50¢

how to understand

HIGH FIDELITY

the new science of home music reproduction explained for the beginner . . . a basic primer for those demanding the best in listening enjoyment

FOREWORD

Listening to one's favorite music through a high-fidelity sound system for the first time is an electrifying experience. We enjoy all the thrilling "highs" and the booming "lows" as they were heard in the recording studio.

To be able, whenever we desire, to enjoy music with all the exciting realism it possessed when originally recorded is truly one of the most wonderful achievements of this electronic world of ours.

Engineers have been striving to reach this goal for well over half a century. However, until recently it was necessary to assemble your own high-fidelity music system from a number of component parts to be able to enjoy this new sound in your own living room.

Now the development of quality completely assembled RCA Victor high-fidelity "Victrolas" and tape recorders, coupled with improvements in recording techniques, brings high fidelity within the reach of all of us.

Frank M. Folsom
President
Radio Corporation of America

HIGH FIDELITY

Prepared for RCA Victor by the Maco Magazine Corporation

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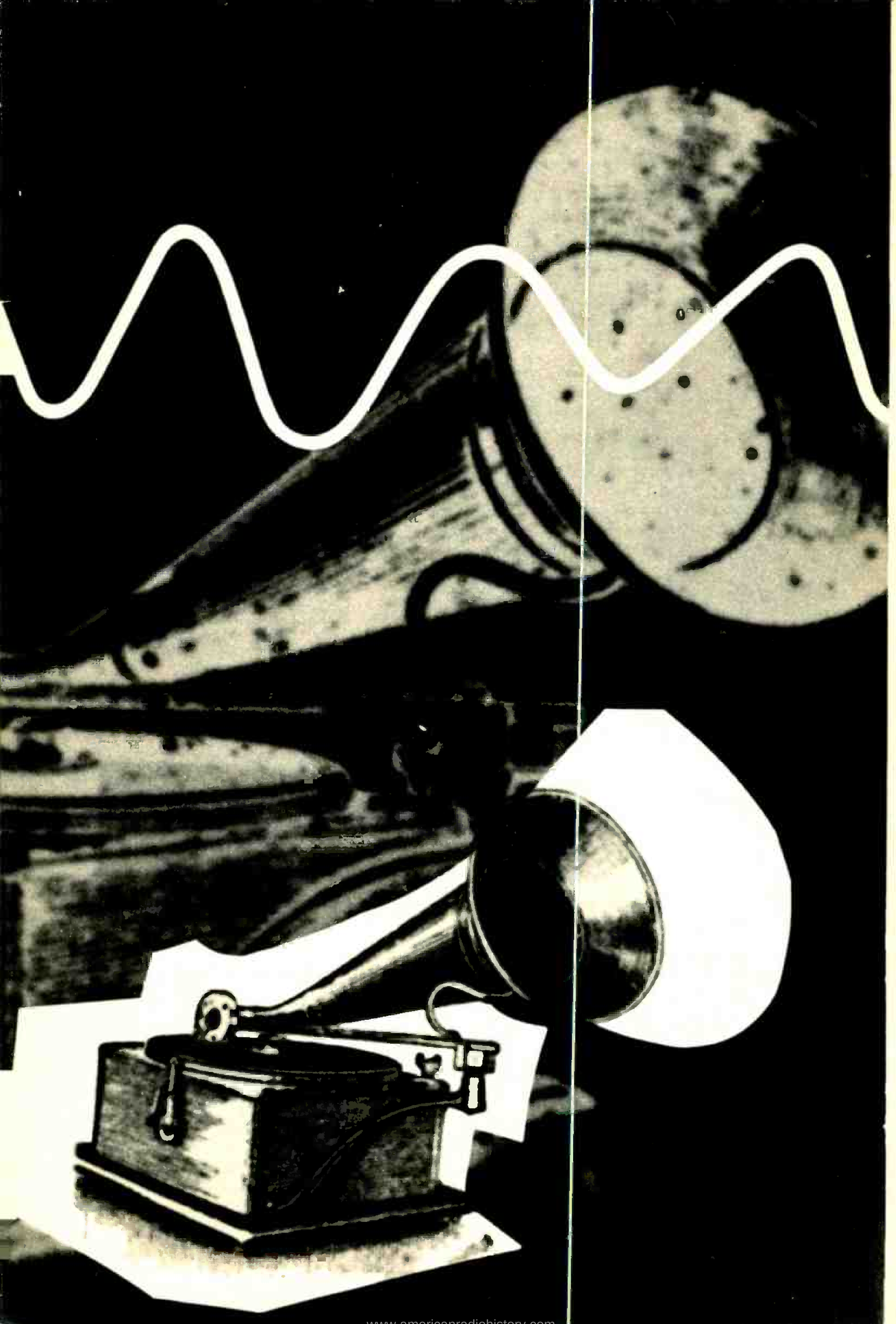


CHAPTER 1

HISTORY OF RECORDED SOUND

Until you've listened to high fidelity, you

don't know how lifelike recorded music can sound. It's

come a long way since Edison's talking machine

In 1889 a certain Colonel Gouraud took one of the first gramophones to Paris to demonstrate it before the Academie Française. Among the people he met on his journey was Giuseppe Verdi. Somehow he persuaded the composer to play the piano and sing his "Ave Maria" into the machine. Then he played back the results. "My God!" said Verdi. "What fidelity!"

This was the beginning; it would be a brave man who would predict the end.

The phonograph record is a device which stores sounds for reproduction at another time and in another place. The value of the device is obviously proportional to its accuracy—if you couldn't make out what was on the record, the record would have no value at all—and to the quality of the reproducing machine. Though the speaking voice and the brute noise have both been recorded fairly often, the most common use of the phonograph has been for the reproduction of a musical performance. This was true from the very beginning. Morse sent "What hath God wrought" as the first telegraphic communication; Edison, testing out his phonograph, sang "Mary Had a Little Lamb."

As a new way of making music, effortlessly, in your own home, the phonograph in its early days had to compete with the player piano and the harmonium. Its advantage was that it could bring you the performances of real-life great artists. Few people outside the large cities in which opera houses and concert halls were maintained could ever hope to hear stars like Enrico Caruso, Emma Calve, Jan

Enrico Caruso (right), the first musical celebrity to sign a contract with the Victor Talking Machine Company, led other stars to follow his example. Shown here are Frieda Hempel and Maria Duchene, seated: Leon Rothier and Andres de Segurola, standing

Kubelik or John Philip Sousa. Yet these and many other musical greats recorded for the new-fangled phonograph—most of them for the Victor Talking Machine Company, which was destined one day to become an important part of the Radio Corporation of America family.

THE EARLY PHONOGRAPH

Those early recordings were, by today's standards, ludicrously distorted and unlifelike, and the machines they were played on didn't improve them. The early phonograph was an entirely mechanical device. The turntable (or revolving cylinder, in the first Edisons) was spun by a spring, which was wound by a handle, which was turned by a human hand. The phonograph needle which stood on the record (with tremendous weight) had at its other end a diaphragm which produced the sounds indicated by the wiggling of the needle. Attached to the diaphragm was a horn not unlike the one your deaf great-uncle used to hold to his ear. The resulting noise was satisfactorily loud, but it is hard to understand now what else about it could be treasured.

The very first phonograph, as you probably know, was invented by Thomas A. Edison in 1877. It was cumbersome and the reproduction was very poor and indistinct, but its essential principles, successively refined, were in use for many years. Somewhere about 1887 another inventor, Emile Berliner, developed a disc record, as opposed to the cylinder record of the Edison machine, and a method of making duplicate records from a single "master."

But the phonograph, or gramophone, was still a toy (most people called it a "screech box") when Eldridge R. Johnson, later the founder of the Victor Talking Machine Company, became interested in it. He was operating a small general machine shop in Camden, N. J., and someone brought an ailing screech box in for repair. Johnson recalled later that it sounded like a partially educated parrot with a sore throat. But he was fascinated by the crude little machine, and saw in it the beginning of a new art. He began the manufacture of gramophones for the Berliner

Company in 1896, and organized his own company, Victor, in 1901. An enthusiast and an engineer, Johnson was personally responsible for many of the early improvements in phonograph construction and design.

RADIO COMES OF AGE

Even as early as this, a few years after the turn of the century, events were taking place which would have a far-reaching effect on recorded sound—although no one guessed it at the time. Scientists were tinkering with something they called wireless, or radio. In 1906, at Brant Rock, Mass., violin music was played over a radiophone. In 1910 a prophetic event occurred: Caruso, Destinn and other artists of the Metropolitan Opera sang into a De Forest radiophone backstage at the opera house.

In 1915 a young man, David Sarnoff, caught a clear view of what was ahead and put it into a memorandum predicting a "radio music box" which would be in every home. It would bring in music and voices from a radio transmitter located as much as 50 miles away! World War I delayed Sarnoff's dream, but in 1920, with the advent of public broadcasting, the radio music box became a reality.

Some people said the phonograph industry was doomed. But those pessimists were wrong—or only partly right. True enough, the mechanical phonograph *was* doomed. But the phonograph which adapted itself to the principles of radio was destined to grow in popularity, in usefulness, in fidelity of reproduction.

As noted earlier, the first phonograph was mechanical. Radio was electronic. Before radio came along to change everything, all recording and reproducing employed acoustical methods. Sound waves set up by the recording artist caused the recording diaphragm to vibrate which, in turn, actuated the recording stylus. It was as simple as that—and as crude.

