audio systems

CLYDE N. HERRICK

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Clyde N. Herrick

San Jose City College

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PREFACE

Audio devices, circuits, and systems have evolved rapidly within the past several years. Quadriphonic sound has become an important activity in the high-fidelity field. The bipolar and field-effect transistor, the integrated circuit, the light-dependent resistor, and related devices have made obsolete the traditional audio building blocks. Intercommunication systems have become more sophisticated and are often combined with high-fidelity equipment and paging units. Public-address systems have also become more sophisticated, owing both to recognition of the Haas effect and to the demand for high-fidelity reproduction in concert halls and ballrooms. Improved microphone and speaker designs have aided the development of PA systems significantly.

Broadcasting studio and audio systems have also evolved rapidly. Improvement of field audio facilities is particularly marked, both from the standpoint of utility and operating convenience, as well as improved reliability and quality of performance. Commercial telephone systems have become highly sophisticated in

recent years, and human operators are still employed only in PBX systems. Automation has been accelerated by introduction of solid-state devices and computer technology into commercial telephone switching systems. Theater sound systems provide greater realism and higher fidelity than in the past. Moreover, new techniques have been introduced that provide greater flexibility for actors, directors, conductors, and technicians in studio activities.

Electronic organ sound systems have kept pace with advances in other areas of the audio field. The modern electronic organ with its polyphonic characteristics is a far cry from first-generation melodic organs. As in various other audio fields, computer technology has made important contributions to modern organ design. Although less prominent than various other audio systems, carrier-current audio systems have undergone extensive development and are now a dominant aspect of telephone engineering practice. Simultaneously, power-line carrier communication reflects modern electronic advances, thereby becoming more efficient and utilitarian. In a more visible and dramatic area, new-music (electronic-music) audio systems have captured wide popular attention. Whether one likes or dislikes the new music, it is "growing up" rapidly and cannot be ignored. Finally, audio measurements have become increasingly sophisticated and make greater demands on the expertise of audio technicians than in the past.

To provide a broad foundation of understanding and to facilitate transfer of training by the student, the conceptual approach has been emphasized in this text. On the other hand, the "hardware" aspect of the discipline has not been entirely ignored, inasmuch as the tangible facets of audio systems make a legitimate contribution to overall perspective. Mathematics has been introduced only to the extent required to provide ample rigor at the introductory level. Prerequisite courses are basic electricity, electronics, and semiconductor technology. However, an otherwise qualified student can cope with this text successfully if he is taking a concurrent course in semiconductor technology.

Troubleshooting of audio circuits and systems is systematically covered in this text, inasmuch as the treatment is oriented toward both the vocational student and the college-preparatory student. Grateful acknowledgement is made to the manufacturers who have been credited in the text for their cooperation and their generosity in providing photographs, diagrams, and technical data. Acknowledgment is also made to the faculty of San Jose City College, who

have provided numerous constructive criticisms. An author does not work in a vacuum, and, in a significant sense, this text represents a team effort. It is appropriate that this book be dedicated as a teaching tool to the instructors and students of our technical schools and junior colleges.

Clyde N. Herrick

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HIGH-FIDELITY COMPONENT SYSTEMS

1.1 GENERAL CONSIDERATIONS

Most high-fidelity connoisseurs prefer component systems. For example, a chosen pair of speakers may be used with a preferred type of two-channel amplifier, plus a selected brand of record player, a desired design of AM-FM tuner, a chosen reel-to-reel tape deck, and/or an eight-track tape deck, or a favored cassette deck. On the other hand, high-fidelity stereo instruments are also available in unitized form and housed in elegant furniture cabinets. A stereo equipment *console*, as the unitized arrangement is termed, eliminates the necessity of planning a component system. Some consoles contain equipment that favorably compares with a first-rate component system. Other consoles have mediocre equipment housed in expensive furniture cabinets. A console contains a speaker in each end of the cabinet.

One type of stereo instrument, termed the *compact*, has sepa-

rate speakers, with a record turntable and stereo amplifier on the same base. The speakers are often mounted or placed about twelve feet apart. The main unit of a compact may contain an AM and/or FM tuner in addition to a record turntable. Another design of compact has a record changer mounted on top of the main unit, under a clear plastic cover. A compact is sometimes called a *modular* hi-fi unit. This usage of the term *modular* should not be confused with the printed-circuit modules that may be used in amplifiers. Amplifier modules are explained in greater detail subsequently.

A hi-fi buff often selects the speakers first. A matched pair of speakers, such as illustrated in Fig. 1–1, is employed in a stereo system. A pair of high-quality stereo speakers usually costs from $200 to $400. However, good-grade high-power speakers are more costly. Some hi-fi enthusiasts like to listen at comparatively loud levels and larger speakers are required to handle the additional audio power. A bookshelf-type speaker, as shown in Fig. 1–2, is adequate for moderate volume levels, but it will distort the sound output or burn out if driven at high power levels.

