to make one continuous performance from two or more records the length of time it takes for this last note to fade out becomes an unnatural interruption, which must be corrected.

The adverse effect of high reverberation time on the last sound from a record can be made practically unnoticeable by reducing it to one second and splicing the first sound from the next record or side in the following manner. When employing a recorder which operates at a speed of 7½ ips, find the position at which the last note on a side or record begins and cut the tape in two at a 90-degree angle 7½ inches after this point. The next step is to cut the end of this tape at a 60-degree angle starting 3¾ inches from its end. The section of tape to be joined is then cut at the same angle 3¾ inches from the beginning of the first note. When these two ends are spliced the recordist will find that, while the reverberation time of the last note has been shortened to one second, it fades out in a natural manner due to the gradual reduction in volume level caused by the long diagonal cut which gradually reduces the width of the tape.

The second type of transition is equally simple to join into an uninterrupted whole. It usually occurs in 78-rpm record albums and is one in which the recording engineers, of necessity, had to chop the composition into three- or four-minute sections by cutting the music at the end of each side and resuming on the next side or record, usually at a point four or five notes before the point of the previous cut. Where a movement, act or an aria is cut in two it is quite simple to join the two sections by finding the note on the second side which duplicates the last note on the first side, eliminating it by cutting, and joining the two sections with a 45-degree splice. This can be accomplished very simply by cutting out all of the unrecorded tape between records and making a temporary splice, as illustrated in Fig. 9-4, at the point at which one side of the record ends and the other begins. The tape is then played back at normal speed while listening carefully to the section at which the splice occurs for any duplication of notes. The duplicate notes can then be very easily removed by cutting, and the two ends then joined with a permanent splice.

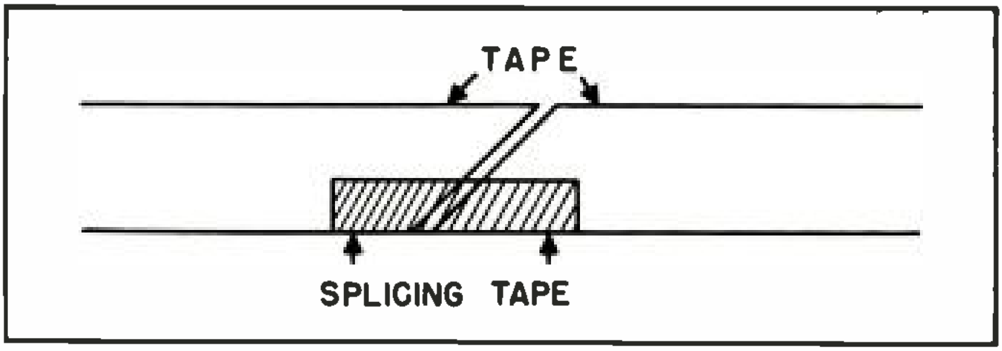


Fig. 9-4. How a temporary splice is made.

The third type of transition, while it is not employed too frequently, appears often enough to be worthy of mention. In this type of transition the music ends with a diminuendo passage, a gradual fade out, on one record, while the following record starts with the same passage but crescendo, a gradual fade in. The recordist will usually find that the first note of the diminuendo passage and the last note of the crescendo passage are the same in both the score and in volume level, consequently it is a simple matter to remove the surplus music from the first and second sections and join them, of course eliminating one of the duplicate notes.

We have thus far described the procedure employed in editing and splicing tape recordings made from records. During Chapter 7 we explained the factors which were responsible for the majority of the noise on phonograph records and described the most effective methods of eliminating or reducing this noise. However there are certain records (the earlier 78-rpm and the low-priced modern 78-rpm records) which are inherently noisy due to the material of which the record is manufactured. As explained earlier, the shellac base material of which these records are made is not uniform in structure but is built up of small grains. These grains, pressing against the stylus tip as the record revolves, create random impulses which are translated as noise.

Educators, musicians and those who require perfect re-recordings on tape, can greatly reduce even this type of noise. Tape recordings can be made from these records which are actually less noisy than the records themselves.

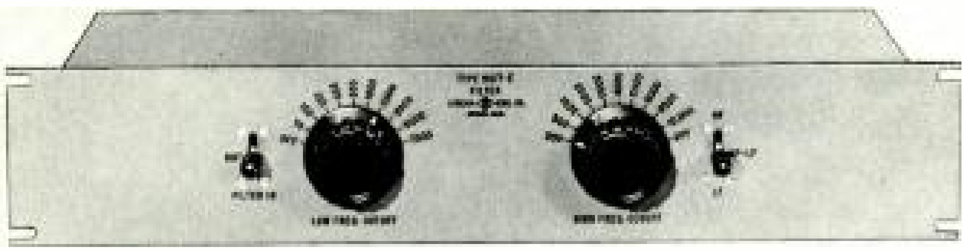


Fig. 9-5. A professional-type program filter. (Photo Courtesy of Cinema Engineering Company.)

Since the greatest percentage of the surface noise from a record lies at the high-frequency end of the audible spectrum, it can be eliminated by restricting the frequency range of the tape recording in such a manner that the noise-carrying high frequencies are not recorded. This is accomplished professionally by employing a filter such as is illustrated in Fig. 9-5, one section of which cuts off all sound above certain frequencies. This filtering action, while it eliminates the noise, also results in the elimination of any music above the selected filter frequency. This is not quite as serious as it may sound since the records we are discussing do not usually contain any signals above the frequencies given in the following paragraph.

The very early 78-rpm records cut off at about 3500 cps. As the art of recording on discs advanced the high frequency range was extended to 5000 cps. Some of the 78-rpm records released just prior to the introduction of the long-playing vinylite record had a frequency range somewhat higher. Thus it can be seen that we do not lose very much in the way of music when we restrict the frequency range by filtering, especially when the cut-off frequency is properly chosen for the particular record being re-recorded.

Fig. 9-6. An inexpensive compensator. (Photo Courtesy of General Electric Company.)

Figure 9-6 illustrates an inexpensive unit which may be used to provide the filtering action we require. This unit can be employed only when the recordist uses a magnetic phonograph cartridge for record reproduction.

Since the average recordist does not usually have any idea of the frequency range of the record he wishes to "dub" onto tape a

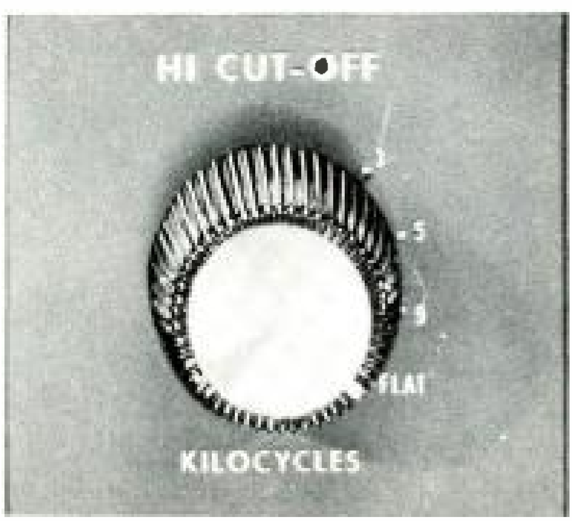


Fig. 9-7. Close-up showing positions of a hi cut-off filter.

cut-and-try method must be employed. The high-frequency cut-off control is first set at the FLAT position as illustrated in Fig. 9-7, then gradually moved to the left, step by step, until the position is found which provides the greatest amount of noise reduction and has the least effect upon the music. For example, an early 78-rpm record may be in good condition or it may have been recorded at a high enough level so that the music overrides the surface noise. To utilize the full range of this record the recordist can set the filter at the 5-kc position. On the other hand, if a record is in poor condition or contains a violin solo recorded at a low level, in which case surface noise often overrides the signal, it would possibly require a 3-kc cut-off. Listen to the record to be recorded first, then adjust the filter for maximum signal and minimum noise. This is the setting which should be used when the record is re-recorded.

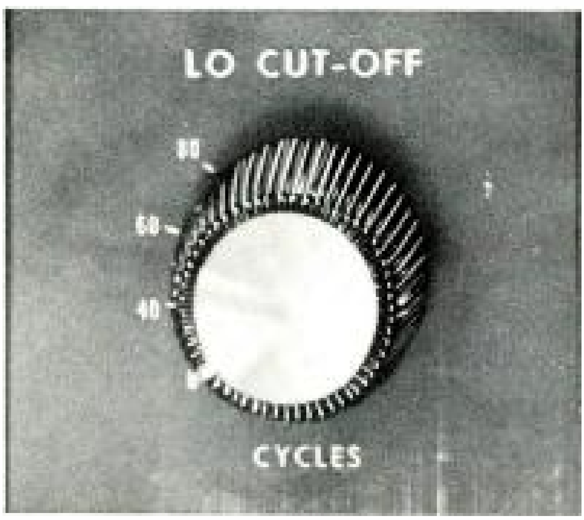


Fig. 9-8. Close-up showing positions of a low cut-off filter.

There is one other factor often encountered when re-recording early 78-rpm records which can be corrected when the recordist wishes to obtain a better recording than is provided by the original record. Many of these records have a pronounced low-frequency rumbling sound when played back on modern equipment. This rumble may be caused by a faulty recording or playback turntable, warped discs, or tone arm vibration.

This low-frequency rumble may also be eliminated by proper filtering. The knob at the extreme left of the units illustrated in Figs. 9-5 and 9-6 controls a low-frequency filter which eliminates all sounds lower in frequency than the one marked on the dial. This filter is first set at the zero position and gradually turned to the right until the rumble is minimized. The positions of this control are illustrated in Fig. 9-8. The manipulation of this control also results in the cut off of all music below the chosen frequency, consequently the same cut-and-try method suggested in connection with the high-frequency filter should be employed with this one.

Those who own a collection of long-playing records and play them on a conventional radio-phonograph are well aware of the fact that some of their records seem to sound better than others and that some even seem to have better bass and/or treble than others. Some of these records may sound better on your neighbor's radio-phonograph than they do on yours or the reverse may be true. There are two reasons for these very noticeable differences in reproduction from record to record, and since these reasons also affect the quality of a tape recording made from records we will explain them.

The low frequencies on the modern record are progressively attenuated as the frequency drops below what is known as the "turnover" point, usually 1000 cycles, to eliminate the possibility of the recording stylus breaking through the groove walls as the disc master is being recorded.

As the equipment for the recording and reproduction of records was improved and the frequency range extended, it was found that another problem appeared. The improved records very often had excessive noise, and the softer passages were sometimes lost in the background. This occurred because of the fact that the level of the recorded signal fell off progressively as its frequency was increased. The record manufacturers soon discovered that when the level of the recorded signal was increased as the frequency increased, the sound would override the noise level. This was done but the signal output of the record then became similar to line (B) in Fig. 9-9 instead of linear as is depicted by line (A).

Feeding a tape recorded with a signal displaying this characteristic would result in a recording which would sound shrill, high-pitched and would seemingly lack bass. In order to play this type of record correctly some means had to be found which would increase its output at the lower frequencies and decrease its output at the higher frequencies. Such a device is called an *equalizer*. Its response is illustrated by line (C) in Fig. 9-9 and will be seen to be the exact

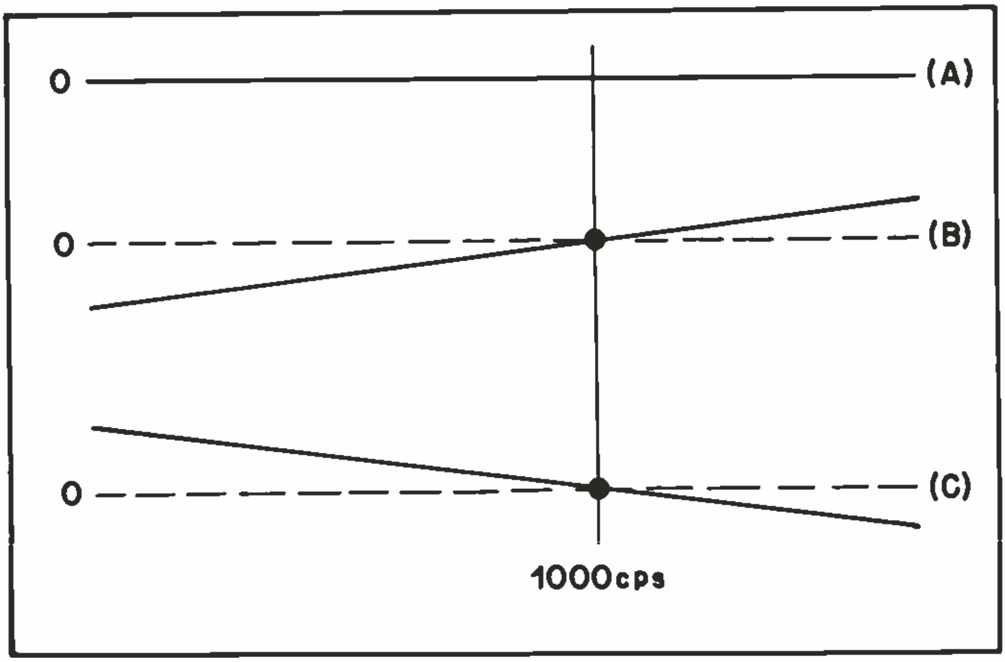


Fig. 9-9. Phonograph records are recorded with low frequencies attenuated and high frequencies accentuated as shown by line (B). They are played back through an equalizer which has characteristics which are exactly opposite to those of the recording amplifier, as depicted in line (C). The net result is the flat frequency response shown in line (A).

opposite of that of the record. When lines (B) and (C) are combined, which occurs when the output from the record is fed into the equalizer, the resultant signal becomes linear as shown by line (A). This signal is now substantially identical to the output of the microphone in the recording studio.

This problem of record equalization is further complicated by the fact that each record manufacturer, for various technical reasons, has his own recording curve, though laudable efforts have been and are being made to set an industry standard. This difference in recording curves results in the fact that any equalizer must be variable and be able to compensate for a variety of record characteristics.

The type of equalizer we have been discussing is incorporated in the General Electric Three-Way Filter illustrated in Fig. 9-6.

From our previous paragraphs it should be obvious that when superior tape recordings are desired from records it is essential that you employ an equalizer-filter such as we have described.