Artists worked under great handicaps. They spoke, sang or played into a large recording horn, like the one on the parlor phonograph—only much bigger. Big as it was, this horn wasn't suitable for large groups of musicians. Recording of more than 20 instruments playing together presented a serious problem of grouping in order to bring all members of the orchestra close enough to the horn. The usual solution was to pack them tightly together on tiered seats. The standard violin couldn't be used. Instead, a special recording violin was required—one with a horn that threw the sound in one direction only. With the musicians crowded shoulder to shoulder, it was not uncommon for the violinist to run his bow into the neck or face of the adjoining clarinetist, or for the trombonist to stab the back of the man in front of him, causing unhappy moments during a recording session.

THE FIRST ELECTRICAL RECORDING

In 1925 all this confusion came to an end with one of the most significant developments in the history of the art—electrical recording. The microphone replaced the recording horn. The recording stylus was actuated not by sound waves but by electrical impulses. High frequencies and low frequencies—that is, high and low musical notes—never before heard on a record were put on wax.

The difference between acoustical and electrical recording is illustrated in these two photographs. Above: Rosario Bourdon's musicians huddle around a big horn. Below: By the mid-20s, an early microphone had replaced the horn and given the players elbowroom

In the years after 1925 many more changes came to the art and science of recording. Electrical recording was followed by electrical reproduction, replacing acoustical reproduction. Needles began to give way to the more efficient and durable jewel pickups. The automatic record changer was introduced.

BETTER RECORDS AND SPEEDS

Paradoxically, it was radio—recording's stiffest competitor—which not only became the star salesman and showcase of records but revitalized the phonograph industry. Radio, together with automatic coin machines, brought popular music to people in all walks of life. By the late 30s, record manufacturers rubbed their eyes and pinched themselves to see if they were dreaming. Record sales, which had hit an all-time low in 1933, had begun to chalk up sizable annual gains. Radio dealers were stocking phonograph needles as well as vacuum tubes, and in leading cities many of the plushest shops were dealing in records and record players.

Pioneering in the field of long-play records was begun by RCA Victor in the early 1930s, and for a number of years its catalogs listed 33⅓ rpm selections. Apathy on the part of the buying public, however, caused a halt of production until public interest was rekindled a few years ago.

THE "45" SYSTEM

In 1939, RCA Victor initiated a comprehensive study of the record and record-playing situation. Less than ten years later, despite delays necessitated by World War II, this study resulted in a new phonograph system. The goal of the engineers in this project was the development of a music-reproducing system that would eliminate the shortcomings of conventional phonograph systems and incorporate the advantages made possible by the increased knowledge of electronics, recording techniques and instrument engineering.

This goal was achieved by the RCA Victor 45-rpm system, introduced to the public in 1949. The "45" comprised an array of major *firsts*—first record and changer literally made for each other; first record of distortion-free performance over 100 per cent of its playing surface; first record designed in a single size to play all classifications of music; new unbreakable, light-weight record of smaller size to solve home-storage problems; speediest record changer, half the size and requiring 25 per cent fewer parts than conventional models.

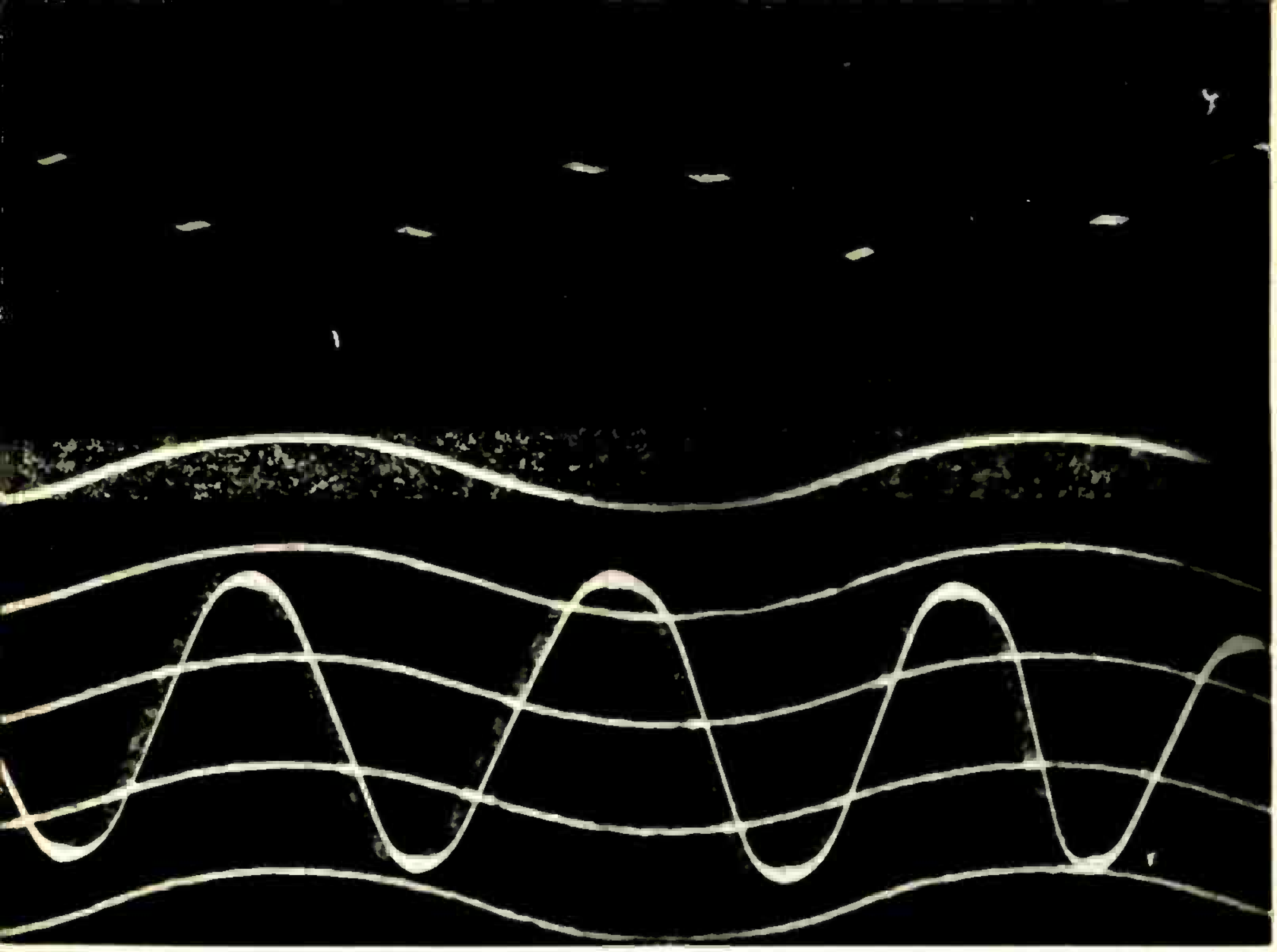
The RCA Victor "45" system has made history. Music critics and technical experts hailed the "45" as setting a new high standard in recorded music. And, in 1954, RCA Victor introduced another advance—the "Extended Play" record. These "45" EP records increased playing time from three to eight minutes per side—still maintaining the truly remarkable quality of the "45" record.

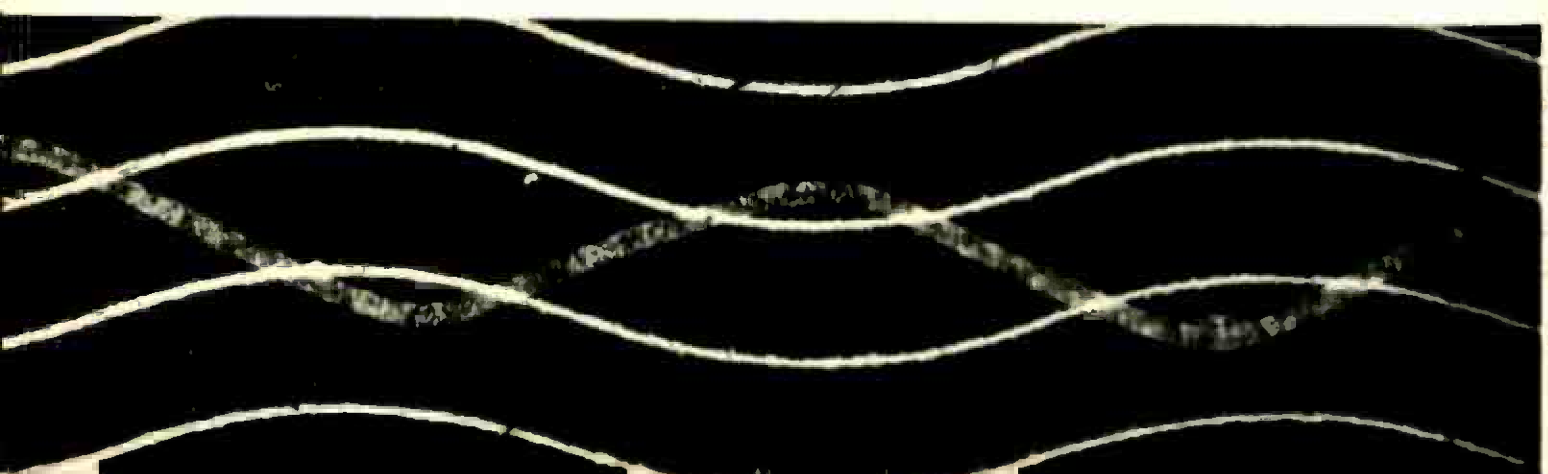
Improved records and reproducing units brought recorded sound nearer and nearer to the ultimate goal—perfect fidelity. That goal—absolute perfection—has not yet been reached. Just as today's high-fidelity music systems for the home are infinitely better than the best machines known in the 1920s, better even than the best console radio-phonographs of five or six years ago, future systems will undoubtedly embody improvements and refinements of the components in present use. But this can be said of modern high-fidelity reproduction: musicians, with their exacting standards, find it intensely satisfying and believe that the recording process we now use has only minor flaws.

