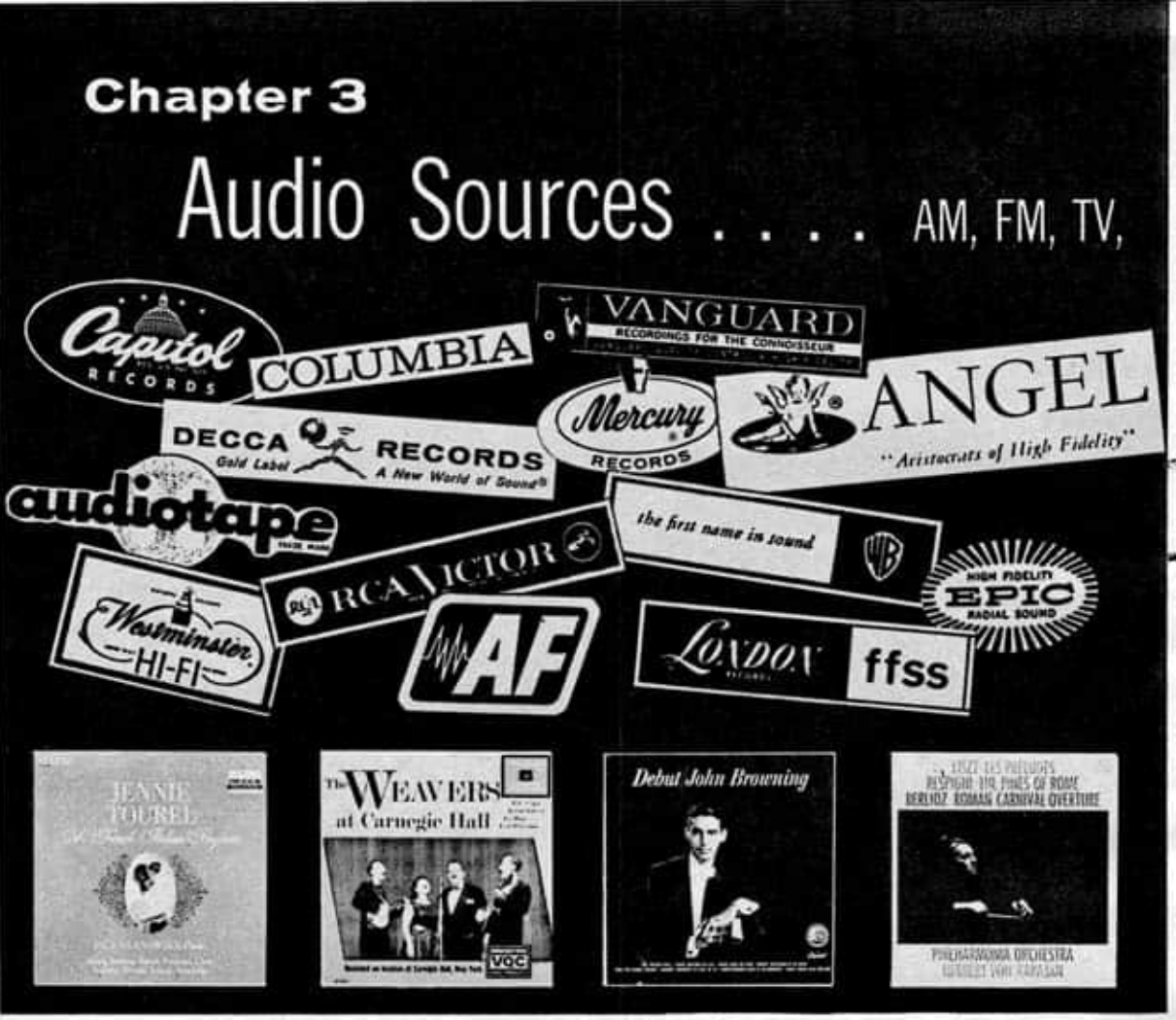
Chapter 3

Audio Sources . . . . AM, FM, TV,



IT has become rather stylish in the past few years to have "a hi-fi" in the home, by which most people mean simply a souped-up version of a record player. But as we saw in Fig. 1 of Chapter 1, this notion is no more than 25 per cent accurate. Today the phonograph record is but one part of the group of hi-fi sources, the others being tape and radio, plus an additional bonus of TV audio.

