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# realistic guide to HI-FI and STEREO

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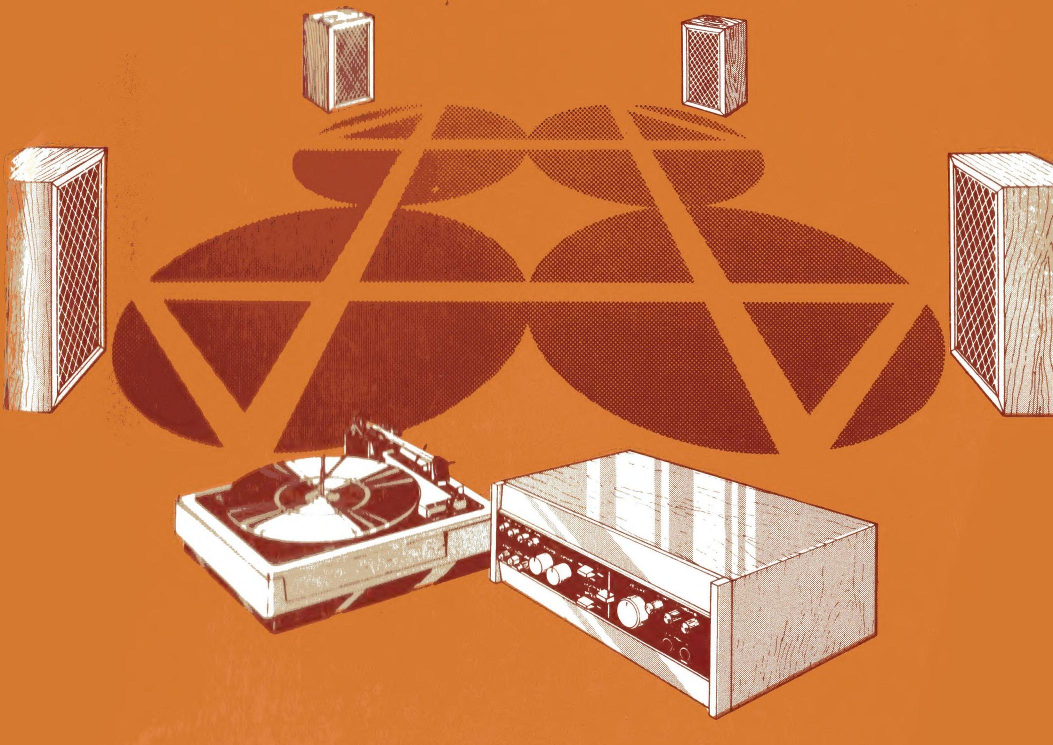

# Realistic Guide to HI-FI and STEREO

by

Leo G. Sands

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# PREFACE

Shortly after the turn of the century, people started being thrilled by listening to the phonograph. However, the sound reproduced from the phonograph had little resemblance to live music. Gradually, the phonograph was improved. When the 1926 Orthophonic phonograph was brought onto the market, many people thought that it reproduced the ultimate in sound. In 1928, however, the Victor Electrola was introduced, followed by the Columbia-Kolster electric phonograph. These were among the first hi-fi systems.

The "radio music box" suggested by the late David Sarnoff became a reality in the 1920s. Millions of people bought radios which reproduced music in a manner which today would be considered highly unsatisfactory. As the years passed, loudspeakers and electronic amplifiers improved. In 1935, Philco introduced its Model 200-X which reproduced music in a very satisfactory manner. By 1939, the art of electronic sound reproduction had improved dramatically.

By 1953, there was a big demand for hi-fi equipment. The demand grew even faster when stereo phonograph records were brought onto the market. Hi-fi ascended to a new plateau when solid-state technology had developed to the point that transistors were used in lieu of tubes. It brought a new dimension to hi-fi—the engineers called it "presence."

The advance of hi-fi from the early days of monophonic systems to today's quadraphonic systems can be appreciated by many. However, such an advance in technology results in more sophisticated systems and terminology. The more complicated hi-fi becomes, the more an individual needs to have a "working" knowledge of its complexity.

To gain this knowledge, quadraphonic systems (both discrete and synthesized), as well as two-channel stereo systems, are discussed at length in this book. Many illustrations have been provided to show exactly what is being discussed. In addition, complete stereo systems are shown to further aid the reader's knowledge of hi-fi. Changers, cassettes, eight-track cartridges, speakers, and inverters are a few of the many topics discussed.

This book was written to enlighten people who know little or nothing about electronics and who want to know more about hi-fi, two-channel stereo, and quadraphonics before buying new equipment or replacing old equipment.

LEO G. SANDS

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CHAPTER 1

# REALISTIC REPRODUCTION OF MUSIC

High fidelity (hi-fi) is supposed to mean *faithful reproduction of sound.* However, it is a much abused term. It is often applied to record changers; tape players/recorders, and decks; and to radio receivers which are not capable of faithful reproduction of sound. To many people, any music reproducing system is a *hi-fi* or a *stereo* just as any refrigerator is a Frigidaire. But, they're wrong. A true hi-fi system must meet certain criteria. However, this criteria is subject to many interpretations.

## MUSIC SPECTRUM

A good hi-fi system can do much more than just present a faithful reproduction of sound. It can be a producer of sound the way you want to hear it. When bass and treble controls are provided, you can make the violins and picolos stand out, or make the bass boom, or both. This is not necessarily faithful reproduction, but it can be extremely satisfying.

But to be a producer of satisfying sounds, a hi-fi system must first of all be capable of reproducing all frequencies (pitches) within the range of the human ear. Then, by adjusting the controls, the sound can be adjusted to your taste.

Long before the hi-fi era began, the public became accustomed to the sound of radios, home phonographs, and juke boxes which exaggerated the bass tones. Radio listeners had developed such a liking for the *radio sound* that many no longer knew what music was supposed to sound like. But when the hi-fi era began, the "audiophiles" (hi-fi enthusiasts) listened intently for all of the sounds in the music spectrum. However, many went for exaggerated treble sounds.

That's what hi-fi is all about—music the way you want to hear it. But, as said before, the hi-fi system must be capable of faithfully reproducing the entire music spectrum with a minimum of distortion. Then you can adjust the controls to obtain the kind of sound you want.

The human ear can sense sounds at frequencies within a limited spectrum known as the *audio-frequency* range. Most people can't hear sounds below 20 Hz or above 20,000 Hz. While no musical instrument produces fundamental frequencies as high as 20,000 Hz, it is the *overtones* that give music its brilliance. An overtone is a harmonic (multiple) of the fundamental frequency. For example, overtones are produced when a violin string is bowed. Fig. 1-1 shows the frequency spectrum of the orchestral instruments, not including the overtones. If a hi-fi system reproduced only the fundamental piano string frequencies, the sound would lack brilliance and naturalness. Therefore, it is necessary that a hi-fi system be capable of reproducing the overtones.

A small radio is usually capable of reproducing sounds at frequencies up to around 5000 Hz and down to perhaps as low as 100 Hz. While music reproduced by such a radio might satisfy some people, it is woefully inadequate for those who appreciate the true sound of music. The frequency response of such a radio is inadequate for anything except for voice reproduction.

The frequency response of the telephone is deliberately restricted to the so-called voice range or speech band for various technical reasons. It has been found that speech can be clearly understood and more readily transmitted over the telephone system when the system frequency response is limited to approximately the 300-3000 Hz range. Wider frequency response would make the speech sound more realistic but intelligibility would not be improved. But, for realistic reproduction of music, the home music system should have a frequency response extending from at least 50 Hz up to 10,000 Hz.

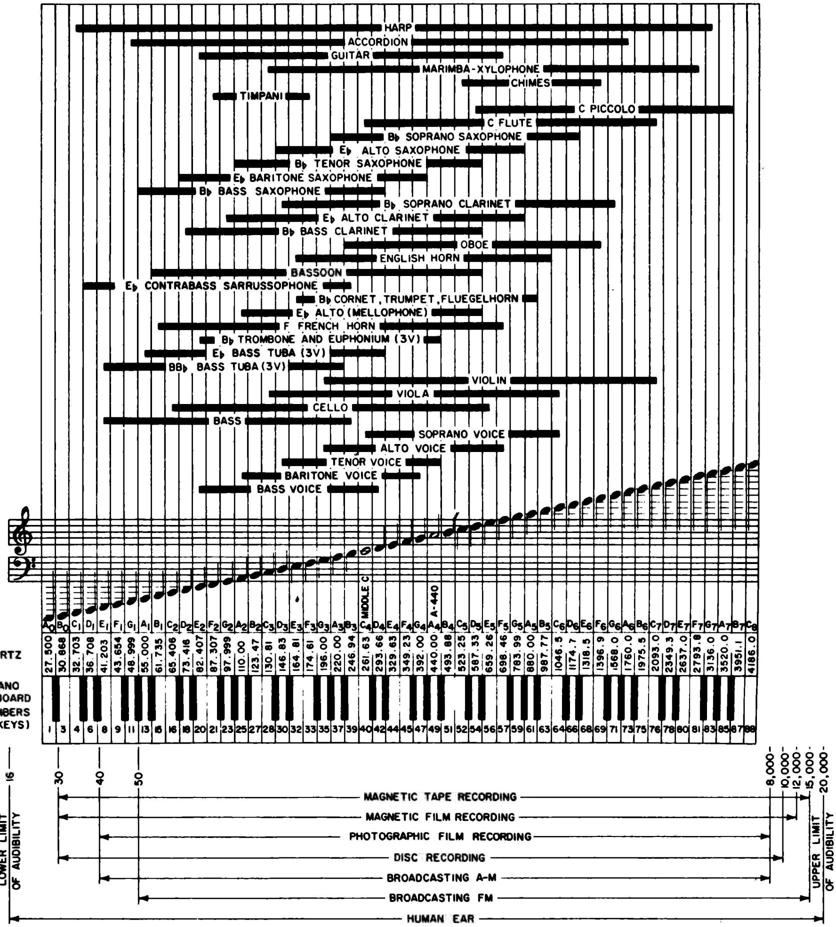



**Fig. 1-1. Frequency range of orchestral instruments excluding overtones.**

## DISTORTION

Another characteristic of a small radio and some so-called hi-fi systems is *distortion.* Many people do not notice distortion immediately. But after prolonged listening, distortion grates the nervous system.

There are several kinds of distortion. *Harmonic distortion* is produced when the sound system generates harmonics which do not exist in the original music. However, these unwanted harmonics should not be confused with wanted overtones. For example, when a 440-Hz tone is produced by an instrument (the instrument causes harmonics to be produced also) you will also hear a new tone at 880 Hz (second harmonic), 1320 Hz (third harmonic), and so on.

*Intermodulation distortion* is the result of one tone being modulated by another. For example, if a 440-Hz tone is modulated by a 50-Hz sound from a drum, the 440-Hz tone will sound blurred and additional sounds at 390 Hz (440 − 50), 490 Hz (440 + 50) and other frequencies will be heard. These are the sum and difference frequencies.

*Phase distortion* results when sounds at different frequencies are not reproduced in the same manner as originally produced. For example, a 440-Hz tone might be causing sound waves to be pushed forward toward your ear while a 4000-Hz tone pulls the sound waves away from your ear.

## PRESENCE

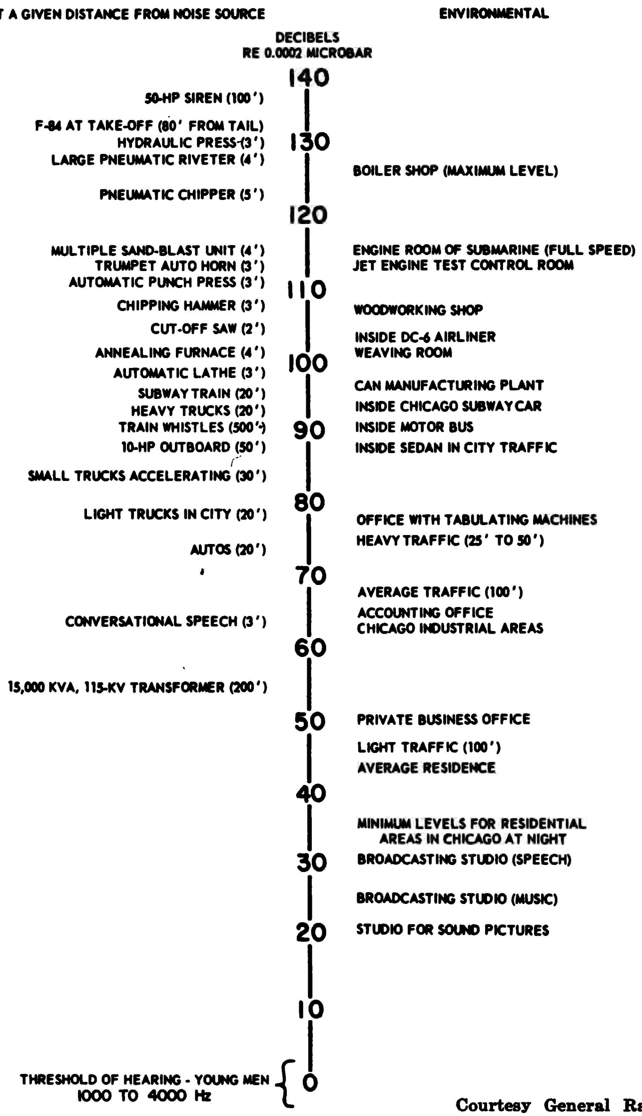
When you sit in a concert hall and listen to a live orchestra, you feel its *presence*. When listening to a small radio, this feeling of presence is absent. However, this presence can be felt when listening to an adequate hi-fi system.

## LOUDNESS AND DYNAMIC RANGE

The loudness of sound is expressed in terms of decibels (abbreviated dB). Fig. 1-2 shows the approximate decibel levels of various sounds. One decibel is the smallest change in the loudness of sound that the normal ear can sense. The dynamic range of a hi-fi system is not as great as that of a live orchestra because of such practical considerations as sound levels in a home. Few people would tolerate such wide variations in loudness as from a solo oboe passage to a full orchestra crescendo. Nevertheless, for realistic reproduction of music, the hi-fi system must have a wide dynamic range.

## MONAURAL SOUND REPRODUCTION

In a monaural sound system, the sound is processed through only one mike, amplifier, and speaker. As shown in Fig. 1-3, the sound picked up by the microphone is amplified, and then




Courtesy General Radio Co.

**Fig. 1-2. Approximate decibel levels of various sounds.**

reproduced by a single speaker. In this example, there is only one input and only one output.

If you add a second speaker, as shown in Fig. 1-4, you will still have a monaural sound system since there is still only one

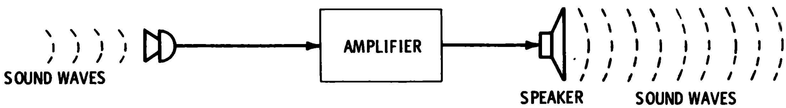



Fig. 1-3. Monaural sound system.

input. The two speakers reproduce the same sound in unison. And, of course, both ears will hear the same sound.

## STEREOPHONIC SOUND REPRODUCTION

Stereo (abbreviation for stereophonic) is much older than most people assume. Many years ago, some engineers from Bell Telephone Laboratories demonstrated stereophonic sound at Carnegie Hall. The sounds of an orchestra in Philadelphia were picked up by two microphones and fed through two separate amplifiers and telephone lines to Carnegie Hall where each *sound channel* was separately amplified and reproduced by two loudspeakers, as illustrated in Fig. 1-5. The audience heard somewhat different sounds from the left speaker than those emitted by the right speaker.

The introduction of stereo home music reproducing systems was delayed until the two-track magnetic tape recorder/player was developed. It then became practical to record two separate sound channels on a single tape and to play them back as shown in Fig. 1-6, through two separate amplifier/speaker systems. But home stereo did not become popular until the stereophonic phonograph record was developed.

Listening to stereo is quite different from listening to monaurally reproduced music. There is a greater feeling of presence since each ear hears somewhat different sounds. The stereo effect is even more dramatic when listening to music through stereo headphones.

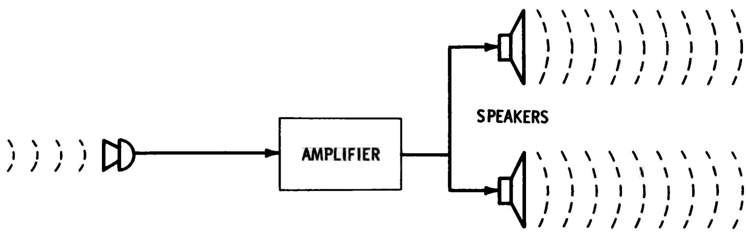



Fig. 1-4. Monaural sound system using two speakers.

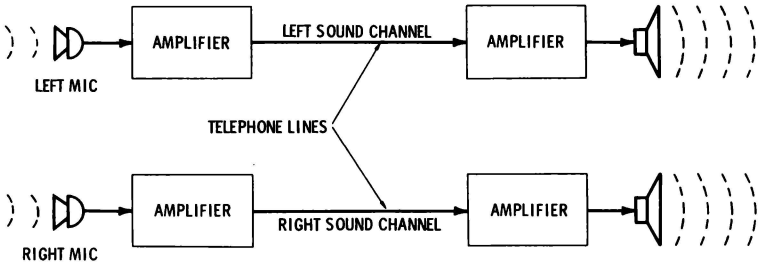



**Fig. 1-5. Early demonstration of stereophonic sound.**

A modern stereo system (two channel) is illustrated in Fig. 1-7. This type of system is referred to as a component system and will be discussed in subsequent chapters. The stereo ampli-

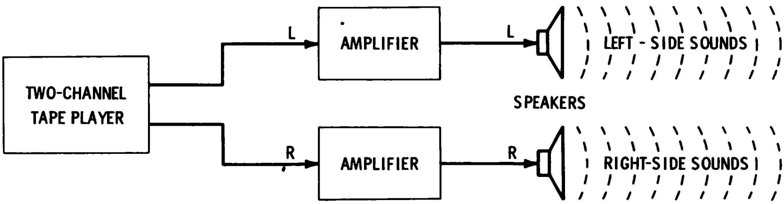



**Fig. 1-6. Playing back a two-channel recording.**

fier can amplify the stereo signals (two channel) from either the record changer, tuner, or cartridge player. The stereo signal would then be reproduced in the two speakers (one channel per speaker).

**Fig. 1-7. Modern stereo component system.**

Three-channel systems were also developed, but did not become popular for home use. The three-channel stereo system is used in some motion picture theaters when showing wide-screen films. The sounds are projected toward the audience by three sets of speakers behind the screen. When the image of a performer moves from the left side of the screen to the right, the voice of the performer seems to follow the image, adding to the realism of the action.