WHAT IS HI-FI?

What is the difference between a high-fidelity phonograph and any good ordinary phonograph? Just this: the high-fidelity instrument has been specially designed and constructed to give you sound that will be, as nearly as possible, the same sound you would hear if you were sitting in the Metropolitan Opera House listening to Roberta Peters sing, or in Carnegie Hall listening to Charles Munch conduct the Boston Symphony Orchestra.

What you get in a hi-fi set is probably best defined as "presence"—a feeling of life and nearness in the music. Once you have heard high-fidelity reproduction, it will be hard for you to find satisfaction with anything less.





CHAPTER **2**

RECORDING AND PLAYBACK

The tiny grooves of a record contain the sound and color of a musical performance. Here's how it gets there, and how it's reproduced by your phonograph

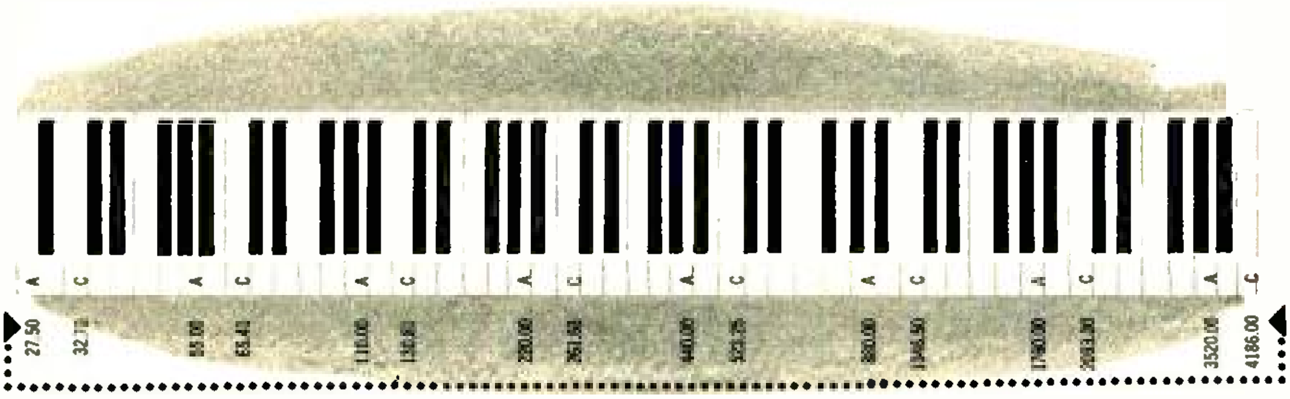
The phenomenon that we call sound is a wave in the air, pulsing at a certain speed. The wave hits against the eardrum, alternately pushing it and releasing it. Connected to the eardrum is a system of three bones, which act as levers and move every time the eardrum is agitated. This lever system agitates a smaller membrane at the entrance to the inner ear, and the vibrations of this smaller membrane are translated by the brain into the sensation we describe as sound.

Not every sound wave of a given intensity, however, will be identified by the brain as sound. A wave pulsing slower than 20 times a second may be felt by your body, if it is strong enough, but it will not be recognized by the ear. Pulsations faster than 15,000 times a second are "supersonic," and are also missed by the ear.

Since each pressure wave gradually increases and decreases in intensity, with a recognized crest and a recognized trough in every wave, the pulsations are described as cycles. These are measured in cycles per second, usually abbreviated to cps in hi-fi literature. The number of cycles per second in a given sound is described as its "frequency of sound." The phrase, therefore, is that most people hear sounds within a frequency range of 20 to 15,000 cycles.

FREQUENCY RANGE OF MUSIC

A musical sound is distinguished from mere noise by the fact that it continues throughout its individual duration at the same frequency, making a pleasing sound to the human ear, while a noise is a patternless jumble of frequencies. A low-frequency sound is a low note, a bass note. A high-frequency sound is a high note, a treble note. The range of sounds that can be written in ordinary musical notation runs from 16 cps of a pipe-organ, which is four full octaves below middle *c*, to 4,186 cps, which is four full octaves above middle *c* (see illustration). The piccolo registers of a few organs go even higher.



Shown above are the frequencies of musical sounds, in cycles per second, for the notes on a piano keyboard. A, at 440 cps, is the note to which orchestra instruments are tuned

Now almost every musical note that any composer has ever written on score paper sounds at less than 4,000 cps. Hi-fi enthusiasts, however, insist that a phonograph be capable of reproducing all frequencies up to 15,000 cps—and even the most conservative musician will demand at least 12,000 cps. The reason for their fussiness is the complexity of musical sound, which creates vibrations in the air far above the frequency of the notes written on the page.

HARMONICS

A violin string, properly stroked to sound *a*, will vibrate along its entire length 440 times per second. As it vibrates in its entirety, however, it will also vibrate in its parts—each half, each third, each quarter. The halves vibrate at twice the rate of the full string, producing the same note an octave higher; the thirds at three times the rate, producing the dominant an octave higher; the quarters at four times the rate, producing the fundamental note again, two octaves higher.

Each of the tones produced by a vibrating part of the string is called a "harmonic." The second harmonic is one octave up; the third, an octave plus a fifth; the fourth, two octaves. Harmonics are heard by the listener as an enrichment of the fundamental tone (except in a faulty instrument in which the fifth, seventh, eleventh and thirteenth tones, objectionable when not inaudible, may be sounded.)

But all these harmonics emerge from the instrument simultaneously, so that the actual sound of a violin playing *a* becomes an extremely complicated set of sound waves. The sound quality of the instrument playing the fundamental note will be determined by the relative strength of the harmonics—and by their relation to each other and to the fundamental note, the *a* written on the score.

This interrelationship of harmonics not only distinguishes one violin from another, it distinguishes a violin from an oboe or a flute playing the same note. (One of the great disadvantages of the old, low-fidelity records was that you couldn't tell the various instruments apart. Even today, careful recording is necessary to keep the identity of the individual instruments distinct.)

When two different musical notes are sounded at the same time, they will "modulate" against each other. Two violins, one playing *c* and the other *g*, will therefore produce not only a series of *c's* and *g's*, but a series of tones caused by the interaction of the notes and their respective harmonics at varying strengths. Imagine, then, the enormous complexity of sound waves in the air that results from the concerted playing of a 100-man symphony orchestra.

It seems miraculous that a musical sound of this complexity can be adequately caught in a groove only .0025 inch wide.

THE RECORDING PROCESS

Until the middle 1920s, all records were made by the "acoustical" method. A sound wave in the air is a physical phenomenon, and as such it can be represented in some other physical manner. This was the essential discovery behind the phonograph: by singing into a horn containing a tightly stretched parchment diaphragm, you made the diaphragm vibrate. If you attached a needle to the diaphragm, it would vibrate, too. If you spun under the needle a platter or cylinder coated with lampblack or thin tin foil, the needle would leave the impress of its vibrations. Then you could make the impression permanent, and run the platter or cylinder under a needle to which was attached a diaphragm to which was attached a horn—and the horn would give off a sound somewhat similar to the sounds sung into it at the time of recording.

If you required this device to reproduce a set of sounds so complicated as that made by a symphony orchestra, however, the result was easily identifiable as a musical composition, but without the degree of perfection that is possible today.

ELECTRICAL RECORDINGS

In the 1920s the gradual development of electronics showed that it would be possible to make records electrically—that is, to translate the sound energy into electrical energy, and use electrical energy to drive the cutting needle on the platter. The translation of energy from one form to another invariably involves loss. In the case of the microphone, considerable "amplification" of the original electric signal was necessary to make it strong enough to drive the needle. These two factors—making a microphone sensitive to all the sounds of the musical spectrum, and an amplifier that would enlarge the microphone's signal with accuracy—were chief problems of the record business through the first decade of electrical recording.

The early microphones used as a diaphragm a very thin, charged metal plate,

Popular singers Perry Como and Jaye P. Morgan share a microphone as they record a duet. The electric impulses created by their voices are magnetized onto tape

which would move in response to minute sound waves and start an electric signal every time it moved. Several microphones generally were used to pick up all the instruments of an orchestra, but the electric signals from the various microphones were "mixed" successfully to produce a sound that would recall the concert hall, even to an unimaginative listener.

The upper limits of the equipment's frequency response was approximately 5,000 cps, which eliminated most violin harmonics and similarly rich musical sounds. It was not possible then to design an electro-mechanical device which would accurately drive a cutting needle to wiggle faster than 5,000 or 6,000 cps, and existing amplifiers became unreliable at the higher frequencies. Since radio broadcasting on the AM bands is itself generally limited to a top of 5,000 or 6,000 cps, the records sounded fine. And, if you are willing to make certain allowances, they don't sound too bad even today.

This is probably as good a place as any to proclaim the infinite superiority of a clean recording which cuts off at 5,000 cps to a distorted recording that goes all the way out to 20,000 cps. The first is music which lacks its top octave and a half; the other is essentially unmusical noise.

Well, today they make microphones so sensitive that recording companies have been known to scrap a whole "take" for no other reason than that you could hear the keys jangling in a musician's pocket. Amplifiers, as maintained by record-company technicians, are practically perfect. And the magnetic cutter can wiggle as fast as 25,000 times a second.

RECORDING ON TAPE

The magnetic cutter, however, is no longer present at the recording session. Instead of transforming the signals from the microphones directly into the physical wiggles on a disc, they are magnetized into a plastic and iron-oxide tape, which moves past the magnetic recording head of a tape recording machine.