Records still offer the greatest variety of music, of course, with the well-advertised advantage of "music you want when you want it." With an automatic changer you can stack up a dozen 45-rpm for a half-hour of continuous playing time, while ten 12-inch LP's will provide better than three hours of listening.

With the plain turntable, without a changer, you will have to manually change after each record. Since the playing time of a 12-inch 33-rpm disc runs from 20 to 30 minutes, this is no great chore. We'll explore the relative merits of turntables and changers in the next chapter, so we'll hold that question open for the moment.

Music on tape can be either recorded by you, or purchased on prerecorded tape. Recorded tapes are usually copies of the same master tapes used for duplication of disc recordings. Since magnetic recording is inherently a better system, recorded tapes should theoretically be higher in quality than discs. But since the tape duplicating processes sometimes leave something to be desired, this advantage isn't always obtained.

The same general observation holds for the two types of ra io broadcasting. Theoretically FM is the superior system. But with any broad statement of this sort, we have to qualify it with "all other things being equal." And they are not a ways that.

Far too often we find an entrenched AM operator running a little FM station as a

sideline, merely to maintain a franchise. And when a flea-power FM rig has to run in competition with an AM powerhouse, we needn't tell you who comes out on top. But FM at its best will still run rings around AM.

The audio portion of television broadcasts is also FM. This is not to say that you can pick up the TV audio with an ordinary FM broadcast receiver, but rather that the same general method of transmission is used. For certain technical reasons, the FM used for TV audio is not as high in quality as that in FM broadcasting, but it is certainly very much better than one would think from listening to the average TV set.

Most of the manufacturing cost of a TV receiver is assigned to the video portion, and the audio takes the leftovers, with skimpy circuitry and cheap speakers. If you haven't heard the audio part of the better TV shows reproduced through a hi-fi system instead of the junky little TV audio system, you don't know what you're missing.

The transmission of sound over radio waves, whether they be AM, FM or TV, involves the superimposition of an audio wave, called the *modulation*, on the radio *carrier* wave. This modulated wave is transmitted through the air to the antenna of a radio or TV receiver.

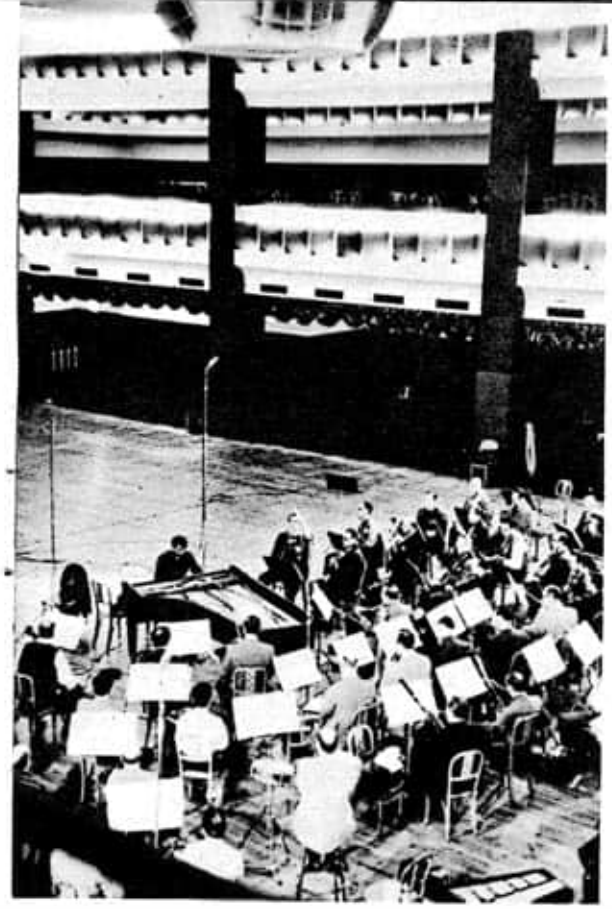
In the tuner section of the radio or TV set the audio component of the signal is recovered by a process called *detection* or *demodulation.* The carrier wave's mission is now completed and it is discarded. The audio which remains is an electrical signal, very little different from that of a microphone, phono pickup or tape head. In other words, at this point it can be treated just as any other signal which is fed into the input of a hi-fi system.