A three-channel public-address system is used in the huge Radio City Music Hall to give the illusion that the voices of the performers come from their locations on the vast stage. Some three-channel music centers were produced for home use, but they were actually two-channel systems which employed a third speaker that projected a mixture of left and right sounds, as illustrated in Fig. 1-8.

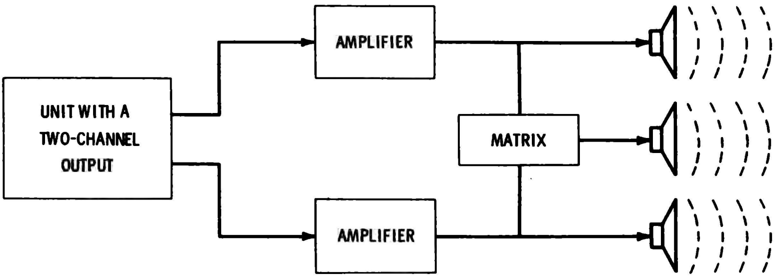



**Fig. 1-8. Employing a third speaker.**

## QUADRAPHONIC SOUND REPRODUCTION

The two-channel system (stereo) was a dramatic improvement over the single channel system (mono). And so is *quadraphonic* sound (four-channel stereo) an improvement over two-channel stereo.

When you go to a theater to see a live musical, the pit orchestra's string instruments are left of the conductor. The sounds do not emanate from one, two, three or even four points. Since they spread out into the auditorium and are reflected back by the walls and ceiling, you are literally surrounded by the music. The sounds reach the ears of the listeners from all directions. The sound is louder directly from the pit orchestra than from the reflecting surfaces. Since it takes longer for the sound waves to reach the ears of the listeners via reflected paths than by the direct paths, the phase relationships of the numerous tones vary. The same is true in a concert hall where the orchestra is on the stage.

It is the objective of a quadraphonic home music system to reproduce music in a manner that closely simulates the sounds heard in a theater or concert hall. This is achieved with a *discrete* four-channel system or a *synthesized* four-channel system. A discrete four-channel system can be easily understood by referring to Fig. 1-9. The sounds picked up by microphone A are reproduced by speaker A, those from microphone B are reproduced by speaker B and so on. When seated at point X, you will hear different sounds from all four speakers—two in front of you—two behind you. You are surrounded by sound and the effect can be thrilling.

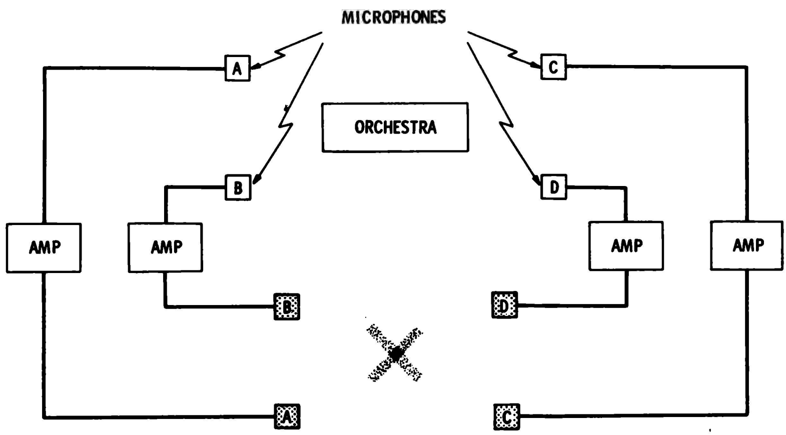



**Fig. 1-9. A discrete four-channel sound system.**

Essentially the same basic effect can be achieved by using a synthesized four-channel sound system now also being called a *quadraphonic* sound system. As shown in Fig. 1-10, the left channel signal is fed to the left front speaker and the right channel signal is fed to the right front speaker. The left and right channel signals are also fed into a matrix in which two new (synthesized) signals are developed, one of which is fed to the left rear speaker and the other to the right rear speaker. The best listening position is at point X which is equidistant from all four speakers.

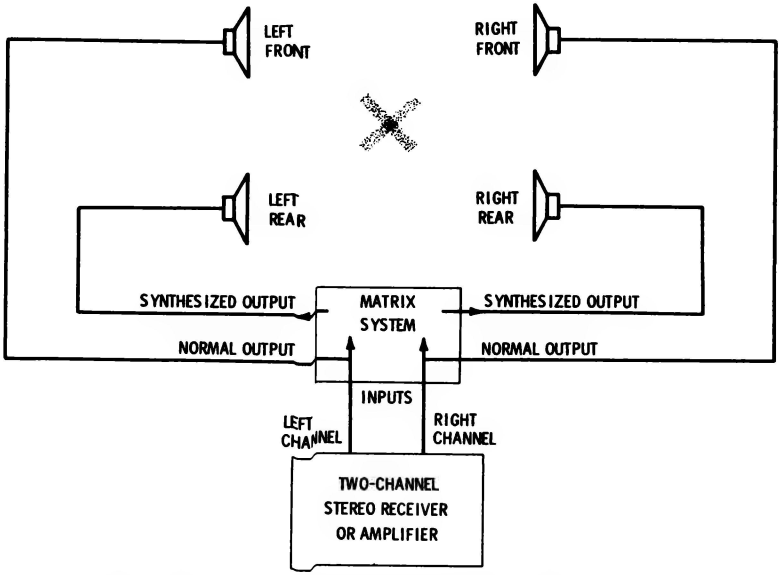



**Fig. 1-10. A synthesized four-channel sound system.**

A modern quadraphonic (discrete) sound system is illustrated in Fig. 1-11. This system, which is available from Radio Shack, is capable of operating from almost any four-channel program source as well as conventional two-channel stereo.

Two-channel stereo records and tapes can be played back through a four-channel synthesized quadraphonic hi-fi system

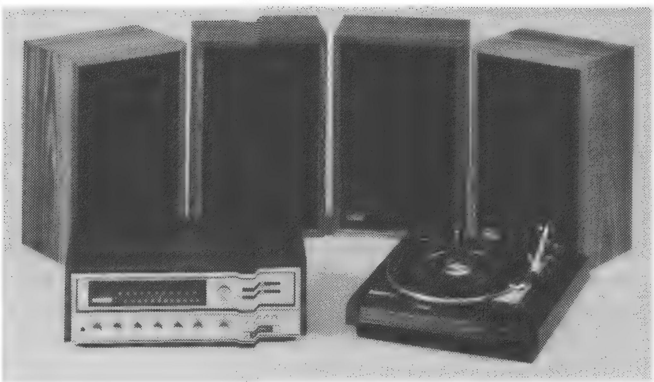


**Fig. 1-11. A modern quadraphonic (discrete) sound system.**

to produce the effect of being surrounded by music. Four-channel stereo records and tapes are also available which are designed for playback through a discrete four-channel hi-fi system. The two-channel stereo records are compatible in that they can be played back over a monaural hi-fi system, but without the stereo effect. The four-channel stereo records are also compatible in that they can be played back through a two-channel stereo system, synthesized quadraphonic system, or discrete four-channel system.

CHAPTER 2

# HIGH-FIDELITY AMPLIFIERS

A *component* hi-fi system consists of an amplifier and one or more speakers plus one or more program sources such as a record changer, tape recorder and/or radio tuner. The amplifier may be a separate unit or a part of a receiver (tuner-amplifier combination). Fig. 2-1 illustrates a typical hookup of the component hi-fi system.

## AMPLIFIER POWER REQUIREMENTS

The function of a high-fidelity amplifier is to take a weak signal from such units as a record changer, tape recorder, tape deck, or radio tuner and increase this signal so it will have enough power to drive one or more speakers. It requires very little power to drive the receiver of a telephone—about 1 milliwatt (.001 watt). However, it requires considerably more power to drive a high-quality speaker at peak listening levels.

The maximum audio output power of a hand-held portable transistor radio is about 250 milliwatts, and that of a typical table radio is about 2 watts. But neither is normally played at its maximum output capability level. There is a considerable amount of reserve power.

In a quiet room, a small radio delivering 100 milliwatts of power into its speaker sounds quite loud. So why does anyone need a 100-watt or even more powerful amplifier? First consider what the radio delivers—music within a relatively narrow band of frequencies. It's quite different when driving a large

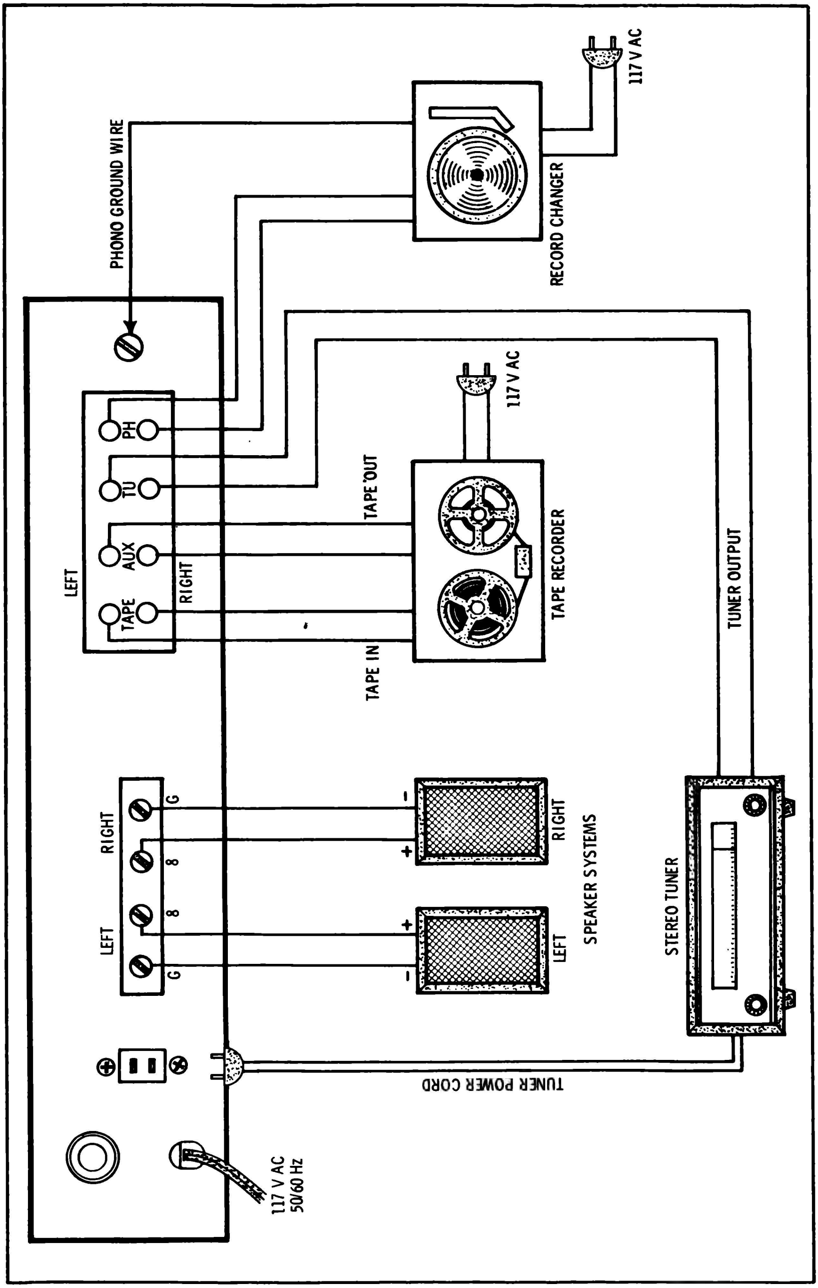



**Fig. 2-1. Typical connections of a component hi-fi system.**

speaker system and reproducing sounds containing a broad spectrum of frequencies.

How much amplifier power is required depends upon the size and acoustics of the room, the ambient noise level, the number and types of speakers used, and the loudness levels desired by the listeners.

For realistic reproduction of music, the amplifier should be capable of delivering much more power than normally required. Considerable reserve power is required for driving speakers so they will faithfully reproduce the roll of the kettle drum, full orchestra crescendos, and the majestic sounds of the pipe organ.

## STEREO AND QUADRAPHONIC AMPLIFIERS

Most hi-fi amplifiers on the market are either stereo or quadraphonic types since mono hi-fi systems are now considered almost obsolete. A stereo amplifier actually consists of two mono amplifiers within the same assembly. Fig. 2-2 is a block diagram of the amplifier shown in Fig. 2-4. A quadraphonic amplifier may consist of four separate amplifiers or two amplifiers and a quadraphonic synthesizer.

## AMPLIFIER GAIN REQUIREMENTS

The amount of amplification produced by an amplifier is known as its gain, which is expressed in dB (decibels), or in terms of the number of times the voltage or power is amplified. Table 2-1 lists the relationship of dB to voltage and power gain

**Table 2-1. Relationship of Decibels to Voltage and Power Ratios**

| dB | Voltage Ratio | Power Ratio | dBm | Output Wattage* |
|---|---|---|---|---|
| 0 | 1 | 1 | 0 | 0.001 |
| 3 | 1.4 | 2 | 3 | 0.002 |
| 6 | 2 | 4 | 6 | 0.004 |
| 10 | 3.1 | 10 | 10 | 0.01 |
| 20 | 10 | 100 | 20 | 0.1 |
| 40 | 100 | 10,000 | 40 | 10 |
| 50 | 310 | 100,000 | 50 | 100 |
| 60 | 1000 | 1,000,000 | 60 | 1000 |

*With reference to .001 watts input

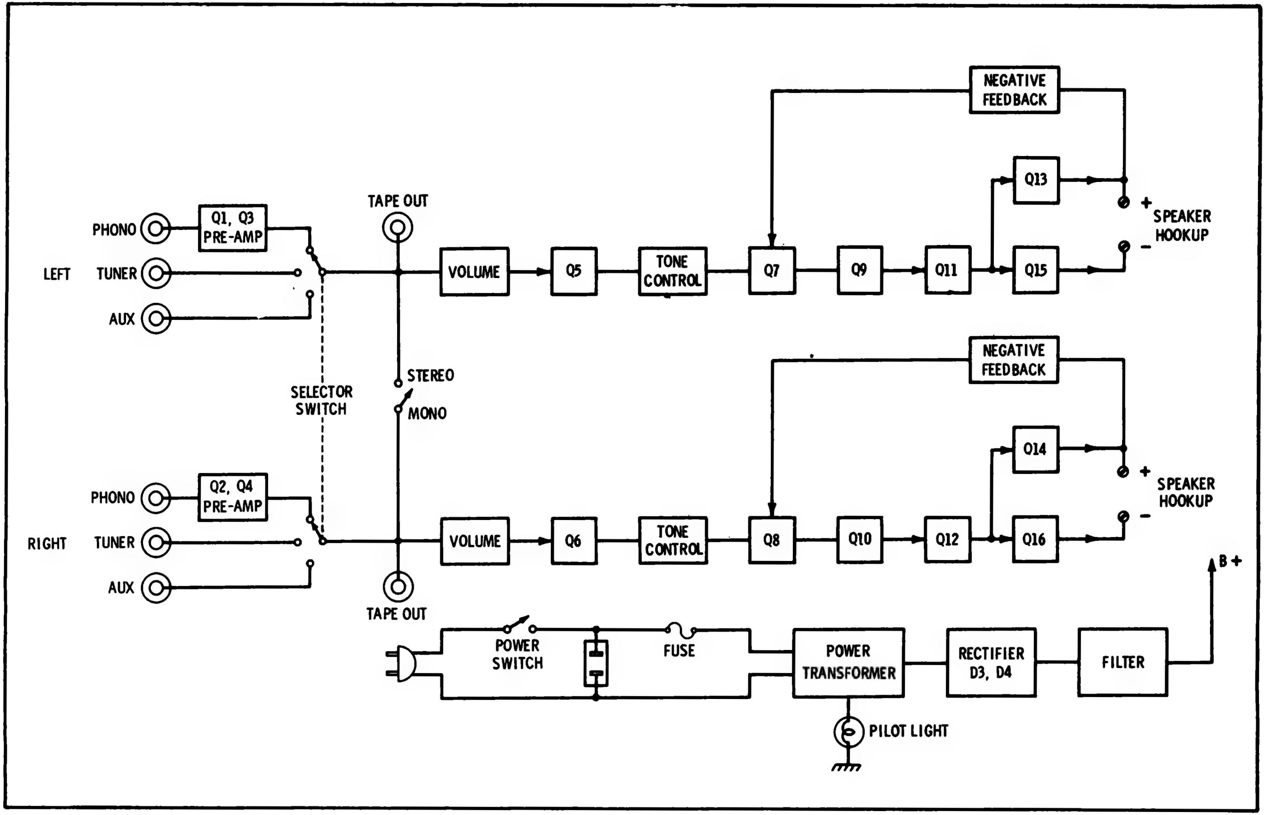



Fig. 2-2. Block diagram of a stereo amplifier.

ratios, and dBm to output wattage. For example, an amplifier with a gain of 40 dB is capable of amplifying the power of a signal 10,000 times. This would correspond to a voltage ratio (output/input) of 100, a power gain ratio (output/input) of 10,000, 40 dBm up from .001 watt, and an output wattage of 10 watts.

The use of decibels is another way of referring to the gain of a device. It basically indicates the ratio of power output to power input. Notice that a 3-dB gain corresponds to doubling the power. The dBm column is merely using dB in reference to a level of 1 milliwatt. Therefore, a gain of 3 dBm means we have come 3 dB up (double the power) from a reference level of 1 milliwatt. The voltage and power ratio columns indicate their respective output/input ratios.

The required amount of gain depends upon the level of the signal produced by the input device. The amount of gain required is determined by the amplifier or receiver manufacturer. Instead of specifying the gain, the manufacturer specifies *input sensitivity.* These ratings for a typical amplifier are 2-5 millivolts magnetic phonograph input, and 200-300 millivolts auxiliary input.

## AMPLIFIER DISTORTION

The distortion introduced by a modern high-grade amplifier is extremely small. For example, the rated harmonic distortion of the Realistic SA-900 amplifier (Fig. 2-3) is less than 0.8% at rated power. A small table radio or hand-carried portable tape player could introduce harmonic distortion of 10% or greater.

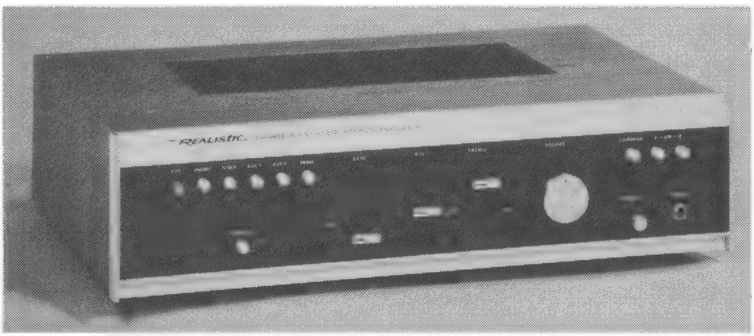


Fig. 2-3. Realistic SA-900 amplifier.

