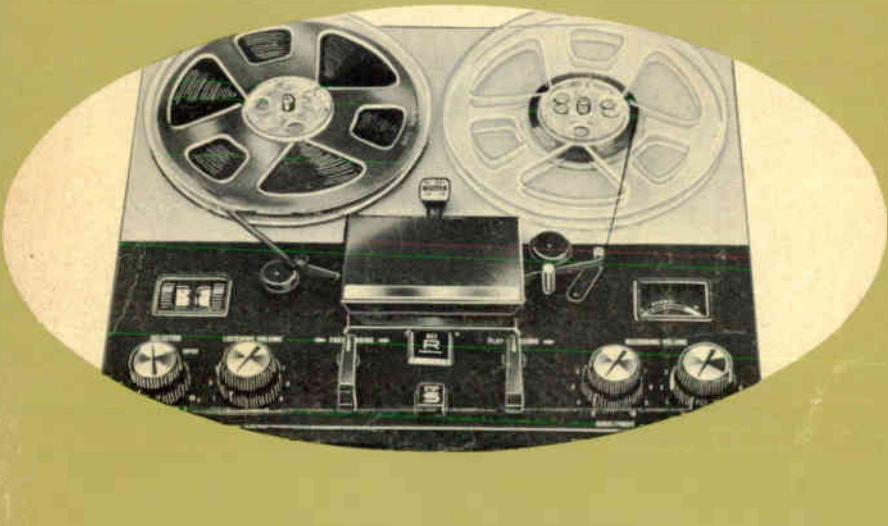
an ALLIED publication

using your

tape recorder



The ABC's of Tape Recording
for the Non-Professional User–
How Tape Recorders Work–
Recording Techniques for
all Program Sources–
Applications–

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USING YOUR TAPE RECORDER

Allied's Handbook on the Tape Recorder

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PREFACE

Within the past decade, the tape recorder has become thoroughly entrenched as a medium of entertainment in the home, where it augments the phonograph as a source of musical program material, permits the day-to-day recording of events of all sorts which have a permanent —or even temporary—interest to its owner. Such never-to-be-forgotten sounds as baby's first words, the last words of a loved one, speeches of world-famous personalities, or the treasured moments of a fleeting radio or TV program can be stored permanently, to be enjoyed over and over again—and all at a fidelity which was unheard of heretofore in any home recording medium—or the tape may be erased and used to record another program which you may keep as long as you like.

While the tape recorder itself is a complex instrument, its operation has been simplified so that in most instances one has only to push buttons or turn a few controls. The real joy in using a recorder is in creating for yourself something which can not be obtained in any other way.

This book suggests a number of applications for your tape recorder, and then tells you how to go about it—how you can record original musical performances, how you "dub" from phonograph records, how you record "off the air," how you can create your own sound effects and combine them with music and narration to enhance your slide shows and home movies.

Familiarity with your tape recorder and the techniques of using it will give you countless hours of fun and pleasure, and this book will open the door to an enjoyable pastime.

TABLE OF CONTENTS

Chapter 1

Sound—What Is It?

There is a tremendous interest in the recording and reproduction of sound. The primary reason for this interest is unquestionably 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 in the past ten years 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 a home recorder that are far 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 employ tape exclusively for their original recordings. After the tape is made and carefully edited, the recorded sound is transferred to a disc master.

The modern tape recorder, an outstanding example of which is illustrated in *Fig.* 1, 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 and trade publications. 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 good 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 original work or, if necessary, erase it completely and start over again using the original material.

Fig. 1-1. Typical high-quality home tape recorder—Knight Model 4450 or Knight-Kit KG-415

When the user is armed with a little knowledge, which we hope to provide, and acquires 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.

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 performances of selections not otherwise available may be recorded. For those interested in church or 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 inexhaustible store of material and its program director will usually cooperate and advise you of impending broadcasts of special interest. However, this material should not be employed for any purpose other than home entertainment. To do so is a violation of the copyright laws.

Popular music may also be recorded, and those selections which become boring through constant repetition can easily be erased and that section of the tape reused for a later release.

Authentic native music from far off places, rarely available commercially, can be recorded via short wave.

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 uninterrupted 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 your existing color slides.

Tape recorders are utilized extensively as valuable tools for language and 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 such incidents will be extremely helpful to both the pupil and the 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 employed was the conventional home recorder, but during which the temporary guest operator was more familiar than the owner of the machine with the microphone techniques 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.

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.

What is sound?

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 system. 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 of a clarinet, a tuning fork, a human vocal cord, and so on.

Since the 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.

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 be 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 at (A) in *Fig.* 1-2. This compression increases the atmospheric pressure of the adjacent layer of air to a point where it is above normal.

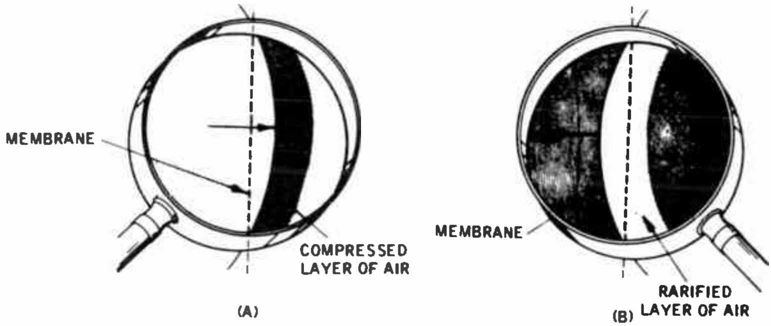

Fig. 1-2. (A), outward motion of a struck membrane, showing compression of adjacent layer of air. (B) inward motion, showing rarefaction.

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 adjacent layer of air to a point where it is below normal, as shown at (B) in *Fig.* 1-2.

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 at (A) in *Fig.* 1-3.

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

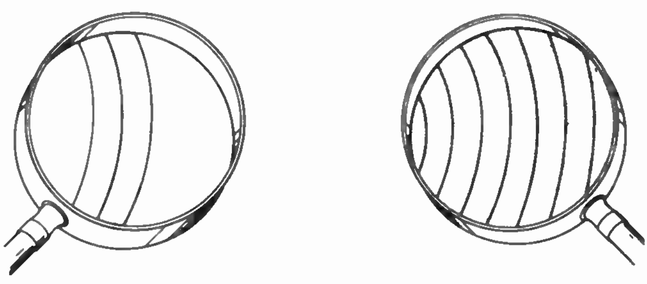

Fig. 1-3. (A), sound wave resulting from a single cycle of sound, and (B), sound waves resulting from a continuing sound source.

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 shown at (B) in *Fig.* 1-3, and which all move outward from the sound source.

If we were 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 *Fig.* 1-4.

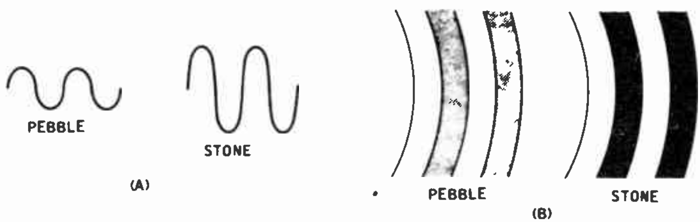

Fig. 1-4. (A) waves created by pebble and stone dropped into water. (B) representation of weak and strong waves in air corresponding to the water waves.

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.

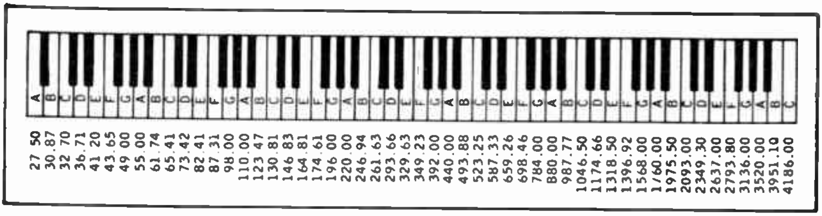

Fig. 1-5. Frequencies of the notes on a piano keyboard.

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 *Hz.** For example, when the Middle A key on the piano is struck (see *Fig.* 1-5) 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-Hz. 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.

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 tone higher in pitch than the first one. In stretching the rubber band we have reduced its thickness and increased its length and tension.

To return to the piano string; if 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.

* *Hz*, the abbreviation for Hertz, an early scientist credited with discovering "hertzian" waves.

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 Hz. This is known as the frequency response of the human ear.

As mentioned previously, striking different keys of a piano produces sounds of different frequencies. Returning to *Fig.* 1-5 we find that the piano will produce sounds ranging from 27½ to 4186 Hz. This is called the fundamental frequency range of this instrument. *Figure* 1-6 illustrates this range in comparison with the frequency ranges of other musical instruments, sounds and voices.

The lower portion of *Fig.* 1-6 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 *hertz,* or cycles per second. The horizontal lines supply the frequency ranges of the various instruments and sounds. For example: The solid black line at the word trombone extends from roughly 85 to 520 Hz. This is the fundamental frequency range of that instrument.

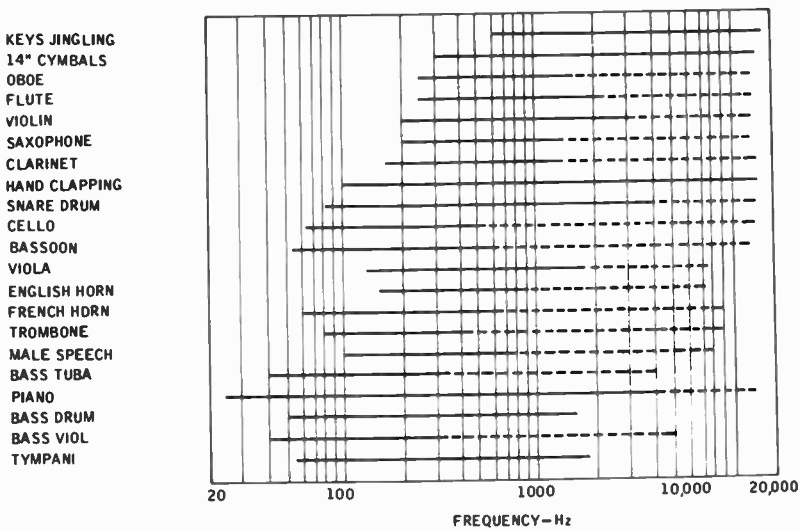

Fig. 1-6. Frequency ranges of musical instruments and other sound sources. Solid lines are fundamentals; dashed lines indicate the range of the harmonics.

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 only fundamental tones without any harmonics, it would sound exactly the same as all other voices or instruments, unless the frequency range or volume were 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.

How harmonics are produced

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 at (A) in *Fig.* 1-7. 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 ex-

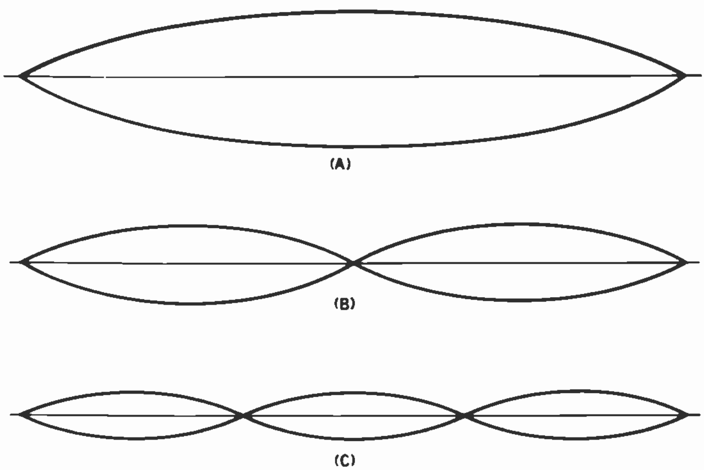

Fig. 1-7. Vibrations of the string on a piano or violin. (A) as a whole, producing the fundamental tone; (B) in two parts, creating the second harmonic; and (C) in three parts, resulting in the third harmonic.

ample, 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 Hz. In addition the string will also vibrate in two sections as shown at (B) in *Fig.* 1-7. This secondary vibration causes what is called the second harmonic, in this case a tone whose frequency is 880 Hz. It is also possible for the string to vibrate in fourths, sixths, eighths, and so on. A string vibrating at the third harmonic, or 1320 Hz, is shown at (C) in *Fig.* 1-7.

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 examples, produces overtones above 8000 Hz, despite the fact that its fundamental range extends only to 4186 Hz. This extension of the frequency range of the various musical instruments is given in *Fig.* 1-6, where it is indicated by the dotted section at the high-frequency ends of the lines showing the frequency range of the various sounds.

Any discussion of sound must, in addition to pitch or tone, 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.* 1-8 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 intercepts, and is affected by, sound energy in

Fig. 1-8. Speaking directly to a sheet of paper causes it to vibrate just as the diaphragm of a microphone does.

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 it. These waves then pass through the auditory canal and affect the ear drum which acts as a diaphragm 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 by the nervous system 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 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 unwieldy. For example, the intensity of a quiet whisper would be 10,000. That created by the normal conversation in the average city home 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 is consequently 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.* 1-9.

Figure 1-9 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 engine increased the known level of sound 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 1-9 will also provide some idea of the relative levels of various sounds when we explain that a sound twice the intensity of a reference sound is only 3 dB higher in level. When a sound is four times the intensity of 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 the intensity of another, it is 10 dB higher in level. When a sound is one hundred times the intensity of 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.

Your microphone has a diaphragm which is similar to the diaphragm in the human ear which we call the eardrum. Both respond in exactly the same manner to any changes in the frequency or loud-

0	THRESHOLD OF AUDIBILITY
10	RUSTLE OF LEAVES
15	QUIET WHISPER
20	AVERAGE WHISPER AT 5 FEET
23	STUDIO NOISE LEVEL
30	NOISE IN SUBURBAN STREET
48	NOISE IN STORAGE WAREHOUSE
60	NOISE IN AVERAGE RESTAURANT
63	AVERAGE CONVERSATION
70	CITY STREET NOISE
78	NOISE IN FACTORY (AVERAGE)
80	LOUD RADIO PLAYING IN THE HOME
90	NOISY FACTORY
97	SYMPHONY ORCHESTRA AT 20 FT.
120	THRESHOLD OF FEELING
135	THRESHOLD OF PAIN

Fig. 1-9. Intensity levels created by some common sounds.

ness of a sound wave and in essentially the same manner in converting the mechanical energy of the sound waves. The human ear, upon intercepting sound waves, converts them into minute nerve pulses. The microphone converts them into minute electrical impulses.

When a sound with a frequency of 16 Hz is intercepted by the microphone, it is converted into exactly 16 small electrical impulses per second. A 5000-Hz sound wave would be converted into 5000 electrical impulses per second. The frequency of the electrical wave is exactly the same as that of the sound wave which created it.

If we were to increase the loudness or intensity of the sound wave intercepted by the microphone, it would increase the strength or voltage of the electrical impulses it generates. The electrical impulses generated by the microphone vary in exact proportion to the sound waves which generated them in respect to both loudness and frequency.

Chapter 2
Your Recorder

Since more electrical power is required to make a recording than the minute impulses provided by a microphone, it is necessary to magnify or amplify them to usable proportions. This is accomplished by the recording amplifier which is an integral part of your recorder. The microphone is connected to the amplifier when it is plugged into the microphone jack, (Mic Input). Also connected to the amplifier are two components which are extremely important for proper recording.

The first is the volume control, as illustrated in *Fig.* 2-1. This control is used to vary the amount of amplification provided by the amplifier. It is necessary that this be variable since the sounds we wish to record all vary in level—some require more amplification and others less.

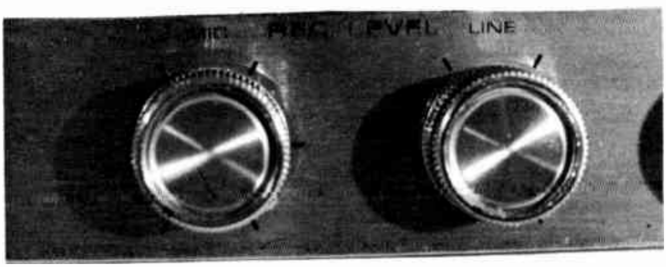

Fig. 2-1. The volume control on a typical tape recorder.

For example, earlier in *Fig.* 1-9, we indicated that the sound level created by average conversation was 63 dB; actually the sound levels created by the human voice will vary. A male voice can produce sound levels ranging from a whisper up to a sound level of 15 dB, or with the same voice shouting or singing, it produces a sound level up to 92 dB.

If we were recording a person whispering we would obviously require more amplification than would be necessary to record the same person shouting. In order to compensate for the differences in the levels of the sounds we wish to record, the amount of amplification must be variable. The dial markings on your volume control permit you to note the amplification employed for particular types of recordings and allow you to return to the same setting when making recordings of a similar nature, much as the photographer does in presetting his lens.