When the recordist owns a high-fidelity music reproducing system which incorporates a preamplifier-equalizer of the type illustrated

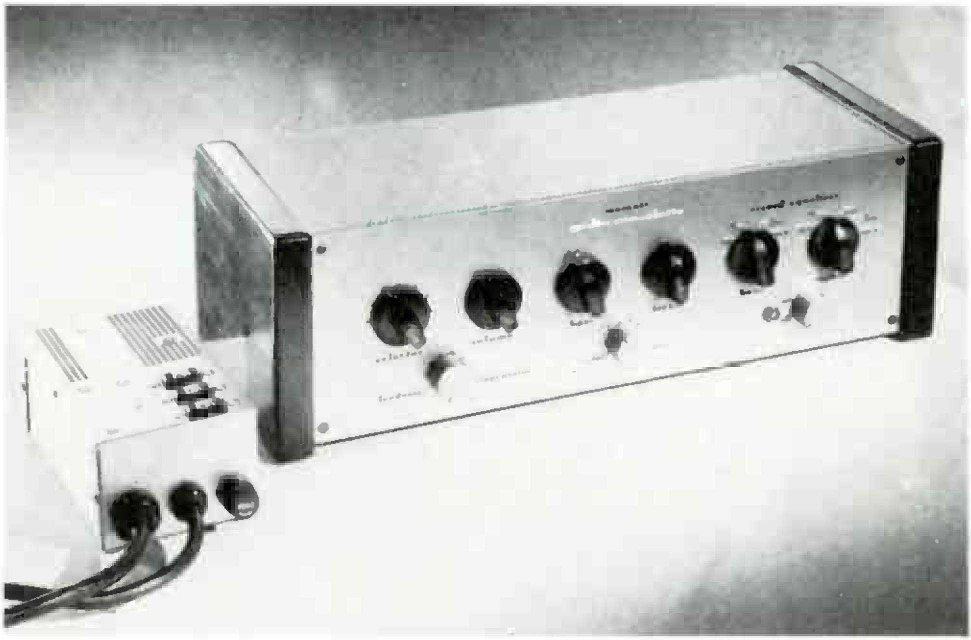


Fig. 9-10. A preamplifier-equalizer for a high-fidelity music system. (Photo Courtesy of S. B. Marantz, Inc.)

in Fig. 9-10, the various equalization positions are usually available as part of his equipment and all that is required in addition is a Hi-Lo cut-off filter such as is illustrated in Fig. 9-11. While the additional equipment we have suggested will result in an appreciable

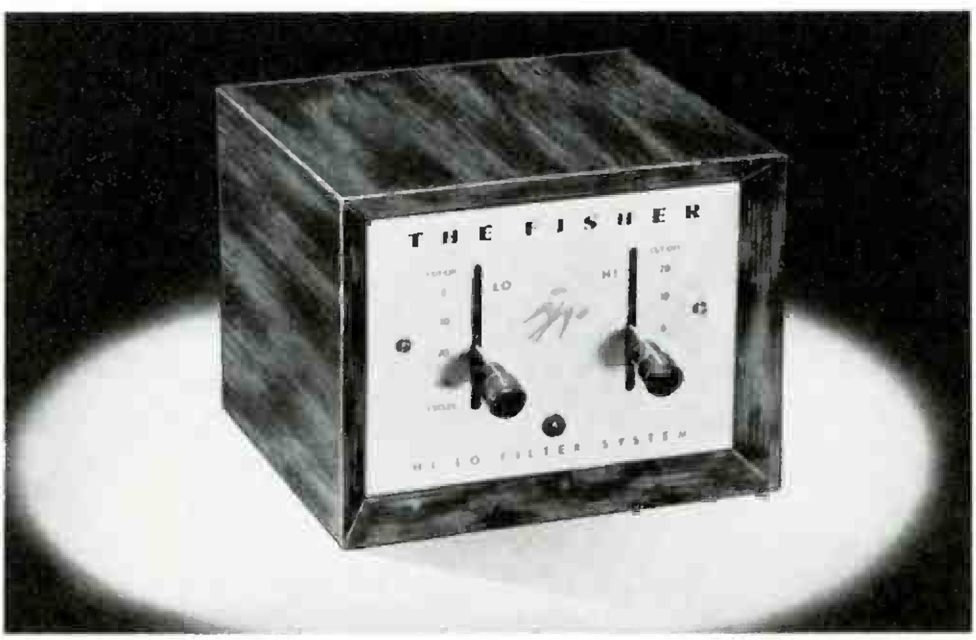
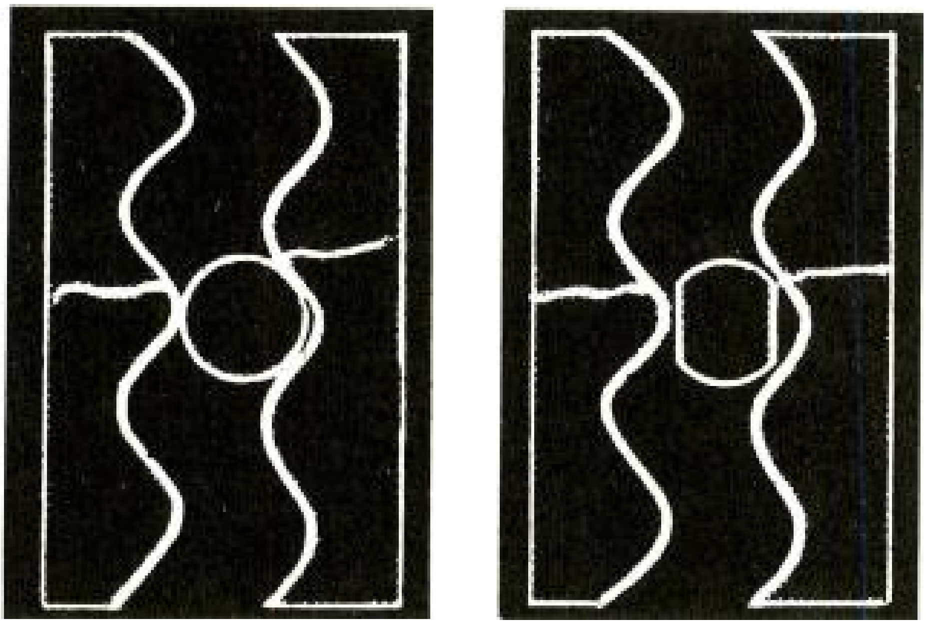


Fig. 9-11. Hi-lo filter system. (Photo Courtesy of Fisher Radio Corporation.)

improvement in the quality of tape recordings made from records, the recordist who uses a conventional radio-phonograph for this purpose should not be discouraged since with it he can obtain excellent tape recordings.

We will close this section on editing tape recordings made from records with information on how to record from records which are cracked or broken.



(A) (B)

Fig. 9-12. Here is shown at (A) the position of a new stylus tip in a record groove at the point of a crack; (B) indicates the position of a worn stylus at the same spot.

The first requirement is a brand new stylus; diamond is preferable because it retains its original shape for a longer period of use. Our reason for specifying a new stylus should be obvious from Fig. 9-12, which shows at (A) a new stylus tip in a record groove at the position of a crack or break, while (B) illustrates a partly worn stylus tip in the same position. It is quite obvious that the sharp points at the sides of the worn stylus tip are more likely to catch in the crack or break as the tip moves past it. A new stylus tip also rides the groove walls as shown in Fig. 7-6, and not the bottom which is another point at which a worn stylus tip is likely to catch in a crack or groove. We are concerned with the ease with which the stylus tip passes over the crack or break since the less it catches the lower will be the noise created.

When recording early 78-rpm records try both a 2.5-mil and a 3-mil stylus tip, since if a record was made to use a 3-mil tip and a 2.5-mil tip is employed it will ride the bottom of the groove and thereby increase the possibility of the tip catching in the crack or break.

When a record is merely cracked it may often be recorded without additional doctoring if a brand new stylus tip is used. On bad cracks the author uses splicing tape on the reverse side of the record to hold the crack together more firmly. Splicing tape is employed since its adhesive does not bleed off into the grooves, thus making the reverse side more difficult to record later.

When a record is broken into pieces only one side can be re-recorded since the other side must be glued to a sheet of cardboard. For this purpose the writer uses rubber cement of the type employed by art studios. This cement fills the grooves and makes a firm bond to the cardboard.

Fig. 9-13. When a record tends to repeat a single groove due to centrifugal force which pushes the stylus against the outer wall, the tendency may be nullified frequently by tipping the turntable toward the center as shown.

If the record to be re-recorded keeps repeating a single groove because of the centrifugal force created by the revolving disc, which thrusts the stylus tip outward in such a manner that it catches on the crack or break on the outside wall of the groove, it can be made to play by tipping the changer or player inward and to the left as illustrated in Fig. 9-13.

After the sound on the record has been recorded on tape any clicks created by the crack or break can be removed or at least greatly reduced in intensity by employing a 90-degree splice. The click is spotted and marked as illustrated in Fig. 9-3. The tape is then cut at the exact center of the mark. The two ends are then trimmed very slightly; about 1/64-inch is sufficient for the first cut. They are then joined with a temporary splice and played back. If, after the tape has been played, it is found that the click is still noticeable, the splice is removed and the tape clipped again. The space occupied on the tape by the click is only 1/32 to 1/64-inch at 7½ ips and consequently very little tape need be removed. When too much tape is removed the splice will become evident by a skip in the musical content.

Editing any tape recording becomes very simple and the editing will pass unnoticed if the recordist remembers one important factor. The background sound must match perfectly when any two sections of tape are joined. A change in the background may be caused in a number of ways. By a change in acoustics when the recording locations are different. By a difference in the type of background sound. By the sudden elimination of some background sound or by the sudden appearance of a background sound not on the previous section of tape.

As explained in an earlier chapter, any change in the acoustics of the recording location results in a very definite and noticeable change in the character of the recorded sound. This change in the character of the recorded sound is particularly obvious when two sections of tape recorded in different locations or under different acoustic conditions are played back, one after the other, as they would be when they are spliced. The reader has a perfect example if he made the test tape suggested in an earlier chapter.

The simplest solution to this important phase of editing can be obtained when making the original recording. If it is at all possible listen to the recording you have made before leaving the scene.

When you discover that an error has been made, re-record the defective section immediately. For example, if a dramatic teacher records a play and a pupil fluffs a line, all of the performers should be asked to go back to a point, just before the fluff was made and start over again. It is then a very simple matter to remove the unwanted section and splice at the point which is least noticeable. In the event an error passes unnoticed until after the tape is completed and the instructor wishes to correct it by inserting a new section, this section, if at all possible, should be recorded under the same conditions and in the same location as the original. However since this method of insuring the same background is not always practical, the recordist can fake it by using a room of similar size and acoustics. When using this method remember that the apparent acoustics of a room can be varied by a change in microphone position as described in Chapter 4. By careful choice of microphone position the teacher can often make a duplicate section which, when inserted, cannot be detected.

As mentioned earlier, a splice will also become quite noticeable when there is a difference in the type of background sound: for example, a bird lover who records the songs of a number of birds and, after listening to the recording at home, decides to identify them with his own commentary. He normally proceeds to record the desired commentary in a nice quiet location in his home and inserts it in the proper positions in the original recording. The recordist is then usually surprised to discover that regardless of how well both recordings were made the finished result sounds amateurish, and that the sections recorded at home stand out like a sore thumb.

The difference is so noticeable simply because there is either no background sound or a different background sound in the sections made at home. The sections made outdoors have the sound of leaves rustling in the breeze, possibly the sounds of insects, or even the sound of a rippling brook in the distance. The omission of these sounds in the sections recorded at home disturbs the listener. He is subconsciously aware that the scene has changed and, since a sudden change of scene is unnatural, he becomes very conscious of this fact.

If the bird lover had taken the precaution of recording a few minutes of just background sound, the entire recording could have been greatly improved when he decided to add commentary. With this section of background sound he could add a commentary which would make the recording sound as though the birds had performed at his command and, what is more important, as though the comments were actually made on location.

This little trick can only be accomplished when the recordist has taken the precaution of obtaining a few minutes of uninterrupted background sound. The tape on which the background sound has been recorded is loaded onto the recorder in the conventional manner. A strip of 35-mm film is inserted between the erase head and the tape, the recorder is then turned on and the commentary made in the normal manner.

Upon playing this section of tape the recordist will find that his voice has been superimposed upon the background sound obtained on location. The level of the background sound has been reduced enough so that the voice of the commentator can be easily understood.

When this tape is added to the tape of the bird songs the recordist will be very pleasantly surprised to find that the commentary no longer sounds as though it was made at a different time and in a different place. The background sounds are the same, therefore the listener immediately assumes the comments were made on location.

This method of utilizing background sound taken on location is the simplest means of insuring a smooth tape when sections must be inserted at a later date, however, this again is not always possible. When the recordist must make insertions without the aid of such a background it can often be duplicated artificially. This aspect of recording will be discussed in detail in Chapters 10 and 11.

In closing Chapter 7 we mentioned that when recording "off the air" the quality of the finished tape was dependent to a great degree upon the proper editing of the recorded material. One of the most important aspects of editing this type of recording is the elimination of unnecessary material such as commercial announcements, periods of overly long applause, superfluous conversation between the announcer and the artists, etc.

When a broadcast is not played before a studio audience and there is no applause to contend with the problem is quite simple. As the reader will remember, we suggested this type of ending be handled by a quick fade-out with the record level control. Play this section of tape and locate the point which is the end of the quick fade-out, then mark it with a china marking pencil.

The next step is to locate the point at which the announcer introduces the next artist, if you wish to include this section of the program on your tape. In the event you do not, mark the beginning of the first note of the second selection. After both positions have been marked make a 45-degree cut on the tape which ends at the very end of the fade-out; another 45-degree cut, this time in reverse, is then made at the beginning of the first word of the introduction or the first note of the next selection, whichever has been chosen. Both of these ends are then joined with a temporary splice as illustrated in Fig. 9-4. The partially edited tape should now be played back and the transition from one number to the next should be smooth and unmarred by extraneous sound; if it is, most of this editing job has been completed.

Occasionally this simple editing job is complicated by a quick talking announcer or master of ceremonies who leaves very little space between words. In this event the transition may be marred by the last syllable of the word spoken immediately before the introduction of the succeeding number. This, incidently, was our reason for suggesting a temporary splice. An unwanted sound of this nature can best be eliminated with an editing pencil which can erase as little as one-half inch of tape without affecting the sound adjacent to the erasure.

Open the temporary splice and lay the tape on a non-magnetic surface. Press the red button on the editing pencil and gradually bring it toward the very end of the tape. Do not allow the pencil to come closer than 1/4 inch from the mark as it will then erase part of the first word or note of the selection.

After the unwanted sound has been eliminated the two ends of the tape may be joined. As explained earlier in this chapter, the finished tape will sound more natural if there is a five-second pause between selections.

When a broadcast is recorded which plays to a studio audience, editing the end of a selection becomes slightly more complex due to the applause. In the section on recording "off the air" we suggested that the reader record the entire transition without touching the recorder when a studio audience is present. Applause usually begins immediately after the last note is sounded, in fact the author has often noticed that many people in an audience have their hands poised ready to applaud even before the last note sounds.

This rapid reaction on the part of some listeners in the studio audience often results in the sounds created by their applause being superimposed upon the sound of the last note. Making a clean separation between them is almost impossible by conventional editing methods. When the tape is cut close to the last note to eliminate the applause, the recordist may find that he has clipped the note itself. When the sound of the last note is allowed to die out in a natural manner the recordist will often find that it is marred by the

Fig. 9-14. A single tone of short duration, such as a hand clap, may be removed by holding the tape against the recording head for a moment, then gradually drawing it away.

applause. This problem is not quite as difficult as it may seem if we analyze the tape in terms of length rather than time.

Since the time it takes a sound to die out in a large broadcast studio or a concert hall may vary from one to four or five seconds we will assume two seconds as an average. This means that an average of fifteen inches of tape is occupied by the sound of the last note from the time it ends until it actually dies out. A fast audience reaction is one-half second, which simply means that the first 3¾ inches of tape after the last note starts is the only part not likely to be marred by applause. The end of this section should be marked with a china marking pencil. From this point on the tape is usually marred by one or two hand claps, since applause normally begins in a scattered fashion and then builds up in intensity. The elimination of this applause is fairly simple. Mark the location of each handclap with the pencil, then remove the tape from the recorder. Turn the recorder on and adjust the controls as you would for recording from a microphone. Remove the microphone plug from the recorder. Next the tape is held as shown in Fig. 9-14, with the mark indicating a handclap directly over the gap on the record head. After the tape has remained in this position for about a second gradually draw it away. When this section is played again the reader will find that this procedure has resulted in partial erasure, thus reducing the initial impact of the handclap and making the remainder almost unrecognizable. In the event the tape recorder used does not permit easy access to the record head the individual handclaps should be cut out with scissors, using a 90-degree splice to join the sections. However if this is not done carefully it may result in a skip which can be even more annoying than the applause.

As the reader will notice, we have attempted to make our examples of a general nature in order that the suggestions be applicable to the majority of the problems encountered in editing by the average recordist. The most important part of editing takes place at the time of recording. Always take some background of each recording as it is made, particularly when there is a change of scene. This extra background sound can be employed when editing and also will be extremely valuable when bridging two scenes.

Chapter 10

Sound Effects-How They Are Made

SOUND EFFECTS are an extremely valuable tool to anyone who records dramatic performances or who wishes to add sound to home movies. Sound effects can set the scene, create the mood, increase the illusion of reality and provide an illusion of depth which cannot be obtained in any other manner. For example, in an earlier chapter we mentioned a home movie of a barbecue party. Normally, this scene would not have been particularly interesting to anyone except the participants. However, after sound effects were added, the scene took on new life and interest. Everyone who saw it was fascinated. One particular shot was of the table, the fireplace, the host and his guests drinking and eating.

During a lull in the conversation at the table a closeup shot was made of the steak broiling, and later the writer added the sound of the steak sizzling over the fire. After about three seconds, the sizzling sound was faded down and the song of a bird was heard very softly in the distance. Although it was just perceptible, it was louder than the sizzling sound which had been reduced in volume. One of the guests remarked, "listen to that beautiful bird song." At this point all sound ceased for one or two seconds as everyone strained to listen. The momentary silence served to emphasize the next sound, the song of the same bird made louder as he started to sing again.

At the same moment we also heard, for the first time, the swishing sound of palm trees which was used as a background for the bird song. As the bird song ceased, it was replaced by the chirping of crickets in the distance, still with the swishing of palm trees as a background. A guest then commented on the beauty of the bird song. The host replied that there would be a full moon that night and that he would hear that mocking bird really sing. In our case, to establish the locale more clearly, the host was asked to say, "There will be a full moon over Miami tonight."

These few short, simple sound effects elevated this very commonplace scene of people eating and made it more interesting to the average viewer. In addition, they set the scene and described its location. The song of the mocking bird is heard primarily in the southeastern United States. The palm trees narrowed the area to Florida. The remark, "moon over Miami," localized it still further in a natural manner and completed the description.