## FREQUENCY RESPONSE

A modern high-quality amplifier will amplify equally all signals in the 20-20,000 Hz-range within ±1 dB, when the bass and treble controls are set for a flat response. In actual use, the frequency response is adjusted by the user to emphasize the higher frequencies and/or lower frequencies to obtain the most pleasing effect.

## HUM AND NOISE

A low-frequency humming sound is heard in the speakers if the amplifier or its built-in power supply are not correctly designed. Other noise is generated by the amplifier itself. However, both hum and noise can be made almost totally inaudible. For example, the hum/noise rating of the Realistic SA-900 amplifier is −60 dB with respect to the phono input, and −70 dB with respect to the auxiliary input.

## INPUT/OUTPUT TERMINALS

Generally an amplifier has phono jacks for phonograph and auxiliary inputs and either screw terminals, spring terminals, or phono jacks for the speakers. Some amplifiers have screw terminals for 4-, 8-, and 16-ohm speakers. This means that an 8-ohm speaker should be connected between the common (C) and 8-ohm terminal. Most amplifiers now have only one pair of screw terminals (or one phono jack) for each channel to which any speaker, whose impedance is between 4 and 16 ohms, can be connected.

## BASIC CONSIDERATIONS

Although a hi-fi system is often operated using minimum output power, reserve power is required to reproduce music without loss of its dynamic range. The use of a 50-watt or even a 200-watt (IHF) amplifier in a living room, therefore, is not ridiculous.

When studying amplifier specifications, look for adequate frequency response (i.e., 20-12,000 Hz at least), low distortion (less than 1%), and low hum/noise (−60 dB or more—the

**Table 2-2. Examples of Amplifier Specifications**

| | Model X | Model Y | Model Z |
|---|---|---|---|
| Power output (IHF watts ±1 dB) | 90 | 55 | 200 |
| Speaker load reference (ohms) | 8 | 8 | 8 |
| Power output (continuous watts) | 45 | 30 | 120 |
| Frequency response (hertz ±1 dB) | 20-20,000 | 20-20,000 | 20-25,000 |
| Harmonic distortion (percent) | 0.8 | 1 | 0.5 |
| Hum/noise: | | | |
| phono (decibels) | —60 | —50 | —65 |
| tuner/aux (decibels) | —70 | —65 | —75 |
| Output impedance (ohms) | 4-16 | 4-16 | 4-16 |

bigger the dB number, the better). Examples of amplifier specifications are listed in Table 2-2.

## TUBES VERSUS TRANSISTORS

Older hi-fi amplifiers employ electron tubes, whereas nearly all modern amplifiers (Fig. 2-4) are *solid-state* types which employ transistors and integrated circuits in lieu of tubes. An integrated circuit (IC) is a small, single module (circuit package) which may contain many transistors, diodes, resistors, and capacitors.

A tube-type amplifier consumes more electric power than a solid-state amplifier because transistors are electrically more efficient than tubes. Tubes convert more of the electric power into heat than do transistors. This heat is wasted electric power.

**Fig. 2-4. Modern solid-state amplifier.**

Tubes wear out in time and must be replaced. Transistors, on the other hand, are said to have infinite life. They do not wear out, but can become damaged if abused. A transistor normally is either good or no good whereas a tube can be no good at all, noisy, weak, or in a satisfactory condition.

Transistors can also be superior to tubes in regard to performance—they are more highly responsive to momentary sound peaks, making the reproduced sound have a better presence effect.

CHAPTER 3

# SPEAKER SYSTEMS

A speaker is the device in a system that changes electrical impulses into sound waves. The most common type of speaker in use today is called a pm (permanent magnet) speaker. The general construction of a pm speaker is shown in Fig. 3-1. The conical diaphragm is made of heavy paper or plastic. As it vibrates, sound is produced and radiated into the air.

The vibration of the cone moves the air ahead of it and produces sound waves. The cone is moved by the voice coil, which is a coil of wire wound on a cylinder of fiber or plastic and suspended in a small open ring in the magnetic assembly. The electric current flowing through the voice coil causes the voice coil to move back and forth and vibrate the cone.

## SPEAKER TYPES

Since a single speaker cannot effectively reproduce the whole range of frequencies from a good amplifier, a combination of speakers is often used. The low frequencies are reproduced by a large speaker called a woofer. This speaker is designed with a loosely suspended cone so that the very low tones move the cone in rather large increments. The woofer is used to reproduce up to about 500 Hz in three-way systems, and to 2000 Hz when only two speakers are used.

The speaker designed to handle the high frequencies is called the tweeter. Physically, the tweeter is a small unit that nor-

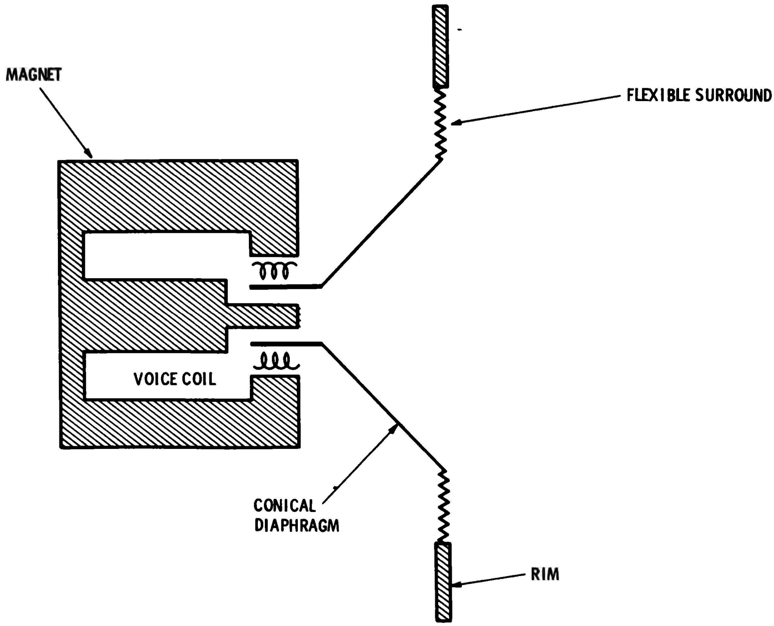



**Fig. 3-1. Constructión of a typical permanent magnet speaker.**

mally reproduces only the frequencies above 2000 Hz. It can be a pm cone, electrostatic, or horn speaker. Some tweeters used in a three-speaker system are designed only to reproduce the frequencies above 5000 Hz.

In a three-speaker system, the midrange speaker reproduces frequencies from 500 Hz to about 6000 Hz. This speaker is also a cone type, but smaller in diameter than the woofer and with a stiffer cone. This allows more rapid movement and better reproduction of the middle range of the audio frequencies.

As a result of the demand for physically smaller speaker systems, coaxial and triaxial speakers have been developed. The response characteristics of a woofer, midrange and tweeter are combined in one unit. A coaxial speaker combines both a high- and low-frequency unit into a single speaker along with a crossover network. However, three-way coaxial speakers are available where both a tweeter and midrange are coaxial mounted in up to a 12-inch speaker. In this type of situation, a frequency response of 24-18,500 Hz can be obtained. A triaxial speaker contains three independently driven units in a single speaker.

## SPEAKER BAFFLES

Because of the movement of air around a speaker, some type of baffle must be used. If the speaker cone does not have some isolation between its front and rear surface, there will be some cancellation when the air movement from the rear of the speaker, which is out of phase with the front air movement, leaks around the speaker, as illustrated in Fig. 3-2. The effect is not noticed at the higher frequencies but it has a large effect on the lower frequencies. The ideal or infinite baffle exists when there is no air path between the front and rear of a speaker. An example of this would be when the speaker is mounted in a hole in a wall with its front surface in one room and its rear surface in another. With this setup, the front and back waves never meet. Since this is seldom practical, a speaker enclosure is used.

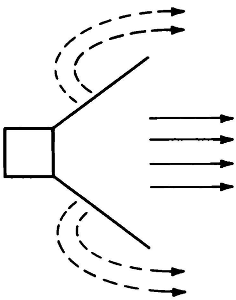


Fig. 3-2. Movement of air around an open speaker.

## SPEAKER ENCLOSURES

In the bass-reflex enclosure, illustrated in Fig. 3-3, the movement of air from the rear of the speaker is used to reinforce the front air movement and thus improves the bass response of the speaker. The bass-reflex enclosure is a box of the proper cubic size for the speaker to be used with a round mounting hole for the speaker and a rectangular hole below. The hole or *port* must be designed so that the rear air wave is reversed in phase before it comes out of the port. The wave then adds to the front wave instead of cancelling it.

A disadvantage of the simple bass-reflex enclosure is its size. A well designed unit is usually quite large and does not blend in very well in smaller rooms. A method of decreasing the size

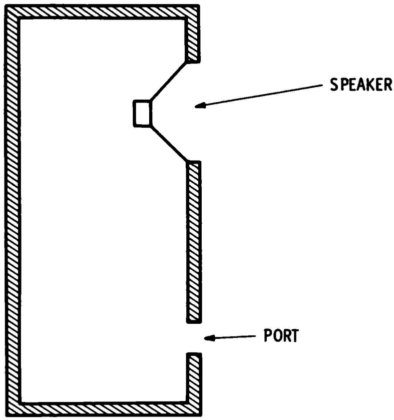



**Fig. 3-3. Construction of a bass-reflex enclosure.**

of the box without any loss of bass response is to duct the rear air through a tube to the port. This changes the phase of the air waves coming from the rear of the speaker and requires much less space than the standard bass-reflex enclosure.

During the last few years, there have been many innovations in the field of speaker systems. The general trend has been toward the smaller type of cabinet that does not involve as much space. The enclosures are now being designed as furniture that blends into the surroundings rather than large boxes that occupy too much space.

One of the developments has been the *acoustic suspension system.* The speaker has a very soft cone that offers very little resistance to movement. This speaker is installed in a completely sealed box; the back-air motion prevents excessive movement of the cone. This type of system can reproduce the very low frequencies that formely required cabinets with at least ten cubic feet of space. It is necessary, however, to purchase the speaker and cabinet as a system in order to achieve the proper frequency response and get the quality that is desired.

In most speaker systems where multiple speakers are used, a means of separating the frequencies is required. This is called a *crossover network.* The crossover network in a two-way system separates the bands of frequencies and directs the lower frequencies to the woofer speaker, while the high frequencies are passed to the tweeter section of the system. The network is a filter circuit that presents a very high impedance to the undesired frequencies and a low impedance to the desired signals, and is connected as shown in Fig. 3-4.

Some crossover networks also include a volume or level control to properly balance the outputs from the speakers for the particular acoustical characteristics of the listening area involved. These networks are available as separate items but in most cases, it is much better to purchase the speakers, network and enclosures, as a complete system to avoid any problems that might arise if separately purchased items are used.

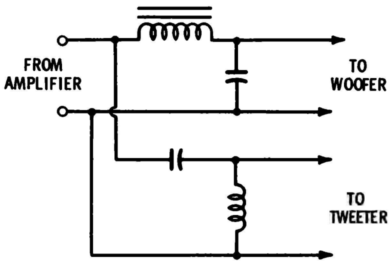


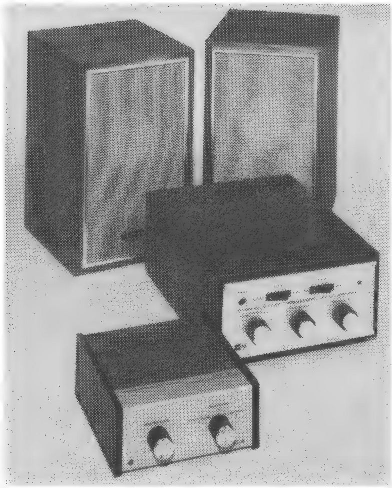

**Fig. 3-4. Schematic diagram of a crossover network.**

As mentioned previously, the speaker enclosure is a critical part of the system. It cannot be a randomly constructed box that simply holds a few speakers. It must be designed, to add to, rather than detract from, the audio frequencies that must be reproduced. The speaker enclosure must be sturdily built and acoustically insulated from the amplifier in order to prevent any mechanical feedback. The speakers in a stereo system should be matched so that both the right and left channels are properly balanced and the tonal qualities are the same.

A very popular style of speaker system is the bookshelf type. This name is used because these units are designed to fit on or in a standard bookshelf and therefore require no floor space. These enclosures are designed for either acoustic suspension speakers or small coaxial speakers, and usually are purchased as complete units. Each enclosure is carefully designed and constructed to bring out the very best quality of sound from the speaker employed.

The system shown in Fig. 3-5 uses a very small speaker, 4 inches in diameter, which is acoustically suspended in a sealed cabinet that measures only 9¾ × 8 × 6⅝ inches and yet has a frequency response from 30 Hz to 17,000 Hz. The unit in Fig. 3-6 is the tuned-duct type enclosure employing a coaxial

Fig. 3-5. Stereo system incorporating acoustic suspension speakers.



speaker that has a frequency response of 50 Hz to 14,000 Hz and is $14\frac{1}{2} \times 11 \times 5$ inches in size. These are moderately priced systems that fit well into apartments and other areas where space is at a premium.

A slightly smaller version of the bookshelf system is the compact speaker system. These units are rated at 10 to 15 watts and have specially designed acoustic suspension woofers that extend the low frequency response to below 40 Hz. The high frequencies are fed through a high compliance tweeter for a response up to 20,000 Hz. The units shown in Fig. 3-7 are typical of a compact speaker system. These units are less efficient

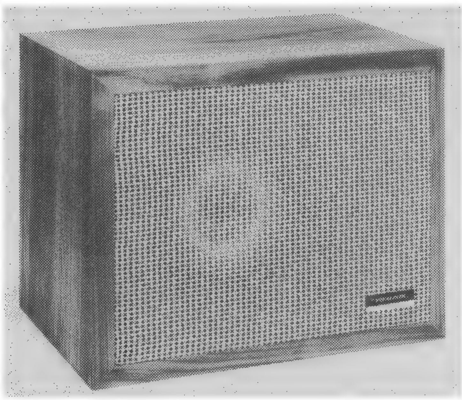


Fig. 3-6. An enclosure incorporating a coaxial speaker.

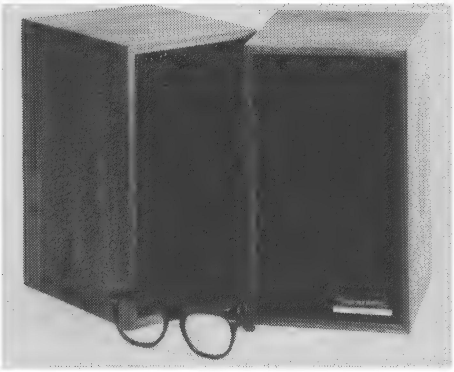


Fig. 3-7. A compact speaker system.

than some larger speaker systems but have excellent response and are perfectly designed for listeners who want good reproduction, but are limited as to the space available for equipment.

Where space is not a major problem and the ultimate in sound reproduction is desired, the larger speaker systems are usually employed, as shown in Fig. 3-8. A unit of this type usually has variable control for the midrange and tweeter

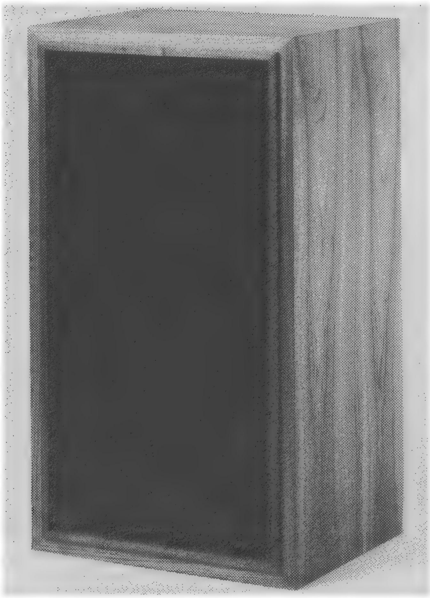


Fig. 3-8. Realistic Optimus-5 speaker system.

response so that any variation in room acoustics may be correctly compensated for to insure smooth response over the entire audio spectrum.

The latest innovation to be introduced is the decorator styles of speaker system. These are the larger floor-standing types of speaker systems that are designed with a two-fold purpose. They are primarily speaker enclosures, but they are also used as pieces of furniture. Fig. 3-9 is a *sound column* (decorator) type of system that is designed to be used as an end table. Another type which is shown in Fig. 3-10, has a cushioned top to be used as an extra seat. These speaker systems are designed to fit into the decoration scheme of the room rather than be just large boxes that must have the room arranged to accommodate them.

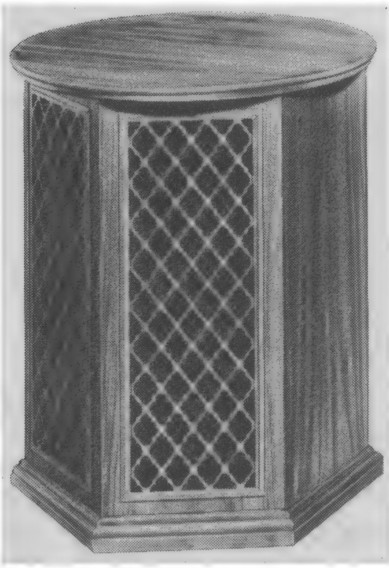


**Fig. 3-9. Decorator speaker system.**

**Fig. 3-10. A speaker/seat system.**

## OMNIDIRECTIONAL SPEAKERS

In rooms where placement of the speaker system may be difficult, another type of enclosure is available. This type provides omnidirectional sound dispersion—that is, an equal amount of sound is sent out over 360°. The speaker may be placed anywhere in a room and an equal amount of sound will be radiated in all directions. This type of system (omnidirectional) may be similar to the decorator style described previously, or it may also resemble the unit shown in Fig. 3-11. This unit radiates the sound directly down toward the base and it is then reflected off the base equally in all directions. A unit of this type uses an acoustic suspension speaker in the small enclosure to improve the overall frequency response of the system.

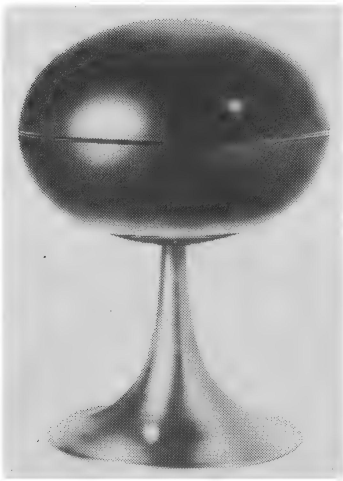


Fig. 3-11. Omnidirectional speaker system.