The second component connected to your amplifier is the recording level indicator, which informs you of the maximum sound level usable without introducing objectionable distortion.

If we were to record only speaking voices it would be much simpler to make recordings, since the human voice, speaking as in normal conversation, remains comparatively constant in level. The difference in volume level between the loudest sound and the softest sound it produces is very small (only about 10-12 dB) unless the talker becomes excited and shouts. This difference between the loudest and the softest sound produced is called the loudness range.

Unlike the human voice while speaking, the sound level of a musical instrument or a singing voice varies considerably during the rendition of a musical selection. Some passages are soft, others are loud. These changes in the volume level are one of the means by which the composer and the musician create variations in mood and expression.

Figure 2-2 depicts the loudness or *dynamic range,* as it is correctly called, of the various musical instruments which we are apt to encounter in recording. The dynamic range of a musical instrument or singing voice is the difference in volume level between the loudest and softest sounds it can produce. From this illustration we can see

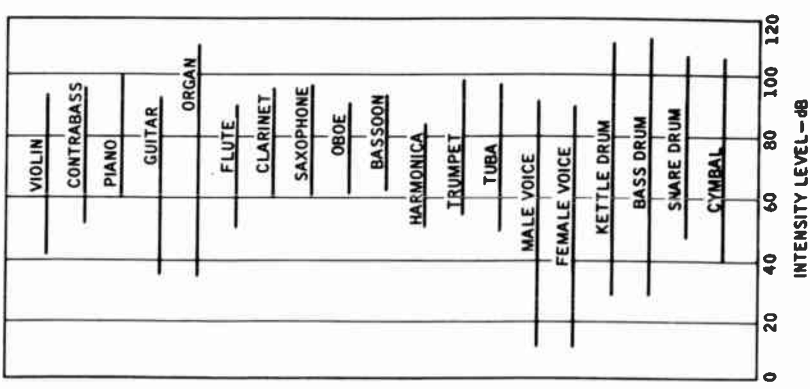

Fig. 2-2. Loudness or dynamic range of musical instruments and other sound sources.

that the instrument which produces the greatest sound intensity and has the widest dynamic range is the organ. Next are the drums and cymbals, followed by the piano.

Dynamic range is important in recording since there is a maximum level which can be handled by the recording equipment and tape without introducing objectionable amounts of distortion. Any level above this optimum level results in a recording which is noticeably distorted. The maximum level which can be handled without distortion is shown by various types of record-level indicators.

The single neon lamp produces an indication only when the recording is being made at or above the distortion level. When the recording level is too low, the lamp will not indicate how much too low, which results in an increase in noise level. The second type employs two neon lamps. One, called distort, ignites at the maximum permissible level; the other, called normal, ignites at 6 to 10 dB below acceptable distortion. The object is to adjust the recording level so that the normal lamp is ignited most of the time, but the distort lamp gleams as seldom as possible.

The third type is the magic eye. If the eye overlaps occasionally there will be no harm done. However, should the eye close completely or worse, overlap, very often the recorded signal will be distorted. On the other hand, if the eye never or very seldom closes the recording level is too low. The fourth type is the meter in which the zero mark on the scale indicates the "zero" level over which excessive distortion occurs.

Just as there is a maximum recording level above which distortion is introduced there is also a lower limit which is the minimum recording level. Below this level parts of the recording may be obscured by background noise of various kinds, e.g., the tape hiss which is created by the tape, and the residual hum and noise level of your recorder. A person speaking rarely falls below this level whereas a singer may do so often during the rendition of a selection. It was for this reason, as we indicated earlier, that your recording should be made at a point slightly below the maximum recording level. Recording below this point makes it necessary to raise the playback volume to the point where any hum, noise, or hiss may become objectionable.

The correct adjustment of the volume control for recording a vocalist or a solo musical instrument is obtained in the following manner; when a VU meter is employed, have the vocalist or instrumentalist take a position about 18 inches from the microphone. Ask the performer to render the loudest portion of the selection you are about to record, adjust the volume control until the needle of the record indicator hovers somewhere between −8 and slightly above the "zero" mark, never higher than + 1, even on the loudest prolonged passages.

Next ask the performer to render the softest part of the selection. The record-level indicator should read somewhere in the range be-between – 8 and – 20. If it does you have obtained the optimum recording level and can proceed recording. You may find that you cannot always achieve this optimum condition since the dynamic range of either the selection or the vocalist is too great. The recording then calls for more advanced microphone technique and handling of your recorder. This additional information is provided in the section on microphone recording.

The information we have thus far provided on the adjustment of recording level and dynamic range is equally applicable to any type of musical recording whether the program source is a microphone, or from radio, TV, phonograph, or another tape recorder.

Choosing your recording speed

Modern recorders provide a choice of recording speeds: 7½ inches per second (abbreviated ips), and 3¾ ips. When a speed of 7½ ips is employed, a 7-inch reel of 1200 ft. of standard-play tape will provide 30 minutes of uninterrupted playing time for each track. The second speed of 3¾ ips will provide a playing time of one hour for each track. The resultant economy is not achieved without some sacrifice of the excellent quality of which your recorder is capable at the higher speed. The maximum frequency response of your recorder is obtained at the 7½ ips speed. At 3¾ ips or any lower speed the high-frequency response is reduced, as may be seen from your recorder specifications. However, if the recording speed is carefully chosen to fit the program source to be recorded, you may have your cake and eat it too, since not all the program sources you will record require the wide frequency response obtained at 7½ ips.

When recording with microphones you can determine which speed to use by reference to *Fig.* 1-6. It is quite simple: If you determine that the frequency range of the instrument or combination of instruments you wish to record falls within a range, let us say, of 40 to 8000 Hz, the 3¾-ips speed can be used to obtain adequate fidelity with maximum economy. For example, when recording male speech, or the solo performance of a Bass Viol or English Horn, the speed of 3¾ ips can be used with no sacrifice of quality since none of these sources produces any frequencies above 8000 Hz. On the other hand, if you are recording an orchestra, a clarinet solo, or a soprano voice, only the higher speed (7½ ips) will provide the necessary fidelity.

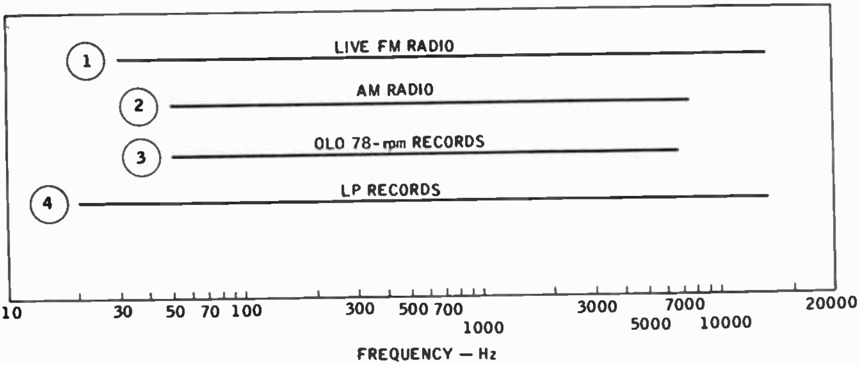

Fig. 2-3. Frequency ranges of a number of sound sources.

When recording from sources other than microphones, *Fig.* 2-3 should be used as a guide. Line 1 is the transmission range in Hz of a high-quality live-studio FM broadcast. When recordings are broadcast, the range of the transmitted music is, of course, limited to that of the record.

Line 2 illustrates the transmission range in Hz of a high-quality AM station. This seldom exceeds 7500 Hz; in fact this is an exception rather than the rule.

Line 3 is the frequency range of the older 78-rpm records. Even the finest seldom went beyond 7000 Hz. This range is also an exception, and most older electronic recordings never produced frequencies higher than 6000 Hz.

Line 4 is the frequency range produced by high-quality modern 33⅓-rpm LP records.

It becomes obvious that employing the 7½ ips speed for re-recording of old 78-rpm records and of AM broadcasts would be wasteful since the range they produce is well within the response of your recorder at its lower speed.

Chapter 3
Microphone Recording

Correct microphone placement is the basic secret of good recording. However, merely advising you as to how and where to place your microphones—as we intend to do basically—is not the complete answer, since each recording situation differs in accordance with the acoustics of the room in which you record.

Up to now we have considered only monophonic microphone recording. Recording in stereo is similar in many respects. All of the information provided on monophonic techniques is equally applicable to both mono and stereo recording. However, one additional factor must be considered—the degree of separation between the microphones for the various positions. The stereo effect is largely dependent upon this factor and the exact separation varies with room acoustics and the type of microphones employed.

When recording a single speaking voice in stereo, as you should do to start, the placement of the microphones should be determined by the manner indicated for mono recording, employing a separation of two to five feet between them. Make the first section of the recording with a separation of two feet; the next with a separation of three feet, and so on until you have reached a separation of five feet. Play this test recording back. When the spacing is too great you will encounter the effect known as "hole in the middle" in which the voice plays back through one speaker or the other, depending on where you stand while listening. The spacing should then be reduced to where the voice seems to come from a point midway between the two loudspeakers.

We will assume that all of our examples are to be recorded in a living room of average size—under five thousand cubic feet—with the microphones generally acquired with the recorders. All of the microphone distances suggested are given for average conditions and are basic figures.

Tape recordings may be grouped into four categories: the speaking voice, solo musical instruments, singing voice with musical accompaniment, and larger vocal or instrumental groups. The most common is the monophonic recording of a single speaking voice.

In recording a speaking voice, intelligibility is usually of paramount importance. Consequently, the microphone should be placed fairly close to the performer, unless special effects are required. A distance of between one and three feet is usually correct, with the exact distance dependent upon room acoustics. In a comparatively "dead" room, such as the average living room, the placement should be closer to the maximum distance to avoid the artificial, too-intimate sound characteristic of a small room. In a larger or more live room, the placement should be closer to the minimum distance to avoid the possibility of echo or reverberation. Microphone placement is, of course, also subject to the volume of the performer's voice. A loud, powerful voice will require more-distant placement than a comparatively weak voice.

When recording a single speaking voice in stereo, use the method indicated earlier. After a few attempts at stereo microphone placement you will notice that the optimum distance between the microphones and the performer will always be slightly less than for mono recording, since two microphones will pick up slightly more room sound than one. For all stereo recording where comparatively low-level sound-producing sources are employed, a preamplifier for each channel may be necessary at distances greater than three feet from the microphone.

Recording more than one person, as in a dramatic performance, or when adding sound to home movies or slides, can be made much more realistic by introducing aural perspective. The position of the lead voice is obtained, as outlined previously for a single speaking voice. This position is then employed as a key for the physical placement of the remaining performers.

To simplify the illustration showing suggested microphone placement, we use a square to indicate a microphone; the letter "M" inside the square indicates a mono mike, and stereo mikes are indicated by the letters "L" and "R" for left and right channels respectively. "C" represents an additional "center-channel" microprone for stereo. When used, "X" in a square represents an additional mike employed with a mixer.

When recording small dramatic groups in stereo, the microphones should be separated by six to eight feet as a beginning, with the distance from the lead performer the same, as shown at (A) in *Fig.* 3-1. All performers should be kept within a twenty-degree angle from the microphones. Move the microphones apart gradually until the "hole in the middle" becomes apparent and the sound level of the performers at the center of the stage begins to drop. Then reduce the microphone spacing until this effect is eliminated.

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. The important difference between the

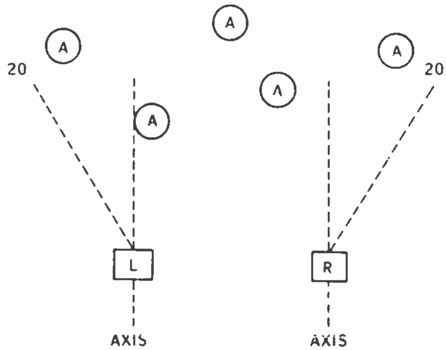

Fig. 3-1. Microphone position suitable for recording a small group in stereo.

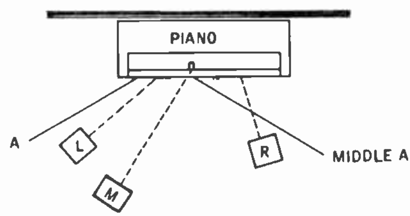

Fig. 3-2. Microphone placement for recording a piano.

two is the variation in the loudness or dynamic range produced by the instrument, and this must be considered when adjusting the recording level. The dynamic range of various instruments is shown in *Fig.* 2-2.

The most commonly used musical instrument is the piano. An earlier paragraph said, "Learn the characteristics of the instrument you wish to record." As an example of the variations you will encounter in recording musical instruments, we will explain, in detail, the different methods employed in recording the piano. There are two general types of pianos—the upright, with its smaller version, the spinet, and the grand piano, with its undersized counterpart, the baby grand. The upright and spinet will be discussed first.

We will assume that the piano occupies the usual position against the wall, as illustrated in *Fig.* 3-2. For mono recording the microphone is placed as shown with its axis directed between Low and Middle A for good tonal balance. Though this position is best for an intimate pickup it may give rise to another problem—the mechanical noise created by the keys may be picked up and recorded. To avoid this, the microphone should be placed on a stand at least two feet higher than the keyboard. This positioning will usually eliminate these mechanical sounds. When the piano is a conventional upright with a hinged top the noise problem is even easier to solve—merely place the microphone at a point about six inches higher than the top of the piano, and raise the top several inches. Because of the slightly greater volume of sound obtained, the microphone should be moved about six inches further from the instrument.

If the mechanical noise is noticeable when making an intimate recording of a spinet, the simplest solution is to move the piano at

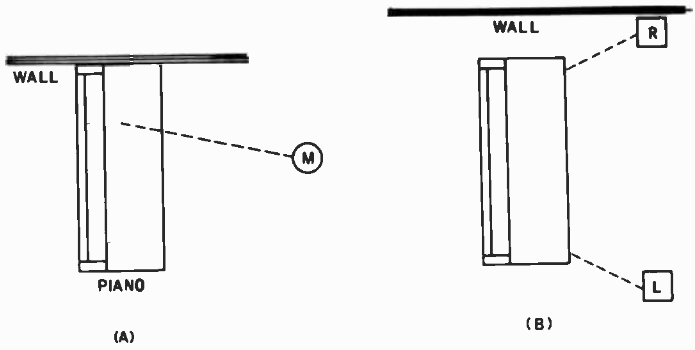

Fig. 3-3. Moving the piano at angles to the wall often helps in reducing mechanical noise of the keys.

right angles to the wall as shown at (A) in *Fig.* 3-3, with the microphone placed as shown.

When recording either an upright or a spinet in stereo, the microphones are placed three to four feet from the keyboard and separated by six to eight feet as shown at (A) in *Fig.* 3-2, with their axes angled inward. This placement allows the pianist the necessary freedom of movement and eliminates any possibility of his blocking the microphones with his body as he plays. If mechanical noise is noticeable, the solution is the same as for mono recording (see B in *Fig.* 3-2).

The best method of eliminating mechanical noise when recording a spinet in stereo is to move the piano at right angles to and away from the wall, as shown at (B) in *Fig.* 3-3. Place the microphones six to eight feet from the back, separated by the same distance.

The methods employed to record a baby grand also apply to the standard-sized grand, since for recording purposes they are similar. With both types, the sound issues from the side when the top is open; consequently we must consider the open side our sound source. When making a mono recording, place the microphone as indicated at (M) in *Fig.* 3-4. The intensity of the sound radiated from a grand is greater than that from an upright piano, so the microphone should be placed at a greater distance. For the baby grand a distance of five to six feet seems to provide the most satisfactory results. For the standard-sized grand with its 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—each note will be sharply defined, crisp, and clean. When the recordist wishes to create the illusion of in-

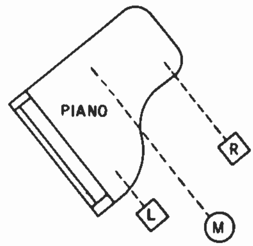

Fig. 3-4. Placement of microphones for recording a grand piano in either mono or stereo.

creased space and to obtain more blending of notes the recommended distances should be doubled. To obtain the illusion of concert-hall sound the distance between the instrument and the microphone should be again doubled. Changing the distance, as we have found, also changes the character of the recorded sound; the correct microphone position is the one which makes the recording sound most nearly like the original performance.

When recording either of the grand pianos in stereo, place the microphones as shown at (A) in *Fig.* 3-4. With the left-channel microphone about three feet from the keyboard and slightly to its right, place the right-channel microphone four to seven feet to the right of the left one. This placement provides an intimate pickup. If an illusion of increased space and more blending of the sound is desired, the microphones can be moved back to three or four feet and the separation increased by 50 per cent.