The original modulation method employed by Dr. Lee DeForest is still the most

Making a record is an exact science. Elaborate mike setups are tested and retested. Photo, left, shows pianist Glenn Gould during recording session at the Columbia Record studios.

Left and below: Conductor George Szell, members of the Cleveland Orchestra, and violin soloist Zino Francescatti, making a record. Keeping in constant touch with control room, piece is rehearsed until conductor, soloist and producer are satisfied with results. Then taping begins for final recording.

Columbia Records photos



Full orchestra recording here is the New York Philharmonic, with Leonard Bernstein as piano soloist and conductor. Note novel seating plan.

Main console of Columbia Records' New York 30th Street studio control room. All sound is fed through here before going onto the tape machines.

widely used today. This is AM, the abbreviation for *amplitude modulation.* In this system the power output of the broadcast transmitter is alternately increased and decreased as the audio level varies. The power thus swings above and below its normal unmodulated value, the amount of these swings being determined by the intensity of the audio signal.

We must realize that, while it is theoretically possible for AM radio to meet hi-fi standards just as well as any other method, the fact is that in today's commercial broadcasting setup it doesn't do so. There are several reasons for this, some of them physical and some economic, but it was another characteristic of AM that Major Armstrong hoped to improve on when he advanced the idea of FM broadcasting.

Experimenters before him believed that "static" noise was inseparable from radio signals because the two are identical in character. It was this noise that Armstrong wanted to eliminate, and he devoted many years to the problem. His first efforts were concerned with receiver circuits, and while the famous superheterodyne circuit was among those which came out of these researches, the noise problem was still present.

Concluding that nothing more could be accomplished by working on the receiver alone, Armstrong then decided to consider the system as a whole, including both transmission and reception. If AM radio and static noise are so similar in character, he thought, perhaps some other method of modulation could be used which was *not* like static. From this line of reasoning came the system of FM radio broadcasting as we know it today.

It is easy to infer from its name that in FM the frequency is varied, rather than the amplitude or power of the carrier wave. The power, on the other hand, remains perfectly constant, regardless of the modulation. With a receiver which is insensitive to variations in amplitude—and this is essential—the FM system will provide substantially noise-free reception.

Since freedom from noise is one of the criteria for hi-fi, as we noted in the preceding chapter, this characteristic is certainly useful. And since dynamic range, another of our criteria, is also closely related to noise level, we are still another step closer to hi-fi radio broadcasting.

Frequency response and distortion, the other two objectives mentioned in Chapter 2, *can* be excellent with the FM system, as they can with AM. But in the case of FM, very high standards were legislated into

Columbia Records

Two tape machines are used to simultaneously record the program material. Tapes are then edited and spliced, giving one final master tape which becomes the basis of the commercial recording.

the system by the Federal Communications Commission, including a frequency range of 30 to 15,000 cps. With the exception of the bottom octave, this is about all we expect out of the best hi-fi systems today. But with FM we had this nearly a quarter-century ago.

The recording art was comparatively in the dark ages in those days, although it has recovered a lot of lost ground since then. Magnetic recording was still in the early experimental stages then, although it is, of course, now widely used, even in disc recording.

Today all original recordings, regardless of the ultimate form they are to take, are first made on magnetic tape or film. At the studio session, performances are recorded not just once, but many times over, and perhaps not completely, but in many short segments. The best complete tapes may be picked as the masters to be rerecorded to disc, but more often there are a couple of intermediate steps.