## ELECTROSTATIC SPEAKERS

The electrostatic speaker uses a completely different type of sound reproduction technique. It depends upon an electrostatic charge between thin metallic plates. A center sheet of thin metal has a high dc voltage applied between it and two outside plates. The audio signals are applied to the two outside plates. As the voltage rises on one plate, it falls on the other plate. This causes the center plate to move toward the plate with the rising voltage. This causes a movement of air in front of the plate.

## BUILT-IN SPEAKERS

Cone-type speakers are usually installed inside of an enclosure—a cabinet which is a piece of furniture. However, a speaker can be built into a wall or ceiling or mounted through a closet door. When mounted in a door, it is necessary to cut a round hole in the door. The front-side of the hole can be covered with a grill cloth of appropriate color.

For four-channel sound reproduction, two of the speakers can be mounted into doors and two built into the wall on the other side of the room. Or, all four speakers can be built into the wall. Another possible arrangement is installing the speakers in the ceiling.

The door, wall, or ceiling acts as a baffle. Since the sound waves emanating from the front of the speaker cannot reach the back of the speaker cone, an infinite baffle is formed.

CHAPTER 4

# RADIO TUNERS AND RECEIVERS

A radio tuner (Fig. 4-1) is similar to a radio receiver except that it does not contain a power amplifier or speaker. It is intended for use with an external amplifier, as shown in Fig. 4-2. A so-called receiver consists of a tuner and an amplifier. An am/fm tuner or receiver is used for receiving both a-m and fm stations, whereas an fm tuner is not designed to receive a-m stations.

## A-M BROADCASTING

The a-m (amplitude modulation) radio broadcast stations transmit monaural programs on frequencies within the 535-1605 kHz band. During daylight hours, a-m stations can usually be received at somewhat less distances than at night. At night, some a-m stations can often be received hundreds or even thousands of miles away. Certain powerful a-m stations, such as WOR in New York, can be received during daylight from Montreal to North Carolina, and at night in approximately 37 states.

## FM BROADCASTING

The fm (frequency modulation) radio broadcast stations transmit either or both monaural and stereophonic programs on frequencies within the 88-108 MHz band. The distance at

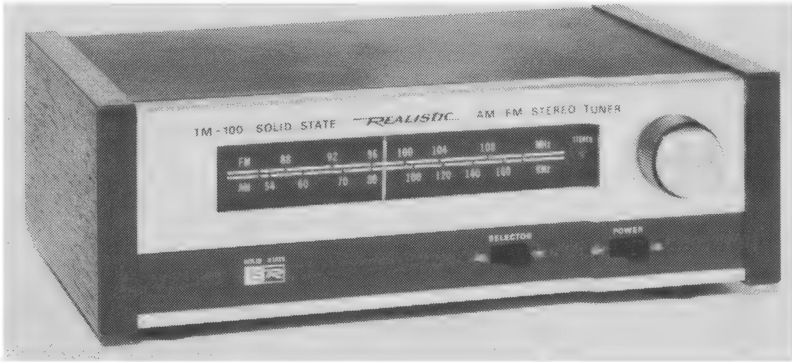



Fig. 4-1. Am/fm radio tuner.

which an fm station can be received is the same day and night and is usually limited.

The objective of an fm station is to serve its own local area, not distant areas. However, fm stations can be received at greater distances depending upon the height of the transmitting antenna and transmitter power. Since the fm signals travel to slightly beyond the horizon, they can be received at greater distances by increasing the height of the receiving antenna.

## STEREO BROADCASTING

Although an a-m stereo broadcasting system has been developed, a-m stations in the United States broadcast only monaural programs. Fm stations, on the other hand, broadcast either or both mono and stereo programs.


Fig. 4-2. Typical amplifier to be used with a radio tuner.

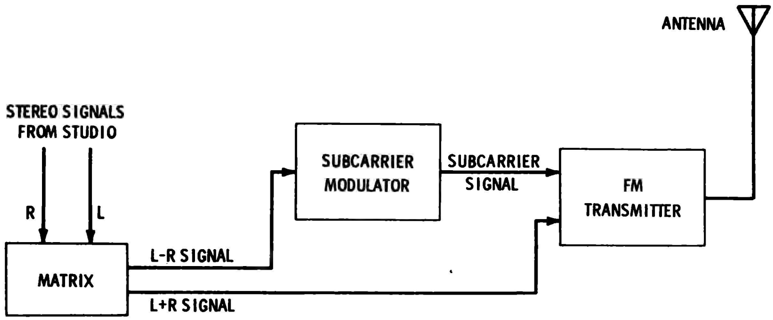



**Fig. 4-3. In fm stereo broadcasting, the L — R signal enters the subcarrier modulator.**

To broadcast fm stereo programs, the station uses a multiplexer. The left and right program channels are combined and used to directly modulate the fm transmitter. When intercepted by a mono fm receiver, a mono program is reproduced.

At the same time, the left and right channel signals are matrixed to produce an L – R signal which is fed to a subcarrier modulator, as shown in Fig. 4-3. When intercepted by a mono fm receiver, the L – R signal has no effect—only the L + R signal is heard.

But, when intercepted by an fm-stereo receiver, both the L + R and the L – R signals are utilized. These two signals are fed into a stereo demultiplexer within the receiver (or tuner) which separate the L and R signals and routes them to the left and right channel amplifiers, as shown in Fig. 4-4.

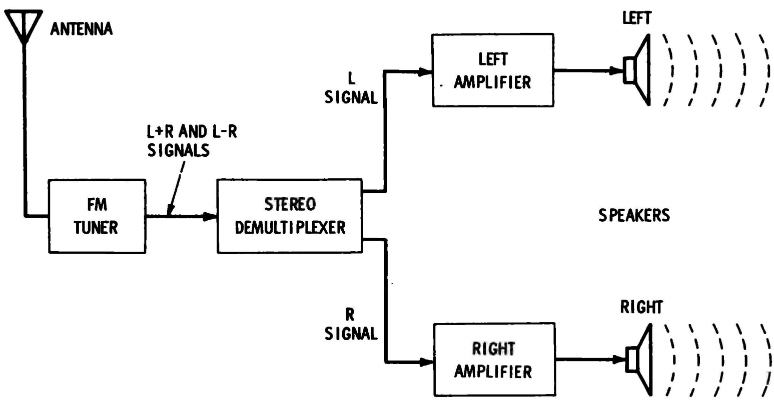



**Fig. 4-4. The stereo demultiplexer separates the L and R signals.**

## SELECTIVITY

A receiver (or tuner) should be selective enough to enable tuning of one station without interference from an adjacent station. The a-m channels are spaced only 10 kHz apart whereas the fm channels are spaced 200 kHz apart. Therefore, an a-m receiver must be much more selective than an fm receiver.

When an a-m transmitter is modulated by music containing frequencies up to 5000 Hz, the bandwidth of its signal is 10 kHz. When an fm transmitter is modulated by music containing frequencies up to 15,000 Hz, its band occupancy is slightly in excess of 200 kHz (20 times greater than the band occupancy of the a-m station).

Either an a-m or fm receiver can be designed to be excessively selective. For communications purposes, this is desirable. But for music reproduction purposes, selectivity should not be excessive. The receiver bandpass should be wide enough to pass the entire signal. If not, the quality of the reproduced music will be impaired. Ideally, the receiver bandpass should be adequately wide and at the same time the receiver should be able to totally reject the signals of a station on another channel. This is achieved by a well-designed receiver which will accept only one signal at a time. In fm, when two signals are intercepted simultaneously, the stronger of the two will be reproduced. This is known as the *capture effect.*

## AUTOMATIC FREQUENCY CONTROL

A well-designed fm receiver incorporates an afc (automatic frequency control) circuit which automatically prevents distortion that would otherwise be caused by gradual self-detuning of the receiver. The afc circuit automatically keeps the receiver tuned so that it will receive only one station at any one time, and so that it will pass the entire signal.

## SENSITIVITY

A very important characteristic of a receiver is its *sensitivity.* This is really a measure of its gain. Typically, the sensitivity of a high-quality fm receiver is 5 microvolts. If its sensitivity is 2.5 microvolts, it is twice as good. The sensitivity rating is the extreme limit. Usually, the signal received from an fm station is many times stronger than the rated sensitivity. While it is seldom necessary to be able to receive a 5-microvolt signal, it is good to have this reserve sensitivity.

## FM TUNER SPECIFICATIONS

All standard fm tuners and receivers are manually tunable to any frequency within the 88-108 MHz band. Fig. 4-5 shows an example of an fm radio tuner containing a stereo demultiplexer.


**Fig. 4-5. Fm radio tuner.**

Most fm tuners include afc (automatic frequency control) which keeps the receiver tuned to the selected station so you won't have to fiddle with the tuning dial after tuning in the station. An afc on-off switch is usually provided. When tuning in a weaker station, it is best to turn the afc off so that the stronger local station can not overpower the desired station and make it impossible to receive the weaker station. Once the station selection is made, the afc may be turned on again to prevent any drift in the receiver. It is imperative for good stereo reception to have the receiver tuned correctely.

Most fm receivers have either one or two tuning meters. When a signal-level meter is provided, the receiver is tuned for a maximum meter reading. And when a signal-symmetry meter is provided, the receiver is tuned for center-scale indication.

Specifications for typical am/fm tuners are listed in Table 4-1. As can be noted, fm sensitivity is rated at 2 microvolts or less (The smaller the number of microvolts, the more sensitive the receiver.) The stereo separation is rated at 35 dB. The fm capture ratio is rated below 3 dB which means that a signal approximately twice as strong as an interfering signal on the same channel will *capture* the receiver and be heard without interference from the weaker station. The harmonic distortion is rated at less than 1% which means realistic sound reproduction.

**Table 4-1. Examples of FM/AM Tuner Specifications**

| | Model X | Model Y | Model Z |
|---|---|---|---|
| Fm sensitivity (microvolts) | 2.0 | 1.8 | 1.5 |
| Stereo separation (decibels) | 35 | 35 | 35 |
| Fm capture ratio (decibels) | 2.5 | 1.55 | 1.2 |
| Fm signal-to-noise ratio (decibels) | 65 | 65 | 65 |
| Fm harmonic distortion (percent) | 0.6 | 0.35 | 0.3 |
| A-m sensitivity (microvolts) | 100 | 40 | 120 |
| A-m image rejection (decibels) | 40 | 40 | 80 |

The a-m sensitivity ratings are better than 120 microvolts when using the built-in antenna. When an external a-m antenna is used, the sensitivity will be even better. The image rejection is better than 40 dB in two cases and better than 80 dB in the third case. When the image rejection is 40 dB, it means that a signal from a potentially interfering station operating on another frequency (an image frequency) would have to be received at a power level much higher than the level of the desired station to cause interference. If the rejection is 80 dB, the interfering station would have to be even stronger to cause any interference.

The specifications for amplifiers (applicable to the audio portion of receivers) are discussed in Chapter 2.

## TUNER OR RECEIVER

A separate tuner and amplifier combination will provide excellent performance. The trend today, however, is to buy a complete receiver (tuner and amplifier), such as the one shown in the system illustrated in Fig. 4-6. However, if you already

**Fig. 4-6. Sound system incorporating a receiver.**

have a good stereo amplifier and a record changer or tape deck, you can add radio reception by simply buying a tuner. The big advantage of a complete receiver is compactness and minimization of cabling requirements.

Receivers are now available in both two-channel and four-channel models. All usually have input jacks for record changers, tape decks, and auxiliary input devices.

CHAPTER 5

# ANTENNAS

Most fm stereo receivers have a built-in antenna which is usually adequate for reception of nearby fm stations. Almost anywhere, however, better reception will be obtained when using an outdoor fm antenna. Good, clean fm stereo reception requires having strong signals at the input of the receiver.

## FM ANTENNAS

An fm antenna is one whose dimensions make it an efficient interceptor of radio signals at frequencies within the 88-108 MHz fm radio broadcast band. Some fm antennas are omnidirectional—they receive equally well from all directions. Others are unidirectional—they are more sensitive to signals from a specific direction.

The S-curve antenna shown in Fig. 5-1 is an example of an omnidirectional fm antenna for receiving fm stations up to 35 miles away. The fm antenna shown in Fig. 5-2 is an even more efficient (high-gain) omnidirectional fm antenna.

For receiving fm stations up to 110 miles away, a directional antenna is required (Fig. 5-3). The five-element directional array is easy to install and provides gain. This means that the antenna provides the effect of a preamplifier by capturing more of the radio energy than a conventional omnidirectional antenna.

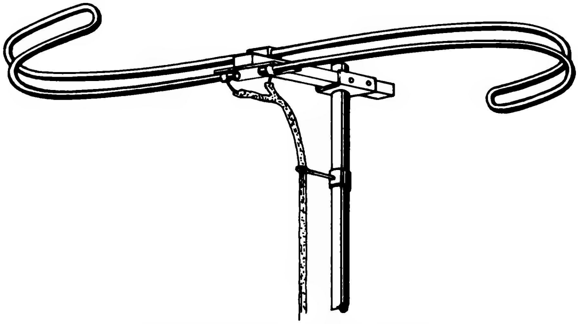


Fig. 5-1. S-curve, fm antenna.

Fig. 5-2. High-gain omni-directional fm antenna.

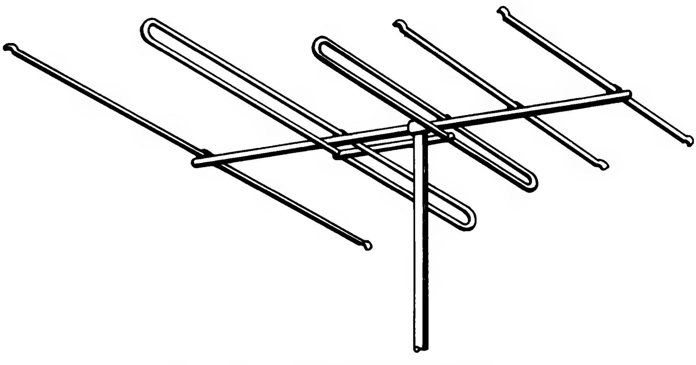


Fig. 5-3. Directional fm antenna.

## ANTENNA ROTATOR

When using a directional fm antenna, station reception from a specific direction is desired. However, at a location where reception of several stations in different directions is wanted, the antenna can be mounted on a *rotator*. The antenna assembly is rotated by an electric motor which is controlled with a knob on the remote control unit placed close to the fm receiver. The Archer antenna rotator control unit is shown in Fig. 5-4.

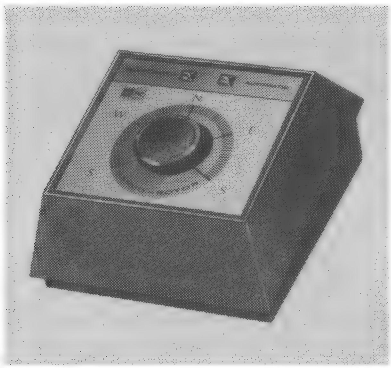


**Fig. 5-4. Archer antenna rotator control unit.**

To rotate the antenna, simply turn the control knob to the desired azimuth setting. When the location of a station is unknown, turn the knob until reception is best.

## MULTIPATH RECEPTION

Distorted fm reception sometimes occurs when the signal arrives at the antenna via two or more different paths. This is illustrated in Fig. 5-5. In this example, the signal is received via a direct (primary) path and also via a reflected (secondary) path. It takes longer for the signal to travel via the secondary path than it does over the direct path. Since the direct path signal arrives first, the reflected path signal will not be in phase with the direct path signal and distortion may result.

This kind of distortion can usually be eliminated by using a directional antenna mounted on a rotator. The antenna can be rotated so that an unwanted reflected signal will either not be picked up at all, or at least weakened so that it will have no adverse effect on the desired signal.

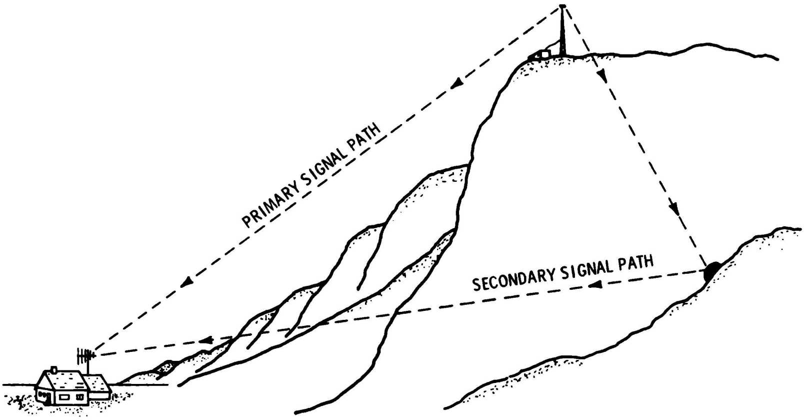



**Fig. 5-5. Secondary path can produce distortion.**

## USE OF TV ANTENNAS

A tv antenna can be used for both tv and fm reception by installing a signal coupler (Fig. 5-6) and connecting it as shown in Fig. 5-7. Both the tv and fm signals are routed to the coupler. The coupler has two outputs. The signals are routed through the coupler to the tv set and to the fm receiver.

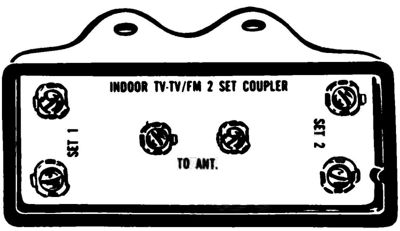



**Fig. 5-6. Signal coupler.**

All tv antennas do not efficiently receive fm signals. However, the Radio Shack Color Eagle series of tv/fm antennas are excellent. The 25-element VU-145 antenna, shown in Fig. 5-8, for example, is capable of 145-mile tv reception and 70-mile fm reception.