Tape has added great flexibility to the recording operation. Now, if a mistake is made, a few bars can be repeated. The section of tape which contains the error is cut out of the reel and the corrected version simply spliced in. A great deal of improvement can be accomplished on the tape before the disc is even cut. Sometimes recording engineers find it necessary to spend two or three hours playing with the tape (boosting this range or that, adding echo effects or "presence") for every

In his glass-enclosed booth, an engineer manipulates controls while the complex sounds produced by a full orchestra are recorded. To reproduce these sounds exactly is the task of your hi-fi set

1. Steps in making a record: A recorded tape is being re-recorded on a master disc. Electric impulses cut grooves in the plaster surface of the record

2. A mold is then made from the master disc. Here the mold is being carefully separated from the master. Each step in record-making calls for utmost precision

hour actually spent in the recording studio. Tape has also, of course, a wide and enticing variety of uses in the home, but that is a story for Chapter 5.

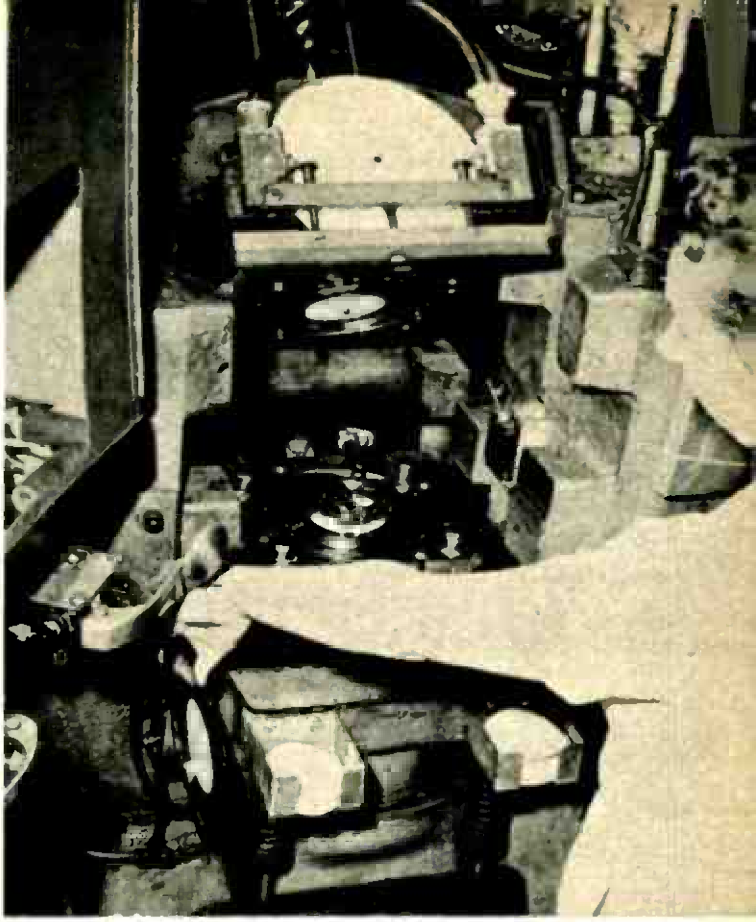
The electrical impulses imprisoned on the tape are transformed into side-to-side wiggles on a disc by an extraordinarily complex machine. The heart of this machine is a very heavy turntable which rotates at 78, 45 or 33⅓ rpm, according to the type of record being cut. Above the turntable is mounted the magnetic cutter on a carriage which moves from the outer edge of the record to the inside, from the circumference of the disc to the spindle at its center. A lacquer disc is placed on the turntable, and the music from the tape is recorded on it by means of the cutting stylus. It is from this master disc that all the records of that particular recording session are made.

PRESSING A RECORD

The method of pressing records is basically the same as it was 50 years ago—but with the refinements that make the difference between the record of yesterday and the excellence of present-day reproduction. The lacquer original, after inspection, is successively electrochemically plated with a layer of silver only a few millionths of an inch thick, a thin layer of nickel and a thicker one of copper.

From the master the "mold" is made. The silver surface of the master is chemically treated, plated with nickel, then copper. The mold, about .02 inches thick, is actually a metal record, an exact duplicate of the lacquer disc, but because it is made of metal, it is capable of withstanding the strains of the pressing process.

3. From the mold, a nickel stamper is made for pressing records. In order to center the stamp accurately, the operator shown above is using a microscope



4. The stamper is placed in a press, where an operator inserts the material from which the record is made. Most records are now made of vinylite

5. The pressed disk is inserted in dinking dies for trimming, as shown in the picture above, after which it is inspected for imperfections

6. Completed record is stacked for transfer to the shipping department, where it is placed in a colorful package and sent to a record store

From the metal mold, one more negative version of the disc is made—this time a solid nickel plate slightly less than .01 inch thick. This is the "stamper," from which your phonograph record is made. Two stampers are used for each record and they are placed in the top and bottom of a press which resembles a huge waffle iron.

Material for records—vinylite for 33⅓ rpm and "45" standard and extended-play records; a mixture of synthetic resins, limestone, slate, carbon black and other materials for 78s—comes to the stampers in the form of flat, preheated squares called "biscuits." The biscuit is placed in the press, subjected to high pressures and steam, then bathed in cold water to harden it. When it emerges it is embossed with precisely the same microscopic wiggles that were on the original lacquer disc.

For some time, original recordings were cut on discs of wax, whose surface was brushed with graphite after the recording to make it electrically conductive. But graphite is grainy and caused surface roughness in the subsequent duplications of the wax disc. To eliminate this roughness, the metal masters, molds and stampers were all carefully polished by hand—an operation which distorted and wore down the all-important grooves.

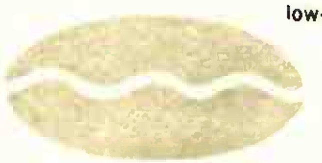
Today records are cut on lacquer, and the metal layers which form the mold, master and stamper are all deposited by electrochemical means. Methods have been found to insure the purity of the nickel used in the various steps—for impurities in nickel lead to surface noise and "ticks." Hand-polishing, with its abrasive effects, has been done away with. The result is a record which, despite all the duplicating processes it undergoes, is actually the same as the original.

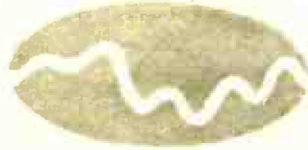
PLAYBACK PROBLEMS

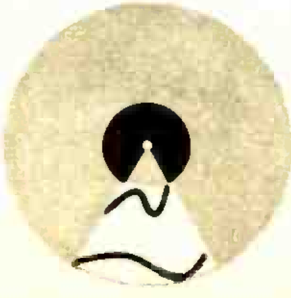
We now have a record. It looks simple, but it is actually an immensely complicated piece of vinylite, and solving the problems which it presents is the business of your phonograph. Problems inherent in records are essentially the same for all speeds.

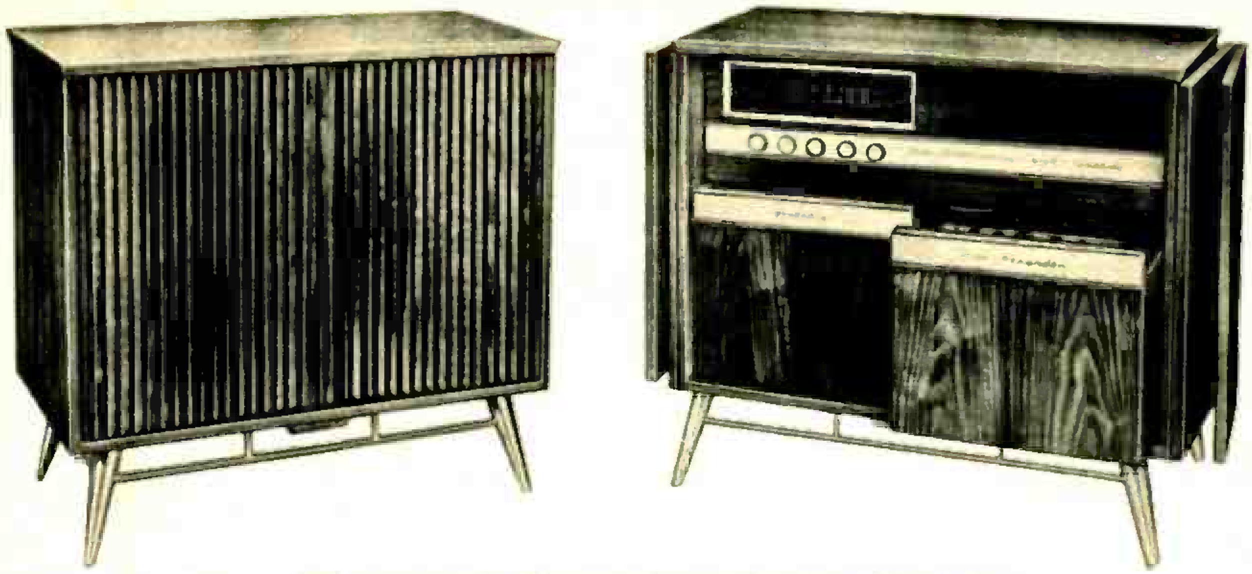
For example, a piece of music involves at least half a dozen sound frequencies,

Wiggles below represent musical tones, the first a low-frequency note, the second a higher note, the third a combination of the two. At bottom, wiggles of same frequency are shown at edge and near center of record. Drawings are exaggerated









RCA Victor's Mark I high-fidelity "Victrola" offers separate speaker enclosure (left), AM-FM radio tuner, record changer and tape recorder. The matched cabinets are available in traditional styling in mahogany or modern in walnut

all going at the same time; and all this musical intelligence is carried inside a single groove .0025 inch across at its widest. Modern high-quality, high-fidelity records spin at the rate of 45 or 33⅓ revolutions per minute. The wiggles are cut in the grooves to make the playback stylus vibrate at the frequencies indicated by the music. But the wiggles will pass below the stylus at the right frequencies only when the playback turntable turns at exactly 45 rpm or 33⅓ rpm. So you need a precision instrument just to spin the record.