Recording the violin

The most popular of the bowed-string instruments is the violin. In order to obtain the maximum quality in a violin recording, the microphone should be placed as close as possible to the instrument without interfering with the performer. The distance will usually be two to three feet. Another limiting factor is the microphone position at which the noise of bowing becomes noticeable. When this occurs the microphone distance must be increased until the noise disappears. These remarks apply equally to all bowed string instruments such as the viola, cello, and the double-bass. However, since the sound output of any instrument increases with its size, the separation between the larger instruments and the microphone should also be increased slightly to compensate.

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 in mono it should be placed from three to four feet from the microphone. When the guitar is employed as a solo instrument the stringed face should be placed directly on the axis of the microphone to insure good high-frequency response. For a stereo recording of a guitar and ukelele the separation between microphones should be three to four feet and the distance from the instrument slightly less than for mono. The ukulele has about half the sound output of a guitar and therefore requires a slightly closer microphone placement; the spacing between the microphones remains the same.

The banjo and the mandolin should be included in this group. The banjo has a volume level considerably higher than that of a guitar. The volume level of a 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 separation between microphones for a stereo recording of the banjo should be four feet; for the mandolin it should be three feet.

The next group we will discuss consists of the woodwind and wind instruments. The most popular of the woodwinds are the saxophone and the clarinet. These instruments are highly directional in their propagation of sound at the higher frequencies; consequently they require exceptionally careful microphone placement for mono recording.

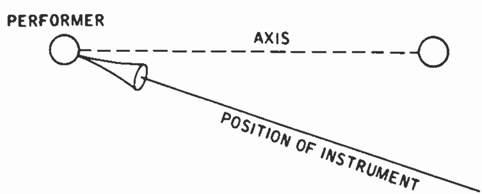

Fig. 3-5. Turning a wind instrument away from the axis of the microphone aids in recording high-level passages.

For solo monophonic recording, the bell of the 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 is to be recorded, the performer may turn his instrument no more than ten degrees off the axis, as illustrated in *Fig.* 3-5 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. The separation between microphones for a stereo recording of a saxophone, clarinet, trombone, or other brass instruments as a solo should be four to five feet, with the distance from the microphone slightly less than for mono recording.

Since the drums produce a larger volume of sound, they may be placed at almost any desired distance from the microphone for solo recording in either mono or stereo. The separation for solo stereo recording should be six to eight feet.

As 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.

We have assumed that the reader makes a recording while listening to the performer, and at the same time watching the recording-level indicator, and that this recording is then played back immediately to check for possible errors. This procedure is quite satisfactory for the simple recordings we have made. However, more accurate microphone placement, and consequently better recordings, are obtainable when earphones are used to monitor the program as it is being recorded.

"Liveness" in mono recording

Remember that the room will sound more live in a recording, especially in mono. Unless earphones are employed for monitoring the recording playback does not sound exactly as you heard it live, while recording. With earphones the recordist hears exactly what is being recorded and is able to make any necessary adjustments in recording level and microphone placement immediately.

Recording a vocalist is quite similar to recording a musical instrument in that we encounter practically the same problems. The volume of the singing voice, unlike that of a speaking voice, does not remain constant. The vocalist may at first sing loudly, then more softly, then loudly again. We must, as we did with musical instruments, allow for this variation in volume level because 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 monophonic 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 had 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 on the power of the singer's voice. A crooner will be discussed separately in a later paragraph.

When recording a vocal solo in stereo, the singer should be placed at a distance of eighteen to thirty-six inches from the microphones, which should be separated by about two to three feet. Then follow the procedure outlined for mono recording.

You may find that while recording bass and baritone voices your microphone will perform to your complete satisfaction. However, when you begin to record tenor, alto, or 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 registers.

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. 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.

Monitor with earphones

Earlier we explained the advantage of employing earphones while recording. They are even more valuable when more than one source of sound is being recorded—for example, a vocalist accompanied by a piano. It is very difficult to obtain the correct balance between two or more separate sound sources when listening "live" in the same room. The record-level indicator will show the combined level of all sound sources, but it will not show any relationship between them in level. When earphones are employed, both the eyes and ears are used together and can provide a more accurate indication of the volume balance.

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

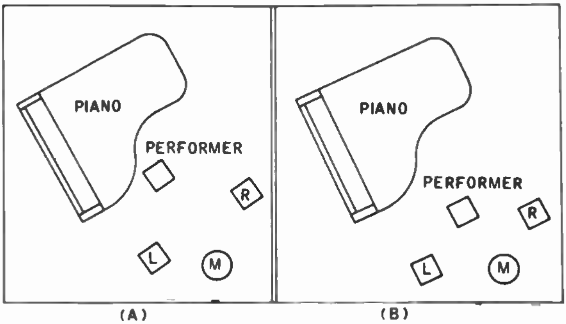

Fig. 3-6. If the piono drowns out the soloist with plocement shown in (A), move the performer closer to the microphones, os shown ot (B).

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 at (A) in *Fig.* 3-6, 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 at (B) in *Fig.* 3-6. Since 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 recording a vocalist with piano accompaniment in stereo, the same problem occurs. The microphone placement at (A) in *Fig.* 3-6 also results in improper balance between the vocalist and the piano, with the instrument again being recorded at too high a level. The solution is practically the same. However, microphone placement becomes much more critical since an additional factor must now be considered—the separation between microphones for optimum stereo effect.

The microphones are placed as at (B) in *Fig.* 3-6, their distance from the piano about seven to eight feet, and the separation between them about the same. These distances permit the vocalist to stand between the instrument and the microphones. The distance between the vocalist and the microphones is then varied until the best volume balance is obtained. Once the correct balance is achieved the separation between the microphones is varied for the best stereo effect.

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

Figure 3-7 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 three to five feet. A test recording should be made to determine tonal balance, and the singer or singers whose voices are too loud should be moved

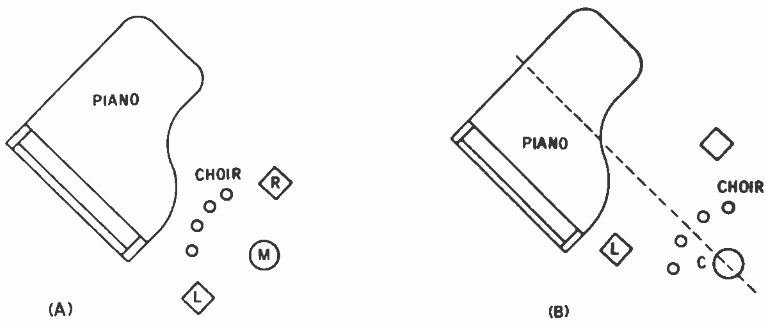

Fig. 3-7. (A) normal placement for recording a small group with a piano. (B) shows an extra microphone at C which can be employed with a mixer to improve balance.

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

When recording a small choral group in stereo, the microphones are best placed as illustrated in *Fig.* 3-7. They are separated by six to ten feet and placed about eight feet from the piano. With this positioning, the singers are moved closer to or further from the microphones to obtain the degree of vocal blending required. The closer the group is to the microphones, the greater the definition of the individual voices, and the less the blending. Changing this distance will, of course, also change the balance between the piano and the voices of the group.

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 instrumental group.

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.* 2-2 and described earlier. 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.

Recording "combos"

The musical groups most often recorded by the average person are the three- and four-piece combinations generally employed for small dances, weddings, and so on. The three-piece combination usually consists of piano, guitar, and a bass fiddle, which are arranged as illustrated in *Fig.* 3-9. The guitar is placed on the axis of the microphone at a distance of two-and-one-half feet. When a baby grand piano is used it is placed at an angle of 45 deg. 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 45-deg. angle to the left side of the microphone axis.

A four-piece combination is usually created by the addition of a saxophone which is placed in position X in *Fig.* 3-9 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.

Small three- and four-piece combinations are equally simple to record in stereo, with the performers placed as shown in *Fig.* 3-10. The microphones are separated by about six feet and placed at a distance of from two to three feet from the guitar. The stereo effect may be altered by changing the microphone spacing. It is interesting to note that commercial recordings employ a slightly different arrangement to obtain a more exciting effect by placing the brass and the piano on one side and the drums and guitar on the other—a sort of musical ping-pong effect.

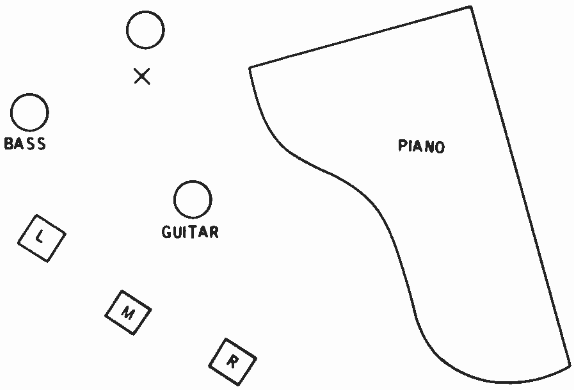

Fig. 3-8. Microphone placement suitable for recording a small combination of instruments.

All of our previous examples have employed a single microphone for mono 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 immeasurably 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 units into the microphone input of the tape recorder. The mixer allows the user to obtain more-exact volume balance from sound microphone separately.

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.* 3-9. 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.

Earlier in this chapter—(B) in *Fig.* 3-6—we illustrated what in

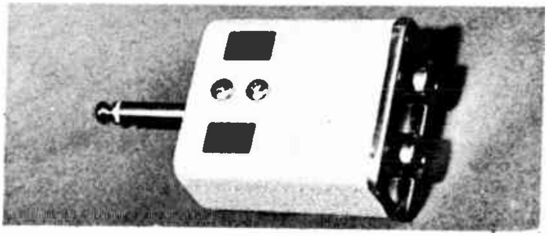

Fig. 3-9. Inexpensive accessory which permits mixing two microphones into one input on the recorder.

Courtesy Switchcraft, Inc.

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 in *Fig.* 3-10. 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 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.

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.

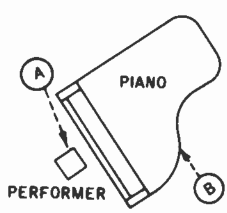

Fig. 3-10. Suggested use of cardioid microphones, which are directional, to separate sound sources.

Chapter 4

"Dubbing" from Records

The ability to re-record 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 one and a half 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 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 or slides, exactly as it is done in broadcasting, TV, and professional motion pictures.

A tape recorder is 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 and is no longer available. 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. Extraneous noise can usually be eliminated or considerably 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. In addition, many of these older recordings are quite rare. For example, the Europeon Xonophon recording of Battistini brings about $300 for a good copy. Collectors even pay substantial sums for tape copies.

The owners of these rare recordings are usually quite happy to obtain a copy on tape, and in exchange often permit you to make another for yourself. You often can also make arrangements to make copies for sale, paying them a percentage on each copy. They can usually advise you of possible clients among their fellow collectors. Many recordists finance their hobby by providing these services to record collectors who may be contacted through the various music societies and clubs.

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 and orchestras. 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 program guides which are available from many FM stations and "good music" AM stations will simplify your selection of the particular music you wish to record and add to your collection.

Don't Tread On the Laws! The average tape-recording family is in about as much danger of running afoul of the law as it is in danger of contacting bubonic plague. All the same, there's always a possibility that some member of the family will unintentionally make a legal error—and an even more remote possibility that someone else might make an issue of it. And so, since "ignorance of the law" is truly a weak-tea consolation when a judge becomes involved, it's only good sense to know the things one must *not* do with recordings.

If you record music or spoken broadcasts only for your own family use and never for profit or wide distribution to your friends without profit, there's little likelihood of copyright laws becoming a problem to you. Nevertheless, here are some facts to keep in mind. For instance, if you or some other member of your family decides to tape some dance music off the air for use at a prom where admission will be charged. . . .

Music, lyrics, broadcasts, and the like are almost always copyrighted. Under the U.S. copyright laws, protection for the originator, owner, or the like, lasts 28 years. This period can be extended another 28 years before the music falls into the public domain where it can be used by anyone without permission from the owner.

Watch those new arrangements!

A possible catch in the public domain situation lies in the fact that a new group of artists can do a new arrangement for a record or broadcast. This adds up to a new and unique work which can be protected again. To put it another way, J. S. Bach has been gone for over half a century, hence his material might be considered as being in the public domain. If, however, you were to tape any of his works "live" off dics, radio, or TV, and then make a profit selling or widely distributing them in any other way, you'd be risking trouble. Normally everyone connected with the work you taped (performer, broadcaster, manufacturer, and so on) is covered by legal rights. It is likely too, that they have to pay a percentage to those who hold rights prior to their own.

Even if a work is unpublished and unregistered in the U.S. Copyright Office, the creator has an unlimited copyright under common law which protects him until his work is published.

Suppose, then you wish to copy records or make tapes off-the-air for sale or free distribution to your friends, or that for a convention shindig you decide to tape material on which a profit will be made for the creative or intellectual work of others. What should you do?

You should obtain written consent to use the material you need. It may involve a flat fee or royalties paid to the right parties. If obtaining permission leads into more red tape than you care to slice, have a lawyer take care of the details for you. As a matter of fact, the fee an attorney will charge is usually reasonable and may well be a good investment in peace of mind.

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 styli. 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 the records and only constant care can reduce their effects. However, when recording on tape, all may be reduced or eliminated permanently, and the resultant tape will be reasonably noise-free and never require attention to keep it in this condition.

When these three factors are considered, you can make recordings on tape which compare with the best commercial records made today.

How the stylus works

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 15,000 times per second. This side-to-side or lateral motion is illustrated at (A) in *Fig.* 4-1 which is a view of the record groove and the stylus tip from

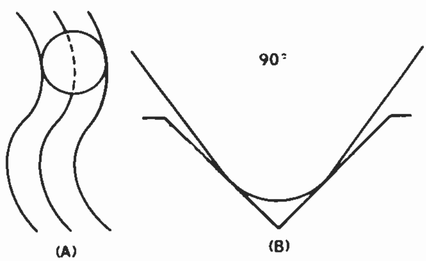

Fig. 4-1. Stylus tip correctly tracking a record groove.

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.

As can be seen at (B) in this figure, the stylus touches the groove walls at only two microscopically small points. Any friction and the re-

Fig. 4-2. How a stylus tip wears—(A), front view; (B), side view; and (C), a new stylus.

Fig. 4-3. Progressive wear of a stylus tip increases sizes of the "flats" worn on the tip.

sulting 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. In *Fig.* 4-2, (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 illustrated at (B). This is a diagram showing a microscopic stylus tip which is worn. It may be compared with the new tip shown at (C).

Figure 4-3 illustrates the progressive wear of a stylus tip. 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 on tape.

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* 4-4 shows the cross-section of two stylus tips at the point of contact with the groove walls. (A) is that of a new tip; (B) is that of a worn tip. We can see that (B) is no longer the perfect circle required.

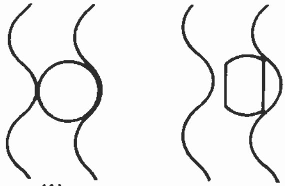

Fig. 4-4. (A), new stylus tip fits groove perfectly; (B) badly worn which does not fit groove will damage your records.

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 inside of the record, and 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 325 hours, assuming it is diamond. When re-recording 78-rpm records the time given may be doubled.

Stylus for 78-rpm records

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 gives 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 become 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 Vinyl 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.

Record cleaning

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 smaller than .0005 inch) and remove particles of stylus dust which are submicroscopic 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 is manufactured by Robins Industries Corp.

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 Vinyl 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 several products available which eliminate or reduce static electricity. The author has found the material shown in *Fig.* 4-5 to be excellent.

Fig. 4-5. Commercial product which reduces static charge on phonograph records.
Courtesy Robins Industries Corp.

The first step in the actual re-recording of a record on tape is to determine the optimum recording level; i.e., the correct setting of the record-level control for the particular disc being recorded. This setting varies from record to record and from section to section depending upon the dynamic range of the music recorded on the disc. The subject of dynamic range was discussed in detail in Chapter 2.

The optimum recording level is easily obtained by playing the record in its entirety with the phonograph connected to the tape recorder as outlined earlier. 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, or advance it if running below 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.

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. When recording in stereo from stereo discs it is easier to perform the preceding operation twice (once for each channel) than it is to attempt to watch both record-level indicators simultaneously.

After the optimum recording level (and channel balance in stereo) has been determined, proceed to record in the normal manner. This method of copying commercial records on tape will insure recording at the maximum undistorted level and provide the full dynamic range. Do not attempt to conserve tape by stopping the tape-transport mechanism between selections since editing can be done much more accurately after the recording is completed.

For the recordist who is interested in improving the quality of the material originally recorded on the disc, we have provided additional information on this aspect of the subject in the chapter on editing.