## USE OF CATV

If you are a CATV (cable television) subscriber, you can connect your fm receiver to the CATV outlet through a signal

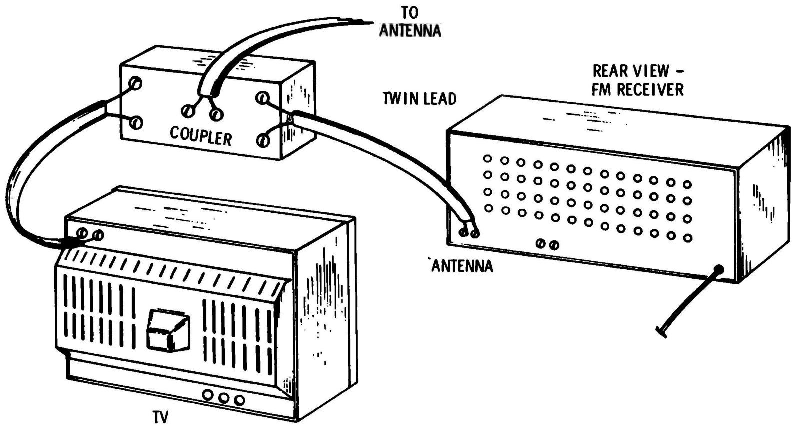



**Fig. 5-7. Connecting tv and fm to a coupler.**

coupler, provided that the CATV system is equipped for distribution of fm signals. This can be determined by asking the CATV system operator.

## ANTENNA TRANSMISSION LINES

Fm antennas are normally connected to the fm receiver through a 300-ohm balanced transmission line. The most commonly used transmission line is called *twin lead* and consists of two parallel copper wires imbedded in a type of plastic. There are various grades of twin-lead cable.

An fm receiver is much more immune to electrical noise than an a-m receiver. Nevertheless, the fm antenna should not be

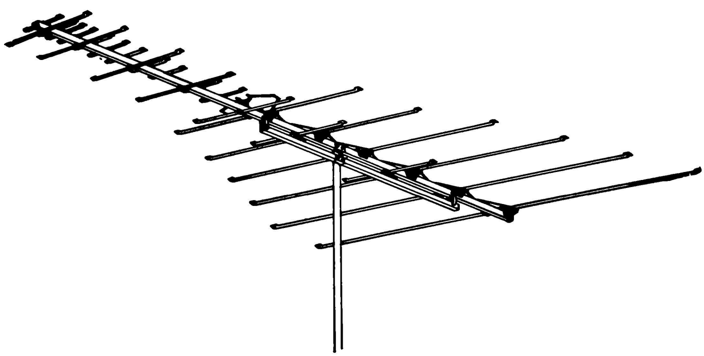


**Fig. 5-8. Archer VU-145 antenna.**

installed close to electric motors, flashing electric lights and other noise sources.

When such interference is picked up by the antenna transmission line, shielded cable should be used in lieu of ordinary twin lead. One type of shielded tv cable consists of a pair of parallel wires imbedded in a type of plastic, surrounded by a metal shield. The shield is then covered by a protective insulating jacket. The connections are the same as for twin lead except that the cable shield is connected (at the receiver end of the cable) to an earth ground or to the chassis of the receiver.

## A-M ANTENNAS

Nearly all am/fm receivers have a built-in a-m antenna which is usually adequate. However, if you live at a considerable distance from a-m stations that you want to receive with very little or no noise, you can install an external a-m antenna.

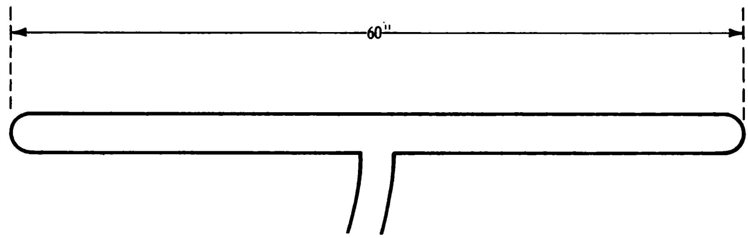



**Fig. 5-9. Folded dipole antenna.**

## INDOOR ANTENNAS

The external a-m and/or fm antenna can be installed in the attic instead of outdoors, but it may not be as effective as a signal intercepter as an outdoor antenna. An attic a-m antenna can consist of insulated copper wire stapled to the rafters. An attic fm antenna can be constructed of 300-ohm twin-lead cable stapled to the rafters. A folded dipole antenna (Fig. 5-9) formed out of the twin-lead cable must be kept horizontal, and the transmission line can be run horizontally and/or vertically as long as it is perpendicular to the folded dipole for the first few feet of its length.

The apartment dweller who has no attic in which to install an fm antenna and who cannot obtain permission to install an

Fig. 5-10. Grounding rod.

outdoor antenna, can install the folded dipole antenna (made of twin-lead cable) along the floor, behind the receiver (or tuner). If the building has a steel frame which acts as a radio signal shield, the antenna should be as close as possible to a window.

## GROUND CONNECTIONS

Some receivers (or tuners) have a terminal to which a ground connection can be made. This can be a connection to a cold-water pipe, radiator, or a rod driven into moist ground (Fig. 5-10). The connection to the rod, radiator, or pipe should be made through a *ground clamp* (available at most hardware stores and from electrical contractors). The pipe or radiator should be scraped clean of paint and dirt before the ground clamp is attached.

CHAPTER 6

# PHONOGRAPH RECORD PLAYERS

Equipment for playing back recorded music was simpler before the lp (long playing) phonograph disc was introduced in 1948 by CBS and the 45-rpm disc was introduced by RCA a short time later. Until then, all commercially available phonograph records rotated at 78 rpm. Thus, only a single-speed record player was required. Now, most record players can be set to operate at 33⅓ rpm, 45 rpm, and 78 rpm. Some also can be operated at 16 rpm for playing *talking book* records. However, regardless of the speed capabilities of record players, most people play only 33⅓-rpm records.

The phonograph disc was developed by Victor Berliner. The now obsolete phonograph cylinder was invented by Thomas A. Edison who later developed the first 33⅓-rpm phonograph disc —many years before CBS developed the so-called lp record under the leadership of Dr. Peter Goldmark. Edison's disc rotated at 33⅓ rpm, as does the lp record, but Edison's disc was made out of shellac instead of vinyl. Edison's early long-playing discs are often played back for visitors at the Edison National Monument in West Orange, New Jersey.

The lp and the 7-inch 45-rpm records are, of course, superior in many respects to the early Edison discs. They are recorded and duplicated differently and are almost unbreakable.

## DISC RECORDING

Sounds were stored on early wax phonograph record masters by the so-called acoustical process. The sounds produced by the performers were picked up by a horn which acted as a sound collector—a megaphone in reverse. At the small end of the horn, the sound waves caused a metal or mica diaphragm to vibrate. The vibrating diaphragm was attached to a stylus which scratched a wavy line in a groove on a wax disc. This wavy groove represented the sound waves. The wax master was then used for making a die which in turn was used for stamping out shellac duplicates of the master.

Later, the electrical process was introduced. The sounds were picked up by microphones which converted sound waves into an electrical signal which was amplified electronically and then fed to an electrically actuated stylus.

Today, master discs are not recorded directly. Instead, the program is recorded on magnetic tape which can be edited. Then, the tape is played back into a disc recording system. Before tape was used, it was necessary to make a whole new recording if an error was made by a performer. Now, only the passage that was marred needs to be recorded. For example, during the recording of a symphony, a player may make an error which, when the direct-recording process was used, required rerecording the entire disc. By making the master recording on tape, the error can be erased and only the marred passage has to be rerecorded.

At a recording studio, as many as 16 channels may be recorded simultaneously on a tape. From this 16-channel tape, the sounds can be blended to produce a two-channel, four-channel, or monaural tape which is played back into the disc recording equipment.

Monaural, two-channel and four-channel phonograph records are all available. The recently developed four-channel records are encoded to produce synthesized output signals that must be decoded. Most recent are the four-channel records that produce a discrete four-channel stereo effect.

## MANUAL TURNTABLES

A record player that does not automatically change records is called a manual turntable. It may be operable at one or more speeds. To be placed into operation, a record is placed on the turntable and the stylus (needle) is placed on the first groove of the record. And when required, the user must manually change the records.

The automatic record changer (also called an automatic turntable) is preferred by most people because it is not necessary to touch it until the last record placed on it has been played. An excellent automatic record changer is illustrated in Fig. 6-1. If five 12-inch, $33\frac{1}{3}$-rpm long-playing records are placed on an automatic record changer, it will play for approximately two hours without requiring attention.

The records (all of the same diameter) are stacked on a spindle to position the records correctly above the rotating turntable. Then, the start button or lever is pushed. The first record drops onto the turntable and the tone arm automatically moves to lower the cartridge so that the stylus will drop into the outer groove of the record. As the record plays, the tone arm moves gradually toward the center of the turntable as the stylus rides in the spiral groove.

**Fig. 6-1. Excellent automatic record changer.**

When the record has been played, the tone arm moves quickly toward the center of the turntable. This movement of the tone arm eventually causes the *trip* mechanism to actuate the record-changing mechanism. The tone arm is then automatically lifted away from the record and moved away from the platter. The next record then drops onto the platter and is played automatically. When the last record has been played, the tone arm is moved back to its rest position and—if the record changer has an automatic shutoff feature—the record changer will turn itself off.

There are many record changers on the market at various prices. From the user's viewpoint they differ with his requirements. The lower-priced record changers are very adequate for playing rock records. But, the music lover who wants to listen to classical music will want the best record changer available. Such a record player is free of *flutter* and *wow* which, because of minute turntable speed variations, will mar reproduction of sustained passages. Also, because the better record changers exert less stylus-to-groove pressure, the records will last longer.

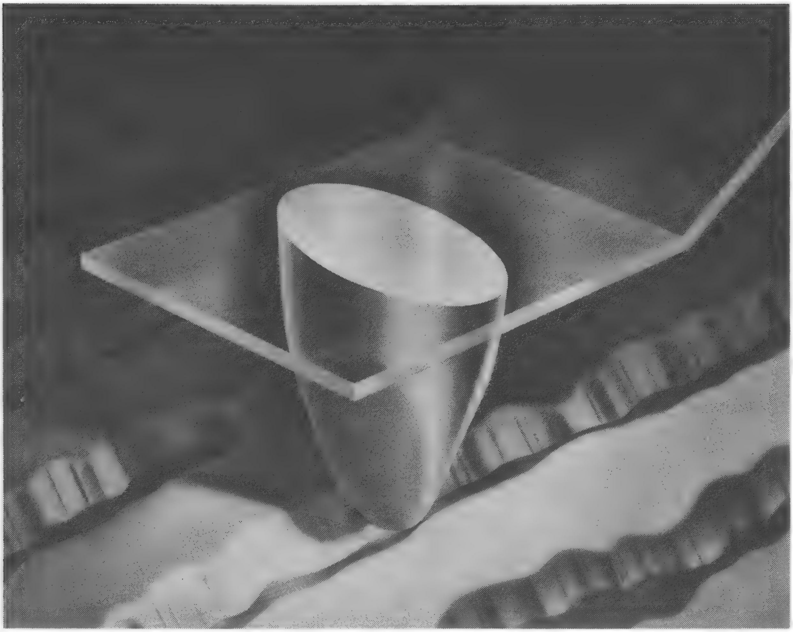
## PHONOGRAPH CARTRIDGES

The cartridge (pickup) is a transducer which converts the recorded sound impressions into an electrical signal. The ceramic and crystal cartridges cost less but do not have the frequency range of the more expensive magnetic and variable reluctance cartridges.

Most cartridges today are designed for playing back both mono and stereo records, as well as the newer four-channel records. They can be used for playing the old 78-rpm discs, but not well. There are cartridges that have a lever which selects a stylus for playing microgroove (16, 33⅓ or 45 rpm) records or a more blunt stylus for playing 78-rpm records. However, few people have need for playing 78-rpm records.

## STYLI

It is the stylus that is extremely important. It rides in the record groove and senses the recorded sound patterns. An enlarged view of a stylus riding in a stereo groove is illustrated in Fig. 6-2. A cartridge equipped with a sapphire stylus will work well. But, one with a diamond stylus will last longer and will cause less damage to records. Since a diamond stylus will wear longer, in the long run it is less costly. Fig. 6-3 indicates the hours wear on three types of styli. However, any stylus should be replaced when sound reproduction quality deteriorates.



Courtesy Shure Bros., Inc.

**Fig. 6-2. Enlarged view of stylus riding in a stereo groove.**

## DRIVE MOTOR

A record changer may contain either a conventional ac motor or a synchronous motor. The speed of the former is subject to fluctuation. The speed of the latter remains constant. How-


**Fig. 6-3. Styli wearing qualities.**

ever, when either is powered through a dc-to-ac inverter or from an ac source other than a power company circuit, the motor speed is likely to vary and wow is apt to result.

## RECORD PLAYER CONNECTIONS

A record player equipped with a mono cartridge is connected to a mono amplifier through a single shielded cable. Most record players, however, are equipped with a stereo cartridge which is connected to a stereo amplifier, stereo receiver, or four-channel decoder through two shielded cables.

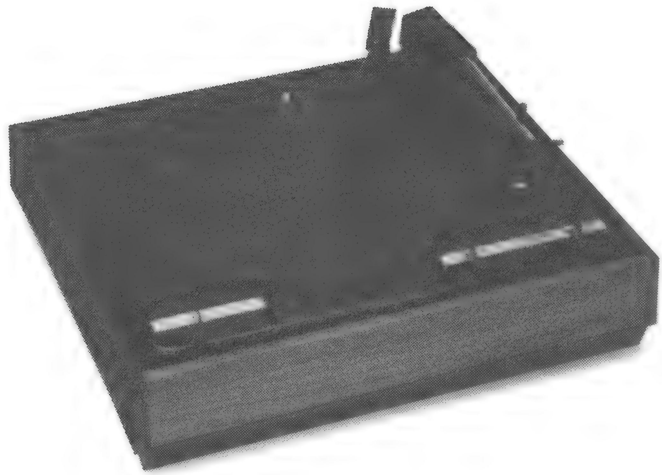


**Fig. 6-4. Good record changer.**

It is imperative that the output of a record player be connected to its amplifier through shielded cables. If unshielded cables are used, excessive hum and noise will be picked up.

**Fig. 6-5. System using a precisely constructed record changer.**

A stereo cartridge can be used to play either mono or stereo records. A mono cartridge can also be used to play mono or stereo records, but the resulting sound will be monaural, not stereophonic.

## PRICE RANGE

Good record changers are available for approximately $20 (Fig. 6-4). They are found acceptable for playing "rock" and speech records by those who do not have critical ears. The more expensive record changers (in the $50 to over $200 price range) introduce less wow and flutter and cause less record wear. Some of the more expensive record changers, such as the one shown in the system in Fig. 6-5, are very precisely constructed and have counterbalanced tone arms which apply the least possible pressure on the record groove.

CHAPTER 7

# TAPE MACHINES AND PRINCIPLES

Deciding upon the type of tape player, recorder, or deck to buy is not as easy as selecting a record changer or turntable. On any currently available record changer, you can play back most standard lp records. But, most tape players will not play back all of the popular types of tapes. Different types of mechanisms are required for playing back tape reels, tape cassettes, and tape cartridges. Furthermore, if you're purchasing a tape machine, you have a choice of a tape player, tape recorder, or tape deck to choose from.

A tape player is capable only of playing back sounds that have been previously recorded on magnetic tape. A cassette tape player is illustrated in Fig. 7-1. It is a complete system, ready to use. A tape recorder can be used for making tape recordings and normally has provisions for playback. A tape deck, on the other hand, normally can record and play back also, but a tape deck does not have an amplifier or speaker system. It may, however, incorporate a preamplifier system. Therefore, a tape deck is normally used in conjunction with a component-type hi-fi system.

## TAPE RECORDINGS

Most phonograph record stores sell magnetically recorded tapes—on reels, cassettes, and cartridges. Tape reels are in-

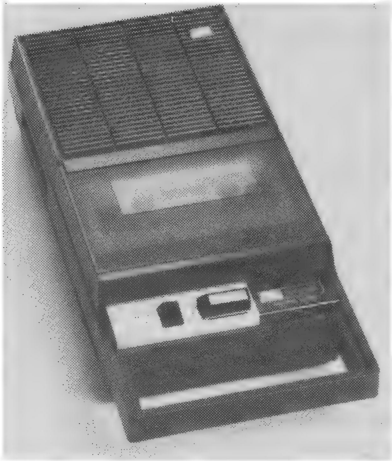


Fig. 7-1. Cassette tape player.

tended for playback on a unit such as the one shown in Fig. 7-2. When you buy a reel of tape, you get *one* reel on which the tape is stored. This is the supply reel. To play the tape, you install it on a spindle and thread it onto the take-up reel in much the same manner as a movie film. As the tape is played back, it is wound up on the empty take-up reel.

A tape cartridge is much easier to use—just plug it into a receptacle in the tape mechanism—no tape threading is neces-

Fig. 7-2. Tape deck for use with tape reels.

sary. As illustrated in Fig. 7-3, the tape is inside of the cartridge.

A tape cassette (Fig. 7-4) is also easy to use. It plugs in or snaps in, depending upon the design of the tape player. No tape threading is required since the tape is inside of the cassette.

## How Sound Is Stored on Tape

The tape itself is a narrow strip of plastic, coated on one side with an oxide which can be magnetized. During the recording

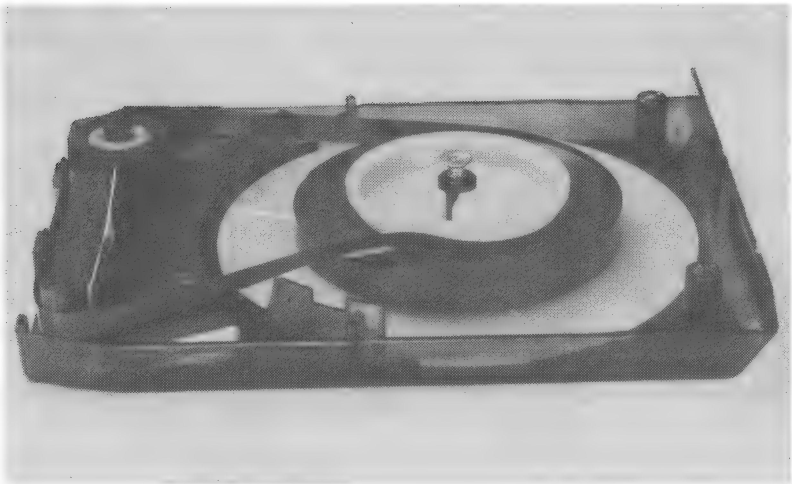


Fig. 7-3. Tape cartridge with top removed.