The reader, if he stops to analyze the sound effects used in this scene, will notice that we made use of a device which is employed quite frequently in radio and motion pictures, namely, never to use one sound effect by itself, but always two or more. For example, the opening bird song was superimposed on the sound of fat sizzling. As the bird song came into the foreground, we used the swishing of the palm trees as its background. As the bird song ceased, we replaced it with the sound of crickets.

The use of two or more sounds provides a sense of aural perspective. Very rarely in nature do we hear one sound to the complete exclusion of all others. For example, the sound of a siren created by a fire-engine or an ambulance is usually accompanied by a background of city noise, the sounds of busses, automobiles, etc.

The song of a bird in the country is not heard by itself; you also hear the sound of rustling leaves in the background. The cry of gulls at the sea shore is always accompanied by the sound of water. It may be the lapping of the wavelets upon the sand, or the pounding of the surf which almost obscures the cry of the birds.

Most sound effects are quite simple to create. With a little time and some practice anyone can build a valuable library of sounds. Many of these sound effects can be created very simply at home with a minimum of equipment. The more unusual ones may be purchased on sound effect records or obtained from radio or television broadcasts, by connecting your radio or television receiver to your tape recorder as you watch or listen to dramatic performances. These broadcasts usually have one or more sound effects per program.

The sound effects most often used are those which imitate water in its various forms. It may be the sea with its varying moods, a rippling stream, a waterfall, a lake with water lapping its shore or the inevitable rain. Therefore we will begin this section on the creation of effects which duplicate the sounds of water as they are used most frequently in recording.

The sound most suggestive of the sea is, of course, the sound of waves. A basic wave sound is made with the aid of a balloon and about 50 BB shot. Put the shot inside the balloon, then blow it up to about 14 to 16 inches. After it has been inflated, tie the opening so that no air escapes. The microphone is placed about three feet from the floor and a rug or blanket placed on the floor directly in front of it.

Hold the shot-filled balloon about four inches in front of the microphone with both hands. A quick dropping motion of the wrists will cause the shot to bounce vigorously in the balloon and, in this manner, create the initial sound of a wave breaking. As soon as the dropping motion is completed give the balloon a quick twist; this will cause most of the bouncing shot to swirl around the bottom and sides of the balloon and provide the sound of the surf which occurs immediately after the breaking of a wave.

The apparent size of each wave is controlled by the loudness of the initial crash. This is varied by changing the distance between the balloon and the microphone. When the wave is made to seem larger or smaller by this method the duration of the surf sound should be altered correspondingly, as a larger wave also creates a greater amount of surf. The duration of the surf sound is controlled by placing the balloon on the blanket or rug, which stops the sound immediately. A rough sea is made by increasing both the tempo and loudness of the waves.

The listener's position in relation to the shore line, near or far, can be adjusted by means of the record level control. Reducing the recording level increases the apparent distance, increasing the level decreases the distance. An important thing to remember when creating the sound of waves and surf is the fact that all waves are not the same, consequently there should be some variation in both level and timing between them.

The sound of a very calm sea, a lagoon, or a bay is obtained by eliminating the crash of the wave as it breaks and using only the surf sound greatly reduced in both volume and duration. Use only 2/3 of the BB shot employed previously, as the wavelets are usually quite small and their wash only rolls 10 to 20 inches at the most.

Very often we are called upon to duplicate the sound of water lapping against the side of a pier, dock, or a small boat. Here we have the same wavelets previously described, but we do not encounter the rushing sound of their wash; an entirely different sound takes its place. It is a combination of a gurgle and a soft slap.

The sound of water lapping is created by filling a bathtub with water and placing a microphone about six inches above the surface. The right hand is held in a grasping position about one inch above the surface. Swish the hand slowly through the water, at the same time closing the fingers one at a time. This action is repeated about once every two or three seconds for very calm water and more frequently for rougher water. Vary the distance between the hand and the microphone with each wavelet since, like waves, their intensity varies.

We have thus far provided two basic sound effects which, with their possible variations, may be utilized to duplicate the sound created by bodies of water ranging in size from the ocean, in all of its moods, to a small bay or inlet.

The sound created by water in a brook or stream is completely different in its character. To create the sound of a rippling stream, first fill the bathtub 1/4 full of water and then fill a pail to the brim. The pail is then placed under the faucet and tilted slightly so that the water it contains drops into the tub in a stream about two inches wide.

Next place the microphone, covered with two layers of handkerchief, about two inches from the point at which the water falls from the pail into the tub. Start the faucet and allow the water to run into the pail and from the pail into the tub. Record the sound of the water splashing from the pail into the tub and you have the sound of a rippling stream. If the flow of the water from the pail to the tub is too great, you will find your stream has become a raging torrent.

If the stream whose sound you are attempting to duplicate is rocky and the season is the spring, with its fast flowing water, use only one layer of handkerchief and increase the splashing sound by slightly increasing the flow of water from the faucet.

The sound of a waterfall is created by employing the same method used for the stream sound effect. However, the handkerchief should not be used and the flow of water from the faucet is increased.

There are also other sounds we commonly associate with water, such as a person diving, a rowboat, a canoe, an outboard motor boat; all can be used in combination with water sounds to increase the illusion of reality.

Dual sound effects can be very easily created with the aid of a strip of 35-mm motion picture film about 1½ frames long.

The tape is loaded on the recorder in the conventional manner and the recording of the sound effect to be used as the background sound is made in the normal way. When using this method to record two sounds on the same section of tape, the first sound must be recorded at the maximum level which can be obtained without distortion, since its level is reduced considerably during the second recording. Should the first recording be made at less than maximum level it may be erased completely, or reduced to such an extent that it becomes masked by the second sound. This trick of dual recording with one microphone can only be employed when one sound is to be used as a background for another.

After the first recording is completed the tape is completely rewound and started again. This time, however, the strip of film is inserted between the erase head and the tape. The recording of the foreground sound is also made in the conventional manner. When the completed tape is played back you will hear the sound recorded first with a 50 per cent reduction in volume level and the sound recorded last at normal volume, but superimposed upon the original sound.

The sound most often used in conjunction with water sounds is that of a person diving or falling into the water. For this effect a bathtub is again employed – this time with a mason jar. Sink the jar in the water and allow it to fill. After it is completely full, invert it so that the bottom is uppermost. The microphone is placed about a foot above and slightly to one side of the position the jar will occupy as it is withdrawn from the water. Pull the jar from the water sharply; this action will provide the sound of a body entering the water in a dive. To obtain the effect of a body falling into the water a larger container should be used, employing the same technique, as a falling body creates a larger splash. The author uses a water pail for this effect.

The sound of a person swimming is also quite simple to imitate. A tub is used again. For this effect timing is extremely important; try to visualize the stroke you are attempting to imitate. The two hands are cupped slightly and thrust into the water with a slight slapping motion by the palms. The arms are then drawn through the water. The combination of the slight slap, the gurgle and the swishing made by the arms as they travel through the water makes this effect quite realistic.

The effect of rowing a boat can easily be created by rythmically turning a squeaky swivel chair. A squeaky door may be used if a squeaky chair is not available. Both duplicate the sound of oars moving back and forth in oarlocks. When this sound effect is added to that of lapping water it duplicates to virutal perfection the sound of a rowboat passing through the water.

The sound of a canoe paddle is obtained by moving a six-inch board through the water in a tub.

You may obtain the sounds of other types of boats by acquiring the various records listed in Chapter 11. We list ferry boats, fishing boats, motor cruisers, yachts, outboard motors, freighters, steamers, and even a Mississippi paddlewheeler.

You will also find listed other sounds of the sea, the river, the lake and the marsh. There are the sounds of channel buoys, ships clocks and bells, foghorns, and the like. These sounds when added to the water sounds previously described make them doubly effective. For example, imagine the sound of surf as a background with the cries of sea gulls superimposed. The effectiveness of this combination can be heard by listening to the famous recording of *Ebb Tide* by Frank Chacksfield and his orchestra.

Sounds in the next group are extremely important and are the most frequently used to establish mood on radio and TV shows. These are the weather sounds, including rain, wind, thunder, and the like.

The sound of rain can be duplicated at home with the aid of a

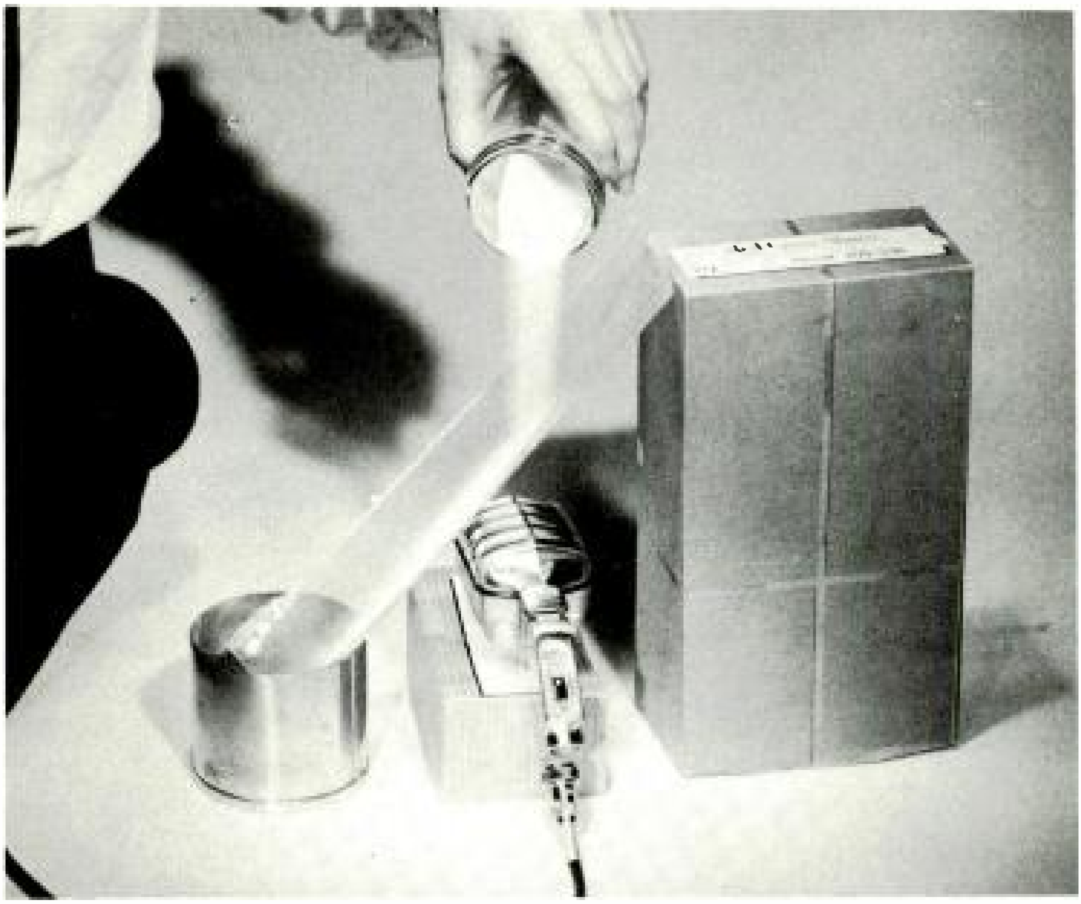


Fig. 10-1. The sound of rain is created by pouring sugar into a trough of waxed paper.

bowl of sugar, some waxed paper, a small box, and a soup plate. Tear a strip of waxed paper four inches wide from its roll, allowing it to retain its natural curl and form a trough as shown in Fig. 10-1. Fasten it to the box at one end as illustrated. The other end is placed in the soup plate. A microphone is placed halfway down the incline and the sugar poured down the trough of waxed paper. The most critical part of this effect lies in pouring the sugar down the incline evenly, to obtain a steady rain. In the event the sound of wind-driven rain is required, varying the amount of sugar as it is poured will provide this particular effect. A finishing touch which may be added to to the rain effect is the sound of water dripping – from the eaves of a house, the branch of a tree, or an overhanging rock. The drip is easily obtained from a faucet by setting up the rain equipment in a tub or kitchen sink and recording both sounds simultaneously.

In the event the scene to be portrayed is an area in which there are trees, extremely realistic effects can be obtained by using the sound of a breeze before rain. To create the sound of leaves rustling in the breeze some patience, or a small son or daughter, is required, in addition to a package of Rice Krispies and a needle and thread. A two- or three-foot length of thread is strung with the Rice Krispies. After about six inches are strung, the need for the small son or daughter becomes obvious. The string of Rice Krispies is held in one hand and slowly pulled through the palm of the other hand about three inches from the microphone. This effect may also be employed as a background sound for outdoor conversation, as in a garden.

Rain is often accompanied by thunder, which is quite simple to simulate. The balloon and BB shot used in the wave effect are employed again. The inflated balloon, with the shot inside, is held in both hands and jerked downward with a sharp motion, so that the shot within strikes the top creating the initial crash of thunder, and then continues bouncing. This time, unlike with the creation of the wave, we do not stop the shot from bouncing but allow it to continue until it dies out. The continued bouncing provides the slowly dimishing reverberations of thunder. When this effect is properly made, it sounds more like thunder than real thunder does when it is recorded from nature, as the initial crash of actual thunder usually causes overloading with its consequent distortion.

To record the sound of a person walking in the rain, use wet newspaper in a bathtub or kitchen sink. The sound of the rain is recorded, as previously explained, and the sound of the person walking is superimposed. This sound is made by pressing both hands alternately on the wet newspaper. The most difficult part of this effect is to obtain the proper timing of the footsteps. While on the subject of walking, we might well mention that the sound of a person walking in snow is created by filling a handkerchief with cornstarch and kneading it with both hands, in the rhythm of footsteps. The volume level created in this manner is very low and the cornstarch-filled handkerchief should be held very close to the microphone.

The sound of a person walking in the woods is obtained by simulating the crunching of underbrush, dried leaves and twigs with paper toweling, cellophane, and wooden match sticks. The paper toweling, when softly crumpled about six inches from the microphone, provides the sound of partially dried leaves and grass as they are stepped upon. Crumpling the cellophane about ten inches from the microphone provides the snapping and popping of dried leaves. The sound of snapping twigs is made by snapping match sticks about six inches from the microphone. Split bamboo sticks, such as are used for model airplanes, are even more effective.

The sound of a campfire or a barbecue fire is obtained by crumpling Rice Krispies about three inches from the microphone and, at the same time, snapping match sticks or split bamboo. Should you wish to add the sound of frying over the fire, have an assistant pour salt or sugar over a piece of household aluminum foil. This last sound may also be used as a broiling sound.

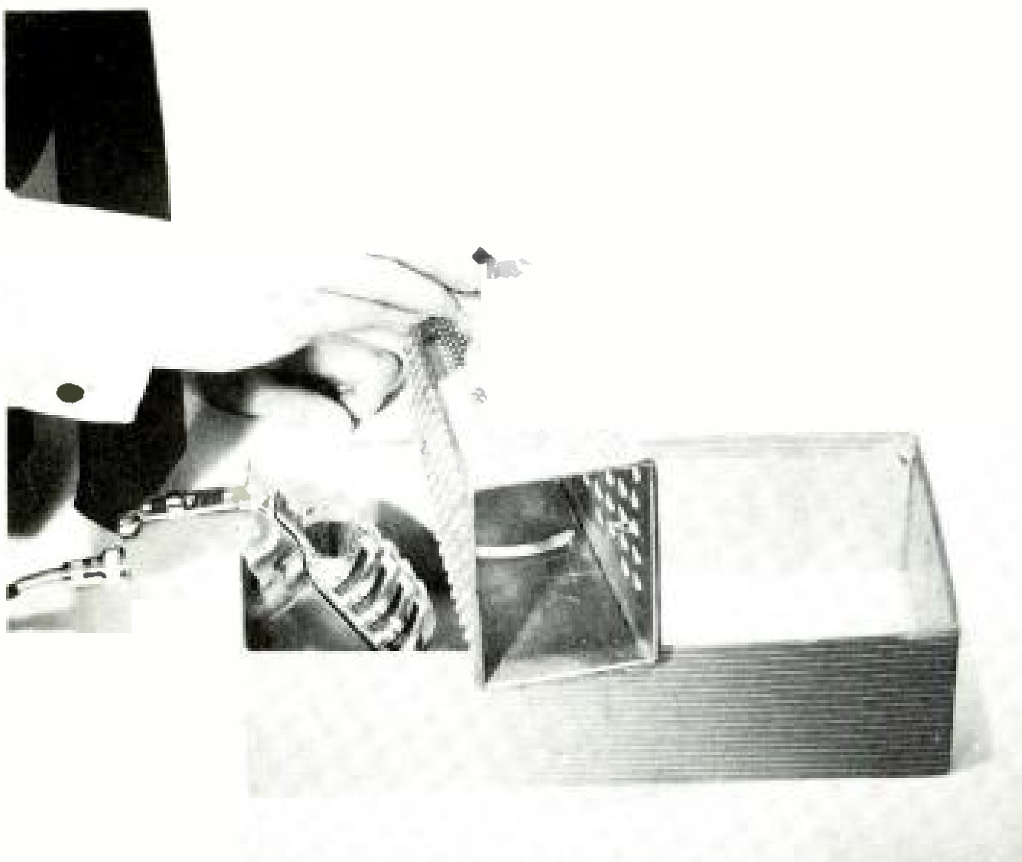


Fig. 10-2. Duplicating the sound of a steam train by brushing a grater which is fastened to a shoe box.