The first of these is editing of the tapes. The best parts of the many recorded tapes are physically cut out of the originals and spliced together to make a new composite master. Thus the performance on the final record is likely better than a live one, even by a gifted performer, because it is really a synthesis of the best of many of his performances.

The composite master, too, could serve as the original for the disc, but more and more often there is still another step: rerecording from tape to tape. The copy tape is not an exact duplicate, but instead a revised version of the original. The signal from the edited original is fed through special filters, equalizers and other control equipment. This permits changes in balance, timbre, dynamics, even changes in pitch. When all of the settings have been established and thoroughly rehearsed, a second tape recorder is started to take down the sound as revised.

When a finished tape is approved for mastering, it is then rerecorded onto a blank disc. A record cutting machine, along with its associated amplifying equipment, receives the sound from a tape reproducing machine and converts it into mechanical motion in an engraving stylus.

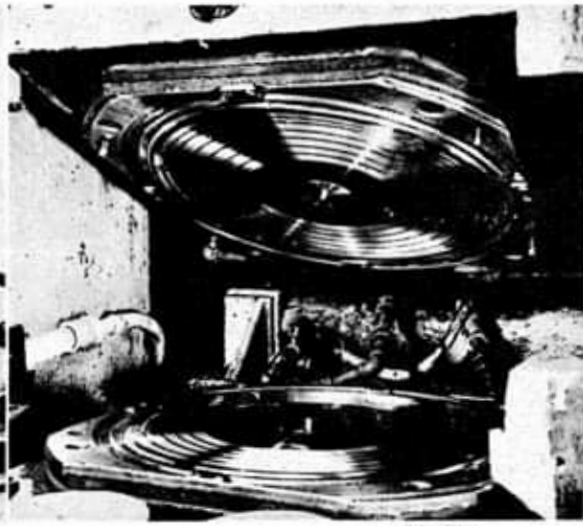
The blank recording disc is a plate of thin aluminum covered with a very smooth coating of black lacquer. One of the basic ingredients of this lacquer is cellulose *nitrate,* which is highly inflammable. For this reason cellulose *acetate* is usually used for non-professional applications, and from this all instantaneous disc recordings have come to be known as "acetates."

To record the maximum information in the smallest possible groove area, the frequency characteristics of the recording

From master tape, music is recorded onto lacquer disc. Photo shows sound grooves being cut into the lacquer master with help of special lathe.

RCA Victor

Here is the "stamper" which presses the records. See drawing at bottom of page for the various steps involved to make a phono disc from tape.



RCA Victor

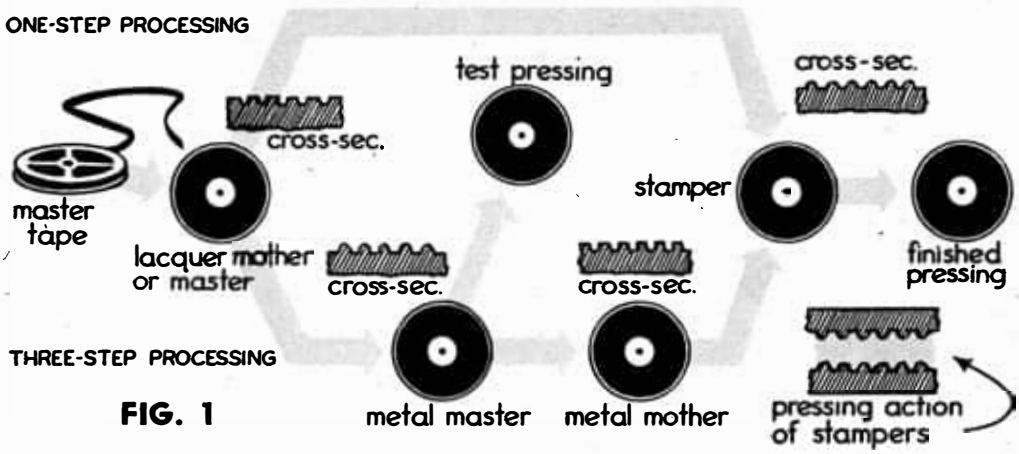


FIG. 1

Two methods, as explained in text, may be used for making a phonograph record.