A 12-inch LP has a circumference of roughly 37½ inches. The first groove with music on it is, say, 36 inches long. It takes slightly less than two seconds for the record to make one complete revolution. Let's say that 20 inches of groove pass under the stylus during the first second. To make the stylus vibrate 15,000 times during that second, the groove must make 750 complete wiggles for each inch. Fifteen thousand cps would not be a frequency with which to start a composition—many members of the audience couldn't hear it. So we might add a 70-cps note, *d*-flat. This appears on the record as a long, slow wiggle that makes only 3½ cycles in the inch. The 750-per-inch high-frequency wiggle is electrically superimposed on the 3½-per-inch low-frequency wiggle (see illustration). Even so, this gives you only two tones, and few passages of music will present less than six at once. The wiggle on the record, as you can imagine, becomes very complex, indeed.

This situation holds for the edge of the record, where the groove whizzes by the stylus at the rate of 20 inches per second on a 33⅓ rpm record and 30 inches per second on a "45." Suppose you move in three inches on the 33⅓ as you play it, to a point where the stylus is only three inches from the center spindle. Here the circumference of the record is only 18 inches, as compared with 36 inches at the outside edge. The record is still turning at the rate of 33⅓ revolutions per minute, and it still takes slightly less than two seconds for the record to make one complete revolution. The length of groove that passes under the stylus during a second has now dropped to 10 inches. Everything is twice as complicated: a 15,000-cps note now requires 1,500 wiggles per inch of groove.

Further complication is involved in the disparity between a groove cut by a

The Mark II, housed in one cabinet, has 4-speed record changer, AM-FM tuner for radio, optional tape recorder

sharp, chisel-shaped instrument and a spherical-tipped playback stylus (it seems sharp when you jab it into your finger, but under a microscope its spherical shape is evident), driven by the turning groove itself. A spherical tip, standing in a V-groove cut by a pointed chisel of the same dimensions, will touch the groove at only two points. Even though the downward push of the stylus is only eight grams, the effective pressure on these two points can amount to many tons per square inch.

This is just the sort of situation that makes problems. Problem one, inescapable and fortunately not terribly serious, is geometric: a chisel-shaped cutting stylus and a hemispherical playback stylus will not trace exactly the same paths over identical grooves. The variation is slight, and the distortion involved is scarcely audible—but this does impose a limit to absolutely perfect reproduction.

On a more practical level, the difference in shape between the cutting stylus and the playback stylus means that the playback stylus is forced higher up in the groove during the rapid whip-arounds of high-frequency wiggles. The pickup which holds the playback stylus, therefore, must be designed to allow this up-and-down motion—to allow it while ignoring it electrically, because all the music is contained in the side-to-side wiggles.

PLAYBACK LOSS

The cutting stylus is driven inflexibly, wherever the electric current says the stylus should go. But a vinylite groove yields a little to the playback stylus, and will not drive it so far or so fast as the motor drove the cutting stylus. Thus, the "level" (the volume) of sound pressed onto the record will be greater than the volume that will actually come off the record when it is played on the phonograph.

As the stylus approaches the center of the record and the wiggles that produce a given frequency become shorter, the playback loss increases—so records are sometimes cut at higher levels near the center. The playback loss is not uniform at all frequencies, however. It is greater in the shorter, high-frequency wiggles. In the

Compact and budget-priced, the Mark VI is a top-opening model mounted on tapered brass legs. It is available in four distinctive finishes

recording process, therefore, the higher frequencies are emphasized (given more than their proportionate level in the music) toward the center of the disc.

SURFACE NOISE

We have a groove turning at the rate of from 20 to 8 or so inches per second, and pressing on that tiny groove at two points is a weight which may be tons per square inch. The result is friction, which translates itself inside the pickup to a high-frequency hiss—surface noise, needle scratch. Surface noise is objectionable chiefly at high-level frequencies—you just don't hear it above the booming bass. This gave the record companies a clue to a method of "masking" this unwanted sound. At the time of recording, they simply make the high-frequency sounds disproportionately loud, thereby drowning out the surface noise—without, however, actually reducing it. Later, during playback, your phonograph must electrically reduce the strength of the high-frequency signals, and *this* process does reduce surface sounds.

Very clever. But here we are in an area in which record companies are taking care of difficulties inherent in the process by asking you to do something positive at home. Your phonograph must be able to reduce the high-frequency sounds by precisely the degree to which the company has artificially increased them in the recording process. We are now talking about "equalization" or "compensation." And a good high-fidelity phonograph is engineered to compensate.

BASS BOOST

Just as it must decrease the intensity of high-frequency sounds, your phonograph must increase the intensity of the low-frequency sounds on the record. This necessity, too, arises from the nature of the phonograph record, which must present sounds both loud and soft.

The cutting stylus is driven in such a way that it moves faster for loud sounds and slower for soft sounds. Now there is no problem about making high-frequency sounds loud, since the stylus must travel pretty fast to whip around 1,000 wiggles in one inch—1/20 to 1/8 of a second. To drive the stylus at the same speed when there are only 50 wiggles in an inch—the number for a low-frequency sound—would require wiggles 20 times as wide from bend to bend. Loud bass notes would thus demand a very wide, rambling groove—and there simply isn't room for this on a phonograph record expected to play for a long time without putting you to the trouble of frequent changing.

To save space on records, the record companies reduce the level of low-frequency sounds as the disc is cut. Once again, your phonograph must compensate for an artificial change in the true sound and, again, a good high-fidelity phonograph is designed to do this.

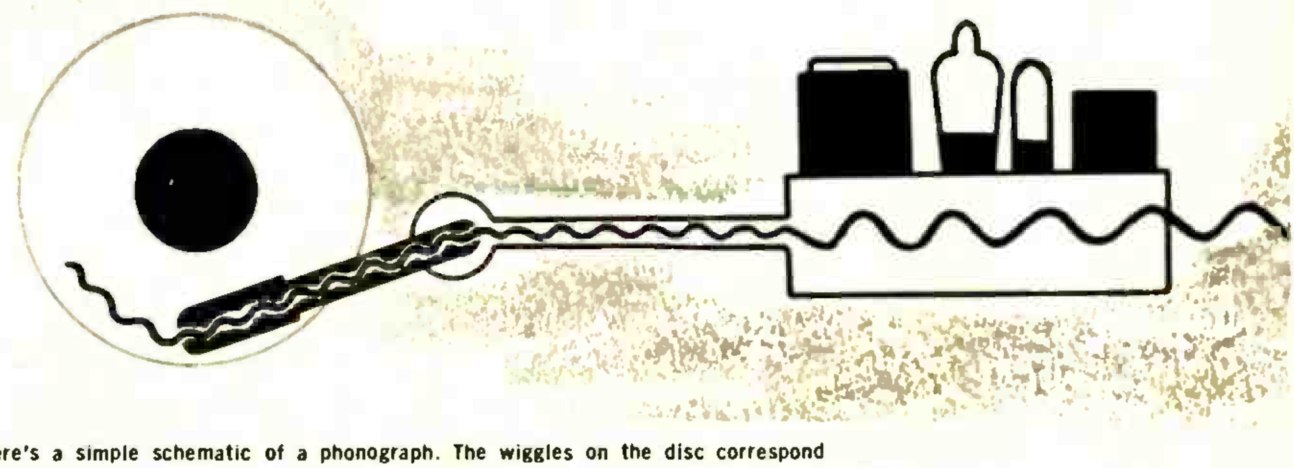
This, then, is the phonograph record—a series of complex wave-form wiggles pressed into vinylite, the high-pitched sounds pre-emphasized all over the disc but especially toward its center, the low-pitched sounds de-emphasized everywhere. The idea now is to play this disc on a phonograph which will reproduce exactly the sounds made in the studio.

The record is a given quantity, a product of skilled engineers and technicians. Their placement of the microphones and the tricks they later played with the tape to improve it are enshrined forever in your record. And this record that you hold in your hands is a technical marvel. If you have a phonograph capable of reproducing precisely the melodies and rhythms in it, you have a definite musical experience ahead of you.

THE PLAYBACK PROCESS

What happens when you play a phonograph record? Essentially, the process is recording in reverse—with a few problems all its own.

A record is placed on a turntable which, quite properly, turns. An arm holds a small cartridge (or pickup) over the turning record. The cartridge holds a stylus which rests in a groove on the record. The wiggles in the groove make the stylus vibrate as the record turns, and the cartridge transforms that vibration into a tiny



Here's a simple schematic of a phonograph. The wiggles on the disc correspond to sound-wave patterns in the air. Pickup produces electrical impulses from the wiggles, amplifier enlarges these signals, loudspeaker transmits the waves electrical signal. This signal is fed into an amplifier, from which it emerges magnified about a million times.

The resulting amplified power is put to work. It is fed into a coil of wire suspended between the poles of a strong permanent magnet. As the current in this coil ebbs and flows it creates a magnetic field of various intensities around the coil. The new and changing field interacts with the fixed field of the permanent magnet to make the coil vibrate. Attached to the coil is a cone or a diaphragm which vibrates with the coil, setting up in the air the waves we call sound.