The next commonly used sounds are the so-called travel sounds. The sound of a stream train is easily made by fastening a vegetable grater to a shoe box with some scotch tape as illustrated in Fig. 10-2.

A wire or plastic brush is rubbed against the rough side of the grater. This should be done rhythmically. The rhythm of a steam engine is on the first of each four strokes. ONE, two, three, four, ONE, two, three, four, etc. When you wish to represent a train passing, begin brushing the grater, have an assistant set the record level control to zero and gradually increase the level, as you continue brushing. The sound of a train moving away is obtained by gradually reducing the level.

This effect may be made even more realistic by the addition of the sound of a train whistle. A whistle duplicating this sound may be purchased from a music supply house. To make the sound of the whistle authentic, use regular railroad signals.

Boat whistles are simple to imitate, particularly large boats which have a deep tone. Obtain a gallon jug and blow over its mouth. This will give a very deep tone. To increase the pitch just add water in the bottle – the more water you add, the higher will be the pitch.

Chapter 11

Recording Special Sound Effects

YOUR RADIO and television receiver may be used to build up a library of sound effects. Programs such as *Zoo Parade* can supply many animal sounds. Other programs such as *Adventure* and *Omnibus* will provide many unusual sound effects. Travelogues provide many of the so called travel sounds. They invaribly begin with the sounds created by a departing ship, train or airplane. Depending upon the subject matter you can acquire sounds which range from the song of a Venetian gondolier to the sounds made by camel bells. All you need do is keep your recorder connected to the receiver whenever you listen to one of these programs.

Many of the sounds you record in this manner may contain snatches of dialogue. This can be eliminated by editing. In the event the duration of the sound effects acquired in this manner is too short, the length may easily be increased. It is necessary to either borrow a recorder from a friend or employ a tape playback machine. This recorder or playback machine must operate at the same speed as the recorder on which the original sound was obtained.

The short sound effect you have recorded is cut from the original tape and an endless loop made by splicing the two ends together. This loop must be sufficiently long to be installed on the second ma-

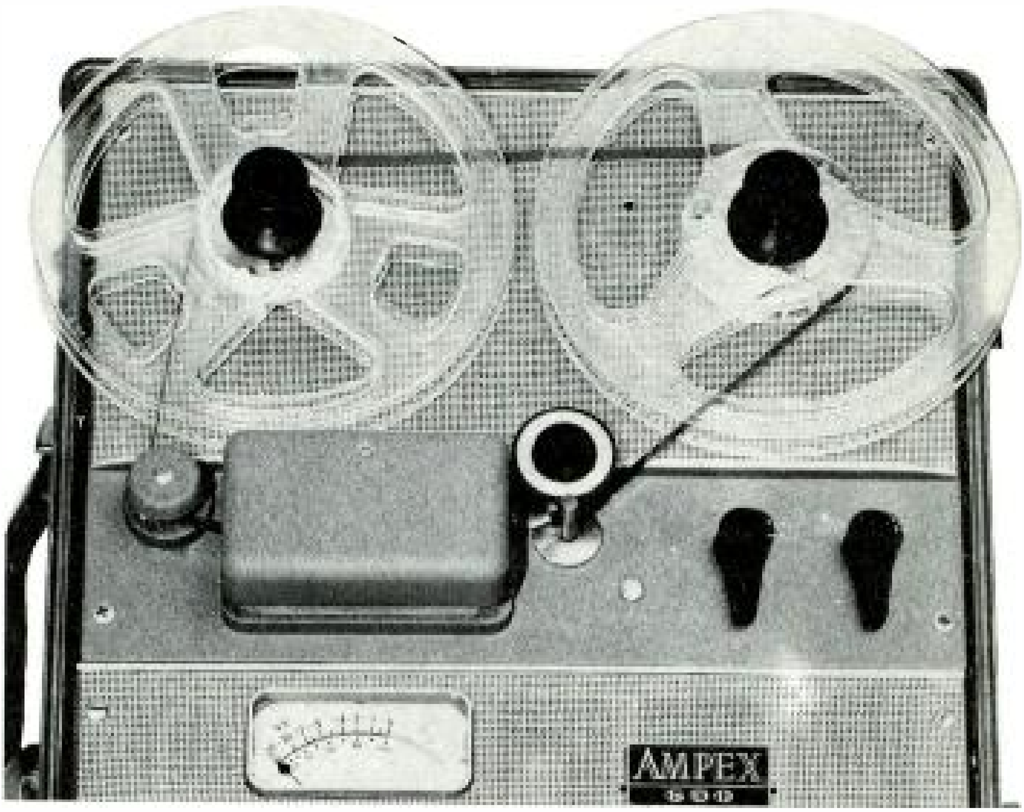


Fig. 11-1. An endless tape loop is employed to provide a continuous recording of background sounds.

chine as illustrated in Fig. 11-1. We cannot provide the exact length of this loop since it will vary with the dimensions of the particular recorder on which it is used. The length required for the recorder employed by the author was 26½ inches. The output of this machine is then connected to the radio/phono input of your recorder which has been previously loaded with a reel of blank tape. Both machines are then started simultaneously. The playback level on the first machine and the recording level on the second machine are adjusted to obtain the correct recording level as explained in Chapter 5. The sound effect originally recorded, which was of insufficient duration, is then re-recorded on the new tape as many times as is necessary to obtain the required duration.

Let us assume the sound effect you recorded originally was that of a bullfrog which you wish to employ as background sound for a three-minute scene. The sound as originally recorded lasted only three seconds. Three seconds at 7½ ips provides 22½ inches of tape, enough to make the loop we require. This loop is re-recorded 60 times. The same sound is repeatedly re-recorded, without interruption for 180 seconds, which is the duration of the background we require.

In the event the originally recorded sound effect is not of sufficient duration to provide an endless loop of the length required for your particular recorder, one more operation is necessary. Add enough timing tape to the too short recorded sound effect to make a loop of the correct length. This loop is then recorded as previously explained. Enough of this interrupted sound effect is recorded to supply you with sufficient material so that it can be cut and spliced into a continuous loop of the correct length. After this second loop has been made it must again be re-recorded to obtain the uninterrupted length required.

After you have obtained a background sound of the correct duration, dialogue may be added as explained in Chapter 10. In Chapter 9 we suggested recording five minutes of background sound to be employed for adding commentary. If for some reason it is impossible to record this much background sound or if it is spoiled by a passing airplane, car or train, and only five or ten seconds is usable, this short length may be increased by the methods described above.

Another source of sound effects is the many records made for use by broadcast stations and motion picture studios, which are also available to the recordist. These records are distributed by Thomas J. Valentino, 150 W. 46 St., New York City, N. Y. who handles the Major line, and by Charles Michelson who distributes the E.M.I. line of records. The following is a listing of the records which will be used most often by the average recordist.

Transportation

Trains

Major 5049 A	Locomotive, coming into station . . . Conductor, All Aboard . . . Locomotive, pulling out of station . . . Freight train . . . Locomotive chugging.
Major 5049 B	Streamliner . . . approaching and passing. Steam train approaches and passes . . . Train whistle.

Major 5020 B	Train whistle . . Whistle and bell ringing . . . Train coming into a station and stopping . . . Train leaving station with click of wheels . . . Whistle with train leaving station and chugging away.
Major 5008 A	Fast passenger train . . . Whistle, train and click of wheels, continuous.

Airplanes

E.M.I. CM 1045 B	Four-engine airliner passing overhead.
E.M.I. CM 1022 A	Engine noise, interior.
E.M.I. CM 1005 B	Helicopter.
Major 5021 A	Start motor, take-off, plane in flight, interior plane landing and coming to a stop.

Boats

Major 5025 A	Ship bells, to set time. One to eight bells.
Major 4004 A	Boat whistles, boats arriving and leaving, docks and piers, shrill sounds of small harbor craft.
Major 5043 A	Harbor background, bell buoy in foreground, whistles in background. Harbor sounds.

Automotive

Major 5041 B	Car starting, running, pulling to stop, all interior perspective.
Major 5042 B	Traffic jam, auto horns, crowd murmurs, two auto horns blowing excitedly.
Major 5005 A	Traffic noises.
Major 5023 A	Greyhound bus leaving terminal with sound of airbrake release. Bus starts and continuous running.
Major 5035 A	Motorcycle, starts, stops, shifts gears, pulls away.

Amusements

Major 5013 B	Calliope for parades and circus background.
Major 5055 A	Carousel with childrens' voices, for amusement parks, etc.
Major 5055 B	Shooting gallery.
Major 5009 A	Parades, contains drums, band marching.

Country Sounds

Major 4021 A	Chickens and roosters, barnyard.
Major 4005 A	Cows and calves.
E.M.I. 1028 A	Milking time.
Major 5009 B	Baa-ing of sheep.
Major 5008 B	Horse and wagon.
E.M.I. CM 1030 A	Pigs.
E.M.I. CM 1031 A	Turkeys.
E.M.I. CM 1029 A	Ducks and drakes.
E.M.I. CMX 2030 A	Tractors.
E.M.I. CMX 2017 A	Blacksmith operations, shoeing, anvil, etc.
Major 7833 B	Farm wagon on soft dirt, start, constant and stop. Start and recede.
Major 5178 A	Mule braying.
Major 4022 A	Chirping of crickets and the croaking of frogs in the dead of night.

The records we have listed thus far can be employed to create many original sound effects. As we explained earlier, very rarely do we, in nature. hear one sound to the complete exclusion of others. For this reason, these records are most effective when used in combination. The sounds they create may be combined by any of the various methods we have described.

For example, the effectiveness of the interior sounds of the fast passenger train can be increased by inserting the sounds of Major record 5049 B, which could be employed to create the impression of a passing train. The carousel sounds can be combined with those of the shooting gallery, to provide a perfect aural impression of a carnival midway. The night sounds created by the crickets and frogs can be interrupted by the sound of a rooster crowing to suggest daybreak. The combinations available are only limited by the imagination of the user. The sounds you take from these records may also be combined with the sounds you are able to create at home, to provide an even greater variety.

The sounds made by birds, insects and frogs can provide very beautiful and interesting backgrounds. The finest bird records available to-day are those which have been made by two professors of ornithology with Cornell University. Their records can be obtained from Cornell University Press, 124 Roberts Place, Ithaca, N. Y. Fine bird records are also available from Book Records, Inc., 680 Fifth Ave., New York City, N. Y. The record album available from Book Records, Inc., contains the songs of the Bluebird, Brown Thrasher, Carolina Wren, Robin, Mockingbird, Balitmore Oriole, Cardinal, Goldfinch, Red-winged Blackbird, Catbird, Yellow Warbler and many others.

The records of Cornell University Press are more specialized. For example, *Florida Bird Songs* contains Mockingbird, Cardinal, Florida Wren, Blue Jay, Boat-Tailed Grackle, Ivory-billed Woodpecker, Florida Sandhill Crane, Limpkin, Barred Owl and Chuck-wills-widow. *Western Bird Songs* contains House Finch, Western Meadowlark, Bewick Wren, Black-headed Grosbeak, Spotted Towhee, Wren Tit, Western Kingbird and others.

American Bird Songs contains birds of the lakes and marshes including Common Loon, Whistling Swan, Lesser Canada Goose, Western Grebe, Pied-billed Grebe, Sandhill Crane, Limpkin, Swamp Sparrow and Virginia Rail.

How many times while showing home movies or slides have you attempted to explain and describe the beautiful song of a mockingbird, or while showing a picture of a vacation scene such as Currituck Sound in North Carolina with its thousands of migratory birds, have you attempted to describe the sound of the Whistling Swan or The Canada Goose? The records we have listed contain these sounds ready to be put on your magnetic tape.

With a battery-operated portable tape recorder such as is illustrated in Fig. 11-2 you can record many of the birds and animals yourself. Recording birds and animals, however, is more difficult than hunting them with a gun. A bullet will accomplish its purpose at a much greater distance than a microphone and a tape recorder. In short, you must be a better hunter to record these sounds than you

Fig. 11-2. A battery-operated portable tape recorder. (Photo Courtesy of Bell Sound Systems, Inc.)

need be to merely destroy the same bird or animal. Yet if you take the trouble to learn the habits of the subject you wish to record and a few simple facts about outdoor recording you can obtain excellent results.

Successful recording of wild birds, or any animal for that matter, is largely dependent on two factors; first, a knowledge of their habits so that you are able to locate them, and second, the ability to use your recording equipment in such a manner that you can obtain good recordings even under the most adverse conditions. Birds and animals in the wild state will very rarely stand at the correct distance from the microphone, nor can you control to any great extent the duration and intensity of any distracting background noise. The obliging ouzel illustrated in Fig. 11-3 is the exception which proves the rule. Birds and animals are not usually this cooperative.

You can acquire some knowledge of the habits and the behavior of birds by the trial-and-error method, but your initial recordings will be much more successful if you devote some time to a preliminary study of the subject. An excellent source of information on bird habits, which includes superb color photographs, has been written by

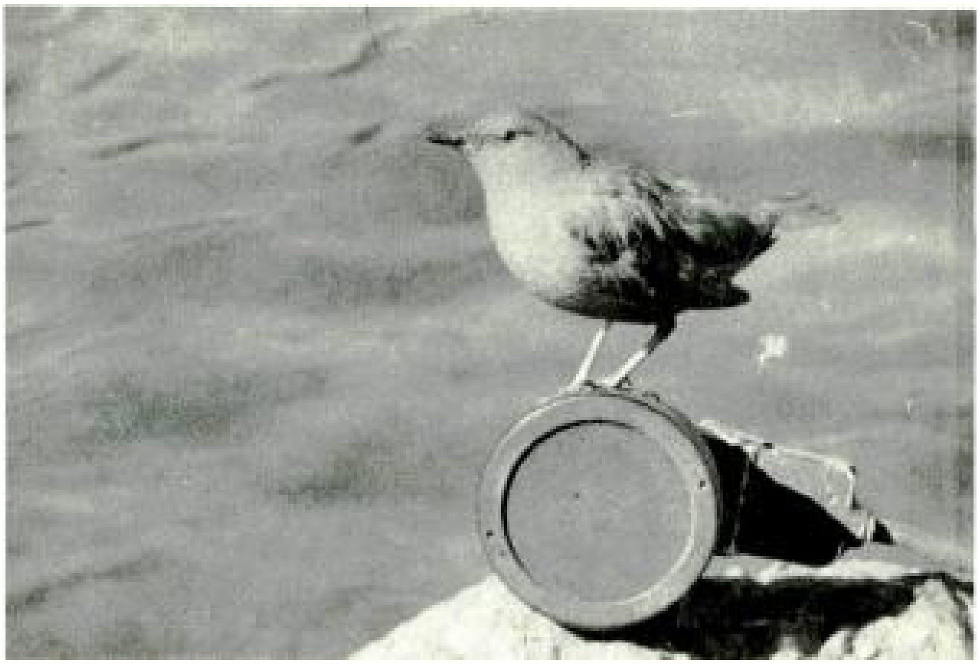


Fig. 11-3. An obliging ouzel "sits" for his singing portrait. (Photo by Arthur A. Allen.)

Arthur A. Allen, the same man who was responsible for the excellent bird records mentioned earlier. This book is entitled *Stalking Birds With Color Camera.* With this book and the records anyone can learn to identify birds by their appearance and their songs very quickly. If you are seriously interested in this particular aspect of tape recording, a telephone call to your local Audubon Society will be well repaid by the information they can provide about local birds.

Once the bird you wish to record is located, recording its song becomes a technical problem whose solution is dependent upon the time of the year and the place where the bird is found. The fundamental problem in all cases is to find the spot where the bird is likely to return, usually a nest. Other places include feeding stations, bird baths and natural locations such as a Florida orange tree in February when the fruit is ripe. Once such a location has been found the microphone placement is comparatively simple.

Placing the microphone in a position where it will pick up the maximum amount of wanted sound (the bird song) and the minimum amount of unwanted sound (airplanes overhead, traffic noise, etc.) with your recorder. When the crystal microphone generally furnished with most home-type recorders is employed the limiting factor in adding microphone cable is the loss of sensitivity. It is not advisable to add more than 15 to 20 feet and this should be of the low-capacitance type.