Chapter 5

Off the Air Recording

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 regularly being broadcast by FM and AM "good-music" stations throughout the country. You can obtain recordings of once-in-a-lifetime broadcasts by famous artists and orchestras. The New York, Boston, and Philadelphia orchestras broadcast regularly in stereo. There are many broadcasts of leading music festivals throughout the country. You also have at your disposal the large record libraries which these stations possess and broadcast regularly. Subscribing to the program guides which are available from these stations will simplify locating dates and times when the music you may wish to add to your collection is being broadcast.

In the event your local stations carry simultaneous broadcasts on FM and AM of the programs you are interested in recording, the use of the FM signal is preferable since both its quality and frequency range are usually superior and interference is usually considerably less. Regardless of which signal is employed for recording, a good roof antenna (where possible) will greatly improve your reception and will provide superior recordings. In the event your location is more than 20 miles from the radio transmitter and you are interested in stereo recording "off the air," a multi-element, directional antenna, such as is illustrated in *Fig.* 5-1 is virtually a necessity. Most recordists do not realize the improvement which can be obtained in FM and particularly in FM stereo reception by employing an antenna system specifically designed for the purpose.

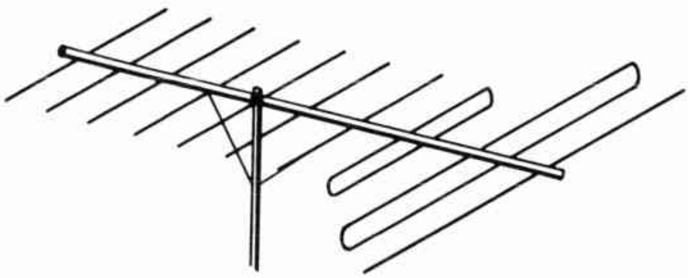

Fig. 5-1. Directional antenna considered a necessity for recording FM programs "off the air."

Most FM listeners with otherwise high-quality equipment are not enjoying the full-range distortion-free programs provided by the FM broadcasters because of inadequate antenna systems! They are under the misconception that the full potential of FM can be obtained with either the built-in or line antenna or, at best, a rabbit-ear antenna, if a *very sensitive tuner is employed.* This is not so! The over-all effectiveness of a system for FM reception is limited by the noise inherent in the receiver; therefore, it is advantageous that the incoming signal be as large as possible before reaching the receiver. A simple analysis of the FM signal received by the tuner will show why and will help explain exactly what can be done to realize the full potential of FM reception.

Ninety per cent of the tuners in use today are employed in urban or suburban areas where one or more local stations provide a satisfactory signal level at the antenna. These signals may have levels of between 1000 microvolts (considered to be the minimum for the prime service area of an FM broadcaster) and perhaps a million microvolts (μV). Under these conditions, almost any tuner would provide adequate reception were it not for other factors not generally taken into consideration.

First, there are exceptions to this ideal condition *even within the so-called prime service area of the station.* There may be obstructions lying in the direct path between the receiving and transmitting antennas, such as hills, mountains, larger buildings, or even trees. All will absorb and/or deflect the desired signal to a greater or lesser degree, with the result that your specific location receives only a portion of the original signal, perhaps 500 μV, while the transmitter provides adjacent areas not in the shadow of obstructions with a level of 1000 μV. This, incidentally, is one of the reasons why FM broadcast antenna are usually located in the highest point within their service areas. The Empire State Building in New York is a good example. There are few obstructions high enough to interfere with signals from the antennas mounted on it. However, most good tuners would still provide adequate reception even with the reduced signal strength, *if there were no noise pickup.*

The threshold of signal

Signal strength is not the only problem involved. FM reception is noise free only when the received signal is above a certain threshold level. Below this level, background noise and hiss interfere with reception. This threshold level in FM reception is the point at which the noise being fed into the tuner by the antenna is equal to the level of the signal being fed into it. This noise affects reception in the following manner: The signal strength of the desired station is, say, 500 μV in a specific area; however, the noise may also be 500 μV. Satisfactory reception is impossible for the signal-to-noise ratio is 1 to 1. If, however, the transmitter were to suddenly double its power to 1000 μV, and the noise remained at the same level, reception would become satisfactory, for the signal-to-noise ratio would increase to 2 to 1.

Where does all of this noise come from? The noise is a composite of all of the electrical interference created within a 360-deg. radius of the antenna by power line switches, motor commutators, and the ignition system of motor vehicles. The noise created by just one automobile can be as much as 1000 μV at a distance of up to 500 feet. Suffice to say that peak noise picked up by your antenna system may be between 30 μV in suburban areas and several hundred μV in the city. If, on the other hand, it were possible to reduce the noise pickup to 250 μV, with the signal remaining at 500 μV, reception would also improve since the signal level is again twice that of the noise and the ratio again increases to 2 to 1.

Obviously, the first key to good FM recording is the signal-to-noise ratio. Any means employed to increase this ratio will result in improved reception. We have seen that this ratio can be increased in two ways—one by actually increasing the signal being transmitted, and the other by reducing the amount of noise picked up. Both are obviously impractical. However, there is a practical method which in effect can more than double the received signal strength while at the same time reducing the noise picked up by at least fifty per cent.

Use a directional antenna

The simplest method of accomplishing this is to employ an antenna which is more directional than the commonly used dipole. The more directional the antenna the higher the level of the signal that will be picked up. Actually the signal received can be increased as much as twenty times with the proper antenna when it is pointed toward the location of the transmitter. As the gain of the antenna is increased the narrower its pickup pattern becomes and the more important it becomes to point it directly at the exact source of the signal. You will notice that we said exact source of the signal; there are locations where the direct path between the transmitter and the receiving antenna is blocked by an obstruction to the transmitted waves and the best signal is obtained by reflection from a nearby structure. Under these circumstances the antenna must be pointed *away* from the transmitter and toward the reflecting structure which to all intents and purposes becomes the signal source.

A highly directional antenna, because of its selective nature, also improves reception in another manner. Just as it is selective to the area from which it will pick up a desired signal, it is also selective to the area from which it will pick up noise. Noise in a reception area is generated within a 360-deg. radius. The directional antenna will only pick up the noise generated within a small sector of this area; in consequence, only a portion of the noise which would be picked by an omnidirectional antenna will reach the tuner.

We have thus far obtained a twofold advantage through the use of a directional antenna. First, it increases the received signal strength. Second, it reduces the amount of noise picked up, thus increasing the signal-to-noise ratio considerably.

Multipath distortion

The third and perhaps the greatest deterrent to good FM reception is multipath distortion. This form of distortion is simple to understand when the FM transmitter is visualized as a searchlight and the various objects surrounding the receiving antenna, hills, buildings, trees, and so on, as reflectors. The light reaches the reception point, not only along the direct path, but also along the paths of reflection from the various obstructions acting as reflectors. The reflected light or signal, however, reaches the reception point a micro-second or so later and creates a second or "ghost" signal which either cancels or augments part of the original signal, thus distorting it. This effect is simple to understand if we consider the "ghost" images on a television screen and the distorted pictures they make. In FM reception these "ghost" signals create audible rather than visual distortion in exactly the same fashion.

The simplest method of eliminating or sharply reducing multipath distortion is to eliminate or reduce the intensity of the "ghost" signal which invariably comes from a different direction than the desired signal. Again the directional antenna provides the solution; since just as with noise, it discriminates against the signals from any direction other than that to which it is pointed. Now the requirements for the antenna become even more rigid; it should be even more directional and pick up as little signal from the rear as possible.

Each of the problems we have discussed becomes even more acute when we consider stereo FM reception. When an FM station transmits a stereo program there is less power than in a monophonic signal, so the station is weaker. The loss in power is actually about 20 dB, or, stated more simply, the antenna receives only 1/100 as much signal as it would from a monophonic transmission. This will explain why the listener who enjoyed excellent monophonic FM reception may be dissatisfied with his stereo reception. For example: if the monophonic signal from a particular station were 1000 μV, and it put on a stereo program, the signal at the antenna would drop to 10 μV. Thus, if the noise in the receiving area were only 10 μV—a negligible amount when compared with the monophonic signal—the stereo signal would have a signal-to-noise ratio of 1, making reception unsatisfactory for stereo. Under these circumstances the use of a high-gain antenna or some other method of boosting the signal strength is imperative.

The multipath distortion problem is much more prevalent and conspicuous in stereo FM too. It has caused more dissatisfaction with stereo reception than all of the others combined and is often blamed on the FM station itself or its recordings, or the receiving components, particularly the tuner. It manifests itself as muddy reproduction of the mid frequencies, harsh rasping highs, reduction in channel separation, and complete elimination of the stereo effect. Actually the *unjustified complaints* to manufacturers of stereo equipment have been so numerous that some, in self defense, have incorporated multipath distortion indicators in their tuners so that the owner could see the true reason and put the blame where it belongs, not on the tuner.

Unfortunately, there is a problem connected with an antenna of the type we have been discussing. It occurs when there is more than one FM station serving an area, since they very rarely lie in the same direction from the receiving antenna. This complicates matters since the more directional the antenna is the less efficient it becomes in receiving signals from any direction other than the one in which it is pointed. This fact, previously to our advantage, now becomes a detriment. The problem can be solved by the use of an antenna rotator which turns the antenna to any desired direction by remote control from the receiver position.

Importance of the "warm-up"

The first step in actually making a recording "off the air" should be to tune the receiver or tuner to the station broadcasting the desired program about fifteen minutes before the program is broadcast to permit the set to warm up. This will reduce any possibility of it tuner "drifting" off the station while you are recording. Next make a test recording of whatever music the station is broadcasting at the moment. While making this test watch the record-level indicator closely and adjust the record-level control so that the indicator does not show over-load on any peak passages. This is not quite as difficult as when re-recording phonograph records since you have an unseen assistant—the control engineer at the station—who is doing exactly the same for other reasons. After you have recorded for 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, which it should not be, it was made at too high a level, and the test should be repeated, with the recording level reduced slightly. Continue this experimentation until you can get good recordings consistently.

The level setting obtained in the manner just outlined is arbitrary since there is no exact method of anticipating the peaks on the following program or even the next selection of 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 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. If, by chance, something should go wrong during the broadcast and the control engineer is napping, any increases in level should be made during crescendo passages along with the natural level increase of the music. In reverse, where you find the recording level is too high it should gradually be reduced during a diminuendo passage. This method of control will make any changes in level practically unnoticeable.

Many station program guides include the playing time of each selection to be broadcast. This information is valuable since it will enable you to determine in advance the amount of tape required. It is most unpleasant to arrive at the end of a reel in the middle of an otherwise perfect recording of a symphony. When the program is a long one, use double-play tape which provide up to one hour of recording time on a 7-inch reel, and few programs are longer than this. Do not attempt to conserve tape by cutting out commercials or other unwanted sections, since this can be accomplished in a more thorough and professional manner by editing after the recording is completed.

Just as in re-recording from records, there are problems involved at the beginning and end of each selection. For example, the simplest program to record is a "live" studio broadcast without an audience. However, a quick talking announcer or master of ceremonies can complicate even this simple recording. He may begin talking just as the music ends or keep talking until the first note of the succeeding selection is played, so it would be impossible to stop or start the tape transport mechanism at a break between the voice and music. It is much simpler to record everything and remove the superfluous parts afterward by editing.

Chapter 6

Tape Editing

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 heard. The only tools required are a pair of scissors and a roll of splicing tape. It is extremely important that the scissors not be magnetized since if they are they will create an audible click or thump at the spot where the tape is cut. Use only splicing tape expressly designed for this purpose. There is a special adhesive on this type of tape which will not ooze out under pressure and cause a sticky splice as do ordinary household tapes. A sticky splice will cause the layers of tape adjacent to the splice to stick to it and create a momentary slowdown of the tape transport mechanism, resulting in an audible "wow" on playback. *Figure* 6-1 illustrates the four steps in making a simple splice on tape. First cut the tape diagonally at a 45-deg. angle with

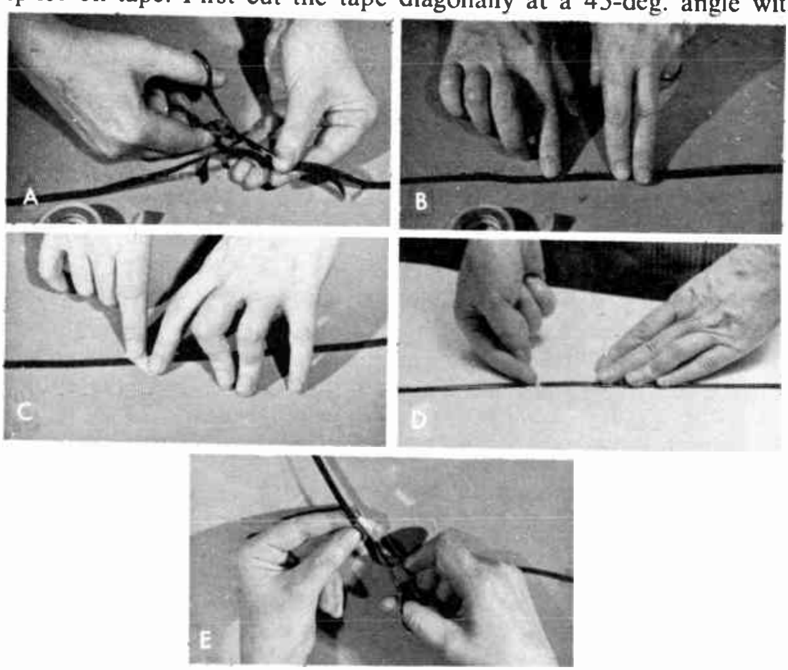

Fig. 6-1. Steps in making a tape splice. (A), making the 45-deg. cut; (B), butting the two ends together; (C), applying the splicing tape; (D), burnishing the splice; (E), trimming the "waist."

some overlap, as shown in (A) so that the ends will line up exactly. Cutting the tape diagonally reduces the possibility of hearing the splice on playback. Step two is to lay both ends of the cut tape, shiny side up, on a smooth piece of wood or plastic. The two ends should be placed in perfect alignment, with no space between them, as shown in (B) and (E). Then cover the joint with splicing tape, as illustrated in (C). The splicing tape should be pressed on firmly and burnished with the flat of a fingernail to secure the ends evenly. Any excess splicing tape is thén removed as in (D). The possibility of a sticky splice may be further reduced by cutting into the tape backing very slightly creating a "waist" at each edge as illustrated in (E).

As may be seen, tape splicing is quite a simple operation. However, it can be made even more so by employing a splicer of the type shown in *Fig.* 6-2. This unit cuts the tape to an exact 45-deg. angle which can be matched precisely to a second cut. It also provides you with another pair of hands, since two fingers hold the tape accurately during the cutting, butting, and actual splicing operations. A second blade—actually a pair of blades—creates the tiny "waists."

Fig. 6-2. Commercial tape splicer which simplifies the job of splicing.
Courtesy Robins Industries Corp.

The simplest material to edit is human speech. You can easily remove or insert paragraphs, sentences, words, or even syllables. This type of editing is done by taking advantage of the silent periods which occur between words and syllables in all speech. The first thing you must do is to find two of these silent periods, one at each end of the section to be eliminated. The simplest method of accomplishing this is to locate the end of the last word of the material to be retained. Play the recording back until this point is located. Do not move the tape any further. With an orange colored china-marking pencil, mark the tape at this point. The spot to be marked is always exactly over the playback head gap. If necessary, a more convenient method of locating the marking point can be employed. Some easily accessible position is found outside the head cover. This may be the point at which the recorded tape first appears from under or behind the head cover, as illustrated by the arrow in *Fig.* 6-3. Then measure accurately the exact distance from the chosen point to the gap on the playback head. Let us assume it is two inches.

Fig. 6-3. Simple method of locating a marking point. Measure the distance from the gap to the side of the head cover, a point which is usually more accessible than the gap itself.

Now mark the tape at the point previously chosen, in the present case the side of the head cover to which the arrow points. Do not cut the tape at this point! Measure off two inches in our case—in yours it will be the distance you have previously determined—to the left of the point marked. This is the exact spot at which the word ends. Next move the tape forward, by hand until the first word of the section to be retained is heard. Mark this position as previously explained. You now have a visual indication of the points at which one word ends and the next word to be retained begins. It is now a simple matter to cut the tape at the silent periods immediately following and preceeding the splice and thus eliminating any unwanted sections. For this type of editing, the cut should be at right angles to the sides of the tape, rather than at 45 deg.

Another simple method of joining two tapes occurs when editing a series of recordings made from a group of unrelated records. The tape, if it has been recorded from an automatic record changer, will have gaps between each recording of ten to twenty 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 player is employed, the pause between selections is often even longer because of the time it takes to remove one record and put another one on the turntable.