A hi-fi speaker cabinet contains more than one speaker unit. The largest speaker, called a *woofer*, is used to produce the low bass tones. The smallest speaker, called a *tweeter*, is used to reproduce the high treble tones. A speaker of intermediate size, often called a *squawker*, or mid-range speaker, is connected to the system so that it reproduces the midde range of tones between the low bass and the high treble tones. Some speaker cabinets contain a pair of middle-range speakers, one of which is larger than the other. In general the size of a speaker corresponds to the audio power that it can handle.

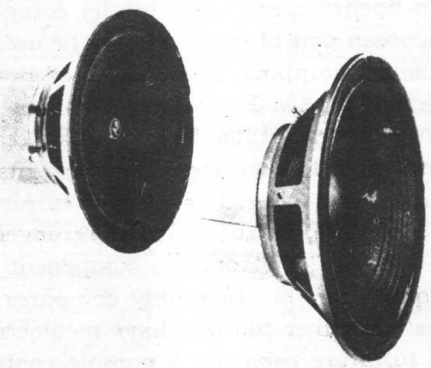

FIG. 1–1. A matched pair of high-fidelity speakers. (Courtesy of Electro-Voice Inc.)

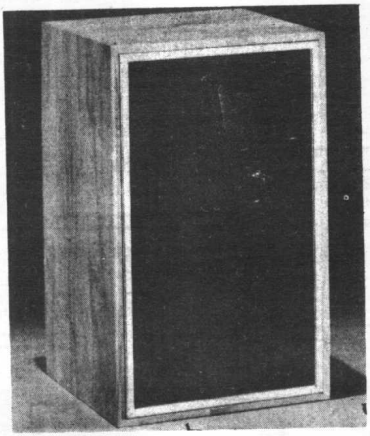

FIG. 1–2. A bookshelf type speaker. (Courtesy of Heath Co.)

A bass speaker is always the largest because the bass tones carry the greatest proportion of the audio power in most musical passages. The speakers and their associated electrical networks in a speaker cabinet, or enclosure, are referred to as a *speaker system.*

Many stereo amplifiers and various compact instruments provide jacks for plugging in stereo headphones. Some hi-fi buffs prefer the acoustics of headphones, while others prefer headphones for privacy. Stereo amplifiers are designed for very low distortion, for a rated audio-power output, and for various types of inputs. These inputs concern the desired program sources. As an illustration, an AM-FM tuner, a reel-type tape deck, and a cassette player each needs an appropriate *input jack.* An amplifier also provides *features* such as tone controls, loudness-type volume control, terminals for additional speakers, filters, stereo balance control, and various jacks as noted above. Hi-fi enthusiasts who make their own tape recordings require an amplifier that provides an appropriate stereo signal for a particular tape recorder. (See Fig. 1–3.)

Figure 1–4 shows a typical stereo amplifier chassis, and Fig. 1–5 illustrates a *receiver* consisting of a tuner and an amplifier. Few separate stereo tuners are being manufactured today; most tuners are incorporated with amplifiers. All stereo tuners have a multiplex decoder to provide stereo sound from stereo FM stations. Some tuners include a Dolby noise-reduction network. Note that hi-fi record changers are generally called *turntables.* An *automatic turntable* holds a number of discs and plays one side of each in

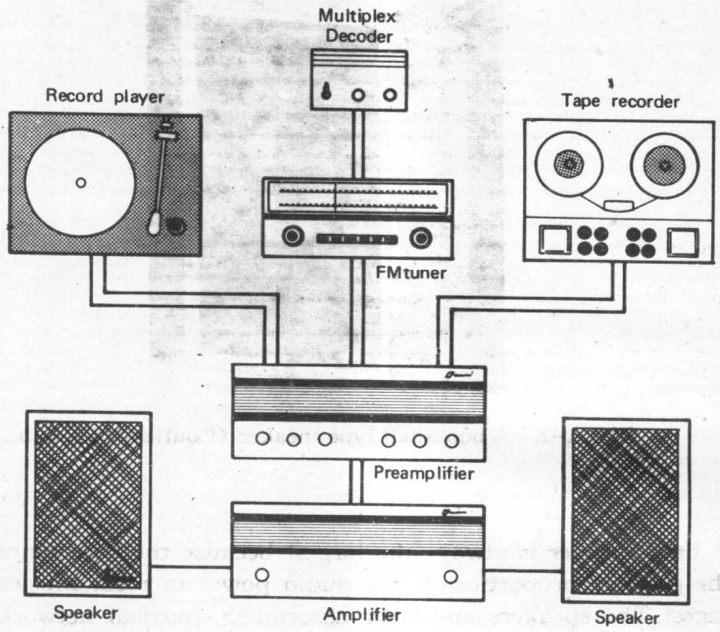

FIG. 1–3. Components of a typical hi-fi stereo system.