When a high-impedance dynamic or velocity microphone is used, any cable added to the length originally furnished with the microphone results in a reduction in the important high-frequency response. As may be seen from Fig. 11-4, increasing the total cable length to 60 feet will reduce the high frequency response (above 4000 cps) at least 5 db. At 10,000 cps the loss rises to about 7½ db. These higher frequencies are particularly important when recording bird songs. When using a dynamic microphone for nature recording it should be of the low-impedance type with a matching transformer at the recorder, since the high-frequency loss due to additonal cable when employing this arrangement is negligible.

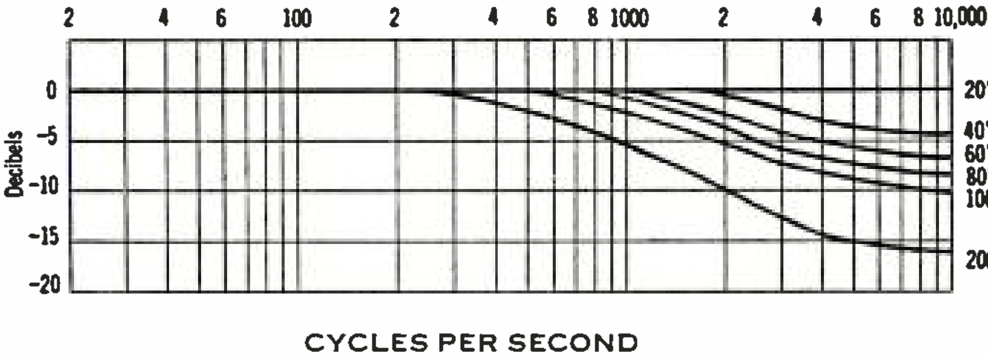


Fig. 11-4. Attenuation effect of extra cable length when installed on 35,000-ohm high-impedance microphone. Based on cable capacitance of .0007 mfd. per 20 feet. (Graph Courtesy of Electro-Voice, Inc.)

The next problem we encounter lies in the fact that the microphone can rarely be placed closer than five to ten feet from the nest, etc. When the microphone furnished with the recorder is used at this distance outdoors a considerable amount of background sound may be picked up. This is one of the many applications where the Electro-Voice Type 664 is the ideal microphone. Due to its directional characteristics it may be placed up to 2½ times further from the source of sound than an omnidirectional microphone such as is furnished with the recorder, and still not pick up any more unwanted background sound.

When recording wild animals or birds where the distance between the subject and the microphone is more than 25 to 35 feet, a

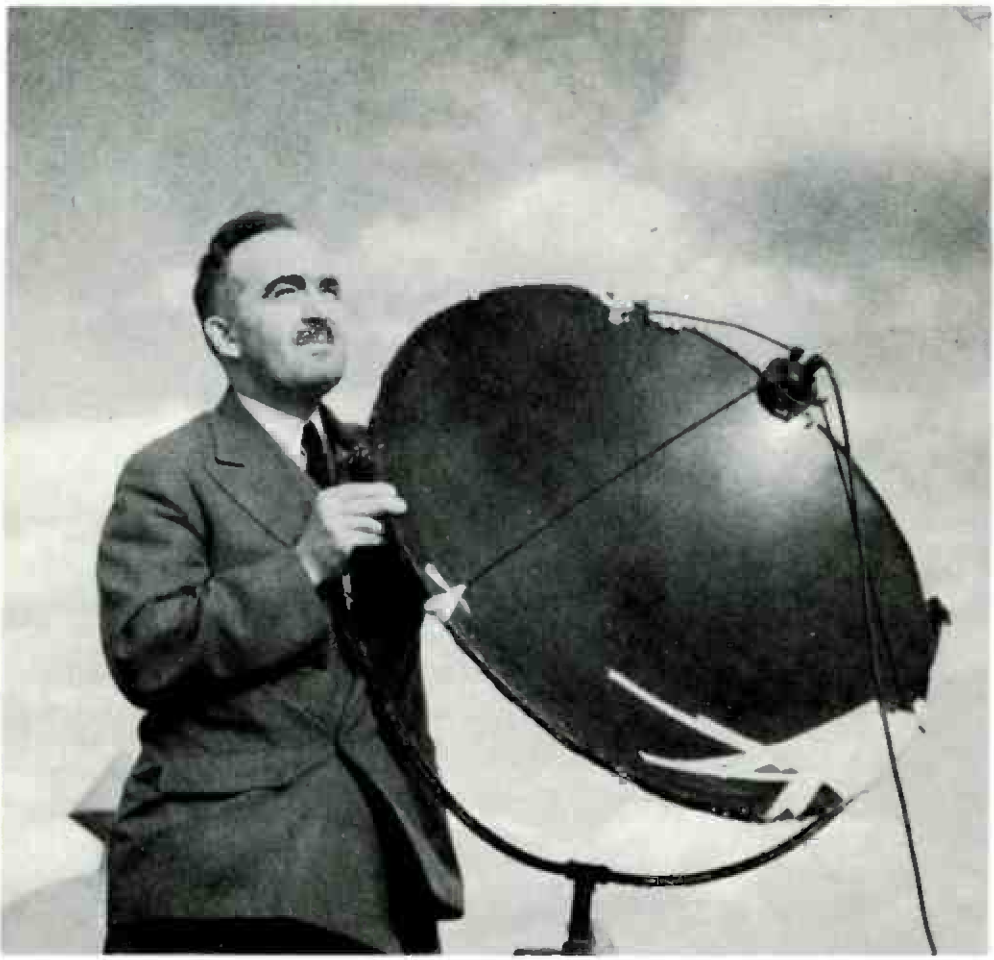


Fig. 11-5. Professor Arthur A. Allen of Cornell University with the "Electric Ear" (parabolic reflector and microphone) for recording the songs of birds. (Photo by Southgate Hoyt.)

parabolic reflector of the type illustrated in Fig. 11-5 should be employed. A reflector of this type may be placed at a relatively great distance from the subject and yet maintain good sensitivity, because of its directional qualities and effective gain. Since the pickup pattern of a microphone, when used with a parabolic reflector, is relatively sharp, the microphone may be placed so that most of the background noise is eliminated. Parabolic reflectors of this type are available from the Atlas Sound Company of New York City.

Folkways Records and Service Corp., 117 W. 46th St., New York City, N. Y., has available recordings of the native music and songs of many lands. This music was all recorded by native singers and musicians, in many cases using authentic primitive instruments. The entire Caribbean area is represented in the Folkways catalog.

The following records are a few of the wide variety available:

P 410 Cult Music of Cuba. This record contains eleven recordings of Afro-Cuban cult music including Lucimi, Abakwa, Djuka, Arra and others. This record is an excellent source of nature music for background sounds of this area.

P 440 Religious Songs and Drums in the Bahamas. The drums on this record include the playing of Fire Dance, Ring Play, Jook Dance, etc.

P 461 Jamaican Cult Music. Includes the songs and services of all the major cults of Kingston with percussion accompaniment. Drums which play a large part in the cult music are featured. Recordings include examples of "trumping" (forced breathing) to heighten ecstatic feeling.

For those who travel further afield Folkways has even captured in sound the ritual of the Cenibo Indians of Peru. As can be seen, there is a wealth of material available for those who require musical or local background sounds for film accompaniment.

found satisfactory. All tapes which were made during the period the recorder was operating at reduced speed will now reproduce at a higher pitch since they will move past the playback head at a speed greater than the speed at which they were recorded.

The most practical method of checking tape speed is to combine several small rolls of blank tape and wind them onto one reel. Should this test reel be intended for use with a recorder which operates at 7½ ips it must contain at least 450 feet of tape. The start is marked with a grease pencil and another mark is placed at 225 feet which indicates a five-minute interval. A third mark is placed at 450 feet. This is the final check point and indicates a ten-minute interval. When the test reel is to be used for checking the speed of recorders which operate at 15 ips the length of the tape and the distances between marks should be exactly double the abovementioned figures. Should a test tape be required for checking 3¾ ips recorders the length of the tape and the distance between marks should be reduced by exactly half. This tape is then placed on the recorder under test. With a stop watch or the second hand of a clock, time the interval between the first and last marks. It should be exactly ten minutes. An excellent permanent professional installation should have an accuracy of 0.75 seconds or better in ten minutes. A very good semi-professional portable recorder is usually accurate to within two seconds in ten minutes. The average home recorder's accuracy may vary between fifteen and twenty seconds in ten minutes.

We have thus far mentioned only one of the results of tape slippage, namely, reduced speed. Tape slippage may also result in annoying cyclic variations (wow and flutter) in the pitch of the reproduced sound. These changes in pitch are particularly noticeable in the reproduction of the higher pitched sounds such as are made by a violin, clarinet, etc. Since the human ear is extremely sensitive to any change in pitch at these frequencies, especially during a sustained note, this type of music should be used for testing. A far which consists of a high-frequency signal recorded at zero level. It superior method is the use of the Sonafax wow-and-flutter test tape runs for about four minutes, allowing sufficient time to locate the source of any speed variation.

Wow and flutter are always due to some specific element in a recorder's mechanical system. The frequency variations usually have a constant rhythm which may often be counted. By checking the number of revolutions per minute made by the various elements in the recorder's mechanical system such as the capstan, pressure roller, pulleys, etc., the source of wow or flutter can usually be discovered quite easily. For example, the variations caused by a capstan with an oily spot would occur at the same rate at which the capstan itself revolves since the slippage occurs only once each revolution. The most common sources of wow and flutter are: uneven pressure on the tape pressure pads, worn capstan or motor bearings, a "flat" on the pressure roller or idler wheel, warped reels, sticky tape due to poor splicing, and rubber drive wheels or belts which have become glazed.

Quite a common tape recorder complaint is that the quality of the tapes originally made on an instrument sound muddy, distorted and lack brilliance. Usually the owner blames the tape manufacturer and changes his brand. Manufacturers of pre-recorded tapes are often accused of releasing poor tapes since the same recorder will also reproduce these poorly. The fault lies not with the manufacturer in either case but with the particular recorder used or, more specifically, its owner. Lack of brilliance is invariably due to reduced high-frequency response and most often occurs because of airborne dust and the microscopic particles worn from the tape itself which have accumulated on the record/playback head and in the gap as shown in Fig. 12-1. These particles may prevent the close contact between the tape and the head which is required for optimum results.

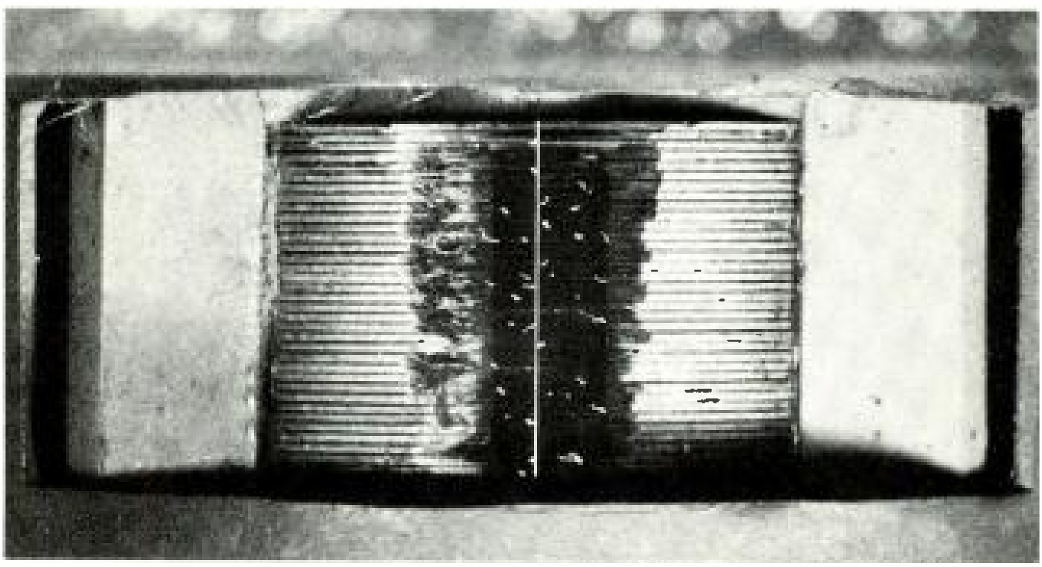


Fig. 12-1. Close-up of record-playback head showing dust particles which may prevent close contact with head which is necessary for optimum results.

In tape recording and reproduction with modern heads it is imperative that the tape maintain an extremely close (less than .0001 inch) and constant contact with the head. Poor contact between the record or the playback head and the tape manifests itself in distortion and reduced high-frequency response. This is because the strength of the magnetic field from the poles on the head decreases with distance and is not impressed on the tape with the correct intensity.

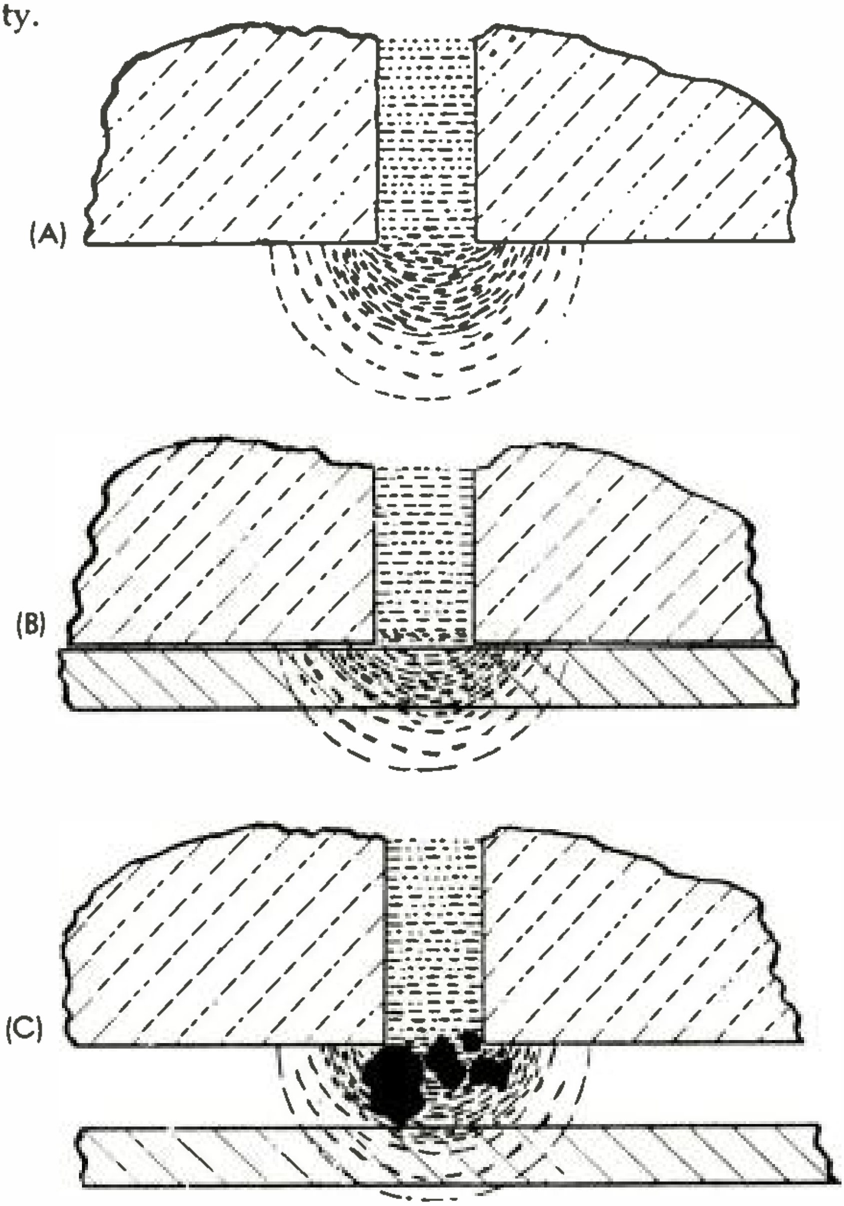


Fig. 12-2. (A) illustrates the magnetic field created by a recording head. (B) shows the same field as a tape passes through it. (C) illustrates the separation between tape and head caused by foreign particles. (Drawing Courtesy Reeves Soundcraft Corporation.)

Figure 12-2 (A) illustrates the magnetic field created by a recording head. From this illustration we can see just how the intensity of this field falls off as the distance from the head is increased. Figure 12-2 (B) shows the same magnetic field as the tape passes through it while recording. We can see from this illustration that the tape is in extremely close contact with the head and thus passes through an area of greater intensity than the tape illustrated in Fig. 12-2 (C) which has been separated from the recording head by dust and oxide particles. This separation obviously results in a reduction of the amount of magnetism impressed upon the tape. This effect appears principally at the higher frequencies, and is even more pronounced in reverse when applied to the transfer of magnetic energy from the tape to the playback head as in reproduction.