The primary reason for editing the tape between selections is to shorten the time lapse between the two pieces of music. When employing a tape speed of 7½ ips, a ten-second time lapse represents 75 inches of tape between the end of one selection and the beginning of the next. The length of tape on which there is no music is usually greater than this since it varies with the length of the run-in and run-out grooves of the records themselves. A splice may be made anywhere between the two marked points, leaving a total of 37½ inches of tape between them. At the 7½-ips speed this reduces the pause to an acceptable five seconds. This method is quite satisfactory for editing unrelated selections since any variations in the transitions between records are concealed by the five-second time lapse.

As explained earlier, when uninterrupted recording of a complete opera or symphony is required, the editing becomes slightly more complicated due to the various types of transitions employed from one record or side to another. The first type of transition takes advantage of a pause in the musical score and presents no problems. The tape is merely cut at the end of the background sound made by the run-out groove, and at the beginning of the background sound of the run-in groove of the next record or side. This 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 when editing this type of transition is that of excessive reverberation time which follows the last note of the music, and may have a duration of two to three seconds, resulting in an unnatural interruption. The adverse effect of high reverberation time can be minimized by reducing the duration of the last note to one second, simply cutting out the remainder. In this length of time the intensity of the note has faded sufficiently to make the alteration almost unnoticeable, particularly when it is immediately followed by another sound.

The second type of transition usually occurs in a 78-rpm record album. On one side, the music is cut at the end of a note and it is resumed on the following side or record, usually at a point four or five notes before the earlier cut. Where a movement, act, or aria is cut in two it is usually quite simple to join the two sections by finding the first 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 is accomplished quite simply by cutting out all of the unrecorded tape between records and making a temporary splice as illustrated in *Fig.* 6-4, at the point at which one side of the record ends and the other begins. Then play back this section of the tape at normal speed while listening carefully for any duplication of notes. If duplicate notes are heard, they can then be removed by cutting and the two ends then joined with a permanent splice.

The third type of transition is one in which the music ends with a

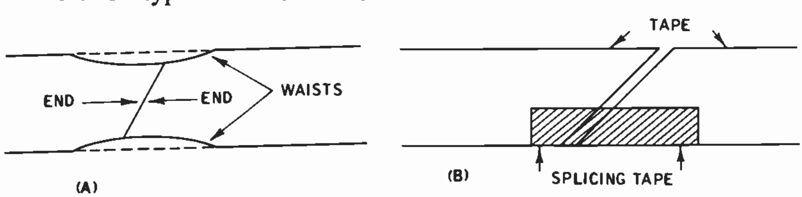

Fig. 6-4. (A), a finished splice, showing the "waists." (B), a temporary splice, using only a small piece of splicing tape.

fading out passage on one record or side, while the following record or sides fades in with the same passage. As previously mentioned, the first note of the fade-out passage and the last note of the fade-in passage are the same, both as to score and volume level. By employing the procedures described earlier, the surplus music is removed, the remaining ends are joined of course, eliminating the duplicate notes.

Occasionally this simple editing job is complicated by a fast-talking announcer. 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, incidentally, was the 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 ½ inch of tape without affecting the sound adjacent to the erasure. An editing pencil is simply a very small erase head with its gap in a tip shaped into a point.

Open the temporary splice and lay the tape on a nonmagnetic surface. Press the button on the editing pencil and gradually bring it forward toward the very end of the tape, then withdraw it gradually. Do not allow the pencil to come closer than ¼ inch from the mark or you will 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. The finished tape will sound more natural if there is a five-second pause between selections.

When a broadcast which plays to a studio audience is recorded, editing the end of a selection becomes slightly more complex on account of the applause, which 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 means. 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 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 five seconds, we will assume two seconds as an average. This means that at 7½ ips an average of 15 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. From this point on the tape usually has 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, and remove the tape from the recorder. Then cut the tape at 90 deg. in the exact center of each mark representing a hand clap. Trim the two ends about 1/64 of an inch, and join them with a temporary splice. If it is found on playback that the hand clap is still noticeable, remove the splice and clip the tape again. The click occupies about 1/16 of an inch on the tape at 7½ ips, so very little tape need be removed.

Editing any tape recording becomes quite simple, and the editing will pass unnoticed if the recordist, when making a "live" recording, 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 number of ways, such as by a change in acoustics when the recording locations are different, a difference in the type of background sound, the sudden elimination of some background sound, or the sudden appearance of a background sound not on the previous section of tape.

As explained earlier any change in the acoustics of the recording location results in a definite and noticeable change in the character of the recorded sound. This change in the 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 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 up a line, all of the performers should be asked to go back to a point just before the fluff was made and start all over. It is then a 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 should be recorded under the same conditions and in the same location as the original if it is at all possible. However, since this method of ensuring the same background is not always practical, the recordist can "fake" it by using a room of similar size and acoustics. When doing this, remember that the apparent acoustics of a room can be varied by a change in the microphone position as described in Chapter 3. By careful choice of microphone position the teacher can often make a duplicate section which cannot be detected when inserted in the original tape.

Record some "extra" background

As mentioned, a splice will also become quite noticeable when there is a difference in the type of background sound; for example, suppose you have recorded the songs of a number of birds and, after listening to the recording at home, you decide to identify them with your own commentary. Normally you would proceed to record the desired commentary in a nice quiet location in your home and splice it in the proper position in the original recording. You will usually be surprised to discover that regardless of how well both recordings were made, the finished result sounds amateurish. The sections recorded at home stand out like the proverbial sore thumb.

The difference is so noticeable simply because there is no background sound or a different background 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, even traffic on nearby roads, an occasional airplane overhead, and so on. 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 conscious of it.

If the recordist had taken the precaution of recording a few minutes of background sound alone, 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 if the birds had performed at his command and what is more important, as though the comments were actually made on location.

Chapter 7

The Tape You Use

There is a large variety of tape available today. Since one may serve your particular purpose better than others we will attempt to explain their various differences, their advantages and possible disadvantages. Three basic ingredients are combined to make all modern recording tape—iron oxide particles, a liquid binder, and a plastic-base film. The oxide particles must be extremely tiny and uniform. In fact in modern tape they measure one micron or less—so small that many millions of them are on each inch of tape. These oxide particles and a liquid binder are combined to form a coating which is applied to the plastic base in thicknesses which vary from 0.18 to 0.65 mils (thousandths of an inch), depending on the magnetic requirements. The thickness of the plastic film base is also varied from 0.5 to 1.5 mils to provide the desired physical characteristics. In addition to thickness, the magnetic and physical characteristics of the finished product are dependent upon: (1) the formulation of the coating, (2) its density, (3) the base material, and (4) its relative smoothness.

The most commonly used tape has 1200 feet wound on a 7-inch reel and provides approximately 30 minutes of recording time per track at 7½ ips. This tape consists of a 1.5 mil cellulose acetate or Mylar* base to which has been applied a coating 0.5 mil in thickness.

The primary reason the average recordist becomes interested in other types of tape is to obtain additional uninterrupted recording time on the same size reel at the same speed. Obviously, the simplest method of doing this is to reduce the thickness of the base to 1.0 mil, which allows more tape to be wound on the same size of reel. However, to increase the recording time as much as 50 per cent it is also necessary to reduce the thickness of the coating slightly, and when we change the thickness of the base we also alter other physical characteristics.

The physical characteristics of tape—its strength, playing time, stability (the maintenance of its original characteristics with age), and its resistance to temperature/humidity changes are primarily dependent upon the base material and its relative thickness. Two plastics—cellulose acetate and polyester, which will be discussed shortly—are in common use today. Some manufacturers employ their own variations of the basic formulations. Each type of film and its

* DuPont Trademark for its brand of Polyester Base.

variations has its own advantages. We will attempt to explain these so that the recordist can intelligently choose the type which serves his purpose best.

One of the most important differences between the various thicknesses and types of plastic bases is strength. Tape is subjected to various stresses and tensions, such as those created by the supply and take-up reels, quick starts and stops, fast wind and rewind, particularly the latter when shifting rapidly between fast forward and reverse. The tape must be capable of handling these various tensions without stretching or breaking.

The strength of tape is judged in two ways—*yield strength,* which is the force required to start stretch and physical distortion of the tape, and *break strength,* which is the force required to break the tape. Of the two, yield strength is the more important to the recordist—a stretched tape introduces distortion in reproduction and changes the recorded frequency in the stretched section. To employ an extreme example for the sake of illustration: if a section of tape is stretched to twice its originally recorded length, the signal which was originally recorded as a 1000-Hz signal will be reproduced as 500 Hz, since at a given speed it will take twice as long for the signal to pass the playback head on reproduction. While this is an extreme example it does indicate the distortion which can result from a stretched tape. Nothing can be done to rectify this condition once it occurs except to cut out the stretched section, thus eliminating part of the original recording. A break, on the other hand, can always be spliced and does not always affect the reproduction.

The differences in both yield and break strength between 1.0- and

	YIELD STRENGTH, lbs.		BREAKING STRENGTH, lbs.	
	50% Humidity	90% Humidity	50% Humidity	90% Humidity
1½-mil ACETATE	5.0	3.0	5.5	4.1
1-mil ACETATE	3.7	1.8	3.9	2.5
1½-mil POLYESTER	6.3	6.3	14.5	14.5
1-mil POLYESTER	4.2	4.1	7.6	7.6
½-mil POLYESTER	2.0	2.0	2.9	2.9
½-mil "TEMPERED POLYESTER"	4.0	4.0	6.0	6.0

Fig. 7-1. Physical characteristics of different tape base materials.

1.5-mil cellulose acetate tape are illustrated in *Fig.* 7-1. The 1.0-mil tape is an excellent choice where extended recording time is required and economy is a factor. When 1.0-mil acetate tape is handled with a reasonable care (no instantaneous switching from fast forward to fast rewind), it will perform very well and provide 50 per cent more recording time at little extra cost.

In the never-ending search for longer playing time and increased strength, a polyester-base tape was developed which would provide 50 per cent more playing time without any sacrifice in strength. As may be seen from *Fig.* 7-1, the 1.0-mil polyester tape is superior to the 1.0-mil acetate tape in both yield and break strength. However, its cost is slightly higher. The added safety factor and increased resistance to temperature/humidity changes is well worth the slight difference in cost. When low-humidity conditions are encountered, acetate-base tape will shrink. In extremes of heat and cold this type of base also has a tendency to become brittle, increasing the risk of breakage. Acetate expands much more than polyester at increased temperature and humidity, which simply means that polyester is less susceptible to aging.

The use of polyester for a base material also makes it possible to obtain a recording time of 1 hour on a 7-inch reel at 7½ ips. This is not true of a cellulose acetate base since the thickness must be reduced to 0.5-mil and it would be much too fragile. Actually the 0.5-mil polyester-base tape must be handled quite carefully since, as may be seen from *Fig.* 7-1, it is not quite as strong as the 1.0-mil cellulose acetate tape.

When it becomes necessary to obtain 1 hour of recording time at 7½ ips on a 7-inch reel we would suggest that the new "treated" 0.5-mil polyester tape be employed. This tape is even stronger than the 1.5-mil cellulose acetate tape in most respects.

The combination of new oxide formulations which permit coatings as thin as 0.18-0.19 mils and "treated" 0.5-mil polyester bases have made it possible to obtain 7-inch reels of tape which allow 1½ hours of recording time per track at 7½ ips. This tape is also stronger than 1.5-mil cellulose acetate tape in most respects.

Figure 7-2 provides the recording times for the various lengths of tapes that we have discussed.

The magnetic characteristics of tape—frequency response, output, and print-through levels—are primarily dependent upon the type of coating employed and its thickness. There are three basic types in use today—the standard "red oxide," a high-output coating, and a low-print-through coating.

The standard "red oxide" coatings are employed on bases of vari-

Recording Tape—Record / Play Time

To The Nearest Full Minute

NO. OF FEET	NO. OF TRACKS	SPEED IN INCHES PER SECOND				
		15	$7\frac{1}{2}$	$3\frac{3}{4}$	$1\frac{7}{8}$	$\frac{15}{16}$
	1 Track	1 hr. 4 min.	2 hrs. 8 min.	4 hrs. 16 min.	8 hrs. 32 min.	17 hrs. 4 min.
4800	2 Tracks	2 hrs. 8 min.	4 hrs. 16 min.	8 hrs. 32 min.	17 hrs. 4 min.	34 hrs. 8 min.
	4 Tracks	4 hrs. 16 min.	8 hrs. 32 min.	17 hrs. 4 min.	34 hrs. 8 min.	68 hrs. 16 min.
	1 Track	48 min.	1 hr. 36 min.	3 hrs. 12 min.	6 hrs. 24 min.	12 hrs. 48 min.
3600	2 Tracks	1 hr. 36 min.	3 hrs. 12 min.	6 hrs. 24 min.	12 hrs. 48 min.	25 hrs. 36 min.
	4 Tracks	3 hrs. 12 min.	6 hrs. 24 min.	12 hrs. 48 min.	25 hrs. 36 min.	51 hrs. 12 min.
	1 Track	33 min.	1 hr. 6 min.	2 hrs. 13 min.	4 hrs. 26 min.	8 hrs. 52 min.
2500	2 Tracks	1 hr. 6 min.	2 hrs. 12 min.	4 hrs. 26 min.	8 hrs. 52 min.	17 hrs. 44 min.
	4 Tracks	2 hrs. 12 min.	4 hrs. 24 min.	8 hrs. 52 min.	17 hrs. 44 min.	35 hrs. 28 min.
	1 Track	32 min.	1 hr. 4 min.	2 hrs. 8 min.	4 hrs. 16 min.	8 hrs. 32 min.
2400	2 Tracks	1 hr. 4 min.	2 hrs. 8 min.	4 hrs. 16 min.	8 hrs. 32 min.	17 hrs. 4 min.
	4 Tracks	2 hrs. 8 min.	4 hrs. 16 min.	8 hrs. 32 min.	17 hrs. 4 min.	34 hrs. 8 min.
	1 Track	24 min.	48 min.	1 hr. 36 min.	3 hrs. 12 min.	6 hrs. 24 min.
1800	2 Tracks	48 min.	1 hr. 36 min.	3 hrs. 12 min.	6 hrs. 24 min.	12 hrs. 48 min.
	4 Tracks	1 hr. 36 min.	3 hrs. 12 min.	6 hrs. 24 min.	12 hrs. 48 min.	25 hrs. 36 min.
	1 Track	16 min.	32 min.	1 hr. 4 min.	2 hrs. 8 min.	4 hrs. 16 min.
1200	2 Tracks	32 min.	1 hr. 4 min.	2 hrs. 8 min.	4 hrs. 16 min.	8 hrs. 32 min.
	4 Tracks	1 hr. 4 min.	2 hrs. 8 min.	4 hrs. 16 min.	8 hrs. 32 min.	17 hrs. 4 min.
	1 Track	12 min.	24 min.	48 min.	1 hr. 36 min.	3 hrs. 12 min.
900	2 Tracks	24 min.	48 min.	1 hr. 36 min.	3 hrs. 12 min.	6 hrs. 24 min.
	4 Tracks	48 min.	1 hr. 36 min.	3 hrs. 12 min.	6 hrs. 24 min.	12 hrs. 48 min.
	1 Track	8 min.	16 min.	32 min.	1 hr. 4 min.	2 hrs. 8 min.
600	2 Tracks	16 min.	32 min.	1 hr. 4 min.	2 hrs. 8 min.	4 hrs. 16 min.
	4 Tracks	32 min.	1 hr. 4 min.	2 hrs. 8 min.	4 hrs. 16 min.	8 hrs. 32 min.
	1 Track	4 min.	8 min.	16 min.	32 min.	1 hr. 4 min.
300	2 Tracks	8 min.	16 min.	32 min.	1 hr. 4 min.	2 hrs. 8 min.
	4 Tracks	16 min.	32 min.	1 hr. 4 min.	2 hrs. 8 min.	4 hrs. 16 min.
	1 Track	3 min.	6 min.	12 min.	24 min.	48 min.
225	2 Tracks	6 min.	12 min.	24 min.	48 min.	1 hr. 36 min.
	4 Tracks	12 min.	24 min.	48 min.	1 hr. 36 min.	3 hrs. 12 min.
	1 Track	2 min.	4 min.	8 min.	16 min.	32 min.
150	2 Tracks	4 min.	8 min.	16 min.	32 min.	1 hr. 4 min.
	4 Tracks	8 min.	16 min.	32 min.	1 hr. 4 min.	2 hrs. 8 min.

NOTE: One-Way Stereo provides same timing as 1-track tapes.
Two-Way Stereo provides same timing as 2-track tapes.

Fig. 7-2. Playing time of various footages of tape on 1-, 2-, and 4-track recorders at five recording speeds.

ous thicknesses and formulations to obtain the different recording times available. This coating has long been the industry standard, since it provides excellent output and frequency response.