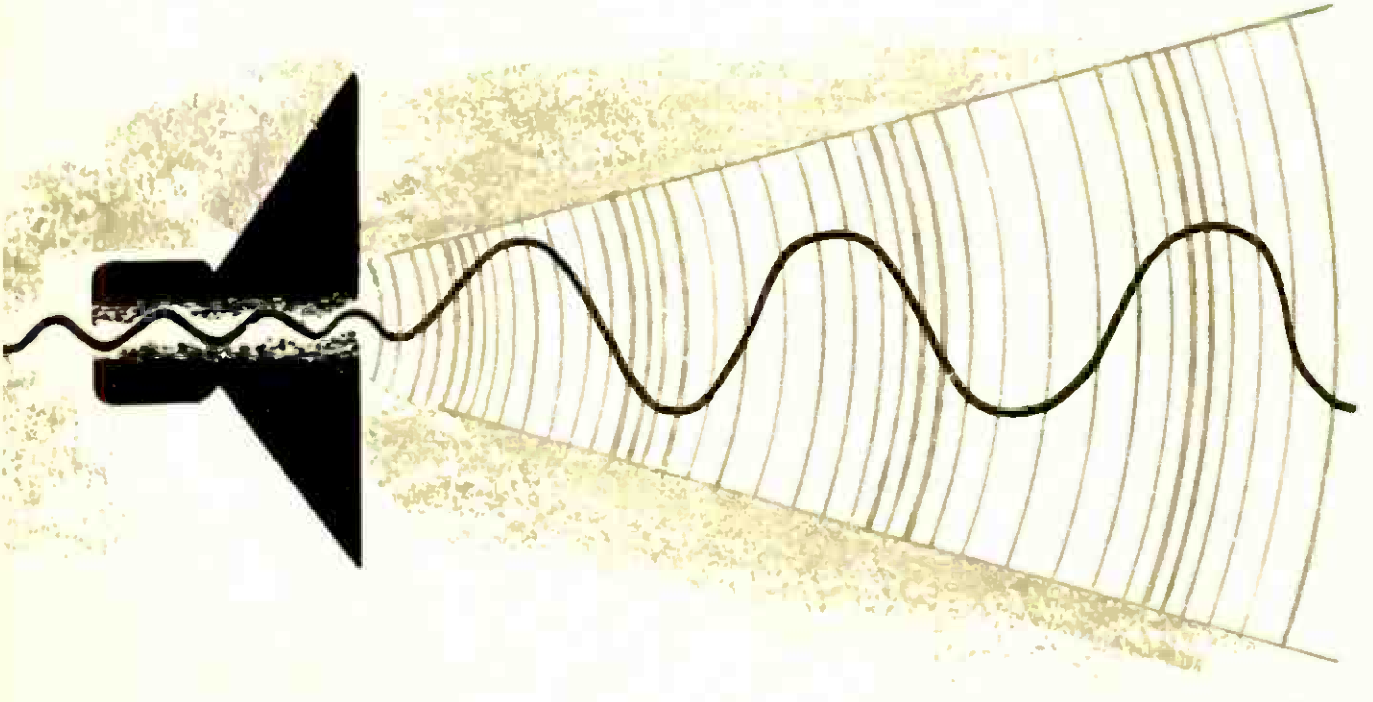
FREQUENCY RANGE

A perfect recording will contain wiggles at frequencies from 20 cps to as high as 20,000 cps. The first problem is that an ordinary non-hi-fi phonograph will not respond at all near the extremes of this range. Some part of the music will be cut off, with the result that the sound is less "live"—you don't hear all the music you should. Yet frequency range *alone* isn't the best test of a phonograph's performance.

FREQUENCY RESPONSE

More important than frequency range is the phonograph's smoothness of response *within* its range. If the record demands sounds of equal intensity at 70 and 9,000 cps, the phonograph should be able to deliver sounds of identical loudness at both frequencies. Suppose a musical sound that is a complex of various frequencies—say 70 cps, 4,000 cps and 9,000 cps—is recorded at an intensity (loudness) of $2x$. On playback, if the phonograph reproduces the 70-cps wiggle at x loudness, the 4,000-cps wiggle at $\frac{1}{2}x$, and the 9,000-cps wiggle at $2x$, the texture of the music will be distorted.

The "smoothness" of response is a primary requirement for a phonograph that is also a musical instrument. If the "response curve" is jagged—too loud at certain frequencies and too weak at others—the music you hear is far from that which was put on the record. The "peaks" in the curve—the places where the phonograph responds too loudly—are far more important than the dips in the curve, because the



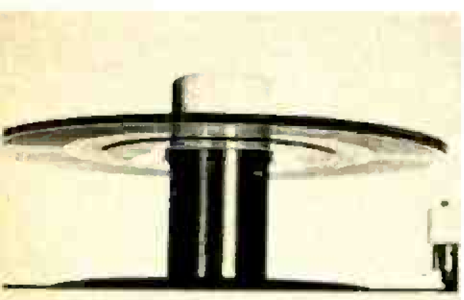
THE FABULOUS "45"

... the world's most popular, most trouble-free, most economical way to enjoy every kind of music

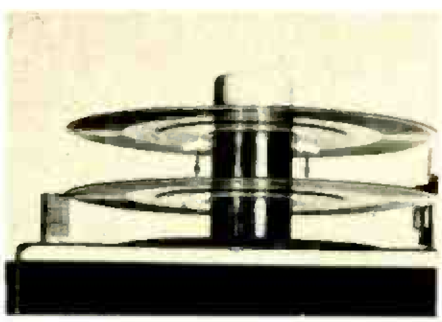
EASY TO LOAD. You'll find it hard to believe that even a youngster can stack up to 14 "45" records at a clip

EASIEST TO OPERATE. It starts at the touch of a button—no arm to hold back, nothing to set, no levers, no complications

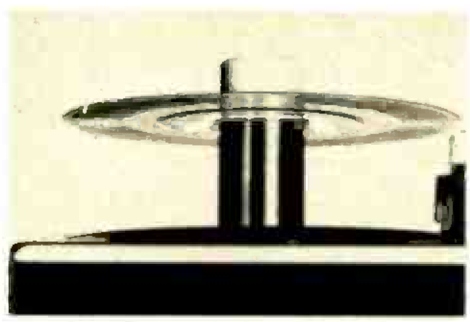
EASIEST TO STORE. You can store almost 150 "45s" in just one foot of shelf space—one-half the area required by old-style records



1. HERE'S HOW THE "45" WORKS. Supports (arrows) project slightly from the spindle head to hold stack of records firmly



2. ONLY BOTTOM RECORD DROPS. These supports retract into the spindle (white arrows) and bottom record floats gently to turntable



3. SPECIAL BLADES HOLD THE STACK. As record changes, blades hold stack (arrows). Blades retract, supports again hold stack after changing

RCA VICTOR OFFERS ONLY HI-FI MULTI-SPEAKER 45 "VICTROLA"

Newest addition to RCA Victor's family of high-fidelity instruments is the budget-priced Mark VIII, shown at left in mahogany, and also available in maple and light rift oak. Its record changer plays up to 14 records—nearly two hours of music at one touch of a button. It takes the popular 45-rpm record and has a frequency range comparable to many high-priced consoles ear often will not miss inaudible sounds, but it can't ignore sounds that batter it violently.

Added sounds crop up all over the instrument. Hi-fi phonographs operate on AC current, which oscillates at the rate of 60 cycles per second: *b*-flat. AC current is fed into most hi-fi rigs at three places—the turntable motor, the preamplifier and the power amplifier. Thus the chances of picking up some added strength at 60 cps are just dandy. This particular added sound is a hum. low but insistent. Hum does not give a key coloration to music. even though it does sound at *b*-flat. It is just a big nuisance. Keeping it out of a good phonograph requires shielding, precision parts—and, above all, good engineering.

HARMONIC DISTORTION

Also annoying is "harmonic distortion," the tendency of a phonograph to add new harmonics to the music being played. Of course, harmonics are musical sounds—but musical or not, they weren't part of the composer's plan when he wrote those notes. Nor does a violin, for instance. sound like a violin when a phonograph adds harmonics that a violin doesn't ordinarily produce. Perfect reproduction—which is what audio engineers are continually striving for—requires the elimination, so far as possible, of these unwanted and out-of-place harmonics.

INTERMOOULATION OISTORTION

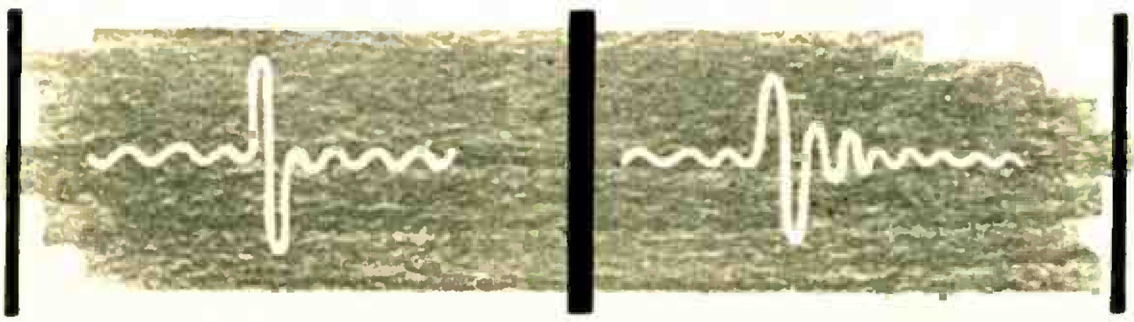
When two musical tones are sounded together, they produce a third tone—a resultant tone—different from either. This is fine. The accurate calculation of resultant tones is one of the arts of musical composition. It is quite possible. however, for a phonograph to alter the relationship between two simultaneous tones in such a way that a "sum" or a "difference" tone is produced—a tone that is harsh. unresonant and unmusical.