Robert von BeHren of Minnesota Mining and Manufacturing Company has made a series of tests to determine the effects which occur when tape is separated from the playback head in reproduction. During these tests a tape was recorded using various frequencies and played back on a high-quality system with good tape contact. It was then reproduced a number of times, each time using a paper shim of a different thickness between the head and the tape in such a manner as to separate them by known amounts. The chart in Fig. 12-3 shows the result of these tests. From this chart we can see that

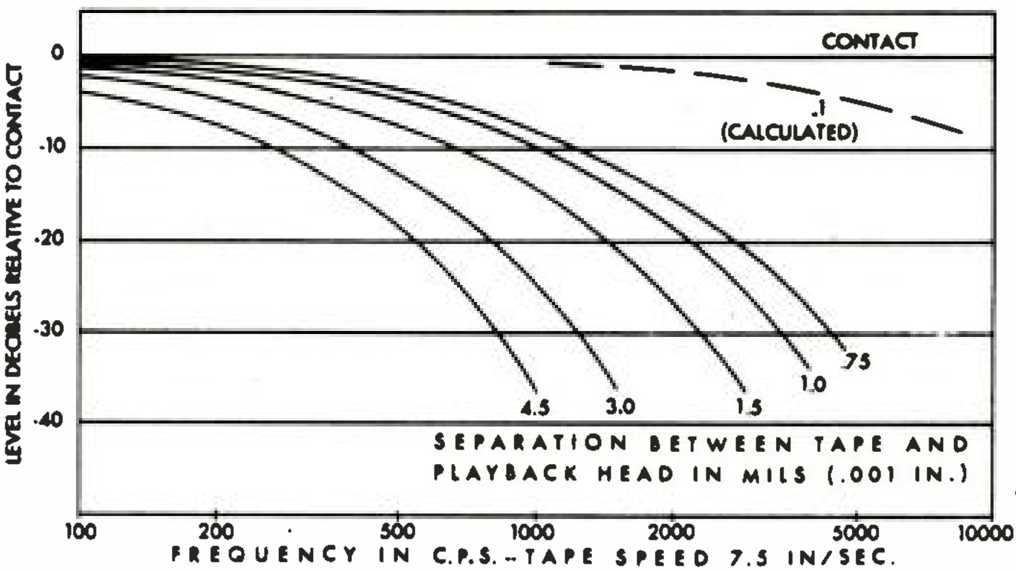


Fig. 12-3. The results of poor contact between tape and playback head. (Chart Courtesy of Minnesota Mining and Manufacturing Company.)

a separation of only 3/4 of a mil at a tape speed of 7½ ips is sufficient to cause an attenuation of 30 db at approximately 5000 cps, which would result in very little audible reproduction of this frequency or any frequency above it on the average recorder.

From the author's investigations conducted during the writing of *The Wear and Care of Records and Styli* he found that one speck of airborne dust or grit is often as large or larger than this figure (3/4 of a mil) and if it should become lodged in the head gap can seriously reduce high-frequency response. Any accumulation of dust and tape particles may easily be removed with a Q-tip, pipe cleaner, or a cotton swab saturated with alcohol. Audio Devices, Inc., has recently introduced a head-cleaning fluid which is much more effective.

Worn or loose tape pressure pads are quite often responsible for poor high-frequency response since they too allow poor contact between the tape and the head. Reduced high-frequency response due to worn or loose pressure pads is usually accompanied by abnormal tape speed. These pads should be adjusted in accord with the manufacturer's instructions. Worn or loose pressure pads can easily

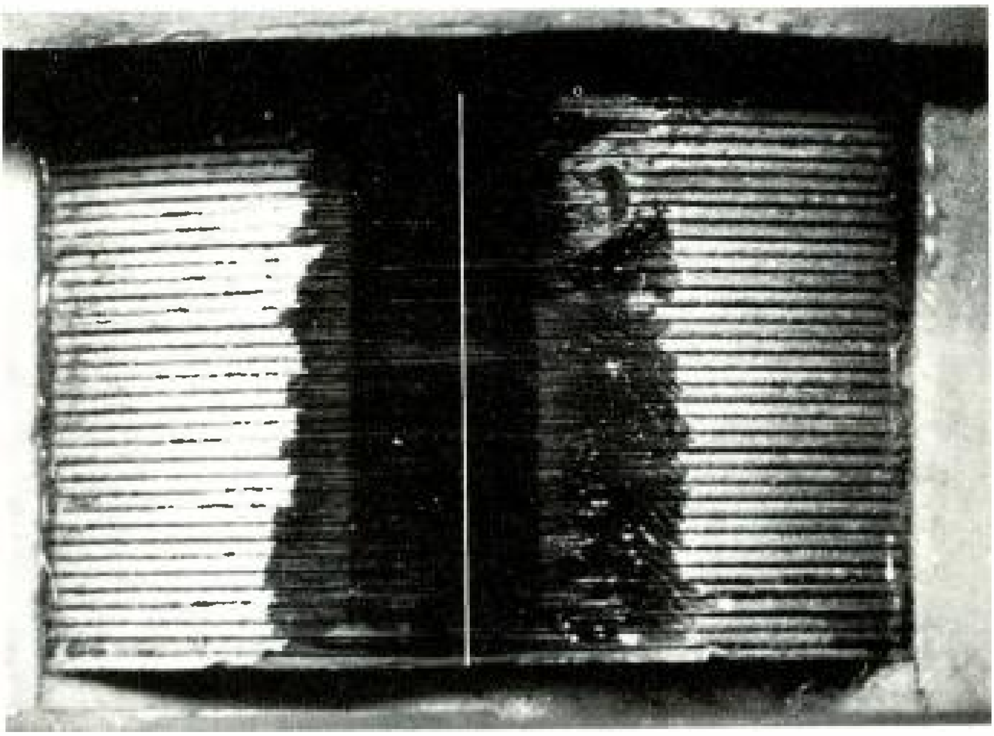


Fig. 12-4. For consistently good reproduction the record-playback head must be perpendicular to the path of the tape.

be located thru the use of Sonafax alignment tape. This test tape is run through the recorder and the pressure pads are pushed in lightly toward the head. When the pressure pad on the playback is so manipulated and results in an increase in signal output, the pressure of this pad is insufficient and should be increased. As previously mentioned, care should be used since if the pad is adjusted too tightly the tape speed will be reduced. In the event adjustment does not correct the complaint the pads are too badly worn and should be replaced.

For consistently good reproduction the playback head must always be perpendicular to the edge of the tape as illustrated in Fig. 12-4. When the recorder was new the head was undoubtedly in this position but due to jars, humps and the constant vibration created by the loudspeaker and motor the head may have shifted as shown in Fig. 12-5. This misalignment results in poor reproduction with

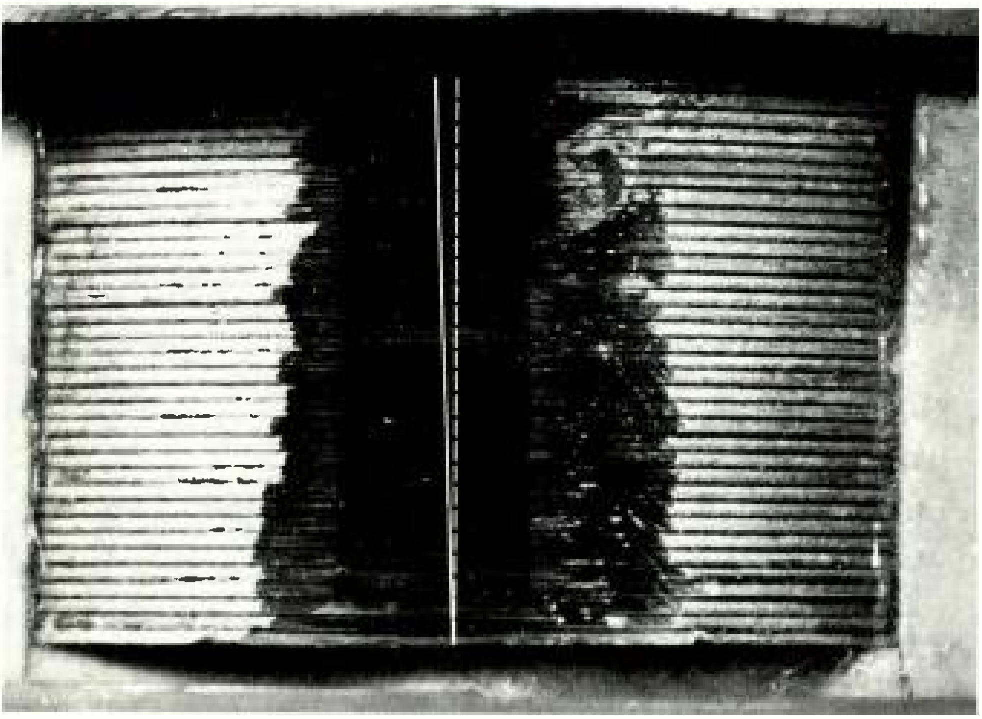


Fig. 12-5. Misalignment of record-playback head results in poor reproduction with greatly-reduced high-frequency response.

greatly reduced high-frequency response as shown by the chart in Fig. 12-6. The greater the degree of misalignment, the poorer the high-frequency response as we can see from Fig. 12-7. From this

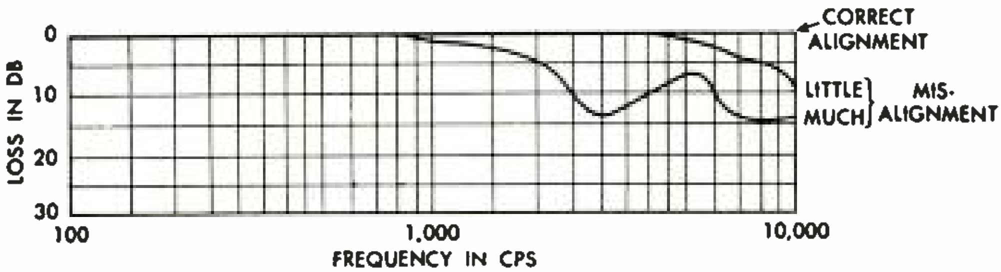


Fig. 12-6. The effect of misalignment of record-playback head on frequency response. (Chart Courtesy of Audio Devices, Inc.)

illustration we can see that a misalignment of only eight minutes of an arc can reduce the output of the recorder about six db at the higher frequencies.

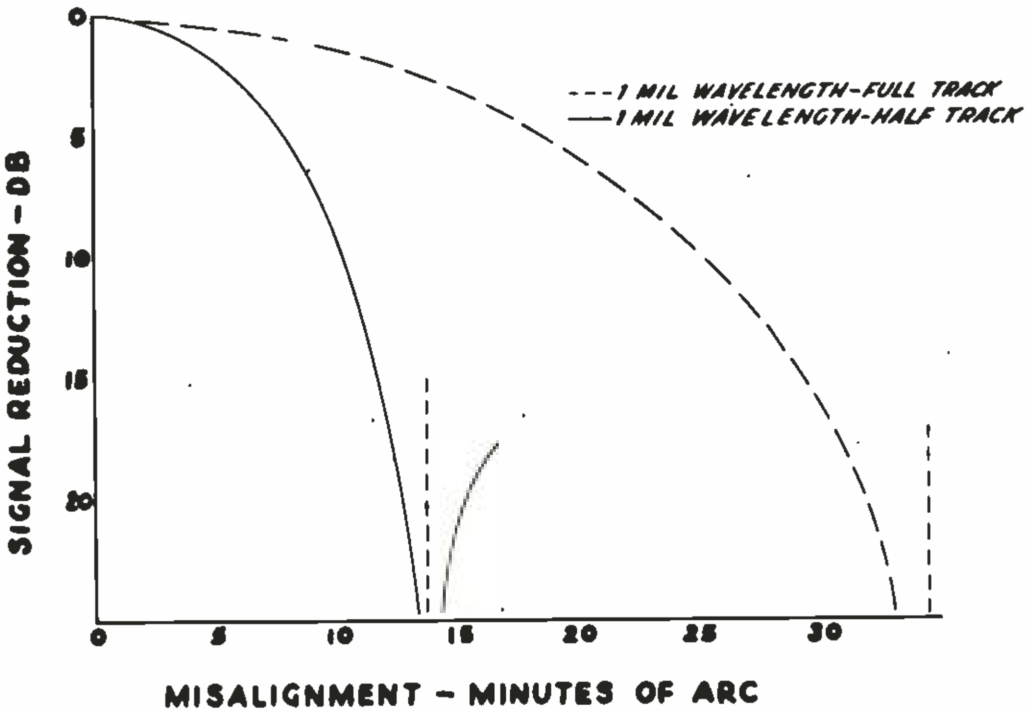


Fig. 12-7. High-frequency response drops off as misalignment is increased. (Chart Courtesy of Minnesota Mining and Manufacturing Co.)

The alignment of the playback head can be checked by obtaining one of the alignment tapes now available under the trade names Audiotape or Sonafax. This tape is placed on the recorder under test and the volume control set to a position at which the test tone is barely audible. The test tape is then "skewed." A wooden pencil

Fig. 12-8. An alignment tape is "skewed" to check head alignment.

or dowel is gently pressed against the bottom of the test tape as shown in Fig. 12-8. If as a result of this procedure the signal intensity increases this fact should be noted. This test is repeated once again, however this time the pencil or dowel is pressed, as illustrated in Fig. 12-9, against the top of the tape. You may find this action decreases the signal intensity or you may discover the reverse is true, that skewing the tape at the top cause a decrease in intensity and skewing it at the bottom causes the level to increase.

Should the signal rise in intensity when the tape is skewed at the top and drop in level when it is skewed at the bottom, or *vice versa,* the playback head is out of alignment. Proper alignment is indicated if the output intensity decreases when the tape is skewed at both the top and the bottom.

Should the recorder under test have a level indicator which functions in the playback position, such as a magic eye or a VU meter, an even more accurate indication of any variation can be obtained.

When the preceding test indicates misalignment of the playback head it may be correctly aligned by running the same tape

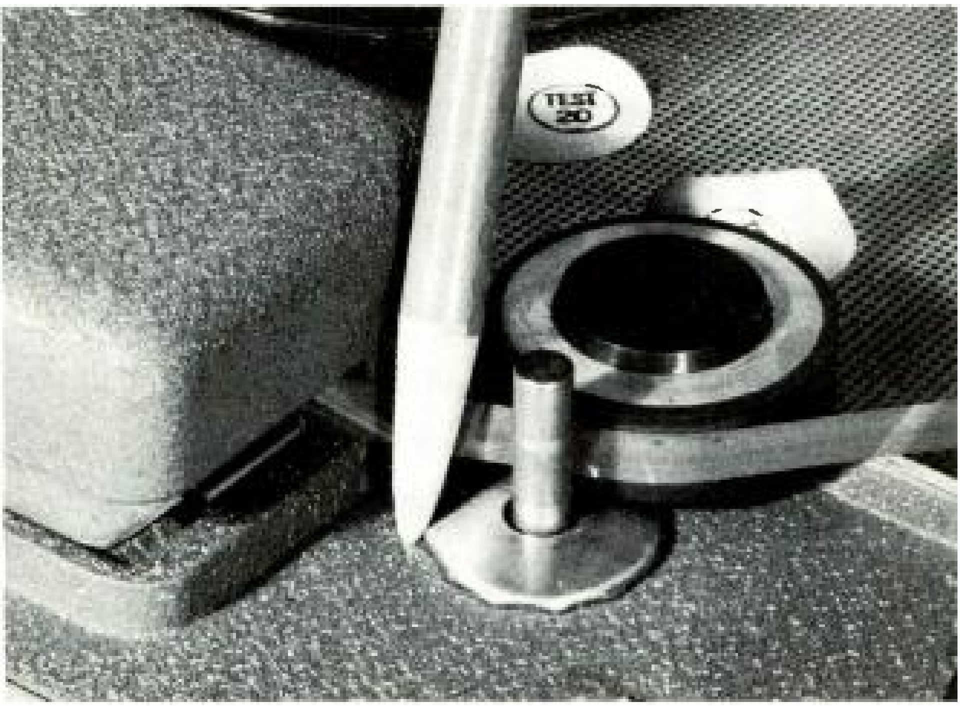


Fig. 12-9. Pressing a wooden pencil or dowel against the top of the tape to check head alignment.

through the recorder. The volume control is set at a position where the test tone is barely audible. The nuts or screws which hold the playback head in position are loosened slightly, (just enough to allow some movement of the head) and the head is rocked back and forth. A change in the level of the test tone will be heard or seen as the head is moved. The head should be so positioned that the maximum signal level is obtained, either visually or aurally. The screws or nuts which hold the head should then be tightened while the test tape is in operation, since tightening them may change the position of the head. This method of alignment also results in the alignment of the recording head function on those recorders which utilize the same head for both operations.