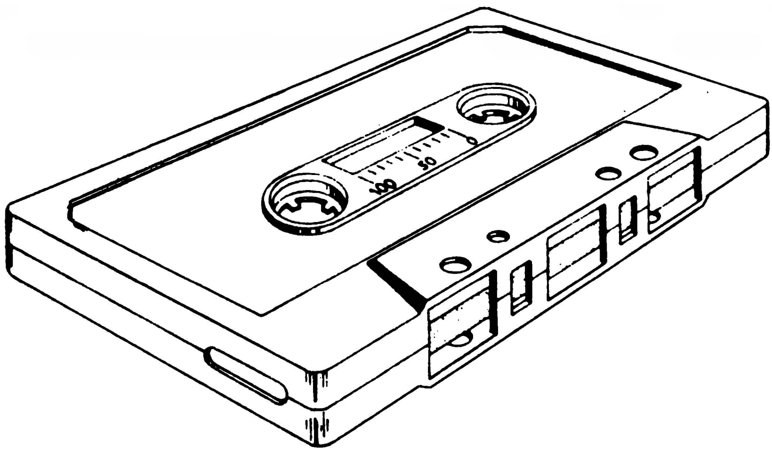


Fig. 7-4. Tape cassette.

process, the tape passes an electromagnet, called the *record head,* which magnetizes the tape. The strength of the recording magnetic field varies with the current flowing through the record head. This varying current is the electrical equivalent of the sound being recorded. When this current is stronger, the increased magnetism causes the tape to be magnetized more intensely, and vice versa.

The *erase head,* which is normally located next to the record head, demagnetizes the tape before a new sound is recorded on the tape. The function of the erase head is to erase whatever may have been previously recorded on the tape and to condition the tape for recording.

The tape is pulled past the record head at constant speed, usually by what is known as a capstan drive.

### How Sound Is Recovered From Tape

When a tape is played back, the tape moves at a constant speed past the playback head. An electromagnet senses the variations in magnetism, and converts the variations into an electrical signal. A tape recorder may have separate record and playback heads, but many employ a combination record-playback head. The sound recorded on the tape will be reproduced at the same frequency at which it was recorded only if the tape is played back at the same speed at which it was recorded.

### Stereophonic and Quadraphonic Tape Recordings

Normally, when sound is recorded monaurally on a reel-to-reel or cassette tape recorder, one track is recorded on approximately one half of the tape width. When one track has been recorded on the full length of the tape, the tape is placed on the supply reel spindle and the empty reel is placed on the take-up reel spindle. Now, the tape runs past the record head again and a second track is recorded parallel to the previously recorded track. The same is true also of a tape cassette. After recording one track, simply flip over the cassette to record the second track.

When recording two-channel stereophonic sound, two parallel tracks are recorded simultaneously, one representing the left channel (track 1) and the other representing the right channel (track 3). When the tape is flipped over, two more tracks are recorded (tracks 4 and 2). The relationship of these sound tracks is illustrated in Fig. 7-5.

The same basic technique is used for recording four-channel quadraphonic sound except that all four tracks are recorded simultaneously.

When two-channel stereophonic tapes are played back, a playback head or combination record-playback head reads both recorded tracks simultaneously. For playing back discrete four-channel quadraphonic tapes, a quadruple head is used.

Synthesized quadraphonic tapes are usually recorded on, and played back from, two tracks. An encoder is used when recording and a decoder is used during playback to derive the effect of four channels from two actual channels.

## TAPE SPEED

As indicated in Table 7-1, a 2400-foot reel of tape run at a speed of 1⅞ ips has capacity for recording and playing back 256 minutes of information per track. If two mono tracks are recorded normally, the capacity is 512 minutes (almost nine hours). If the tape is run at a speed of 3¾ ips, the capacity is

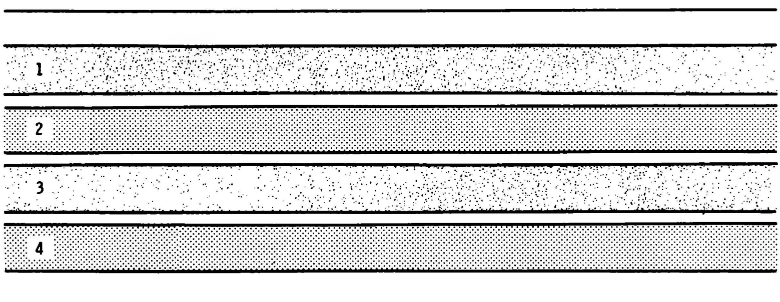



Fig. 7-5. Sound track relationship.

reduced 50%. And, if run at 7½ ips, the capacity is reduced to 64 minutes per track.

For many purposes, recording at 1⅞ ips will provide satisfactory results. But, for maximum sound fidelity, the tape should be recorded at 7½ ips. This greatly improves the high-frequency response.

**Table 7-1. Recording/Playing Time of Reel-to-Reel Tapes**

| Reel Size | Feet of Tape | 1⅞ ips* | 3¾ ips* | 7½ ips* |
|---|---|---|---|---|
| 3" | 150 | 16 | 8 | 4 |
| 3" | 300 | 32 | 16 | 8 |
| 3¼" | 600 | 64 | 32 | 16 |
| 5" | 600 | 64 | 32 | 16 |
| 5" | 900 | 96 | 48 | 24 |
| 5" | 1200 | 128 | 64 | 32 |
| 7" | 1200 | 128 | 64 | 32 |
| 7" | 1800 | 192 | 96 | 48 |
| 3¼" | 1100 | 120 | 60 | 30 |
| 5" | 2400 | 256 | 128 | 64 |
| 7" | 2400 | 256 | 128 | 64 |
| 7" | 3600 | 384 | 192 | 96 |

*Time indicated is in minutes per track.

## PORTABLE REEL-TO-REEL TAPE RECORDERS

The portable reel-to-reel tape recorder shown in Fig. 7-6 is a complete system. It can be used for either mono or stereo recording and playback. At the left and right are the loudspeakers which are attached to the main carrying case by slip hinges. These speakers can be left attached as shown, or detached and placed at a distance. Also shown in the photograph are the two microphones which can be used when making stereo recordings.

The supply reel is at the left and the take-up reel is at the right. The tape moves past the heads from the supply reel to the

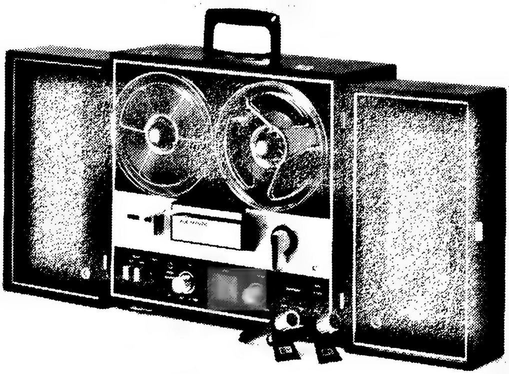


Fig. 7-6. Portable reel-to-reel recorder.

take-up reel at a speed of 1⅞, 3¾ or 7½ ips (inches per second), depending upon the setting of the speed selector. The machine will accommodate reels up to 7 inches in diameter. A 7-inch reel may contain from 1200 feet to 3600 feet of tape, depending upon tape thickness. The playing times of various lengths of tape at the three standard speeds are listed in Table 7-1.

Below the supply reel is a small window through which can be seen a digital counter. It shows how much of the tape has been recorded (or played back) at any given time. At the bottom of the front panel are the two level-indicating meters. At their left is the tone control and at their right is the volume control.

This system can be used for recording and playing back both mono and stereo tapes, as well as for playing back previously recorded tapes. The same is true of the tape deck that was illustrated in Fig. 7-2 when used as a component of a hi-fi system.

## CASSETTE RECORDERS AND DECKS

Because tape cassettes are easy to use and require very little storage space, they are becoming increasingly popular. A few typical cassette tape recorders and decks are illustrated in Fig. 7-7. Almost everyone is familiar with the monaural portable cassette recorder/players which are highly acceptable for recording and playing-back speaking voices. However, some of them are not hi-fi devices. Normally it's not the cassette that limits their capabilities; it's the tape deck and the amplifier-speaker system.

On the other hand, a cassette tape deck, such as the one shown in Fig. 7-8, as part of a stereo system, is a hi-fi instrument. Either mono or stereo sound can be recorded and played back with amazingly good fidelity (50-10,000 Hz ±2 dB record, 40-12,000 Hz ±2 dB playback). The same cassette tape deck is available separately.

## CARTRIDGE PLAYERS AND RECORDERS

The cartridge tape player is easy to use. The tape cartridge is simply plugged in to play and pulled out when you want to

**Fig. 7-7. A few cassette tape decks and recorders.**

play another cartridge. Most cartridge tape players are designed for playback only, not for making recordings. Many are self-contained systems requiring no additional equipment. However, as in the case of reel-to-reel and cassette packaged systems, better sound is obtained when using a tape deck with a component system.

The cartridge player tape deck is normally very compact and should be connected to the auxiliary inputs of a receiver or amplifier. A few cartridge tape players are shown in Fig. 7-9.

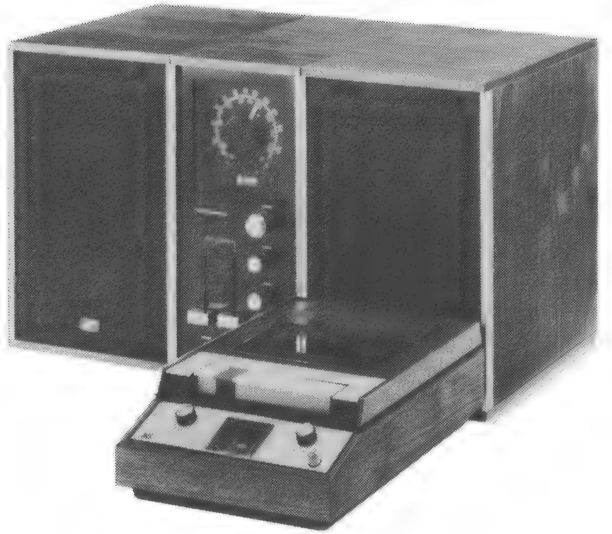


**Fig. 7-8. System using a good hi-fi tape deck (cassette).**

## SHOPPING AROUND

The prospective buyer of a tape player or recorder has so many units to choose from that confusion may result. What is best for one person might be wrong for another.

The sophisticated audiophile usually opts for a professional-grade reel-to-reel tape deck because of its versatility and normally superior performance. Its use requires care as well as dexterity. The owner of a cartridge-type auto stereo system will usually select a cartridge system so the same cartridges can be played at home as well as in the car. For the same reason, if the auto stereo system is designed for playing tape cassettes,

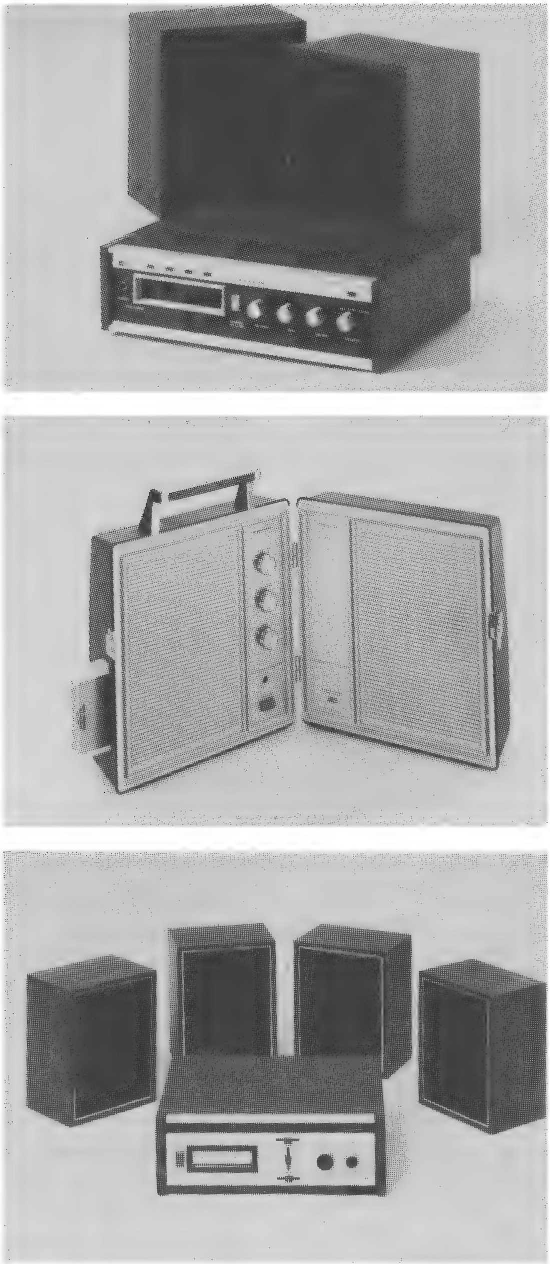


Fig. 7-9. A few cartridge tape players.

the obvious choice for home use is a cassette system. The main advantages of cartridges and cassettes are simplicity and compactness.

A two-track reel-to-reel tape recorder/player or tape deck is used for making and/or playing back monaural recordings. A four-track machine is generally used for making and/or playing back two-channel stereo recordings.

The conventional cassette recorder/player is used for making and playing back monaural recordings. The more sophisticated cassette recorder/player or tape deck is used for making and playing back both monaural and two-channel stereo recordings.

The four-track cartridge players play back two-channel recordings—there are four tracks, but only two are played back at any one time. The eight-track cartridge players also play back two-channel recordings—there are eight tracks, but only two are played back at any one time. Some cartridge machines are also capable of being used as recorders, but most are designed only to be used as players.

Because of the relatively low speed of tape cassettes and the narrow width of the tape inside of the cassette, it had been once considered that the cassette player/recorder could not compete with reel-to-reel tape systems on the basis of quality. But, recent technical developments in both tapes and machines have made the cassette system capable of superb performance.

The Dolby system, which is used by more than 400 recording companies and film studios to do their original sound recording, electronically reduces tape hiss while recording. This is accomplished by automatically increasing volume on quiet musical passages.

**Fig. 7-10. Realistic SCT-6 tape deck.**

During playback, the system reduces the increased volume to its original level. This effectively eliminates most of the noise introduced by the recording process and at the same time provides better high-fidelity reproduction.

The Dolby noise reduction circuitry used in Realistic SCT-6 stereo cassette tape deck, shown in Fig. 7-10, is said to be capable of making home recordings that are almost as good as professionally made tapes.

CHAPTER 8

# MUSIC SYSTEM INSTALLATION

A hi-fi system should be installed so that it will be convenient to operate and so that the sound will be properly distributed within the room. Fig. 8-1 illustrates three different speaker arrangements. The record player and/or tape deck should be close to the receiver or amplifier so that long input cables are not required. When an outdoor antenna is used, the receiver should be placed reasonably near the point where the antenna transmission line enters the room to avoid having to run the transmission line around door frames. However, when it is practical to run the transmission line through the attic or the basement, greater flexibility is possible.

## PACKAGED MUSIC CENTERS

A "packaged" music center is one that is completely contained in a single cabinet or portable carrying case. Such a system can be installed almost anywhere in a room. However, its effectiveness as a sound source is affected by its location since its speakers are not movable separately.

The music center should not be installed next to a radiator, hot-air duct or an electric heater because the heat can affect the performance and life of the equipment. Transistors are heat sensitive.

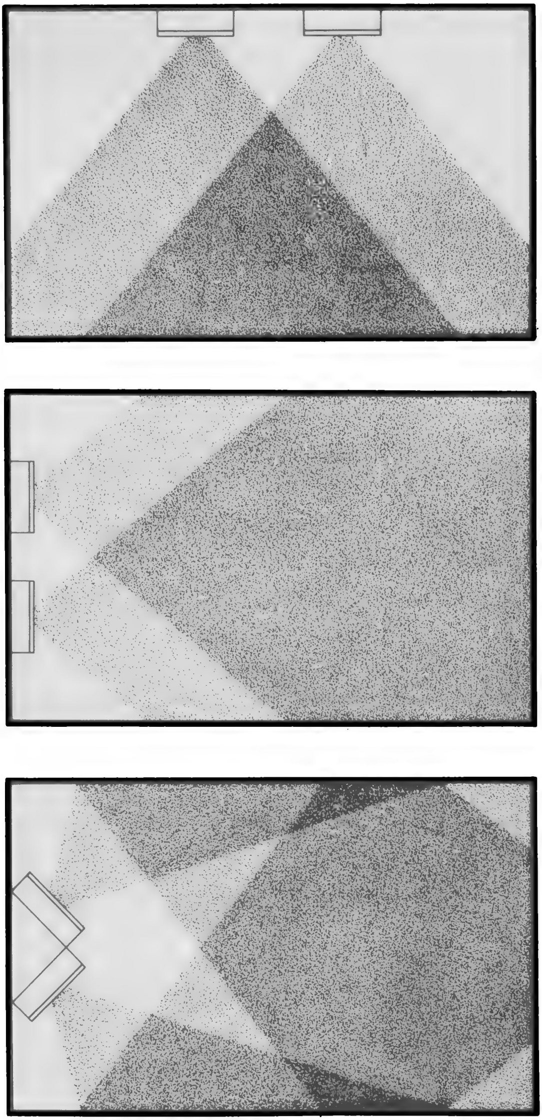


**Fig. 8-1. Three different speaker arrangements.**

In the case of a portable music center whose speakers are detachable, they can be left attached when there is no other space for them. However, if detched, as shown in Fig. 8-2, a more realistic stereo effect can be obtained.

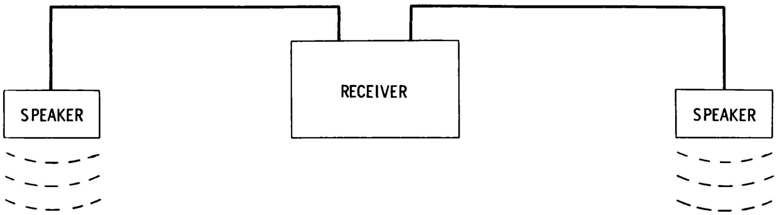



**Fig. 8-2. Block diagram of a portable music center with speakers detached.**

## COMPONENT SYSTEMS

A component system as illustrated in Fig. 8-3 consists of separate record player (and/or tape deck), receiver (or tuner and amplifier) and speaker units. Some of the electronic equipment may be mounted on shelves, where there is adequate air circulation. If installed inside of a cabinet or closet, or even built into a wall, the electronic equipment should not be operated for long periods of time unless the air circulation is adequate.

The electronic equipment generates heat which must be dissipated by the free flow of air. A receiver, tuner, or amplifier that employs tubes, will generate more heat than one using transistors. Electronic equipment employing transistors generates much less heat, but is much more sensitive to an increase in temperature. It isn't so much the temperature of the overall units as it is the creation of "hot spots" that can cause damage.

**Fig. 8-3. A component system.**

In areas where the weather is extremely hot, the temperature of the built-in electronic equipment can be kept from rising to a dangerous level by installing a small fan or blower that will circulate air around the equipment. Power transistors, which can generate considerable heat, are usually attached to *heat sinks* within the equipment. These heat sinks conduct the heat away from the transistors and dissipate it into the air. To let the heat sinks do their job, adequate ventilation is required.