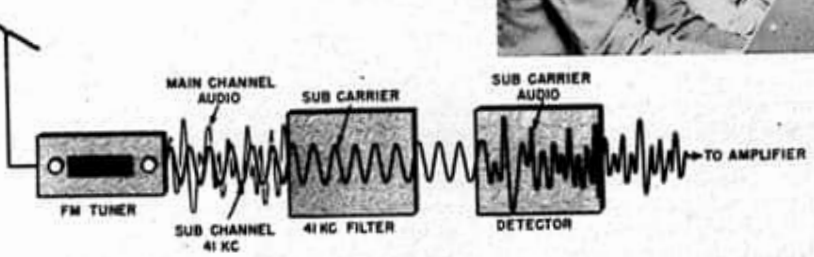
system are deliberately misshapened by a process called "pre-equalization." This consists basically of two techniques. First, the high end of the audio range is increased in level with respect to the midrange, so that there will be a better ratio of recorded sound to high-frequency surface noise. Second, the powerful bass sounds are dropped down in level relative to the midrange, so they won't cause overcutting into adjacent grooves. Just how this is done in recording, and undone in reproduction, is described in Chapter 6.

An "acetate" which is intended for mass reproduction is known either as a lacquer master or mother, depending upon the processing method. In either case an exact reproduction of it will appear on the finished record.

When the record arrives at the processing plant from the studios, it is removed from its special shipping container with all the gentle care accorded a newborn baby. It is first given a mild bath followed by a spray rinse. Next, the grooved side is coated with a thin film of silver by chemical means, in a process very similar to the silvering of glass for mirrors. The silver makes the record electrically conductive, and it can now be electroplated

NBC Television

Multiplex adaptor recovers 41,000 cps frequency which is superimposed on main FM channel in multiplex broadcasting. Drawings below show typical setup.



Radio Station WQXR

An announcer sits before two microphones in studio as the sound engineer prepares stereo tape for broadcasting. AM and FM is used here.

Left: Many audio problems had to be solved in the elaborate TV production of Naughty Marietta. Inset shows video, as well as sound engineers, keeping constant control of program's quality.

Columbia Records

Leonard Bernstein's TV musical programs have been largely responsible for the general public's growing acceptance of good classical music.

with a heavy layer of copper composition.

When the plating builds up to adequate thickness, it is stripped away from the lacquer, and what remains on the silver side is an exact negative impression of the original record, with ridges corresponding to the grooves in the lacquer. With a thin coating of chromium over the silver for durability, this metal negative may be used to press out finished records. When this is done the procedure is called one-step processing, as shown in Fig. 1, and the metal negative is known as a stamper.

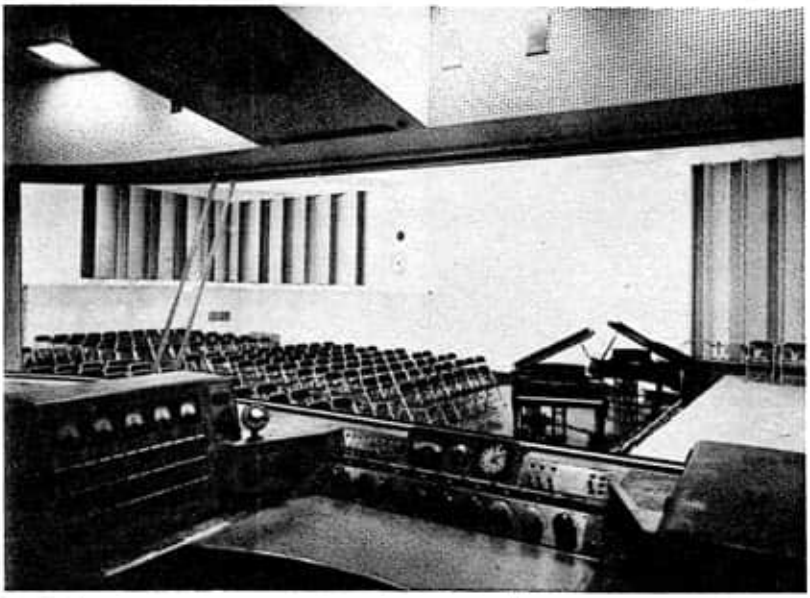
In the older three-step processing method, this first metal part is called a master, and it is used as the source of a number of metal positive parts, called mothers. These second-generation parts are once again electroplated to form negative stampers.