High-output coatings provide the recordist with one primary advantage—they provide the same signal output as the standard coating with a lower signal input. This additional sensitivity is extremely helpful when recording weak sounds from a distance, nature sounds, bird songs, group meetings, and so on. In short, it increases the effective sensitivity of your recorder. These coatings are also capable of handling a greater-than-normal input without distortion. This simply means that your optimum recording level is raised, thus providing a greater safety margin to overload. The combination of these two factors results in a greater dynamic range, thus giving the recordist a recording latitude greater than that which is available with the standard coatings.

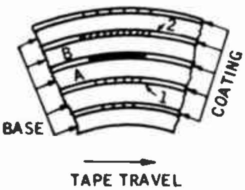

Fig. 7-3. How print-through is caused in tape reel.

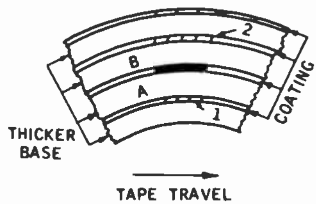

Fig. 7-4. Thicker tape base reduces print-through.

There is one characteristic common to all tape. This is the transfer of the signal recorded on any portion of it to the adjacent layers on the reel. This occurs in the following manner: When a signal is recorded, it creates a concentrated magnetic field on the tape, actually a miniature magnet as explained and illustrated in *Fig.* 2-7. We know that any magnet is capable of transferring its magnetism to any other magnetizable material, and obviously tape is such a material. *Figure* 7-3 illustrates how this transfer occurs. The recorded signal itself is shown as the black portion of the coating on the center layer of the tape. The magnetic field it creates, as shown, passes through the adjoining layers of tape, becoming progressively weaker as the distance from the recorded signal increases. In this manner it creates what are, in effect, magnetic duplicates. These are indicated as the shaded portions on the coatings of the adjacent layers of tape. On playback, these "duplicates" result in "echoes" of the original sound. The higher the recording level, the greater this effect, of course, since the "magnets" created on the tape are proportionately stronger.

As may be seen several of these "echoes" are created. Our concern is only with the two in the adjoining layers which precede and follow the recorded signal. The others are normally so weak that they are never troublesome. Of the two "echoes" the one preceding the recorded signal, shown as (1) in *Fig.* 7-3, is the most important. This "pre-print" as it is called professionally is louder than the "post-print," shown as (2). The pre-print is louder since to reach the surface of the preceding layer (1) it need only pass through the thickness of the tape base material (A). The post-print, on the other hand, must pass through both the thickness of the tape base material (B) and the thickness of the coating (2) to reach its surface. In addition, the post-print is usually masked by the following sounds and reverberation. The intensity of the print-through varies inversely with the thickness of the base material. Usually the thicker the base material the less the print-through, as may be seen from *Fig.* 7-4. The level of the pre-print is the one supplied in tape specifications.

The average recordist will rarely encounter print-through if reasonable care is employed in recording and storage of the tape. There are, however, a number of precautions which will sharply reduce any possibility of audible print-through on even the thinnest tape.

How to minimize print-through

The first and most important precaution is to record below the overload point (maximum recording level). Second, since print-through increases quite rapidly with time and temperature up to 100 hours, and then levels off, your tape should be stored in a cool spot, preferably below 70° F. (not in the refrigerator) for this period, at least. It should then be stored at room temperature (60°-80° F), but not in a hot closet nor near a radiator. Keep the tape away from motors, power lines, or other magnetic fields since they will also increase the print-through level. When a recording is to be stored for very long periods of time without use, or under extreme temperatures, we suggest the use of one of the low-print tapes in which the print-through level is from six to eight dB below the standard type.

We have described the differences in the various types of tape available, and the advantages and possible disadvantages of each. The recordist is now in a position to choose his tape intelligently on the basis of his particular requirements if he buys his standard brand, private-label-brand, or "white-box" tape from a reputable supplier whose guarantee of satisfaction insures the buyer of getting a fully reliable product.

There are other factors involved in the manufacture of tape which have not been mentioned as yet, since all standard-brand tape undergoes rigid quality control which automatically eliminates any necessity for their consideration by the recordist.

As an example, let us use a simple specification closely adhered to by all reliable manufacturers—Uniformity of Output. A manufacturer usually indicates that his tape is uniform within a reel to plus or minus 1 dB. This simply means that when sounds of the same level are recorded at any point on the reel, their reproduced sound level will be uniform to within 2 dB over-all, thus ensuring accurate reproduction.

Just what is involved in achieving this degree of accuracy and of what importance is it? The coating must be applied to the tape base so that its thickness is uniform to within ten millionths of an inch over the entire length of the tape. When the coating thickness is allowed to vary, the low-frequency response of the tape will also vary since it is primarily a function of thickness. For example, if you were to splice together three pieces of tape each employing a different coating thickness and record Middle A from a piano, each piano note would be reproduced at a different loudness level, which is intolerable in normal recording, of course.

Just as the low-frequency response of a tape is primarily a function of the coating thickness and its uniformity, the high-frequency response and its uniformity are dependent upon surface smoothness.

Fig. 7-5. Photomicrographs of tape surfaces—left, poorly finished, and right, well smoothed, as all good tapes should be.

Good high-frequency response is impossible when tape displays surface irregularities and is as rough and uneven as that shown at (A) in *Fig.* 7-5. All reliable manufacturers go to a great deal of trouble and expense to obtain a surface as smooth as that illustrated at (B). They do so since they know from experience that anything which prevents the head from making intimate contact with the tape, *over the entire track width,* results in reduced high-frequency response. A separation of only one ten-thousandth of an inch between the tape and the head can cause a considerable loss in high-frequency response. The actual loss at a tape speed of 7½ ips can be as high as 10 dB at 10,000 Hz.

Aside from the general smoothness of the coating there are other factors which must be carefully controlled. These can create "drop-outs" or the complete momentary loss of the signal, which often results in the elimination of a note or syllable in the recording as the defect passes over the recording or playback head. The first of these is a clump of oxide particles, which have become imbedded in the coating, as illustrated at (A) in *Fig.* 7-6. In properly made tape these clumps would have been carefully filtered out of the coating

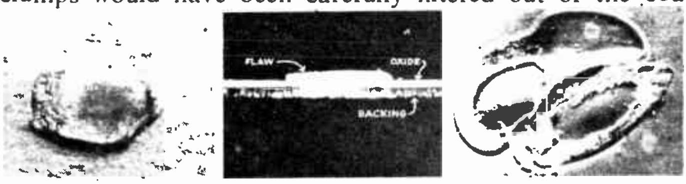

Fig. 7-6. Photomicrographs of irregularities in tape surfaces. (A), a clump of oxide particles; (B), how they keep the tape from close contact with the head; (C), a defect in the base material.

solution, or else the length of tape would have been rejected during inspection. As may be seen from (B), these particles can separate the head from the tape sufficiently to eliminate the signal momentarily. (C) shows a defect in the base material which also affected the regularity of the coating, and can also cause dropouts. The elimination of foreign particles by special filtering processes, and the careful control and inspection of both coating and base material are also expensive operations usually ignored or overlooked in most white-box tape.

We are now aware of the fact that the seemingly simple bit of plastic ribbon we call recording tape is not quite so simple. Recording tape is, as we have found, a highly engineered product. Extremely fine tolerances are employed during every step of its processing, even to the simple slitting operation. The oxide coating is applied to a plastic base some two to four feet wide. This wide sheet is then slit into the ¼-inch widths used for recording. Nothing could be easier! Except, however, that the slitting dimensions must be accurate to within two thousandths of an inch, and this accuracy must be maintained over the entire reel. Not quite as simple as it appears.

Poor adhesion between the binder and the oxide is another culprit. This time it is loose oxide particles, almost as abrasive as diamond dust, which do the damage. Can you imagine the effect on the tape heads and guides if you were to sprinkle diamond dust between them and the tape? The condition is not quite that horrible but almost. These oxide particles also become lodged in the head gaps, reducing their record or reproducing efficiency.

Chapter 8

Adding Sound Effects

Sound effects are an extremely valuable tool to anyone who records dramatic performances or who wishes to add sound to slides or home movies. Sound effects can set the scene, create the mood, increase the illusion of reality, and provide the feeling of depth which cannot be obtained in any other manner.

For example, we have seen many groups of slides and home movies of barbecue parties. Normally these pictures are of interest only to the participants. However, after sound effects are added the pictures will take on new life and interest.

As an experiment the writer made a tape for a friend to be used with this type of movie. Everyone who saw it was fascinated. One particular shot was of the table, 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; to this the writer added the sound of a steak sizzling. 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 using 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 to back it up. 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 buses, automobiles, and so on.

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 by simple methods at home with a minimum of equipment. The more unusual ones may be purchased on sound effect records or obtained from radio or TV broadcasts by connecting your radio or TV receiver to your tape recorder as you watch or listen to dramatic performances. These broadcasts usually have one or more sound effects per program.

How to make sound effects

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 and blow the balloon 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 the 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 since a larger wave 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.

At the beach

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 is that all waves are not the same; consequently there should be some variation in both level and between-wave timing.

The sound of a very calm sea, a lagoon, or a bay is created 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 ⅔ 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 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 lap.

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 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 used 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 ¼ full with water and then fill a pail to the brim. The pail is placed under the faucet and tilted slightly so that the water it contains drops into the tub in a stream of about two inches in width.

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.

Waterfalls

The sound of a waterfall is created by employing the same method used to create 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.

The creation of dual sounds is quite simple when a stereo recorder is used. One sound is recorded on each channel. The volume level of each is adjusted in such a manner that the most important sound is slightly higher in level than the others.

Dual sound effects may be created on a mono recorder almost as easily. A few strips of exposed photographic film are required. These should be cut into sections about two inches square.

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.

How to create water effects

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 filled, 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 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 trying 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 sound 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 rhythmically 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 virtual 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.

Sounds in the next group are extremely important in establishing mood. These are the weather sounds, including rain, wind, thunder, and so on.

The sound of rain can be duplicated with the aid of a bowl of sugar, some waxed paper, a small box, and a soup plate. Tear a four-inch long piece of waxed paper from its roll, allowing it to retain its natural curl. Form a trough as shown in *Fig.* 8-1. Fasten it to the box at one end as illustrated with the other end in the soup plate. Place the microphone halfway down the incline and pour the sugar down the trough of waxed paper. The most critical part of this effect is in pouring the sugar down the incline evenly, to obtain a steady rain. If 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 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.

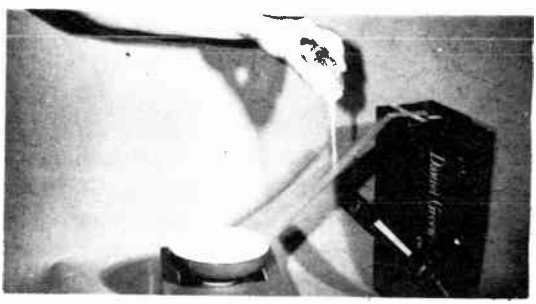

Fig. 8-1. Simple set-up used to create rain sound effects.

In the event the scene to be portrayed is in an area where there are trees, extremely realistic effects can be obtained by using the sound of a breeze before the 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. String a two- or three-foot length of thread with the Rice Krispies as you do with popcorn or cranberries to decorate a Christmas tree. After you have strung about six inches, the need for the small son or daughter becomes obvious. Hold the string of Rice Krispies in one hand and pull it slowly through the palm of the other hand about three inches from the microphone. This effect may also be employed as a background for outdoor conversation as in a garden. The sound of wind is also obtained with a balloon by allowing the air to escape past a microphone. Gusts can be obtained by interrupting the flow.

Rain is often accompanied by thunder, which is also quite easy to simulate. Again we use the balloon and BB shot you used for the wave effect. Hold the inflated balloon, with the shot inside, in both hands and jerk it downward with a sharp motion, so that the shot within strikes the top to create the initial crash of thunder, and then continues bouncing. Unlike the wave effect, do not stop the shot from bouncing, but let it continue until it dies out. The continued bouncing provides the slowly diminishing reverberations of thunder. When this effect is properly made, it sounds more like thunder than the real thing, as the initial crash of actual thunder usually causes overloading with its consequent distortion.

Your radio and your TV may be used to build up a library of effects. Programs such as CBS's *Daktari* can supply many animal sounds. Travelogues are another source which usually begin with the sounds of a departing ship, train, or plane. All you need do is to keep your recorder connected to the receiver whenever you listen to one of these programs and record any suitable effects as they come along.

Sound effects sources

Another source of sound effects is the many records made for use by broadcast stations and which are also available to the recordist. A post card to Elektra Records, 51 West 51st St., New York, N.Y. 10019, will bring you a catalog describing their nine sound-effects records which include diesel and steam trains, interiors of railroad cars, San Francisco cable cars, and Chicago El trains, planes of all types from the single passenger variety to modern-day jets. Sound effects records are also available from Folkway Records, 165 West 46th St., New York, N.Y. 10036.

These records can be employed to create many original effects. In nature, it is rare that we hear one sound to the complete exclusion of others. For this reason, these records are most effective when used in combination. The sounds they provide can be combined by any of the various methods we have described or they can be combined with the sounds you create to provide an even greater variety.

The sounds made by insects, frogs, and birds can provide very natural and interesting backgrounds. For insect background sounds, Folkways record FX 6178 is the best available. It includes crickets, mosquitos, bumble-bees, katydids, and many others. The same company has another excellent record entitled *Sounds of North American Frogs*.

The finest bird records available today are those made by two professors of ornithology with Cornell University. These can be obtained from Cornell University Press, 124 Roberts Place, Ithaca, N.Y. 14850.

There are even sound-effects records for your underwater slides or movies. Folkways FX 6125 *Sounds of Sea Animals* includes manatee, porpoise, parrot fish, snapping shrimp, drum fish, and so on.

Use a portable for outdoor sounds

With a battery-operated recorder you can record many of the birds or animals yourself. Recording birds and animals is, however, more difficult than hunting them with a gun. A bullet will accomplish its purpose at a greater distance than a microphone and recorder. 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 birds, or of any animal for that matter, is largely dependent on two factors—first, a knowledge of their habits so that you can 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 rarely stand at the correct distance from the microphone, nor can you control to any extent the duration and intensity of any distracting background noise. Quite a challenge, but try it anyway.

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. Two excellent sources of information on bird habits, and which, incidentally, include superb color photographs, are *Stalking Birds with a Color Camera,* by A. A. Allen, and the new National Geographic publication, *Song and Garden Birds of North America.* The last has quite a dividend for recordists tucked in the back cover—six records of bird songs which are ideal for sound effects. With these books, anyone can learn to identify birds 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 you have located the bird you wish to record, getting his song on tape 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 where food is plentiful. Once such a location is found, microphone placement is comparatively simple. Place it where it will pick up the maximum amount of *wanted* sound (the bird song) and the minimum amount of *unwanted* sound (aircraft overhead, traffic noise, and so on). The microphone can rarely be placed closer than five to ten feet from the bird's probable position, and when the microphone furnished with the recorder is used at this distance outdoors a considerable amount of background noise may be picked up. Consequently, its placement is critical. This is one of many applications where a microphone such as the type shown in *Fig.* 8-3 is ideal. Because of its highly directional characteristics, it may be placed 2½ times as far from the sound source as an omnidirectional microphone and still not pick up any more unwanted background sound.

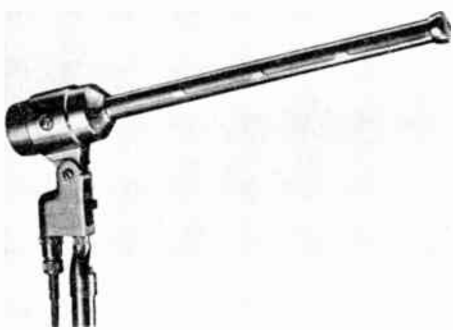

Fig. 8-2. A highly directionol microphone which enobles the recordist to work o greoter distonce from the sound source without losing "close-up" quolity.

Courtesy Electro-Voice, Inc.

Chapter 9

Adding Sound to Slides and Movies

While your tape recorder has many applications, we can think of none more interesting and entertaining than using it to add sound to your slides and home movies.

The author has often tried to describe the sounds he heard as a picture was being filmed. The Elizabethian English which is still spoken by the older residents of the "outer banks" of North Carolina, the peaceful lapping of water against the sides of a boat, the swishing of palm trees—simple sounds such as these can make a scene.

Sound plays a much larger part in our mental impressions than most of us realize. When a picture is taken it is not always sight alone which prompts the photographer. It is often the sound as well. The blast of a steamboat whistle as the boat leaves the pier adds considerably to our visual impressions. Such sounds can do much to recreate your original impressions.

Hollywood has long recognized the advantages of combining sound with sight. Older readers will remember the inevitable piano player of the silent movies. His piano was used to evoke excitement, happiness, sorrow, and so on. It provided continuity and added interest and movement to otherwise static scenes.