This phenomenon is known as "intermodulation distortion." An example: A stylus is being driven in a wide arc to produce a loud 100-cycle tone. Superimposed on this wide arc is the tiny wiggle of a 10,000-cycle tone. The vigorous push of the 100-cycle tone may distort the shape of the 10,000-cycle wiggle, mechanically or electrically, and the result will not be pleasing.

TRANSIENT TROUBLES

A different kind of trouble arises if one of the components of your phonograph is unable to snap into action and snap out of it. Music is a series of transient phenomena—a note lasting a full second is a sustained note indeed. Individual tones are constantly stopping short. and new tones are constantly starting up—and they're usually at their loudest in the instant they begin. To reproduce music successfully, a phonograph must be highly accurate in its "transient response." A slow start on new notes, and especially a ringing on of old notes. will muddy the texture of a musical passage. making all the instruments indistinct.

The phonograph is dependent, however, on physical vibrations at the beginning and end of its work—the motion of the stylus in the groove, and the motion of the cone or diaphragm in the loudspeaker. All physical quantities that move are subject to the laws of inertia: the stylus and the speaker both want to keep vibrating at whatever frequency is presently in the works. "Damping" these vibrations at the proper moment, and starting new ones instantaneously at the proper intensity, are problems that still bedevil the designers of audio equipment.



At left is correct transient response: a drumbeat fading rapidly. At right is incorrect transient response: a hanging-on of the sound produced by the phonograph itself

RESONANCE

These problems come under the general class name of "resonance," and among them they account for most of the difficulties that crop up under each of the separate definitions. Every physical object has its own "fundamental resonance"—that is, the frequency of waves that will start it vibrating all by itself. The most popular example is the water glass and the tenor who shatters it with his high *c*, fortissimo.

Mechanical resonance is a basic problem with loudspeakers and their enclosures, and it can also crop up in the beam that holds a stylus, in the pickup cartridges and in the tone arms. In addition, two objects in contact and moving together may resonate against each other—the stylus against the vinylite groove and against its own spring or other damping mechanism, the pickup cartridge against the tone arm, the tone arm against its mounting.

None of these is a serious noise producer in itself—you could put your ear right on a tone arm and not hear it resonate—but the amplification of signals from a pickup runs into the order of millions, and resonances in this part of the phonograph may show up in the frequency-response charts. Designing equipment in such a way that these resonances will occur outside the range of audible frequencies, or be damped if they occur within hearing range, is a major engineering problem adequately solved by designers of good high-fidelity equipment.

MISMATCHED COMPONENTS

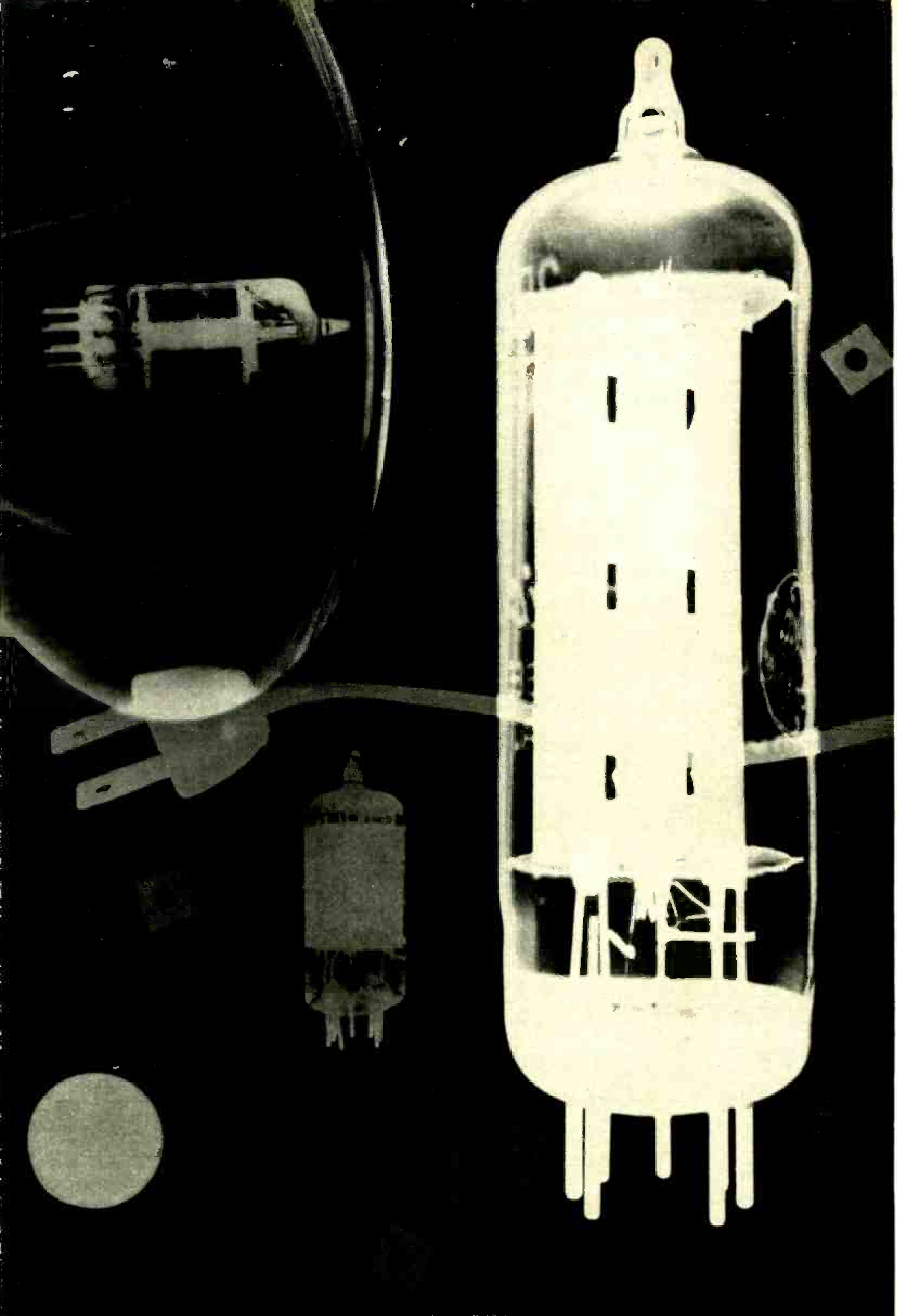
Hum, poor frequency response and distortions of all kinds may arise when audio components of vastly different quality are hooked together in a single system

—or even when all components are of high quality but simply weren't made to work together as a team. Engineers know the importance of matching their hi-fi components, and enthusiastic amateurs who embark joyously on the task of assembling their own hi-fi sets soon find it out.

You can, if you have some technical knowledge and are clever with your hands, buy components separately and build your own hi-fi rig. But for someone without these qualifications, it's a lot of work, with the possibility of less pleasure and more cost in the end than you'd find with a set designed and put together by trained technicians.

Whether you build your own set or purchase one complete and ready to enjoy, you will want to know the functions of its various parts. They are described in detail in the following chapter.

The RCA Victor 4-speed Mark IV incorporates maximum flexibility of operation with minimum complexity. Record storage space inside cabinet is attractive feature of its modern design



CHAPTER **3**

WHAT MAKES UP A HI-FI SET

It takes precision parts, properly matched, to produce high-fidelity sound. From stylus to speaker, here's a rundown on the components and what they do

The work of a phonograph—any phonograph—breaks naturally into three equally important divisions: getting electrical signals off the disc, amplifying the signals and turning them into sound. High-fidelity phonographs are simply those which accomplish this work with the greatest faithfulness to the original sounds sung or played by the artists in the recording studio. The components of the hi-fi set are finely made, carefully selected and matched to perform with precision the chain of processes which produces music from a flat pancake of vinylite or shellac.

THE TURNTABLE

What we want from a turntable sounds simple, but it isn't. In the first place, it must be able to revolve at different speeds—78.26 rpm for old-fashioned standard shellac records, 45 rpm for the convenient seven-inch "45s" with the big center holes, and 33⅓ rpm for long-playing discs. The speed must be exact in every case to reproduce the record properly, because the record was cut to be played at just exactly this speed. If the turntable is slow, the pitch drops; if the turntable is fast, the pitch rises.

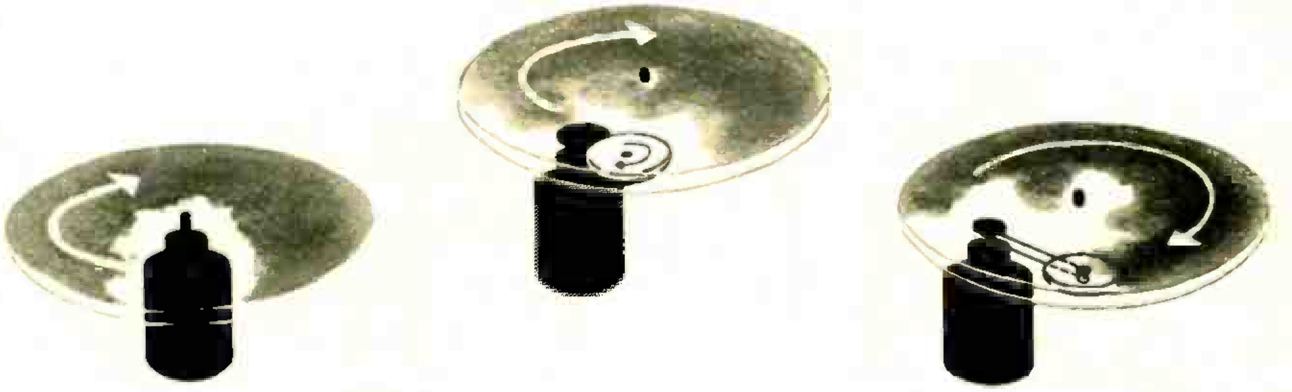
Moreover, the speed must be exact at every instant of playing. A turntable that alternately slows down and speeds up will ruin musical enjoyment even though its average in each rotation is an exact 78.26, 45 or 33⅓ rpm. The phenomenon produced is called "wow," a very expressive word denoting the alternating rise and fall of musical pitch which results from fluctuations in turntable speed. When these fluctuations are rapid, the term is "flutter."