The record player motor generates a small amount of heat. So does the capstan motor of a tape deck. Also, additional heat is generated in tape decks that contain preamplifiers and/or electronic control circuits. Therefore, record players and tape decks also require some ventilation when operated, particularly for long periods of time.

## ELECTRIC POWER CONNECTIONS

The amplifier or receiver should be located near an electric outlet so an extension cord will not be required. If the receiver (or amplifier) has an ac outlet, the changer can be plugged into the receiver. When connected in this manner, power to the record player is cut off when the receiver is turned off.

No other heavy-wattage appliances should be connected to the same electric outlet. An electric outlet will usually accommodate two power plugs. When the hi-fi system is connected to one of the receptacles of a dual outlet, an appliance such as an electric heater or air conditioner should not be plugged into the other receptacle. Such a heavy-wattage appliance can cause a significant voltage drop in the branch circuit. As the appliance starts and stops, the voltage at the outlet can rise and fall and affect the operation of the hi-fi system.

Most residences have 115-volt, 60-Hz (60 cycles per second) ac electric outlets. However, a receiver or amplifier *rated* as operable from a 50-60 Hz power line, can be used safely where the power line frequency is either 50 or 60 Hertz. This is not true of a record player or tape deck. To operate a 60-Hz record player or tape deck from a 50-Hz power line, it will be necessary to have some pulleys or wheels replaced.

In some countries other than the United States, the power line frequency is 50 Hz and the power line voltage is between

200 and 250 volts. To use an amplifier or receiver designed for 115-volt, 50-60-Hz operation from such a power line, it will also be necessary to use a step-down transformer.

While very rare, there are office buildings, hotels, hospitals and industrial plants which have 100-volt dc outlets. Never connect an ac-type receiver, amplifier, record player or tape deck into a dc electric outlet. It is liable to burn out almost instantly.

To operate ac-type hi-fi components in a camper or on a boat with a 12-volt dc electrical system, it is necessary to use an appropriate dc-to-ac inverter. The inverter must have a rated power handling capacity at least twice greater than (in watts) the normal power consumption of the hi-fi equipment so there will be reserve power for loud passages. The inverter illustrated in Fig. 8-4 is rated at 200-watts continuous duty.


Fig. 8-4. Inverter.

## COMPONENT INTERCONNECTIONS

The components of a hi-fi system are usually interconnected through audio cables equipped at one or both ends with a phono plug. An audio cable used for this purpose consists of an inner conductor (wire) surrounded by an insulating material. Over this is a metallic braid shield (outer conductor) and over the metallic braid is a protective plastic jacket. Fig. 8-5 shows some conversion and connecting leads.

Cables with a phono plug at each end are used for interconnecting most hi-fi components, including record players equipped with phono jacks.

Fig. 8-6 shows the cable connections of a typical mono system consisting of a tuner, amplifier, and speaker. The cable connections of a typical stereo system consisting of a receiver, record player, tape deck and a pair of speakers are shown in Fig. 8-7. Fig. 8-8 shows the cable connections of a quadraphonic system

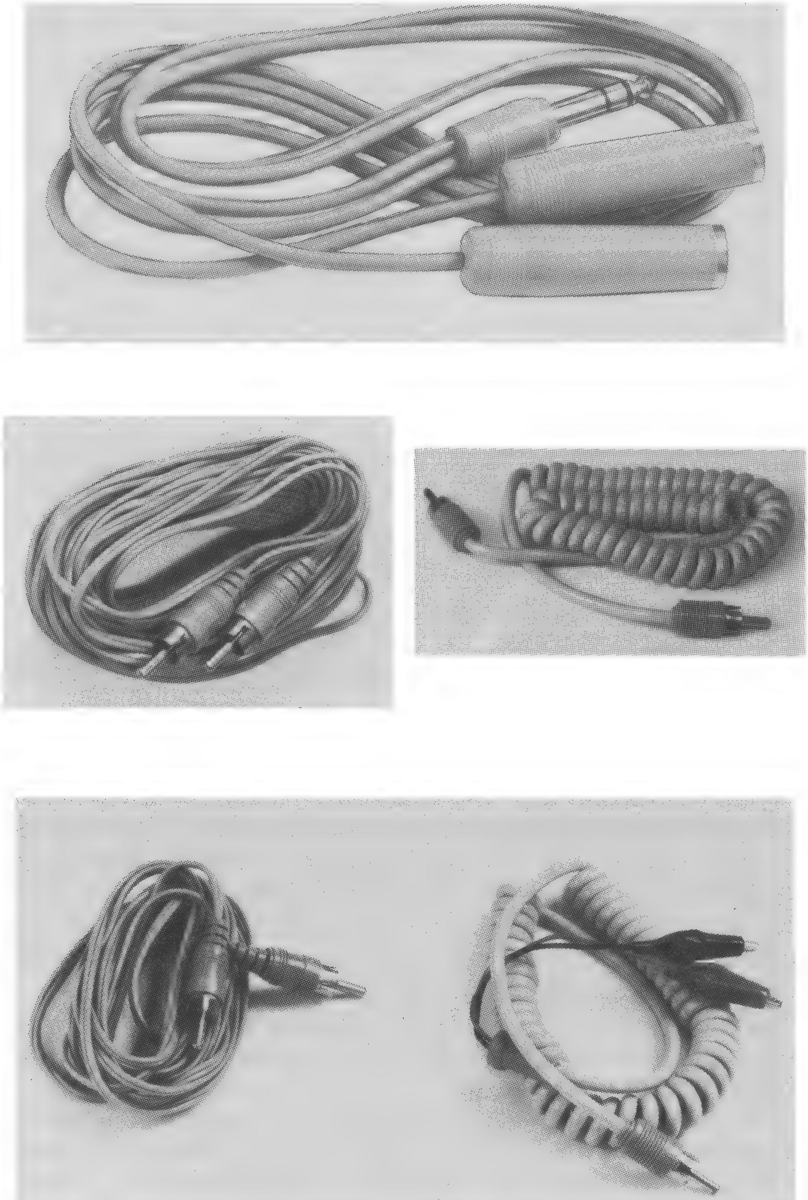


**Fig. 8-5. Conversion and connecting leads.**

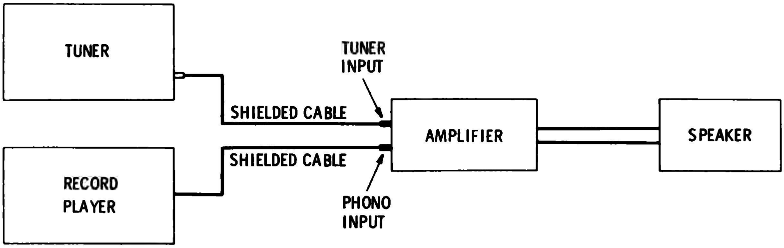



**Fig. 8-6. Cable connections of a typical mono system.**

employing a Realistic ARS-4 adapter. Fig. 8-9 shows a close-up of the ARS-4 adapter. Fig. 8-10 illustrates the cable connections of a self-contained quadraphonic system.

## Amplifier Connections

The typical hi-fi stereo amplifier has a pair of input phono jacks for connecting to a record player, tape deck, and radio tuner; it also has an auxiliary input. A switch within the amplifier enables selection of the desired program source.

## Tuner Connections

An a-m, fm or am/fm monaural tuner usually has only one output jack for connecting it to a mono amplifier. An fm or am/fm stereo tuner, or the other hand, usually has two output jacks for connecting it to a stereo amplifier. When receiving an fm stereo program, the signals at the output jacks differ. But,

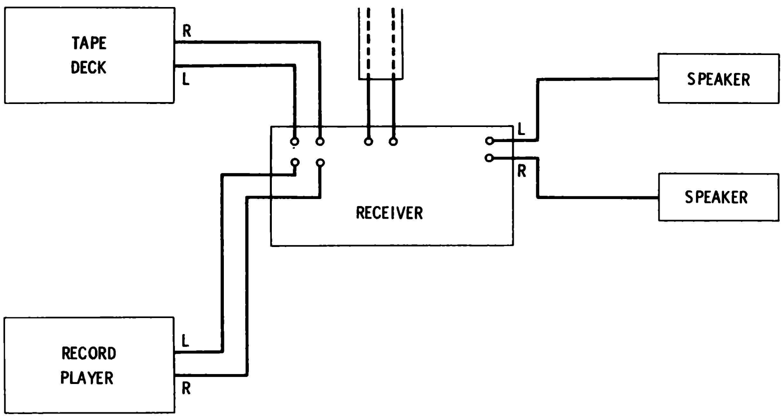



**Fig. 8-7. Cable connections of a typical stereo system.**

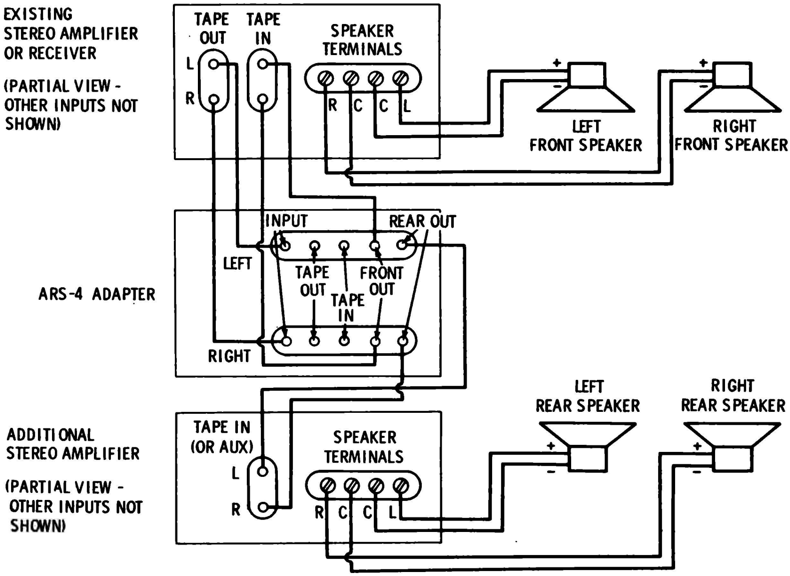



**Fig. 8-8. Cable connections of a quadraphonic system using an ARS-4 adapter.**

when receiving an a-m or fm mono program, the signals at both output jacks are identical.

## Receiver Connections

Most hi-fi systems now employ an fm-only or an am/fm stereo receiver which contains the power amplifier. Phono jacks are usually provided for a record player, tape deck and auxiliary inputs. Either phono jacks or screw terminals are provided

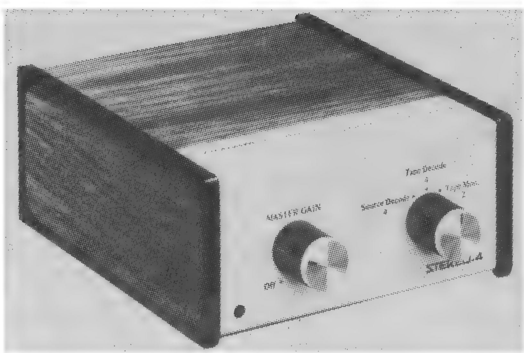


**Fig. 8-9. An ARS-4 adapter.**

for the speakers. Some also have phono jacks or screw terminals for extension speakers. In addition, an fm-only receiver has a pair of screw terminals for an external antenna system, and an am/fm receiver often also has a screw terminal for an external a-m antenna and for a ground connection.

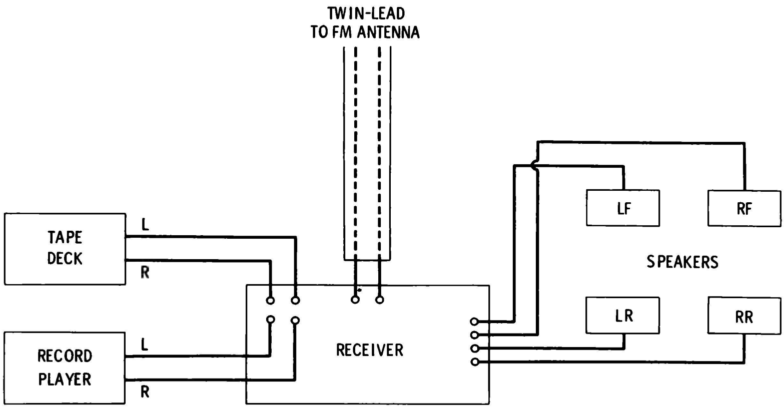



**Fig. 8-10. Cable connections of a self-contained quadraphonic system.**

## Speaker Connections

In most cases, a stereo amplifier or receiver is connected through two cables to two speaker systems. A quadraphonic amplifier or receiver, on the other hand, is connected through four cables, to four speaker systems.

## Extension Speakers

In addition to providing music in the same room in which the hi-fi system is located, the music can be "piped" into other rooms at the same time. The output of the receiver or amplifier is connected to extension speakers directly, as shown in Fig. 8-11, or through adjustable L-pads, as shown in Fig. 8-12.

When the main and extension speakers are permanently connected in parallel, as in Fig. 8-11, the maximum amount of power consumed by each speaker is reduced. The amount depends upon the design of the receiver or amplifier. For example, if the output power rating is 55-watts continuous per channel into a 4-ohm load and 45 watts into an 8-ohm lead, each of two paralleled 8-ohm speakers will receive up to 27.5 watts since

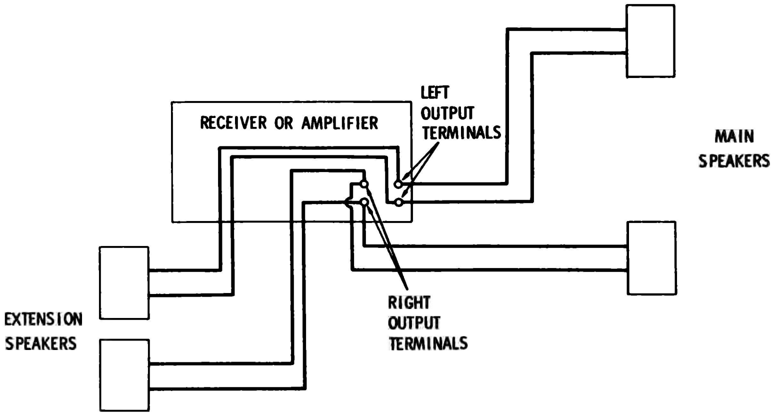



**Fig. 8-11. Connecting extension directly to an amplifier or receiver.**

the impedance of the two speakers in parallel is 4 ohms and each will receive equal power.

On the other hand, when L-pads are used, as in Fig. 8-12, either or both sets of speakers can be operated, and each will receive the amount of power determined by the settings of the L-pads. However, if the leads to the extension speakers are fairly long (more than 50 feet), there will be some power loss in the wires. This loss can be minimized by using heavier gauge wire.

An L-pad is a special type of volume control that prevents the load on the amplifier from changing regardless of the setting of the L-pad. A mono L-pad is used for controlling the level of one speaker. A stereo L-pad consists of two mono L-pads that are adjusted simultaneously with one knob. A T-pad is even better, but more expensive. It maintains a constant load

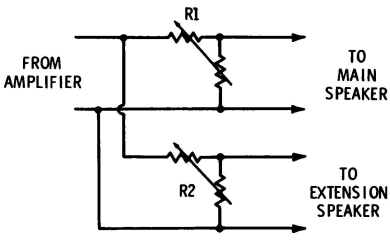



**Fig. 8-12. Using adjustable L-pads between speakers and amplifier.**

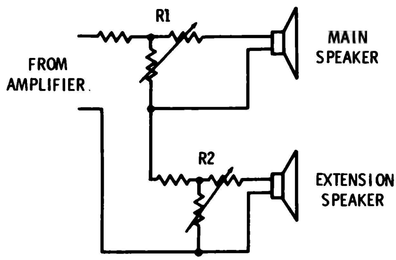



**Fig. 8-13. Using adjustable T-pads between speakers and amplifier.**

on the amplifier and also on the speaker and thus minimizes effects on speaker response at any volume setting.

The L-pad or T-pad should have the same "ohms" rating as the speaker. For example, an 8-ohm L-pad or T-pad should be used with an 8-ohm speaker.

When speakers are connected in series, T-pads can be connected as shown in Fig. 8-13. The volume of each speaker can be controlled independently.

### Wall-Wired Connections

Extension speaker cables can be run along the molding near the floor and around door frames. The owner of his own home may prefer to run the cables inside the walls and/or through the attic and/or basement in much the same manner as electric power wiring.

Assuming that the receiver (or amplifier) has a pair of extension speaker phono jacks, a pair of audio cables could be used to connect the receiver (or amplifier) outputs to a dual-jack input wall plate. This plate is connected to the stereo L-pad through two lengths of single-conductor shielded cable run inside the wall. The L-pad is connected through a pair of similar cables or four short wires to the dual-jack output wall plate. The extension speakers can be connected to the dual-jack output wall plate through another pair of audio cables, if the speakers each have a phono jack. If the speakers have screw terminals, some speaker wire can be used.

> WARNING: The cables should always be plugged into both the input and output wall plates. If the receiver (or amplifier) is set to feed power into its extension speaker terminals and no speaker load is connected, the receiver (or amplifier) could be damaged.

### Built-In Extension Speakers

In lieu of movable cabinet-enclosed extension speakers, extension speakers can be sunk into a wall or attached to a door or wall. The performance may not be as good, but it eliminates the need for extra furniture. Each wall or door-mounted speaker can be attached to a flush-mount speaker baffle. It will accommodate an 8-inch speaker.

## Television Sound

Nearly all television receivers contain a small, built-in speaker whose response is far from hi-fi. To obtain a pleasing reproduction of television programs, the audio (mono) output of a tv receiver can be connected to one of the auxiliary inputs of a hi-fi receiver or amplifier. Since an external speaker jack is seldom provided on a tv receiver, a connection must be made. This should be done only by a professional tv service technician or other person with adequate technical knowledge. Since high voltages are present, improper connections must be avoided. A competent technician will know how to tap the sound channel at the tv receiver sound detector or speaker terminals and what interfacing devices will be required. In use, the tv receiver speaker should be muted and the sound heard through the hi-fi system. To obtain the illusion that the sound emanates from the tv receiver screen, the tv receiver should be located about midway between the two speakers of a two-channel stereo system or the front speakers of a four-channel system.

CHAPTER 9

# HI-FI SYSTEM ACCESSORIES

Various accessories are available for expanding the capabilities and/or the flexibility of a hi-fi system.

## HEADPHONES

Many hi-fi receivers have a built-in phone jack to accommodate stereo headphones, such as the Realistic PRO-1 headphones illustrated in Fig. 9-1. Using headphones, the sound can be breathtaking. Furthermore, if a switch to disconnect the speakers is provided, a person can listen to hi-fi programs privately through the headphones without disturbing others.