Music is employed as a background in the popular media of entertainment—TV, radio, and motion pictures—for the simple reason that it can create a mood and atmosphere much more effectively than the spoken word, and more important, in a much shorter space of time. The time element is important to us for the same reason. You are attempting to compress as much atmosphere as possible into the few seconds your picture is on the screen.

The music for your sound track can be acquired from a number of different sources, such as a friend's or your own collection, or commercial records which contain mood music. Each section of these records contains music specifically categorized by scenes; such as water, pastoral, mountains, and so on, and by moods; such as happy, sad, suspenseful, dramatic, and the like. You can even begin your own collection by recording from radio or TV programs.

Narration plays a much larger part in your "silent" slide or movie showings than you may believe. You add sound each time you show your pictures. Regardless of their technical excellence or interest, you invariably make some comment on each scene, so you are adding sound. You describe not alone what is on the screen, but what is off of it, and, possibly, what is lacking in the picture. Since your comments are usually of an *ad lib* nature, they are likely to be rambling, hesitant, and often repetitious; but they can be improved easily to the point where they are mellifluous and smooth.

All of these—sounds effects, music, and narration—can be combined to make your showings much more interesting to your audience and yourself. However, you cannot just add sound, as the title of this chapter indicates—it should be integrated in such a manner that it becomes part of each picture. Each sound used must serve a specific purpose in enhancing the scene. When the sound is properly integrated it greatly increases the emotional impact and interest of your films. Many who have combined sound and sight have found that it changed their entire concept of photography. They began to think in terms of both while filming, and found that each took on added meaning. Both finally merged to create one new hobby, more powerful than either alone—a hobby which is truly creative.

Your recorder is the perfect tool with which to accomplish this. If you do not have a portable recorder you can obtain authentic sounds by the methods described in previous chapters. You can create a professional synchronized sound showing. It can be as simple as you choose or as elaborate. We will describe the most elaborate, but you may simplify it by deleting any of the three types of sound—music, effects, or commentary. This can be done regardless of the age of your slide projector, even if it is the oldest manually operated unit. More advanced and modern equipment such as an automatic projector unit and a slide synchronizer such as illustrated in *Fig.* 9-1 will make the job easier and much more professional.

Fig. 9-1. Automatic slide projector with tape recorder synchronizing facility.
Courtesy Eastman Kodak Co.

Plan your slide show

The first step in combining sound and sight is to select a group of not more than fifty slides. This number provides a showing thirty minutes long. No single uninterrupted showing should be longer than that unless you are willing to risk your losing the interest of your audience. When the program is longer it should be broken into two sections of 40 slides per section. No individual slide should remain on the screen longer than twenty-five to thirty seconds, unless it is highly detailed and requires a longer description, as for example, a bird's eye view of a city or some area taken from a plane.

Arrange your slides in some order that permits each one to be followed by one which is related to it in some manner. Number the slides in sequence, marking them in the upper right corner with the slide upside down and the shiny side facing you. This is the correct position for insertion in manual projectors. Obtain a number of 3 by 5 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.

Project the first slide with its corresponding file card before you. Jot down the type of background music which you think might be appropriate. For example, if the slide depicts a river, bay, or ocean, the song selected might be *Ebbtide*. If it is the ocean, Debussy's *La Mer* will have one section which fits the mood of your scene perfectly. If the scene is a lake, *By the Waters of the Minnetonka* may be appropriate.

While looking at the slide think of some sound you remember as being part of the scene. The lapping of water against a dock or boat would be effective in creating the desired mood, for instance. Now you are ready for the narration. Start your recorder with the first slide on the screen. Make your usual comments about the slide in your normal manner. You need not be particularly careful with this commentary since its only purpose is to obtain the first "run-through"; you are actually "talking" the initial sound script. Professional movies and TV shows are produced in this manner from a script, but in their case the script combines instructions from both sound and sight while you already have the "sight" on the slide.

Show the group of slides once more and listen to your recorded comments. Make a note to eliminate any remarks which describe what the audience can see on the screen. Instead, try to describe what is off the screen, what is missing from your picture. You are trying to convey your feelings as the picture was taken to provide additional information.

Fig. 9-2. An example of the type of slide for which a description is desirable to increase interest of the viewers.

Now to the most interesting part; a little research will make your slides more interesting to yourself and to your guests. For example, the slide of the strange-looking tree illustrated in *Fig.* 9-2—how would you describe this slide? Guide books and folders can provide much information and are often a source of prepared commentary written by experts. The National Audobon Society provides each visitor to Corkscrew Swamp Sanctuary in Immokalee, Florida, with an interesting folder describing the sanctuary and its points of interest. In it we find the following: "39. STRANGLER FIG (*Ficus aurea*)—Around the large cypress to the left are several round, rope-like roots coming down the trunk. Far above they expand and produce a crown with broad, shiny green leaves. This is an example of a very interesting plant, the strangler fig. The seed may lodge and start to grow as an air plant high on a tree, usually a cypress or cabbage palm, but it soon sends down roots to the ground and starts drawing its food from the earth. In some cases the crown becomes so dense that it shades out the host tree or sometimes the strangler puts roots all around the host and chokes it. Usually by the time the host dies, the fig is large enough to stand alone. It is a close relative of the rubber and banyan trees and is often called by either one of these names. It may also grow from seeds in the ground. The fruits are small red berries growing along the twigs. These are used as food by wildlife."

This is almost a perfect bit of prepared commentary for a slide of a strangler fig. Our next paragraph will explain why we said "almost" perfect.

After you have compiled your information on the card, edit your comments carefully to 60 or 75 words or less. At the rate of 2½ words per second, which is the speed of the average conversation, the commentary for each slide should take 25 to 30 seconds. You may find it a little difficult at first to make your comments this brief. If you persist, however, you will find it can be done. This elimination of superfluous wordage will provide a smooth flowing and crisp description which you will find is much more professional and entertaining. Our reason for indicating the prepared commentary for the pelican slide was "almost" perfect should be obvious—count the words. There are over 170 words, but this paragraph can be edited easily down to 75 words. There are slides in which this may be difficult. The most important thing to remember is that the audience may not share your enthusiasm or interest in a particular subject.

When you have decided exactly which sound effects, music, and commentary are to be recorded for each slide, erase the recording you have made as a guide. As indicated earlier, the sound track you use may be as simple or as elaborate as you choose to make it. We shall describe the most elaborate, but you may simplify it.

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 recording. There will usually be one section which you feel represents the mood of the picture more than others. Mark this section of the record so you can locate it quickly. A slight mark with a china marking pencil on the surface of the record groove will not harm the record and may be wiped off easily with a damp cloth.

You will require an assistant for the next operation. Just before you are ready to record the background music, signal your assistant to tap an empty water glass with a spoon or a pencil. Place the pickup arm of the record player a few grooves ahead of the section you have marked. Monitor the source of signal being fed into the recorder. As soon as the pickup arrives at the section you have chosen, quickly turn the record-level control to zero and gradually bring it back to the previously determined correct maximum recording level as described in Chapter 4. Moving the control from zero to the correct recording level should take not less than one second nor more than two. This procedure will provide a natural "fade-in" of the music for each slide. Record the musical background for twenty-five seconds or the time which you have chosen. When this time has elapsed gradually fade the music out by turning the record-level control back to zero, again over a one- or two-second period. Immediately after the "fade-out" is completed, signal your assistant to strike the glass with the pencil. These sounds will later tell you when to change slides. After the signal has been made, stop the recorder immediately and mark the tape with a china marking pencil as indicated and illustrated in Chapter 6. Rewind the tape to the beginning of the section you have just recorded, and play it back; if the recording is satisfactory you are ready for the next step.

Rewind the tape once again to the beginning of the section you just recorded. Listen to it while watching the slide. Decide where you would like to place your sound effects. For a slide of this type we would suggest the sounds of surf and gulls. When you reach the proper spot, mark the position on the tape where the effect should begin and end. Using the sound-on-sound method described in Chapter 8, record the sound effects in their proper positions. This method of adding sound-on-sound reduces the volume of the original sound each time an additional sound is recorded. You have already compensated for this effect by recording the musical background at the maximum level. The most important thing to remember when employing sound effects is to use them sparingly. Like salt and pepper, a pinch will enhace the flavor while too much will spoil the taste.

Ready for narration

Rewind the tape and listen to the combined recording. You may find the combination of sight, music, and sound effects is sufficient and that no narration is needed. Or you may discover, as is often the case, that the music and sound effects, when carefully chosen, convey most of the story and that the narration need not be as long or as detailed as originally planned. Yours is the choice and the decision.

Recording narration is simple when you employ the microphone techniques described in Chapter 3. Start the recorder and begin reading from the first script card as soon as you reach the previously marked position on the tape indicating the beginning of your earlier recordings for this slide. The narration should end before you reach the mark indicating the end of your previous recording. When employing this method of multiple recording, you must be extremely careful to read the script correctly for the first time, because if it becomes necessary to correct it the erasure will also eliminate the musical background and sound effects previously recorded.

Play this section back once more; if the multiple recording meets with your approval you are ready to start the recording for the following slide. Your next step is to measure 37½ inches of tape from the last marked point, if you are recording at 7½ ips, or 18¾ inches if you are using a speed of 3¾ ips. Mark this spot with a china-marking pencil and rotate the supply reel by hand to wind the tape back onto the supply reel. This unrecorded length of tape allows you approximately five seconds to change the slide before the narration, music, and sound effects for the following slide begin.

When you are ready for the next slide start the recorder again. As soon as the marked point on the tape arrives at the reference position, make another sound signal and repeat the entire procedure for the second slide. This method is followed until you have as many recorded sections as there are slides and cards.

Since integrating sound and sight is a creative process, any changes are permissible which you believe would enhance the showing. Where you have three or four slides related in time or space, such as different views of the New England harbor, the background music can be the same and can run continuously without fade-ins or fade-outs between slides. The same sound effects may also be employed throughout any related scenes. When employing sound effects in this manner always consider the distance at which your subject was filmed and adjust the volume level of the sound effect accordingly. For example, when the scene is a "long shot" of the water, be certain to reduce the sound level of the waves below the level employed for a "closeup" of the same water. If your slide shows gulls in the distance the sound level of their cries should be lower than that used for a slide showing them directly overhead.

With your projector and slides ready, start the recorder. At the signal sound, flash the first slide on the screen. Begin to change the slide after you hear the signal indicating that the sound track is completed. Be certain that the change is completed before you hear the next signal, the point at which the sound for the following slide begins.

When employing an automatic projector, without the slide synchronization feature, the procedure is essentially the same as described earlier. However, since the sound must be timed to match the change cycle, the timing of the sound track is more critical. Set the projector timing for a 30-second interval and restrict your sound to an absolute maximum of 28 seconds. This allows 2 seconds of silence while the projector is changing slides. As originally explained the tape should be marked when the sound is completed. With this type of projector you need only measure 7½ inches of tape when recording at 3¾ ips and 15 inches if recording at 7½ ips since the required time lapse is shorter; then mark the tape again. These marks and their accurate placement are extremely important if sound and slide synchronization is to be maintained throughout the entire showing. They are your only indication of when to begin the sound for the following slide.

If you use an automatic or semi-automatic projector which has provision for a slide synchronizer, such as is shown in *Fig.* 9-1, this attachment is an excellent investment. It permits you to vary the length of time each slide is on the screen and, in consequence, the length of the sound track employed. Its use also eliminates the necessity for the sound signals and the measurement of tape, for it automatically changes the slide when the sound track is completed, being actuated by some type of signal, either sound or mechanical, on the tape itself.

The recording procedure is exactly the same as previously described. However, when the sound for a given slide is completed, you press a momentary contact switch on the synchronizer which records a signal pulse on the tape. Your sound for the following slide should begin immediately upon releasing the momentary switch.

On playback, after the sound for the first slide is completed the signal pulse automatically activates the slide-tripping mechanism on the projector, thus changing the slide before the sound for the next slide begins.

Once you have integrated sight and sound you will never again use silent showings for your slides.

Sound with your movies

Integrating sound and sight for home movies is no more difficult than with slides—in fact, the procedure is almost identical. The simplest, least expensive, and most efficient method of making 8-mm sound movies is to add the sound after the filming is completed. The sound projectors employed for this purpose such as the one shown in *Fig.* 9-3 are basically a combination of a movie projector and a magnetic tape recorder. A magnetic coating is applied to one edge of the film and sound is recorded on it in exactly the same manner as described in Chapter 3 for your tape recorder. This sound can then be played back in perfect synchronization with the pictures as they are screened.

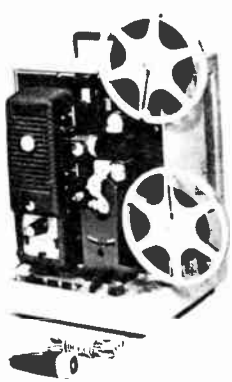

Fig. 9-3. Sound movie projector—a combination of a projector and a magnetic recorder.
Courtesy Eastman Kodak Co.

Adding sound to home movies will be quite simple for our readers since they, at this stage, are probably more familiar with magnetic recording than many commercial "movie makers" and certainly more familiar with the subject than any almost advanced amateur cinematographer.

There are a few aspects of magnetic recording on film which differ from recording on tape. Once you become aware of these you can do a truly professional job of integrating sound and sight for your home movies, particularly since you already own one of the most valuable accessories to a sound projector—your tape recorder. The combination of your recorder, your knowledge of recording, and a sound projector, will allow you to make sound movies of a quality normally requiring equipment costing thousands of dollars.

Since you may already own a silent movie projector and have a tape recorder you may wonder why a sound projector is necessary. Briefly the difficulty in employing a silent projector and a tape recorder to create sound movies lies in synchronizing the tape and film and *maintaining* this synchronization—one containing the sound, and the other the pictures. There are professional methods of accomplishing this feat—Hollywood uses them every day. However, it involves the use of expensive servo-mechanisms and synchronous motors. Reason enough!

Your next question will probably be, why use my tape recorder since recordings can be made directly on the film with a sound projector? The answer is simple. You can produce better sound movies more easily! There are a number of reasons for this—first, a microphone will pick up all sound in a room, both wanted and unwanted. As we have discovered, a microphone does not discriminate. All movie projectors create a certain amount of noise. When a microphone is used in the same room as the projector this noise is picked up and recorded on the sound track, along with any narration, music, or sound effects.

You could, of course, reduce the noise pick-up by placing the projector in one room and projecting through a doorway into an adjoining room in which the narrator is located. This method can lead to complications, the most important of which is that you no longer have a one-man operation and the complete control it provides.

When the sound track on the film is to contain more than simple narration, still another assistant is usually required. It is extremely difficult to provide smooth narration, handle a turntable, and create sound effects at the same time. The second assistant leads to other difficulties. Split second timing of all operations is essential for synchronization when a sound projector alone is employed. It is extremely difficult to coordinate the efforts of three people performing different tasks. When a sound projector incorporates a provision for sound-on-sound (overlap) and includes "mixing" facilities, the problems are not quite as great. However, these projectors are usually considerably more expensive and still cannot provide the flexibility of a recorder/sound projector combination.

The use of your recorder with a sound projector eliminates all of these problems at once, and the addition of a simple remote-control foot switch for the projector allows you to make a one-man operation of integrating sound and sight.

There is a very simple method of making sound movies which is employed by TV stations throughout the country in producing their newscasts. The film is shot without sound. The silent picture is quickly processed and screened. The announcer or commentator records his narrative to fit the pictures during the screening. Some of the TV broadcasters employ a more advanced technique in which music, sound effects, and narration are "mixed" and recorded on tape and then dubbed onto the film. This is essentially the method we shall employ. The only difference between our method and that employed for the newscasts is that the broadcasters employ pre-striped film to save time. Just as with slides, we shall describe the most elaborate method and you may simplify your sound track by merely deleting narration, sound effects, or music.

The best sound movies are those which are pre-planned for integrated sound and sight. When both are considered before and during filming, the finished product is always superior to one in which they are considered separately. The camera techniques for filming movies to which sound is to be added are essentially the same as those employed for silent pictures.

One of the basic differences is that film to which sound is to be added should be shot at 24 frames per second rather than the normal 16 fps employed for silent movies. The reason for the faster speed is exactly the same as explained in Chapter 3 for your tape recorder. The sound is better.

There are tricks of the trade which can greatly simplify the integration of sound. The most important to remember is that there is always a time difference between a screened action and any description of the same action. It generally takes longer to describe a scene than the time a sequence remains on the screen. For this reason, all scenes to which narration will be added should be made a bit longer than is customary for silent pictures. There is one factor which compensates for this to some degree—less narration is usually required to describe a movie than a slide.