The advantage of three-step processing obviously is the ability to get a large number of stampers out of an original recording. In the old days, when the original was cut on wax—and the wax destroyed in the process—the three-step method was an absolute necessity. Today, with the originals on tape, it is just as easy and about as cheap to cut a new lacquer from the tape. Since this cuts down the number of generations between original and pressing from five to three, obviously the quality is better in the one-step method. Although the three-step method is traditional and still widely used, the demands of hi-fi are rapidly forcing a conversion to one-step processing exclusively.

Home tape recordings are still rather more expensive than their disc counterparts, but the price gap, in terms of cents-per-minute of playing time, is constantly growing smaller. It is unlikely, however, that it will ever be possible to manufacture raw tape as cheaply as the few cents worth of plastic used in a disc, so there will have to be further economies in the more efficient utilization of the tape itself.

There are two ways of doing this. One is to use a slower tape speed, and the other is to put more separate tracks of music on the same width of tape. As we note in Chapter 10, the speed of tape has been dropping steadily from the original speed of 30 inches per second. Although passable recordings have been made at speeds as slow as 15/16 ips, today's hi-fi standard is 7½ ips.

While it was once customary to use all of the tape width for a single recording, improvements in tape formulations and in equipment have made it possible to record first two, then four separate tracks on a



CBS Radio

View of typical broadcast studio, designed for the finest of sound reproduction. Today's radio listener gets concert-hall realism and fidelity from the many frequency modulation stations throughout the U.S.

single quarter-inch ribbon of tape. Four-track tape at 7½ ips has now been adopted by Magnetic Recording Industry Association as standard for stereo, about which we'll have more to say presently.

The final source of professional sound for your hi-fi system is television. It took a long time, but television producers have finally come to realize that the audio part of the TV show is just as important as the video, and they are paying a little more attention to getting decent sound on their shows. They aren't wholly to blame for the previous horrible condition of TV audio, because TV sets being what they are, any good sounds broadcast largely go to waste anyhow.

You can get around this shortcoming by taking the TV audio out of its straight-jacket in your TV set and feeding it into your hi-fi system. This is unfortunately easier said than done, as very few TV sets are connected with audio ouput jacks. Thus you'll have to do a little rewiring work yourself, or else have a service technician do it for you. The audio signal should be picked up at the output of the sound detector, and from there fed into the hi-fi input. With this arrangement, you'll be surprised at the results. It even makes the small screen picture *look* bigger!

The Stereo Story

All of your hi-fi sources are now capable of stereo, and three out of the four are delivering it rather regularly. Although TV is as capable of stereo as AM or FM, it is seldom done. And with the problems the television industry is having in getting color off the ground, it isn't likely we'll be hearing much TV stereo for awhile.

The simplest means of accomplishing 2-channel stereo transmission by means of radio waves is simply to use two separate stations, one for the right channel, the other for the left. Whether the two stations use the same system of transmission or not is of no importance. If they are the same, we could have any of three combinations: AM-AM, FM-FM, or TV-TV. In any case, we would need two separate tuners of the same type, one for each channel.

Not many of us are so equipped, but most of us have at least one each of the AM, FM and TV types. Then we could easily listen to stereocasts which were AM-FM, AM-TV, or FM-TV. All of these combinations have been tried, but the only one presently being used to any extent is AM-FM. Many cities have broadcasters airing stereocasts by this method on a regular schedule.