As shown in Fig. 9-2, the frequency response of the Realistic PRO-1 headphones extends from lower than 10 Hz to higher than 24,000 Hz. Therefore, the response goes above and below the range of human hearing with extremely little variation.

Typically, Realistic stereo headphones are provided with a 10-foot coiled cord which uses a standard ¼-inch, three-conductor phone plug. When a 10-foot cord isn't long enough, the 24-foot Realistic headphone extension cord can be added. To enable two persons to listen with headphones at the same time, the Realistic Y-adapter can be used. It has a phone plug on one end for connecting to a receiver or headphone extension cord, and two phone jacks to which the two headphones can be connected.

When a receiver or amplifier does not have a headphone jack, a Realistic amplifier-headphone coupler can be connected to the

Fig. 9-1. Realistic PRO-1 headphones.

audio output terminals. When the headphones are plugged into the coupler, the speaker and headphones operate simultaneously. The Realistic headphone junction box on the other hand, permits use of one or two headphones and has a switch to turn the speakers off.

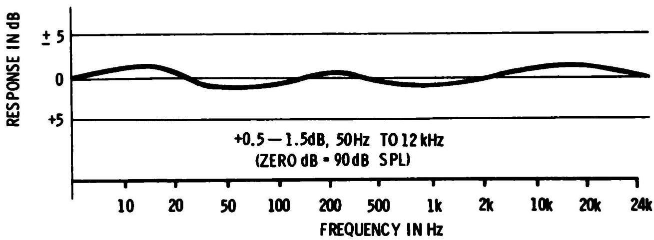



Fig. 9-2. Frequency response of the Realistic PRO-1 headphones.

## AUDIO CABLES

The typical portable cassette tape recorder has an earphone jack that accommodates a miniature phone plug. A Realistic audio cable can be used to connect the recorder's miniature phone jack to one of the receiver's or amplifier's auxiliary input phono jacks.

The same kind of audio cable can be used to connect the earphone jack of a small transistor radio to an amplifier's auxiliary inputs.

To use a hi-fi system as a public-address system, a single microphone can be connected to one of the auxiliary inputs through a microphone preamplifier. The sound will be reproduced monaurally. For stereo reproduction, a second microphone and preamplifier are required.

## SPECIAL-PURPOSE CONTROLS

Normally when a record changer has shut off automatically after playing the last record, the receiver or amplifier continues to remain turned on until shut off manually. To avoid inadvertently leaving the receiver or amplifier turned on when not needed, an automatic shutoff device can be added. The Realistic Hi-Fi Sentinel (Fig. 9-3) will provide a system with

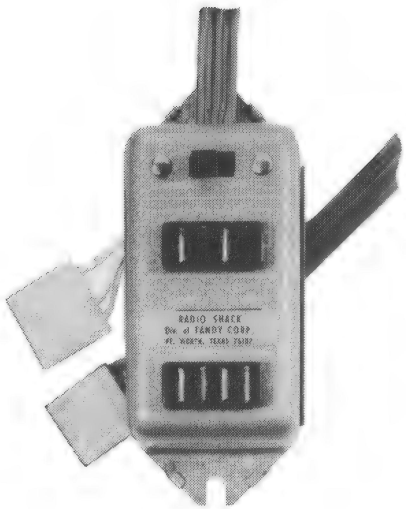



**Fig. 9-3. Realistic Hi-Fi Sentinel.**

this automatic shutoff feature. When the record changer shuts off, the receiver or amplifier is shut off also.

## COLOR ORGANS

Fascinating effects and enjoyment can be obtained by connecting a color organ to a hi-fi system. Various lighting effects

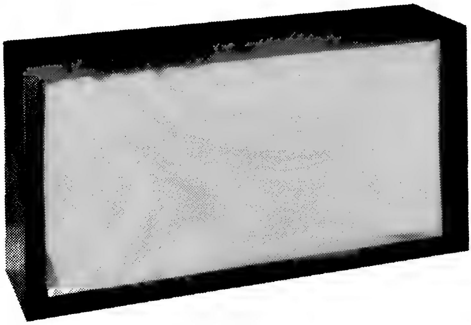


Fig. 9-4. Color organ.

are produced as the frequencies and beat vary. In a way, it enables you to "see the music."

The Science Fair color organ, shown in Fig. 9-4, emits red, blue, and green lights which dance to the music coming from the speakers. It has three slide-pot controls for varying the intensity of the lights, and is actuated by sound power levels ranging from ¼ watt to 80 watts.

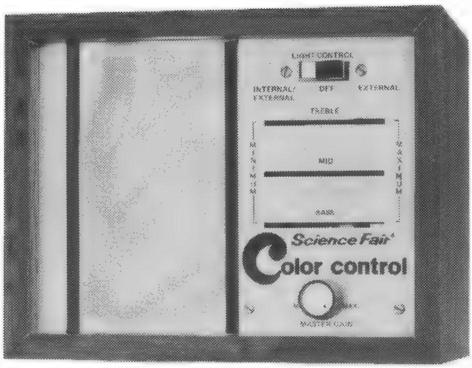



Fig. 9-5. Color control.

The Science Fair Color Control, on the other hand, can be used as a small color organ as well as a control for any type of incandescent light (i.e. room lights, christmas tree bulbs, and other color organs). As shown in Fig. 9-5, it has three slide-pot controls for adjusting the relative response to treble, mid, and bass frequencies. Each of its three channels can handle one or more lamps, with combined ratings of up to 300 watts. The total capacity of the control unit is 900 watts.

These and other color organs are connected in parallel with the speakers without affecting speaker performance.

## TAPE ACCESSORIES

The heads of a tape mechanism should be demagnetized periodically. As the heads become magnetized during use, frequency response is reduced, head life is decreased, and noise and distortion are increased. The heads can be demagnetized easily and quickly with a hand-held demagnetizer, such as the ones shown in Fig. 9-6.


**Fig. 9-6. Head demagnetizers.**

In addition, the tape heads should be cleaned periodically with an aerosol (Fig. 9-7) or fluid head cleaner. The heads of a cartridge tape player can also be cleaned by plugging in a Realistic head-cleaner cartridge (Fig. 9-8), and operating the player for 10 seconds. Cassette machine heads can be cleaned


Fig. 9-7. Aerosol head-cleaner.


Fig. 9-8. Cartridge head-cleaner.

by inserting the Realistic head-cleaner cassette (Fig. 9-9) and operating the machine for about 20 seconds.

Although a tape recorder normally erases previously recorded sound from a tape when operated in the recording mode, a tape can be more thoroughly erased with a bulk tape eraser. The Realistic bulk tape eraser in Fig. 9-10 can be used to erase cartridges, cassettes, and reel-to-reel tapes in just a few seconds.


Fig. 9-9. Cassette head-cleaner.

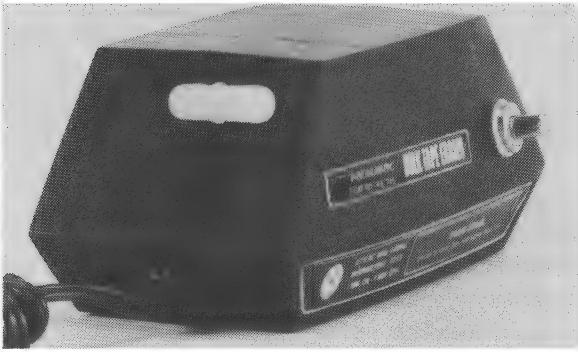


Fig. 9-10. Bulk tape eraser.

## LINE-VOLTAGE CONTROLS

The life and performance of hi-fi equipment can be affected by low or high electric supply voltage. Most homes are supplied 60-Hz ac power at wall outlets. The voltage level is supposed to be between 115 and 120 volts. At some homes, it may be 110 volts or even lower. Hi-fi equipment will not operate at full efficiency when the supply voltage is too low. At other homes, the line voltage may be 125 volts or even higher. Excessively high line voltage can reduce the life of hi-fi equipment.

Also, the line voltage can vary widely, dropping as the total power consumption in the region rises, and vice versa. To offset the effects of line-voltage variations on hi-fi equipment, many solid-state (transistor-type) receivers and amplifiers contain automatic voltage-regulator circuits. Some do not. These built-in regulators do not control the voltage fed to other hi-fi components, such as record players.

The Radio Shack variable-voltage control can be used to raise or lower the voltage fed to the hi-fi equipment and will handle a combined load of up to 500 watts. It is plugged into the ac power outlet and the hi-fi equipment is plugged into the voltage control.

There are also automatic line-voltage regulators which are connected in the same manner. They do not have to be adjusted and will deliver 115 volts constantly as the supply voltage varies.

To determine if your electric supply voltage is high or low, you can measure it yourself with an accurate ac voltmeter, or you can ask the power company to measure it. If your electric lamps burn out quite frequently, chances are your line voltage is high. Or, if your lamps last an extraordinary length of time or if the picture on your tv set does not cover the entire screen, it is an indication that your line voltage is too low.

## INTERFERENCE FILTERS

Occasionally, a hi-fi system owner will complain that he hears radiocommunication transmissions over his hi-fi system, particularly when listening to fm broadcast stations. This kind of interference results from unwanted interception of signals from nearby CB (Citizens band), ham (amateur radio) or land mobile radio systems (police, business, etc.) transmitters.

Sometimes it is the fault of the transmitter. A faulty transmitter could radiate harmonics of its channel frequency. For example, the second harmonic of a radio transmitter operating in the 44-50 MHz portion of the 30-50 MHz land mobile radio band, can often be tuned in within the 88-108 MHz section of the fm broadcast band. If its second harmonic coincides with the frequency of an fm broadcast station, the interfering signal can "capture" the receiver. For example, while listening to a program from an fm station, it can suddenly disappear and be replaced by a voice. When the interfering station ceases transmitting, the program is back. When this happens to you, listen for the interfering station to transmit its call sign. Then call the field office of the Federal Communications Commission (FCC) if there is one in your city, or write to the FCC, Washington, D.C. 20554, and explain that your radio reception is being interfered with and give the call sign of the interfering station. If that station is at fault, the FCC will require the station owner to install a filter or take other steps to minimize radiation of harmonics.

On the other hand, if you hear voice radiocommunication transmissions at any setting of your fm receiver dial, it is because of your proximity to the interfering transmitter. This kind of interference can usually be eliminated by installing a high-pass filter between the antenna transmission line and the antenna terminals of your fm receiver, as shown in Fig. 9-11. These filters are inexpensive and are available at Radio Shack stores.

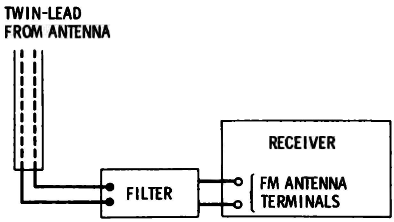



**Fig. 9-11. Antenna-filter installation.**

If you hear voice radiocommunication transmissions while playing a record or a tape, the interfering transmitter is probably in the same building or next door. If the interference reaches your hi-fi system through the power line, it might be stopped by installing an ac line interference filter, connected as shown in Fig. 9-12.

Should the interference continue, it could be that it comes from a powerful ham transmitter (up to 1000 watts) or a CB station using a high-power linear amplifier unlawfully. (FCC rules limit CB station power to 5 watts). You should report this type of interference to the FCC, but only after you have tried to stop it with an ac line interference filter.

Although an fm receiver is supposed to be immune to static-type interference, cracking sounds will sometimes be heard during and preceding thunderstorms and in desert areas where natural static electricity is generated. This kind of interference can sometimes be eliminated by installing a lightning arrester in the antenna transmission line. The lightning arrester is bridged across the twin-lead antenna transmission line. Its ground terminal is connected through the shortest practical length of wire to a cold-water pipe, or a 4-foot or longer copper-plated rod or piece of pipe driven into the ground. Electricity is then discharged to ground by the lightning arrester.

CHAPTER 10

# AUTO STEREO TAPE SYSTEMS

Millions of people enjoy listening to recorded stereo music in their cars. It was the development of the tape cartridge and cassette that makes this practical. Before they were developed, there were phonograph record players that could be operated in moving cars. They, however, did not succeed in attracting a large market. It was inconvenient to change records —which had a short playing time—and the tone arm pressure required to keep the stylus in the record groove caused excessive record wear.

## EIGHT-TRACK CARTRIDGE PLAYERS

The tape cartridge was originally developed for auto use, but has also become popular for home use. The cartridge contains an endless piece of tape which is pulled out at the hub of its reel and wound on top of the tape near the perimeter of the reel. Therefore, it plays continuously. The same tape can be played over and over again without touching it. However, the program can be changed at any time by pulling the cartridge out of the tape player and plugging in a new one.

An example of an eight-track cartridge auto stereo player is shown in Fig. 10-1. It is usually mounted under the dash where it will be easy for the driver or a front passenger to change cartridges. The player contains the tape-driver mechanism and a two-channel stereo amplifier. It can be connected to either two or four external speakers.


Fig. 10-1. Auto cartridge player.

## FOUR-TRACK CARTRIDGE TAPE PLAYERS

Some auto stereo tape players are designed to play four-track tape cartridges. But, they are in the minority. A few years ago, the four-track and eight-track players were highly competitive. But, because of the longer playing time (without automatic replaying) of the eight-track cartridge, it has become the predominant type.

## CASSETTE PLAYERS

Auto stereo tape players that accommodate four-track tape cassettes are becoming increasingly popular. The cassette either plugs in or snaps into place.

In addition to being used for playing music tapes, cassette auto stereo players are widely used for playing prerecorded spoken messages and lectures. For example, a student attending a college can play cassettes containing lessons as well as music. He learns while he drives around. His Radio Shack cassette auto stereo tape player is mounted under the auto radio in his car.

An insurance company mails cassettes to its salesmen which they can play while driving and learn about new sales techniques. The contract producers of these tapes call their technique "Narrowcasting," in contrast to broadcasting, since the information recorded on the tapes is heard by a limited audience.

Some auto-type cassette tape machines (also some cartridge machines) are also designed to be used as recorders. Salesmen and executives can record their reports while driving.

## COMBINATION UNITS

In addition to auto tape players and player/recorders, radio-tape combination units are also available. An fm or am/fm auto radio is combined with a cassette or cartridge tape player or player/recorder. An example of a cassette/fm radio is illustrated in Fig. 10-2.

Fig. 10-2. Combination auto cassette/fm radio.

## SPEAKER INSTALLATION

For stereo operation, the two speakers can be installed somewhere up front or at each side of the rear window. The speakers can be built in and covered by an escutcheon.

When four speakers are used, two are usually mounted up front and two are mounted at the back of the vehicle passenger compartment. Although four speakers are used, the sound is still two-channel stereo. But, the effect produced by being surrounded by music is extremely pleasing.

The speakers are smaller than those customarily used in home hi-fi systems and the baffles are far from ideal, thus limiting the frequency response. Nevertheless, the reproduced music is very pleasant to hear.

## THE VOLTAGE SUPPLY

The dc voltage across a 12-volt vehicle storage battery, when fully charged, the temperature is around 70° F, and when the vehicle engine is not running, is 12.6 volts. In cold weather, the voltage is lower, particularly when the battery is not fully charged. When the vehicle engine is running, the voltage can rise to 14.4 volt as the alternator (or generator) restores the charge in the battery. Since the tape player must run off the car battery, this voltage variation would cause the tape speed to vary if it were not for the tape speed regulator built into the tape player. Changes in tape speed would cause unpleasant variations in the pitch (frequency) of the reproduced music. But, because of the built-in tape speed regulator, this effect is avoided.

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**REALISTIC GUIDE TO HI-FI AND STEREO**

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**62-2043** **$ .95**

**REALISTIC GUIDE TO CB RADIO**

The first chapter contains an introduction to CB radio, covering the advent of CB and its uses. Other coverage includes obtaining a license, different types of CB radio equipment, equipment installation, antenna systems, station operation, and servicing. An appendix lists the locations of the FCC Field Offices.

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**INTRODUCTION TO ELECTRONICS**

Covers basic electron theory. Discusses magnetism, electricity, and radio principles. Explains the structure and uses of resistors, capacitors, inductors, transformers, vacuum tubes, and transistors. The book concludes with several electronic experiments and construction projects.

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**REALISTIC GUIDE TO TAPE RECORDERS**

Explains the various uses for a tape recorder. Describes the functions of the essential parts of a recorder. Covers the advantages and disadvantages of the three types of recorders—reel-to-reel, cartridge, and cassette. Guides you in purchasing a recorder according to its specific use. Covers general maintenance of recorders, tape, and accessories.

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**ELECTRONICS DICTIONARY**

Whether you are a beginner in the electronics field, a student, or experimenter, you will find this book to be a helpful reference. The definitions are written in an easy-to-understand style. Different terms for the same word are cross-referenced. Many illustrations supplement the text for further clarification.

**62-2047** **$1.25**

**ELECTRONIC COMPONENTS ENCYCLOPEDIA**

A listing in alphabetical order of the basic electronic components being used today. The text is supplemented with illustrations where needed for clarification. Where components can be referred to by several different names, cross-references have been included. The book is particularly helpful to newcomers to the field of electronics.

**62-2048** **$1.25**

**REALISTIC GUIDE TO SCHEMATIC DIAGRAMS**

An easy-reading text explaining different electronic components and how they are used in a circuit. Explains the fundamental concepts of tubes, semiconductors, resistors, capacitors, coils, and transformers and their corresponding schematic representations. The final chapter covers circuit tracing with the use of a schematic.

**62-2049** **$ .95**

**REALISTIC GUIDE TO OSCILLOSCOPES**

Begins with the invention and development of the cathode-ray tube. Oscilloscope fundamentals are next and are followed by the basic ways to use the oscilloscope. Electronic servicing applications are thoroughly covered. Intermediate and lab-type scopes are also given coverage. Finally oscilloscope probes and auxiliary devices are discussed.

**62-2050** **$ .95**

**INTRODUCTION TO ANTENNAS**

Begins with a basic discussion of radio waves, frequency, and wavelength. Describes the purpose of antennas as related to radio waves. Covers different types of antennas for television and fm reception. Advises how to choose an antenna for a specific purpose and different locations. Covers installation of antennas and accessories. Also covers CB antennas for both mobile and fixed installations.

**62-2051** **$ .95**

**INTRODUCTION TO SHORT-WAVE LISTENING**

Contains much information on how to enjoy listening to short-wave broadcasts. It explains what short waves are, how they work, and how to receive them. Coverage is given to various receivers best suited for SWL. The type of reception received on each particular band is also given. The functions of the various controls on the receiver are explained, and information on how to use them properly is supplied.

**62-2052** **$ .95**