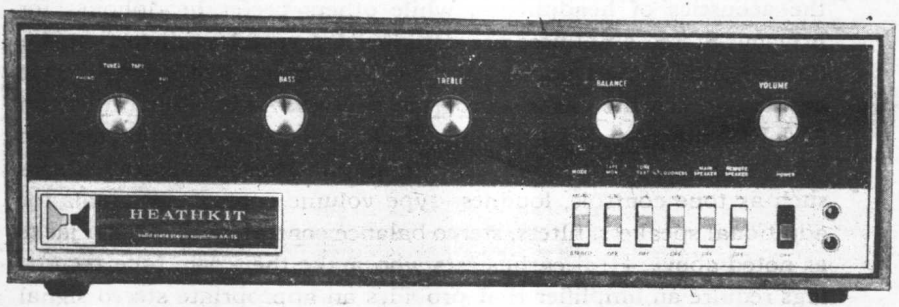

FIG. 1–4. A stereo amplifier chassis. (Courtesy of Heath Co.)

sequence. The most sophisticated types of hi-fi record changers are called *transcription turntables*. Even the simplest types of record changers provide stereo reproduction, with left-channel and right-channel output signals.

A tape recorder provides both recording and playback facilities, whereas a tape player lacks recording facilities. A tape deck

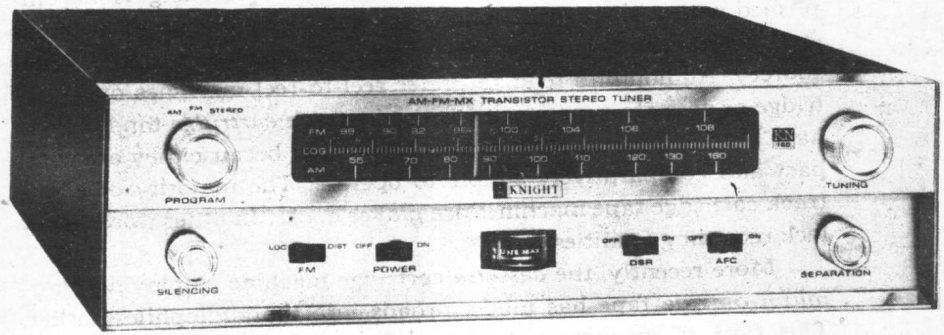

FIG. 1–5. A receiver, consisting of a tuner and an amplifier.

does not have an amplifier and must be used with an external amplifier and speaker system. Note that a tape deck may or may not provide recording facilities. Figure 1–6 illustrates a professional

FIG. 1–6. A professional quality reel-to-reel tape deck. (Courtesy of Ampex)

quality reel-to-reel tape deck. Monophonic recording is accomplished with a single microphone (or audio signal source), whereas stereo recording requires a pair of microphones (or a stereo signal source). Audiophiles tend to prefer reel-to-reel machines over cartridge or cassette-type machines. Eight-track *cartridge* tape players have become popular with the general public because they are compact and comparatively simple to operate. The majority of eight-track cartridge tape machines are *player decks*. In other words, they lack recording facilities.

More recently, the *cassette* cartridge machine employing *chromium dioxide* tape has made inroads into the audiophile market. This type of machine provides hi-fi reproduction of cassette recordings that approaches the performance of high-quality reel-to-reel machines. Eight-track tape players are very widely used in automobiles. All these types provide stereo reproduction and many qualify as high-fidelity units. High-fidelity reproduction denotes a frequency response that is flat within ± 1 dB from 20 Hz to 20 kHz and a distortion level less than 1 percent at maximum power output. Note that hi-fi speakers generally have a frequency response that is flat within ± 6 dB from 20 Hz to 20 kHz.

1.2 AM TUNERS

All high-fidelity consoles provide an AM tuner, although very few of these are capable of hi-fi reproduction. Note that an AM tuner is a high-quality design of a conventional AM radio receiver without an audio amplifier and speaker. There are two basic reasons for the lack of hi-fi reproduction from an AM tuner. First, very few AM broadcast stations provide high-fidelity transmissions. There is seldom more than one hi-fi AM broadcast station in a metropolitan community. Second, since there are so few hi-fi AM broadcasts available, AM tuners are infrequently designed for hi-fi response. Tuners designed for conventional response have the typical selectivity curve depicted in Fig. 1–7. In turn, the audio-frequency response for a conventional AM tuner is as shown in Fig. 1–8. This response can be improved to some extent by means of treble boosting, but it cannot be brought up to high-fidelity standards. If an AM tuner is designed for hi-fi reproduction, a complaint of poor selectivity and adjacent-channel interference is likely to be brought up by the customer. Accordingly, some hi-fi AM tuners have been