The newest method of stereocasting, which shows great promise, uses only one station in a system known as *multiplex*. In this arrangement, a conventional modulator at the transmitter superimposes an audio signal on the carrier in the usual way. At the same time, a supersonic frequency is imposed on the carrier, and audio in turn superimposed on that as well. Thus

the supersonic signal acts as a sub-carrier for the second audio signal.

An FM version of this multiplex system has been known for quite a few years, and quite recently a similar AM system was developed. Some of the better hi-fi FM tuners have a multiplex detection circuit included, and as more becomes known about AM multiplex, presumably there will be equipment available for that, too. Multiplex adapters are also on the market, which are simply plugged into any existing FM tuner, and permit immediate reception of stereocasts.

As we have already noted, magnetic tape is ideally suited to stereo recording, because it can readily accommodate two or more channels. With dual-track monophonic tape, as shown in Fig. 2(A), the tape is first recorded along half of its width in one direction, and then along the other half in the other direction. This gives just double the playing time for the same length of tape.

With two-channel stereo, those same two tracks are recorded simultaneously, with each track getting one of the stereo channels. This is shown in Fig. 2(B), where we see that one-way stereo is nearly identical to two-way monophonic, with only a slight difference in the dimensions of the tracks to gain better channel separation.

The trouble with the one-way stereo system is that it wipes out the double-time advantage of two-way monophonic. And the only way to get it back is either to cut the tape speed in half, or record two tracks in *each* direction, for a total of four separate tracks. Two such four-track systems are in use today, and their arrangement is shown in Fig. 2(C) and (D). The arrangement at (D) has now been adopted as standard by Magnetic Recording Industry Association, and most of the major recorder companies now make machines of this type. These manufacturers include Ampex, Bell, Viking, Pentron, Magnecord and Revere.

The stereo disc is now firmly entrenched, to complete our list of stereo sources. Since the record groove is in the shape of a *V*, it has two sides or walls. The two-channel stereo disc thus has essentially one channel of information engraved on each groove wall. Just how this is accomplished, and what demands it places on the reproducing equipment will be explained in Chapters 5 and 6.

But neither tape nor disc can be played until it is set into motion. A discussion of the devices which accomplish this is next on the agenda. •

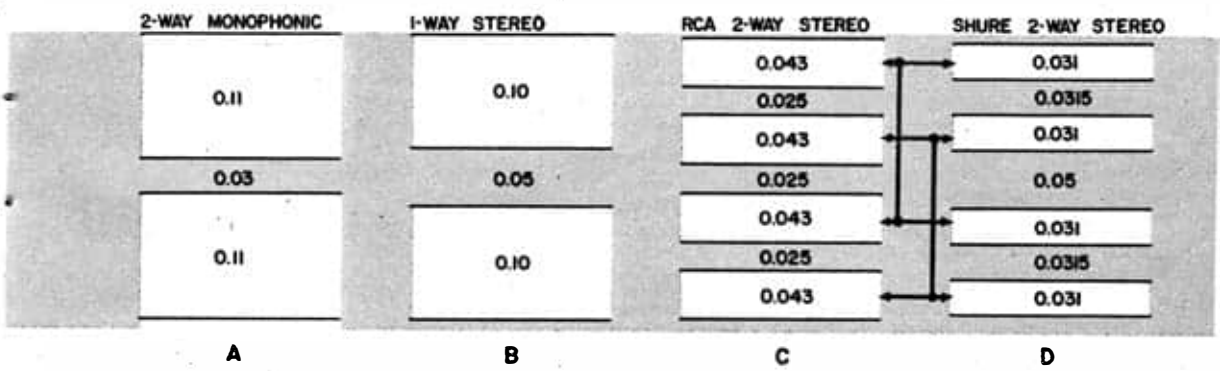


FIG. 2, above, shows in schematic form one piece of tape and what happens to it when exposed to the various head configurations of the different systems. See text for fuller explanation of this subject.