When to start editing

Editing should begin as soon as your film is returned by the processor, while your impressions are still fresh. The first step should be a general screening and the ruthless elimination of all improperly exposed material and that which you consider technically imperfect. The remaining film is then re-examined to determine which scenes will be retained for the final production and to decide upon their screening order.

Cut the selected shots from the roughly edited film, and place them in a numbered editing tray. Make up a 3 x 5 file card for each clip and give it a corresponding number. On each file card note a rough description of the scene, its uncut running time, whether it is a long, medium, or close-up shot, the sound effects and the background music you feel would be appropriate, and any comments which would aid in writing the narration. Do not throw away any technically usable film you have cut out—it may be required later to lengthen a scene.

Then place the file cards in the order you have decided the various scenes should follow. Then reassemble the film clips in this order and screen them once again. During this screening decide upon the final editing, and note the final cut running time of each scene. Make your decisions on any fades, wipes, or dissolves, together with their timing, for they will also affect the running time of your sound track. At this point the final photo editing is done, and you should return the film to your dealer for sound striping.

While your film is being striped you can begin to work on the sound track. When the information on each scene is compiled in the manner outlined earlier for slides, edit your commentary to the exact running time provided on the card for each scene. Normal narration is made at the rate of 2½ words per second. After the script for the narration is completed and polished you are ready to begin your sound track.

With your recorder connected to the record player or another tape recorder as described in Chapter 4, be ready to record the musical background for the opening scene on Track 1. As soon as the phono pickup arrives at the section of the record you have chosen, quickly turn the left-channel record-level control to zero and gradually bring it back to the previously determined maximum recording level, as explained earlier. The length of time for your fade-in of sound should coincide with that employed for your picture fade-in, usually 1 to 2½ seconds. Record the musical background to coincide with the running time of the scene or sequence. After this time has elapsed, gradually fade the music out, as you did for the fade-in. Follow this same procedure with the music for each scene or sequence shown on your file cards.

After all musical background is completed plug the microphone into the right-channel input of the recorder and rewind the tape to its beginning. Set the recorder controls so that Channel 1 can be monitored with headphones while recording on Channel 3. Start the recorder. As soon as you hear the background music begin, start your narration for the scene.

You can introduce variety in the narration, even when the same voice is employed throughout the film, by utilizing the various techniques provided in Chapter 3. For example, when describing a scene of a church or museum interior or commenting on a scene of a deep canyon outdoors, all of which are usually quite reverberant, you can obtain the type of sound we normally associate with these locations by employing your cellar or attic to produce this section of your sound track. This effect may be still further increased by speaking at a distance of 10 or 12 feet from the microphone. With general indoor or outdoor scenes, a normal living room and a microphone distance of 3 to 4 feet will sound correct. The ear can be deceived into believing that narration recorded indoors was actually recorded outdoors by merely adding simple outdoor background sounds, rustling leaves, traffic noises, and so on, as explained in Chapter 8. When recording for long, medium, or close-up shots, the accompanying sound should reflect these differences in camera viewpoint. These subtle differences in tone color and sound character will add tremendously to the realism of your sound track when correctly employed.

This method of recording music and narration on separate tracks has an advantage in that any "fluffs," hesitancies, or errors in the timing of the narration can be corrected immediately without destroying the previously recorded musical background, which would occur if you were employing sound-on-sound (overlay) method. When recording your sound track on tape first you need merely to return to the end of the sound for the preceding scene and repeat your narration.

Last but far from least, you are ready to add the sound effects if you choose. The important thing to remember when adding sound effects is that it is not necessary to add the sounds created by every image that crosses the screen. Sound effects should be included only if their omission would be noticeable or when they are employed to add to the atmosphere or indicate location.

For example, if the screen shows an ocean liner with steam escaping from the whistle, it would increase the realism if the sound of the whistle were included. If the screen were to show a docked liner, the whistle sound would be unnatural and distracting. On the other hand, if the film were of a *bon voyage* party, a close-up of the whistle exhaust with the cry of "All ashore that's going ashore" would make a perfect ending. It is also important to change the sound level of any sound effects as the camera viewpoint is changed. Thus the sound of the whistle on a long shot of the liner leaving the harbor would be recorded at a lower level than it is recorded for the close-up.

Adding sound effects to your previously recorded tracks is accomplished easily with a stereo recorder in the following manner. Set the recorder controls so that both channels are in the playback position. Start the recorder and monitor the sound with the file card for the scene before you. Run through the sound track sequence. You can then decide exactly where you want the sound effect to begin and end. Underline the words on your finished script which are spoken when you arrive at the points at which you wish to begin and end the sound effect. These notations will provide you with the exact cueing for your next recording.

Set the controls of your recorder so that Channel 3 can be monitored while recording on Channel 1. Using the method of sound-on-sound recording described in Chapter 3, record the sound effects in their proper positions. The sound should begin as you hear the underlined word on your cue card indicating the start, and be completed when you hear the underlined word indicating the end. When the completed sound track is played back, you will hear the sound effects superimposed on a now subdued musical background from one channel and the narration from the other, all in perfect synchronization. Our next step will be the "mixing" and dubbing of this sound onto the sound strip of your film.

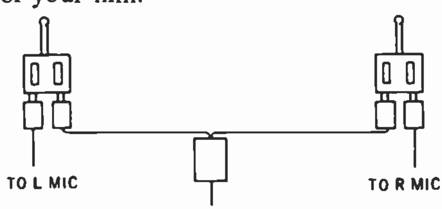

Fig. 9-4. Method of combining two stereo channels from your tape recorder to feed the single input of the sound projector.

It is quite simple to add the now completed sound tracks to your film after it is returned. Connect both preamp outputs of your recorder to the phono input of the sound projector, as illustrated in *Fig.* 9-4, by means of a "Y" connector. This connector "mixes" the signals you have recorded on the two separate channels. Thread the projector for sound, switch the amplifier on, and place the control knob in the STILL position. Set the projector volume control at mid-point, and turn on the tape recorder with the tape transport in the STOP position.

Tape-to-film dubbing

The first step in "dubbing" the sound onto your film is to balance the sound levels of the two channels to your satisfaction. Start the tape transport and monitor the sound from the projector's loudspeaker. The musical background should be unobtrusive. The narrator's voice should always be slightly higher in level than the music. Vary the relative sound levels of both channels with the recorder volume controls. Once the levels of the two channels have been balanced to your satisfaction, mark their positions. Do not alter these settings once they have been determined.

It is necessary to play the tape once again to obtain the optimum recording level on the projector. Start the tape transport and watch the projector record-level indicator. Adjust the volume control of the projector so that the indicator glows intermittently on loud peaks of sound. If it does not, the projector volume control should be advanced so that it does. Then mark the position of the projector volume control carefully.

You are now ready for the final step. Start the projector. The instant the first frame appears on the screen, start the recorder tape transport and record the entire sequence or scene. Stop both the tape transport and the projector movement. You have completed the sound track for the opening scene.

Rewind the film to the beginning and check the sound track on the film for quality, sound balance, and synchronization. It may require several tries to start the sound at the exact moment the first frame appears on the screen, but a little experience will cure this. Once the start of the picture and the sound are matched they will remain in synchronization for the entire scene if your timing of the original tape recording was correct. If the first section of the picture and the sound track are satisfactory, proceed in the same manner with the next scene.

The transition from scene to scene requires accurate timing. After the sound and sight of the opening scene are approved, return the film to a point 2 to 3 feet before the succeeding scene begins. Make sure the Play-Record switch on the projector is in the PLAY position and its volume control is set in the previously determined position for recording. Move the sound track on the recorder to the position at which the sound for the second scene begins. Start the projector, and as soon as the first frame of the second scene flashes on the screen, move the Play-Record switch to the RECORD position and start the tape transport. The most critical part of this operation is that the Play-Record switch on the projector be moved simultaneously with the appearance of the first frame on the screen. If you move this switch before, you will erase the end of the previous recording on the film. Check the recording of this scene and if it is satisfactory proceed in the same manner for each succeeding scene. The final result will be a perfectly synchronized sound movie which will compare favorably with professional movies.

This system of integrating sound and sight has a number of advantages over the conventional methods. You always have a master recording in the event that any of the sections of the film sound track are unsatisfactory and require re-recording. The editing of tape is much simpler than that of the sound track on the film and the tremendous flexibility and control allow you to do almost anything with sound that you can conceive. After you have obtained a little experience, many variations of the foregoing procedure will suggest themselves. Reread the chapter on sound effects for ideas and no not hesitate to try them, because integrating sound and sight is a truly creative process and one which can provide tremendous personal satisfaction to you as the creator.

You may find that minor errors in timing have caused the sound and picture to drift out of synchronization during the final dubbing. If so, and you feel that the drift is objectionable, your only solution is to go back to the beginning of your tape and increase or decrease the time between the sound portion of scenes by splicing in a short piece of silent tape or cutting out a small piece. While it may seem like extra work, you will ultimately be better satisfied that you have a job that is as nearly perfect as possible. In Hollywood, entire scenes are often re-shot just to correct the inflection of a word, all in the continual striving for perfection and the final dubbing is done over and over until the desired result is obtained.

Make it pay!

After you have made a few sound movies and become proficient in the techniques involved, we would suggest that you advise your photo dealer and any local movie clubs that you are available for adding sound to the movies of others for a fee. You will be surprised at the number of clients you can obtain for a service of this nature. However, one word of warning; do not sell any movies you make for commercial purposes since most of the music we have suggested you employ is protected by copyright; while the owners rarely have any objection to the use of their material for your personal pleasure, they do feel that they are entitled to compensation when it is employed for commercial purposes. The largest producer of mood music and sound effects for commercial purposes is Thomas J. Valentino, Inc. They will also provide you with additional information on licensing for public performance.

While on the subject of commercial sound movies we might add that the recent release of Eastman Kodak's new Super 8 movie system makes it possible for anyone with the necessary knowledge of photography and your knowledge of sound to produce commercial movies without the necessity of acquiring expensive professional 16-mm sound cameras and equipment. With this new 8-mm system you can produce sound movies which are acceptable to industrial, educational, and business fields. If your knowledge of photography is a little short of perfection you might team up with a cinematographer to form a combination which could result in the beginning of an excellent and interesting business venture.

Chapter 10

Recorder Maintenance

Our previous chapters have explained the requirements for the high-fidelity recording and reproduction of speech and music. If the original high quality of these recordings is to be sustained, proper maintenance of your recorder is an important requirement. It has been a constant source of amazement to the writer and a tribute to American manufacturing ability that the average tape recorder operates as well as it does, when we consider the small amount of attention it receives.

Any device, be it mechanical, electrical, or electronic, requires some maintenance. A tape recorder is a combination of all three, and has a rather complicated mechanical section consisting of motors, gears, guide pulley, clutches, and capstans. All of these moving parts are subject to wear. One of the most important factors in maintaining consistently good performance from a tape recorder is to be certain that the tape-transport mechanism operates at a high standard of consistency. Any change or variation in speed is indicative of the fact that some physical change has taken place within the mechanical section of the recorder. The importance of tape speed becomes quite obvious when we stop to consider that reproducing a tape at any speed greater than that at which it was originally recorded increases the pitch of the reproduction. Conversely, reproducing a tape at a slower speed decreases the pitch. The degree of pitch change is dependent upon the amount of deviation from normal operating speed.

Reduced tape speed is the most common variation from normal operation and is often accompanied by mechanical sounds which are created by excessive friction. When this condition is suspected the recorder should be removed from its case and a visual inspection made with the tape transport mechanism in operation, but with the volume control in zero position so that no sound issues from the loudspeaker. A common source of reduced speed accompanied by mechanical noise is due to the ventilating fan blades hitting a loose connecting cable. Another source of mechanical noise is loose or bent fan blades. Reduced speed alone without any accompanying noise is almost invariably caused by increased friction due to lack of oil on the moving mechanical components. Check the manufacturer's service instructions for lubrication procedure. When oiling a capstan bearing great care must be exercised so that no oil is allowed to leak onto the pressure roller since it will result in tape slippage which itself is another cause of reduced speed. As a precaution after applying oil to a bearing near a rubber roller or drive belt, the roller or dive belt itself and the metal component it contacts should be thoroughly cleaned with alcohol. While on the subject of rubber rollers and drive belts, let us advise that all rubber surfaces be cleaned regularly since, due to the condensation of the oil on bearings and shafts, these surfaces may acquire a thin film of oil which may result in slippage. The rubber pressure roller which, in some recorders, contacts the *coated* side of the tape should also be cleaned regularly since microscopic particles of iron oxide worn from the tape may clog the pores of the rubber surface, another common cause of tape slippage.

Speed inaccuracy

Excessive tape speed is almost invariably due to worn or loose pressure pads. This condition can easily be determined through the use of an alignment tape which will be discussed presently. The majority of modern tape recorders have some means of adjusting these pads for wear. Extreme care should be used in making adjustments since if the pads are adjusted too tight the tape movement will be restricted, thus increasing the head wear and also reducing the speed. Before any adjustments are made the speed of the instrument should be checked because any changes in speed will effect the pitch of any recordings made previously. This is one of the reasons why we strongly advocate periodic checking. Assume you have made a number of important recordings without having checked the recorder speed for some time. At some later date the instrument is checked and found to operate too slow because of increased friction; it is then oiled and 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 use a reel of blank tape. Should this test reel be intended for use with a recorder which operates at 7½ ips it must contain almost 400 feet of tape. The start is marked with a grease pencil and another mark is placed at 187½ feet which indicates a five-minute interval. A third mark is placed at 375 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 above mentioned 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 a 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 1.5 seconds or better in ten minutes. A very good semi-professional portable recorder is usually accurate to within three 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, piano, clarinet, and the like. 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.

Wow and flutter

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, and so on, 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 source 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 been glazed. Quite a common tape recorder complaint is that the quality of the tapes originally made on an instrument sound muddy and distorted, and lack brilliance. Usually the owner blames the tape manufacturer and changes his brand. Manufacturers of recorded tapes are often accused of releasing poor tapes since the same recorder will also reproduce these poorly. The fault lies not with the tape manufacturer in either case but with the 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.* 10-1. These particles may prevent the close contact between the tape and the head which is required for optimum results.

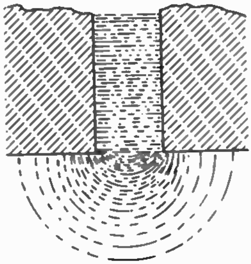

Fig. 10-1. Magnetic field around the recording-head gap.

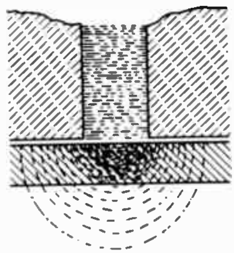

Fig. 10-2. Tape head with tape passing over the gap.

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. *Figure* 10-1 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* 10-2 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.* 10-3 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.

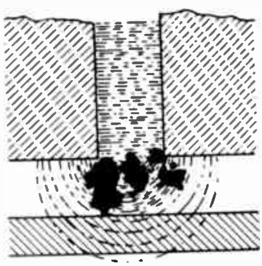

Fig. 10-3. Tape held away from head by dirt on tape or head.

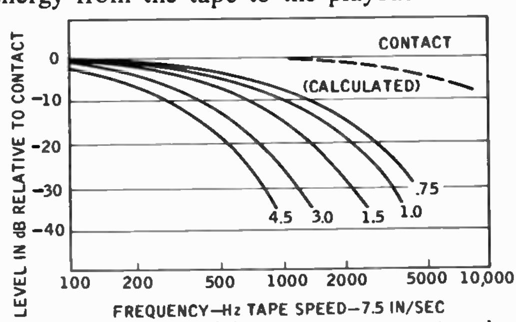

Fig. 10-4. Loss of high-frequency response as tape is separated from head by thousandths indicated on the individual curves.

Robert van 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 repoduction. During these tests a tape was recorded using various frequencies and playback 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 curves of *Fig.* 10-4 shows the result of these tests. From these curves we can see that a separation of only ¾ of a mil at a tape speed of 7½ ips is sufficient to cause an attenuation of 30 dB at approximately 5000 Hz, which would result in very little audible reproduction of this frequency or any frequency above it on the average recorder.

During 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 (¾ of a mil) and if it should become lodged at the head gap can seriously reduce high-frequency response. Any accumulation of dust and tape particles may easily be removed periodically with a Q-tip, pipe cleaner, or a cotton swab saturated with head-cleaning fluid available from suppliers of tape accessories.

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 accordance with the manufacturer's instructions.

There are a number of reasons for high noise level in a recorder. This most common is a magnetized record-play head. As the head becomes magnetized the noise level of a recording may rise as much as 10 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 demagnetization can be accomplished in a few seconds with a tape Head Demagnetizer, there is no reason that it should not become part of your regular maintenance program.

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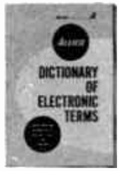

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