With recorders employing separate heads for the recording and playback functions, the alignment of the recording head can be accomplished using the same equipment and procedure. This can be done by first aligning the playback head and then disconnecting it. Its leads are then connected to the record head, whose leads have been previously disconnected. When using this method of alignment the function switch of the recorder remains in the playback position at all times. The recorder head, which is now being used as a playback head is then aligned as described above.

A more accurate method of alignment and one which may be more convenient for the layman requires a signal source which will provide a 6000-cps tone for the alignment of 7½-ips recorders, one-half this frequency for 3¾-ips recorders and double this frequency for 15-ips recorders. A convenient source is the Sonafax alignment record or any frequency record which provides the correct tone. These records are used in conjunction with a motor and a phonograph pickup. This signal source is then connected to the input of the recorder under test. The signal from the record is then recorded on a blank tape. All recorders using separate record and playback heads allow almost instantaneous monitoring, therefore we will be able to hear and/or see the results of any adjustments made. The screws or nuts holding the record head in position should then be loosened slightly (just as we did with the playback head) and the recording head rocked back and forth. Due to the time delay caused by the difference in the positions of the record and playback heads this operation should be performed quite slowly, each position being held for two or three seconds before moving the head further. When the position which provides maximum signal level is obtained, the record head is locked. The same precautions should be observed as when locking the playback head.

Earlier we suggested periodic checking of any tape recorder and mentioned as one of the reasons the fact that any change in tape speed would effect the reproduction of tapes made during the period when the tape speed was incorrect. Misaligned record and playback heads have an even more noticeable effect. In fact if the record head was originally badly misaligned the tapes made during the time this condition prevailed may reproduce very poorly even after proper alignment. For this reason we cannot stress too strongly the importance of periodic maintenance checks. These checks should be made at least after each two hundred hours of operation if the original quality of the recordings and their reproduction is to be maintained.

The iron-oxide coating on magnetic tape is quite similar to crocus cloth in its physical action on the pole pieces of the record, playback and erase heads. The friction of the tape passing over the pole pieces combines with the abrasive action of the oxide coating and results in the gradual wear of the heads. But due to the various types of heads in general use to-day it is impossible to provide an average figure for head life. With some types the initial period of use results in a polishing action which causes a slight improvement in the frequency response. The response of the head then remains fairly constant until the wear progresses to a point at which the flare

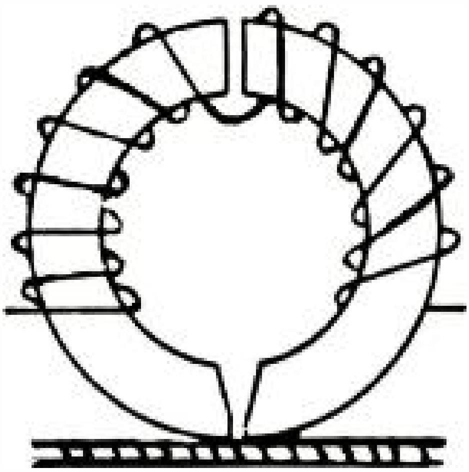


Fig. 12-10. Frequency response of a record-playback head remains constant until wear exposes the flare in the head gap.

in the head gap is encountered, as illustrated in Fig. 12-10. At this point the frequency response of the head begins to fall off. This reduction in response is due to the increase in gap width as the head is continued :. use. The life of tape heads is also dependent upon a number of other variable factors such as tape pressure, tape speed, etc. At the present writing the best method of checking for worn heads is to substitute a new unit.

There are a number of reasons for high noise level in a recorder. The most common is a magnetized recording head. As the head becomes magnetized the noise level of a recording may rise as much as ten db. This rise in noise level is most noticeable on soft passages of music. The magnetization is usually caused by the cumulative effects of starting and stopping a recorder while a strong signal is being applied to the record head. Contact with a magnetized object such as a screwdriver will also result in a magnetized head. When a minimum of background noise is important recording heads should be demagnetized after every five to ten hours of use. Since head

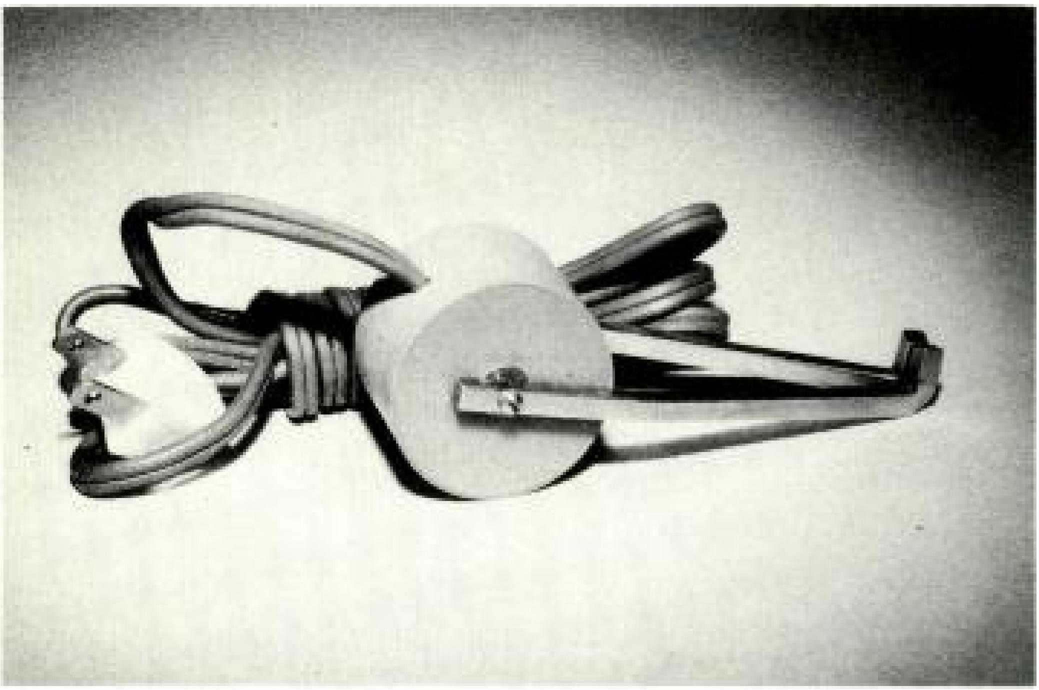


Fig. 12-11. Audio head demagnetizer. (Photo Courtesy of Audio Devices, Inc.)

demagnetization can be accomplished in a few seconds with the Audio Head Demagnetizer illustrated in Fig. 12-11 there is no reason that it should not become a part of your regular maintenance program.

Chapter 13

Adding Sound to Slides and Home Movies

TO-DAY ONE rarely encounters a traveler or a tourist without a camera of some sort. Quite often it is a 35-mm camera and its owner uses color film which will be made into slides to be projected. These persons always carry a camera since they have discovered that through its use they can recreate the pleasant moments of their travels. Many a long winter evening the author has re-enjoyed his vacations in warmer climes via color slides. But there is something missing. The author has often heard himself attempting to describe the sounds he heard while the pictures were being taken. The Elizabethan English which is still spoken by the older residents of the "Outer Banks" of North Carolina, the weird cry of a loon on a lake, the peaceful lapping of water against the sides of a boat.

Now, with a simple strip of tape these sounds can be captured just as you heard them. As film can recreate the sights you see, a strip of tape can recreate the sounds you hear. Sound will add a new dimension to your pictures whether they are slides or home movies. In the event you do not have a portable recorder of the type illustrated in Fig. 13-1, you can obtain authentic sounds in the other ways we have discussed in previous chapters.

Fig. 13-1. The Travis Tapak, a battery-operated portable tape recorder. (Photo Courtesy of Broadcast Equipment Specialties Corp.)

The first step in adding sound to a group of slides is to select the transparencies which best illustrate the story you wish to tell. Arrange them in some order. It may be chronological, geographic or any other order which allows each slide to be preceded or followed by one which is in some manner related to it. Number the slides in sequence, marking them in the upper right hand corner with the slide upside down and the dull side facing you. This is the correct position for insertion in your projector. Obtain a number of 3 x 5-inch file cards and mark them with numbers which correspond to the numbers on the slides. You will now have a set of numbered slides and an equal number of cards which are marked correspondingly.

Next decide on total length of time the presentation will last. No single showing should be longer than twenty minutes if you wish to retain the undivided attention of your audience. In fact, fifteen minutes is even more effective. When the program is longer it should be broken into fifteen- or twenty-minute sections. No individual slide should remain on the screen for longer than twenty-five seconds create the desired mood as on televison or in professional movies. This form is no more difficult to make but requires a little more preparation and time.

Let us assume the first picture in the group to which you wish to add sound is a scene of a New England harbor. Appropriate music would be *Ebbtide*. Listen to the entire record, there will usually be one section which represents the mood of the picture more than the other sections. Mark this section of the record as explained in Chapter 11 so that you can find it quickly.

Place the pickup arm of the record player a few grooves ahead of the section you have chosen. Monitor the signal being fed into the recorder. As soon as you arrive at the section you have chosen, quickly turn the record-level control to the zero position and gradually bring it back to the previously-determined correct recording level as described in Chapter 7. Record the musical background for twenty-five seconds or whatever time you have chosen. When this time has elapsed gradually fade the music out with the record-level control. Mark the point at which the music ends with a china marking pencil. Rewind the tape to the beginning of the section you have just recorded. Play it back; if the recording is satisfactory, you are ready for the next step.

The simplest method of adding commentary is to insert a strip of 35-mm film between the erase head of your recorder and the tape as described earlier in this book. Set the record-level control to the level which you have previously determined is the correct one. Rewind the tape again to the position of the first sound. Start the recorder and read the commentary contained on the first script card. When using this method of dual recording the recordist must be extremely careful to read the script correctly the first time since, if it becomes necessary to correct it, the erasure will also eliminate the musical background recorded previously.

Play this section back once more; if the dual recording meets with your approval you are ready for the next slide. Mark with the china marking pencil the end of the first section and measure 37 1/2 inches of tape from this point. Mark the tape once more at the new point. Repeat the entire operation for the second slide and second section on the tape. The background music for the second slide may be obtained from another section of the same phonograph record or different music may be employed.

The use of sound effects as a background for slide projection will greatly increase the viewers' interest and result in an even more professional presentation. Most of the sound effects you will have occasion to employ are quite simple to create at home. We have provided a number of the more common and useful ones such as rain, thunder, lapping water, surf, etc., in Chapters 10 and 11. They can be created with a minimum of easily obtainable equipment.

As suggested earlier your radio or TV receiver can also provide many unusual sound effects. Programs like *Zoo Parade* will provide many animal sounds. *Omnibus*, which excels in the unusual programs presented, is another good source of sound effects. Dramatic performances and movies on TV are still another source. All you need do to acquire an extensive library of these sound effects is to keep your recorder connected to your radio or TV receiver. Record the sounds as they are produced. These sounds can later be edited, lengthened and transferred to another tape.

The methods suggested provide an infinite number of variations. You may combine music and sound effects, voice and sound effects, voice, music and sound effects, or any of these individually.

Home sound movies, heretofore prohibitively expensive, are now available at reasonable prices. The high initial cost and the high upkeep of optical sound on film have held the use of home talking pictures to a minimum. To-day, through tape recording, anyone with the knowledge provided in our previous chapters can successfully make home movies with sound. The cost has been reduced to a point where anyone who can afford a home movie camera can afford to add sound. Sound effects, speech or music may be recorded simultaneously with the picture taking. Sound can also be added later to pictures you already have in your possessionn just as we have done with slides.

Since there is more than one method of adding sound to home movies we will explain them all and provide sufficient information about each so that the reader may choose the one method which is best suited to his particular application.

You can add sound to your home movies if you own a projector with a variable speed control and a tape recorder which operates at 3 3/4 ips. No physical changes are required on either the tape recorder or the film projector. No auxiliary equipment need be purchased. Merely buy a reel of Revere *Synchro-Tape*, which differs

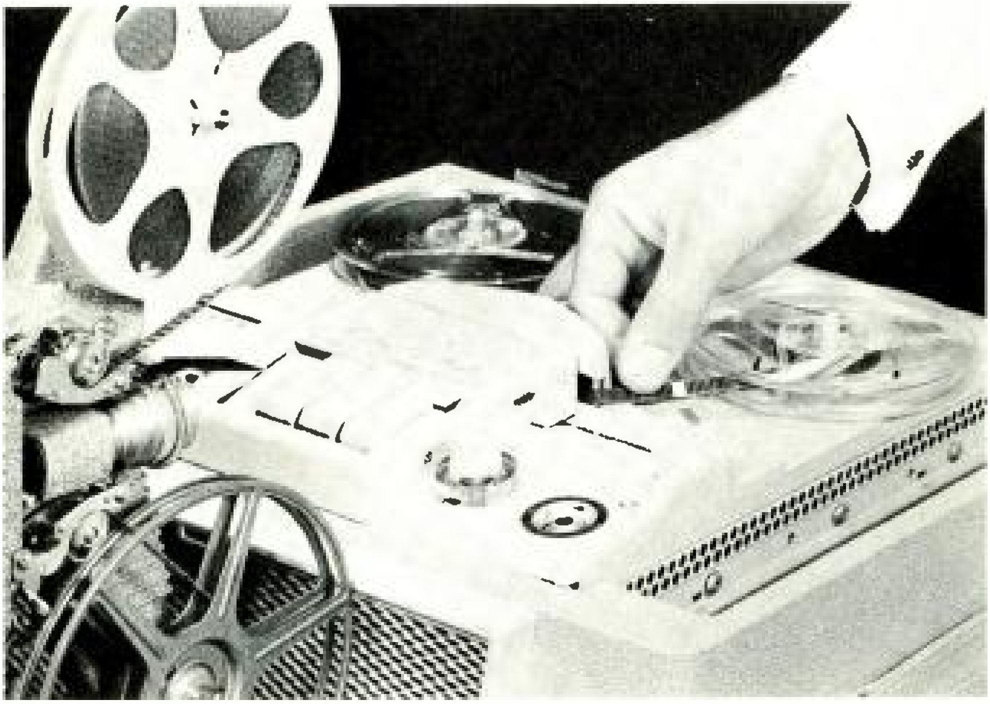


Fig. 13-2. Here is shown the method of aligning marking tape on the recording tape and on the recorder when using "Synchro-Tape" for adding a sound track to home movies. (Photo Courtesy of Revere Camera Corporation.)

from the tape you are now using in that there are a series of vertical lines imprinted on the backing, as illustrated in Figs. 13-2 and 13-5.

When a motion picture is projected the viewer actually sees a series of individual pictures, each frame being projected while absolutely still. The shutter on the projector cuts all of the light from the screen while the film is being moved into position to show the succeeding frame.

You can actually see, when the speed of your projctor is reduced sufficiently, that the light from the lens is intermittent. When an individual frame is projected the light comes through. During the time that the film is moving to the next frame the light is blocked off by the shutter.

This intermittent light from your projector is used in conjunction with the vertical lines on the tape backing to provide a stroboscopic effect which is employed as a visual indication of the projector speed.

When the recorder and the projector are not synchronized these lines will appear to move from right to left when the projector is

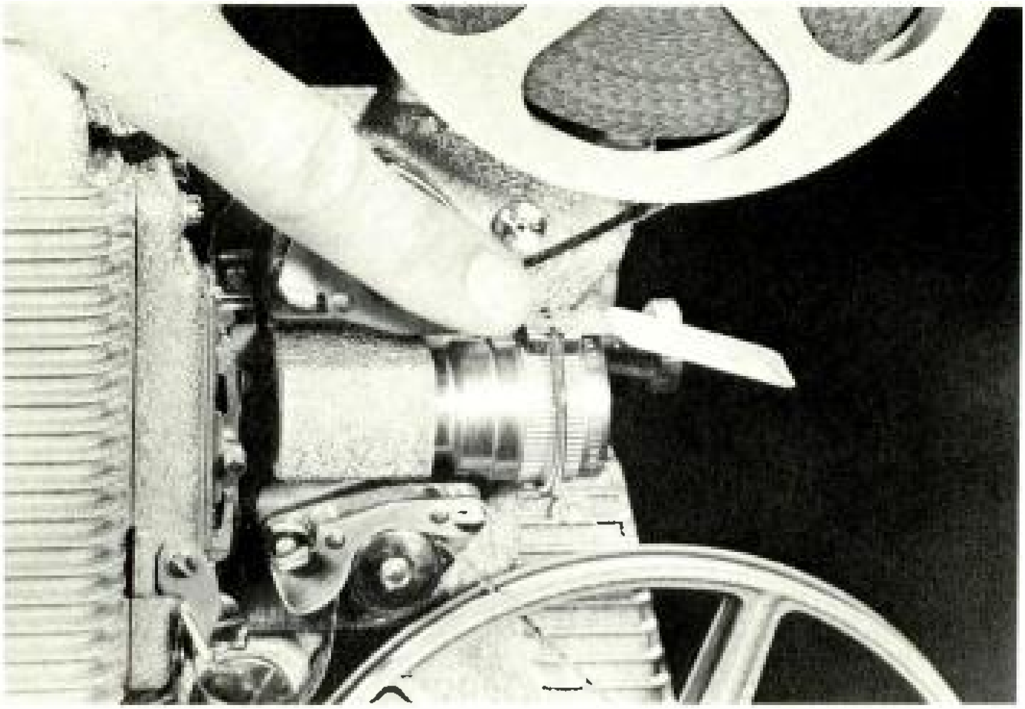


Fig.13-3. A small metal reflector is mounted on the lens of a movie projector to reflect part of the projected light beam onto moving "Synchro-Tape." The reflector does not interfere with the picture in any way, and is easily mounted and removed. (Photo Courtesy of Revere Camera Corporation.)

operating at too high a speed. When the lines appear to move from left to right the projector is operating too slowly. By means of the projection speed control the movement of the lines can be controlled and varied. By proper adjustment of the speed control they can be made to appear stationary, which indicates that the sound and the picture are synchronized. The projector is then operating at exactly 18 frames per second.

This particular method of adding sound to movies operates by utilizing a tiny beam of light from the projector lens which is deflected onto the tape by means of the small reflector furnished with each reel of tape, as illustrated in Fig. 13-3. The diagram in Fig. 13-4 illustrates the entire process. It is that simple to add sound to your home movies. This method may be employed on both 8- and 16-mm film.

To make a recording using *Synchro-Tape*, set up the screen and place the projector and the recorder on a small table or a stand as illustrated. The projector take-up reel should not be more than one inch from the front of the tape recorder. The projector lens should be about six inches above the tape level. It may be necessary to increase the height of some shallow tape recorders by employing books, etc.

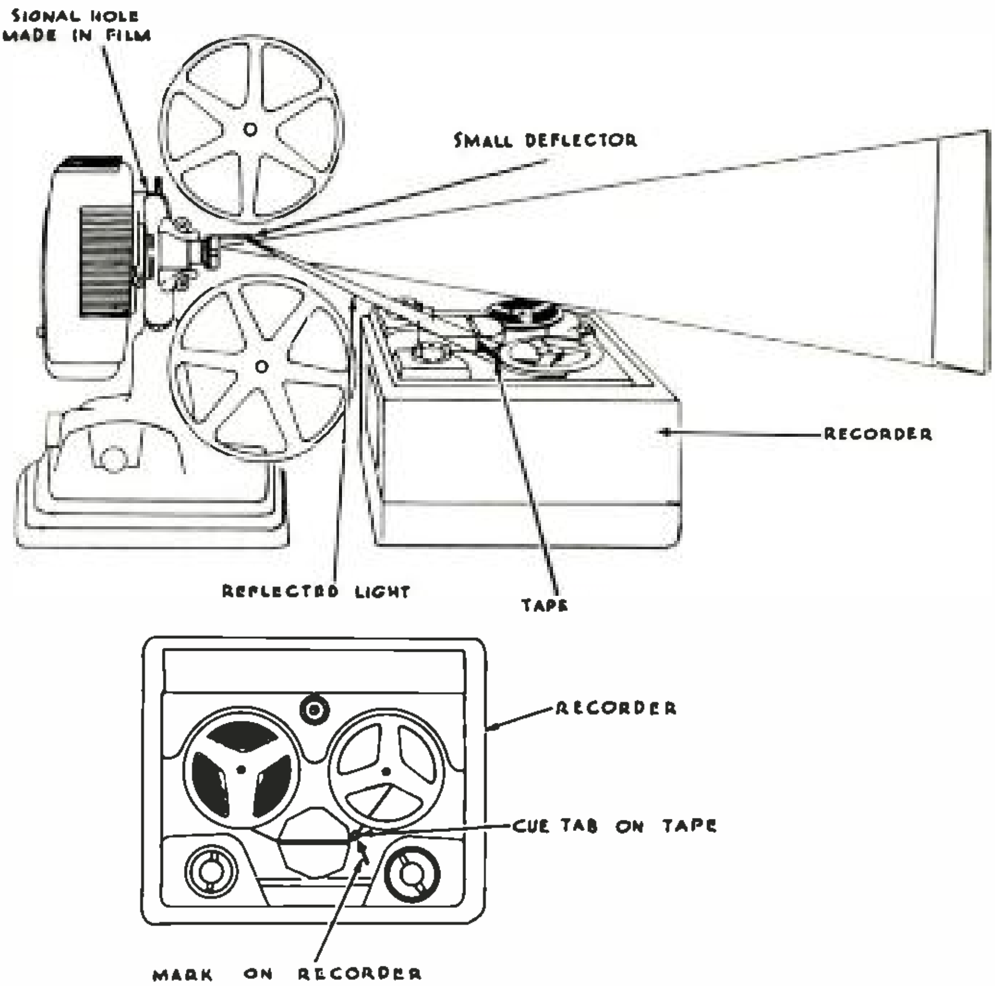


Fig. 13-4. Illustrated here in diagram form is the entire "Synchro-Tape" process for adding sound to home movies. (Drawing Courtesy of Revere Camera Corporation.)

Insert the film in the projector, switch it on and tilt it until the screen is filled with light, then focus the picture. With the projector light still on fasten the small reflector as illustrated in Fig. 13-3. Bend it downward until it deflects a beam of light to the area between the recording head housing and the take-up reel on the recorder as illustrated in Fig. 13-5.

Place a strip of the marker tape, which is furnished with the *Synchro-Tape*, in this area on the recorder top as illustrated in Fig.

13-2. This strip will be employed as a starting mark. Also place a marker of white splicing tape on the *Synchro-Tape* itself, about two feet from the end of the leader tape. Trim off the excess splicing tape with scissors. The tab on the tape and the one on the recorder are then lined up as shown in Fig. 13-2.

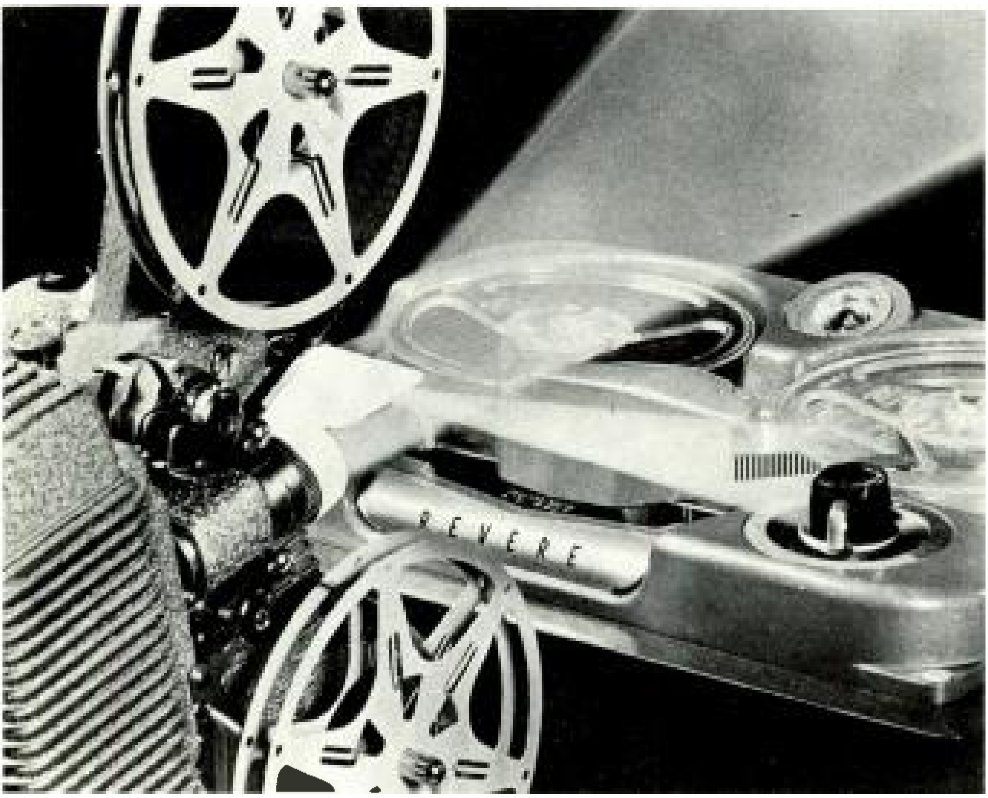


Fig. 13-5. The reflector must be bent downward until it deflects a beam of light onto the area between the recording-head housing and the take-up reel. Notice vertical lines on the exposed tape. (Photo Courtesy of Revere Camera Corporation.)

The next step is to punch a hole in the film or its leader as shown in Fig. 13-6. This hole should be about nine inches before the first scene in the film. When the film is projected the light coming through this hole onto the screen is your signal to start the tape recorder. The projector should always be started first.

Have an assistant placed at the projector speed control watching the lines on the tape backing; if these lines slowly drift to the right the projector speed must be increased, if they drift to the left the speed must be decreased. When a position on the projector speed control is found at which the lines on the tape remain station-

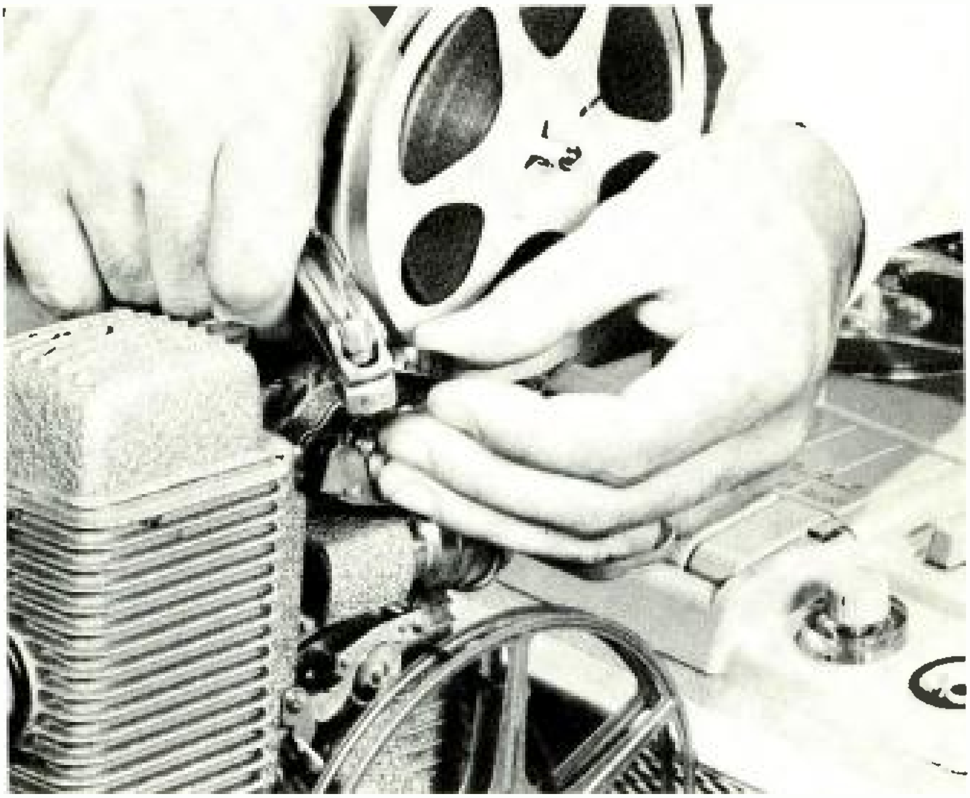


Fig. 13-6. A hole is punched in the leader of the film to provide a visual cue for starting projector and recorder together. When the light from this hole flashes on the screen, the recorder is started with "Synchro-Tape." Starting point of tape is indicated by the cue tab and alignment mark shown in the middle right side of the picture. (Photo Courtesy of Revere Camera Corporation.)

ary it should be marked with a strip of splicing tape.

You are now ready to make a timing recording. Start the projector and as soon as the light from its lens flashes through the hole you have previously punched in the film, start the recorder. The microphone should be plugged in and the record level control set at the half-way point. As the first scene flashes on the screen tap an empty water glass with a spoon in front of the microphone. When this scene ends tap the glass again. Stop both the recorder and the projector and rewind both the film and the tape. With a stop watch or a clock with a sweep second hand time the interval between the two sounds you made. Mark this time on a 3 x 5 library card.

Let us assume the total time of the first scene was 34 seconds. As previously explained earlier in this chapter, the speed of average conversation is 2 1/2 words per second. The time the scene is on the screen is 34 seconds. When this time is multiplied by 2 1/2 words per second we find that the average person can say 85 words. This is the maximum number of words you can use to describe this scene. With movies it is not necessary to maintain a running commentary for the entire length of time the scene is shown. The commentary can be brief and music and/or sound effects may be employed for the balance of the time available.

When employing Revere *Synchro-Tape* to add sound to home movies the actual recording on the tape is made in exactly the same manner as it was on the tape made to accompany projected slides. The primary difference, as explained, lies in the fact that the timing of the narration, musical background or sound effects is completely controlled by the length of the individual scene.

The second method of adding sound to home movies eliminates the necessity for manual synchornization and a separate tape recorder. The movie film itself is employed as the vehicle for the magnetic oxide which stores the sound. A narrow magnetic stripe of the same material used on recording tape is applied to the film itself, after it has been photographically processed. When the film has been

Fig. 13-7. Sound-on-film adapter for using magnetically-striped film. (Photo Courtesy of Foto Corp. of America.)

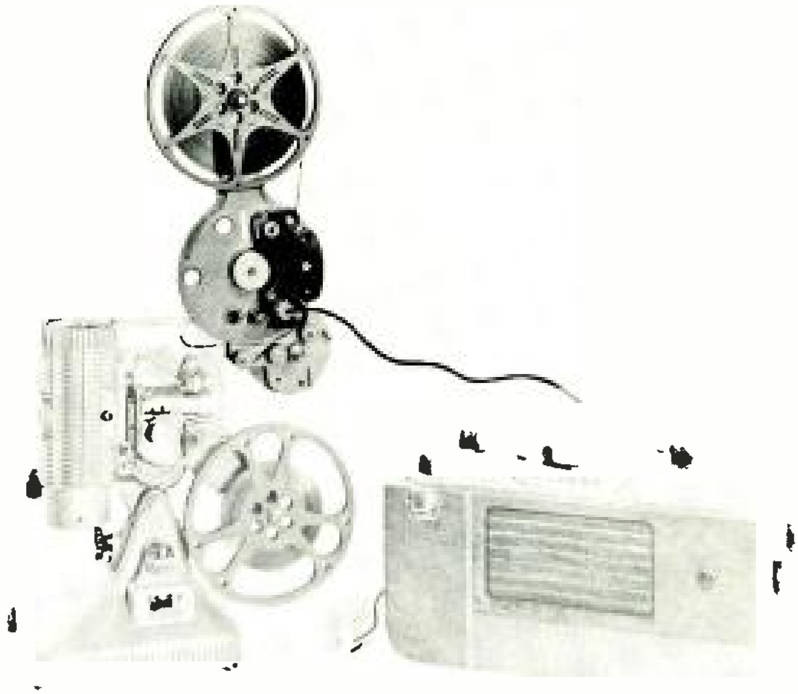


Fig. 13-8. Inexpensive version of the adapter shown in Fig. 13-7. (Photo Courtesy of Foto Corp. of America.)

processed and the magnetic stripe added, you actually have what amounts to a reel of recording tape attached to your film.

The Foto Corp. of America, New York, has developed an adapter which may be added to any projector which will convert it into a sound projector. This adapter, which is illustrated in Fig. 13-7, is actually a miniature tape recorder without the tape transport mechanism. As the film is run through the projector, the magnetic stripe it contains comes in contact with the record-playback head which is similar to the head on a conventional tape recorder. Sound is recorded on the magnetic stripe in exactly the same manner as it is recorded on a tape recorder. The same company also manufactures a less expensive unit which can be used in conjunction with your tape recorder. This unit is illustrated in Fig. 13-8.

Earlier in this chapter and in our chapters on sound effects we mentioned the use of a strip of 35-mm film to produce dual recordings on one tape. Both models of the Cinesone adapters have an "automatic subduer" which accomplishes the same end merely by flipping a switch.

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AUDIO

LIBRARY