DRIVING THE TURNTABLE

Getting the constant speed of your motor up to the turntable (in three different speeds—33⅓, 45 and 78 rpm) takes considerable ingenuity. Some designers have solved the problem by means of a "rim drive"; that is, the final agent is a rubber drive wheel which locks into position between the motor's axle spindle and the inside rim of the turntable. This is the most common way of making a turntable spin. The spindle, the upward-protruding end of the motor shaft, may be cut in steps to three different diameters, the smallest uppermost. When the wheel locks against the part of the shaft with the greatest diameter, the turntable spins most swiftly—at 78 rpm. The middle diameter gives 45 rpm, the smallest 33⅓. Or there may be a turret arrangement of three different-sized intermediate idler wheels, any one of which can be applied to the drive shaft by means of a lever.

On some sets, a belt is used, fitting directly onto the drive shaft at one of the three diameters, and then fitting around the circumference of the turntable. Still another method applies an idler wheel to the outer rim of the turntable.

There are arguments for and against each of these methods. The one using the belt gets the motor farthest from the turntable and the pickup, thus minimizing the

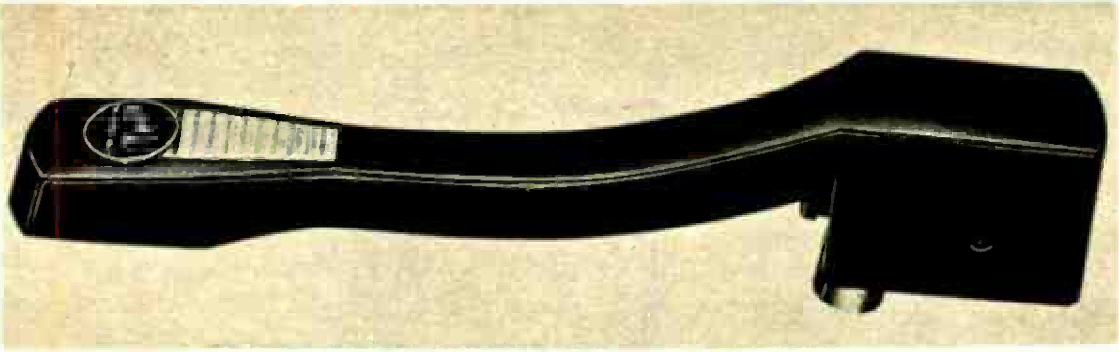


Three common ways of converting power from the motor into an even, far slower speed on a turntable. Left: Direct drive—motor hooked into the center of turntable. Center and right: Rim drive—an idler wheel locks against turntable's inner rim. At center, power comes to idler wheel by friction; at right, by a pulley

noise and vibration from the motor. But, for the same reason, this system is the bulkiest and the ugliest, and it requires the most elaborate mounting. Rim drive is more compact, and therefore more satisfactory for most people. It is also the easiest to repair if anything goes wrong.

TONE ARMS

A turntable does not become a record player until you add a tone arm. You will recall that the cutting stylus rides across the record on a bar from circumference to



RCA Victor tone arm is counterbalanced
to rest lightly on record surface. Some Mark models have
ceramic pickups, others the magnetic type

spindle, following a true radial path always at right angles to the line of motion of the groove. For accurate reproduction, the playback cartridge, too, should always point straight down the groove, so to speak. But we hold the playback stylus in a tone arm, which pivots to make a curved rather than a straight track across the record. In an incorrectly designed tone arm, the playback stylus will sometimes be off as much as 10 or 15 degrees. This is known, ominously, as "tracking error."

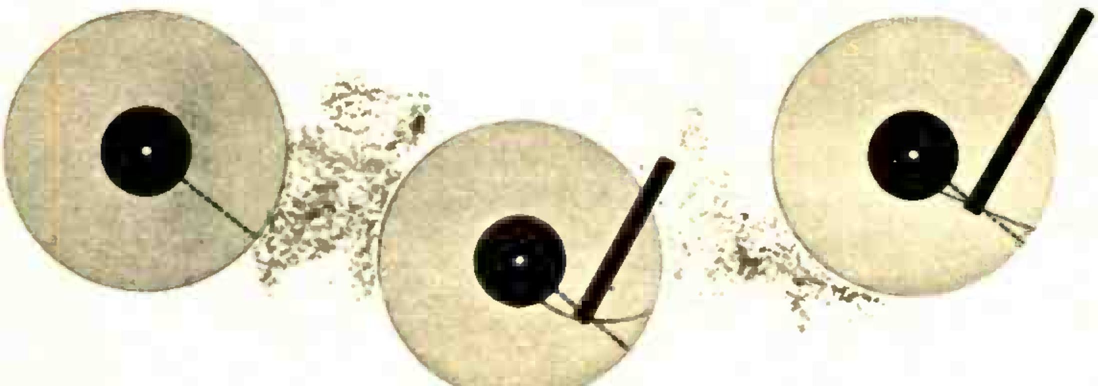
In the old days, before the deep thinkers got at this business, the solution to tracking error was simply to make the arm longer. A short arm tracks a small circle, presenting a more steeply curved arc as it crosses the record; a long arm makes a shallow arc with a closer resemblance to the desired straight line. Then it was discovered that curving the head of a fairly short arm, by the correct degree, would substantially reduce the average tracking error over the course of a whole record. (Angling the pickup in a straight arm gives the same geometric effect.)

The vertical pressure of the playback stylus on the record is a key factor in both stylus and record wear, and various tone arms employ various methods to get the right "tracking weight."

RECORD CHANGERS

Some hi-fi enthusiasts will have no dealings with a record changer, claiming that because it requires a turntable motor to do an extra job—that of lifting and dropping the records—the motor will do its basic job of spinning the turntable less efficiently. While it is probably true that manual players are easier to design, a

Here's what causes tracking error. At left, cutting stylus, having traveled across record on a bar, has made straight line. Center, short tone arm traces a wide arc, holding stylus at wrong angle to groove. Longer arm improves arc



Four-speed record changer—in the new Mark line of "Victrolas" is powered by high-fidelity turntable motor, has muting switch to eliminate noise during record changing

modern, well-designed record changer performs in a fully satisfactory manner. For you, the convenience of a changer may well outweigh the drawbacks which caused another hi-fi owner to decide against it.

Most people have favorite records, old or new, both 45 and 33⅓ rpm, and the convenience of a record changer should be obvious. Those who choose only long-playing records may sacrifice the convenience of a changer for single play.

PICKUPS

A phonograph pickup is considerably smaller than a man's pocket watch and must he machined to exacting standards of tolerance. The best your amplifier and loudspeaker can do is give you exactly what comes out of your pickup.

The pickup must hold the stylus tightly enough to make it stay in the groove even when it is jolted hard hy a strong low frequency signal. At the same time, it must let the stylus swing freely within the groove. When there's a pause in the groove's modulations, the stylus must spring back firmly to dead center, without any extraneous vibrations. At the same time, it must comply effortlessly with the correct vibrations when the music begins again.

The three basic types of pickups in use today are the crystal and ceramic, the magnetic and the capacity. The crystal and ceramic pickups are most widely used.

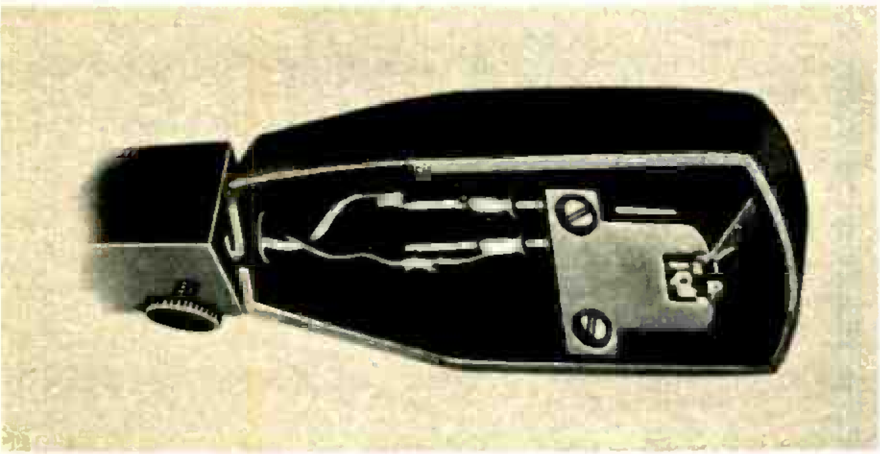
THE CRYSTAL PICKUP

Crystal and ceramic (synthetic crystalline material) pickups operate on a principle discovered by an Italian scientist named Piezo. His experiments showed that a crystal made of Rochelle salts would give off an electric signal when made to bend. In piezo-electric pickups the head of the stylus (or, more commonly, a lever attached to the head of the stylus) is inserted into the crystal or ceramic. The side-to-side motion of the stylus bends the crystal, and the result is a fairly sizable electric signal which, after amplification, can be translated into sound in the loudspeaker system.

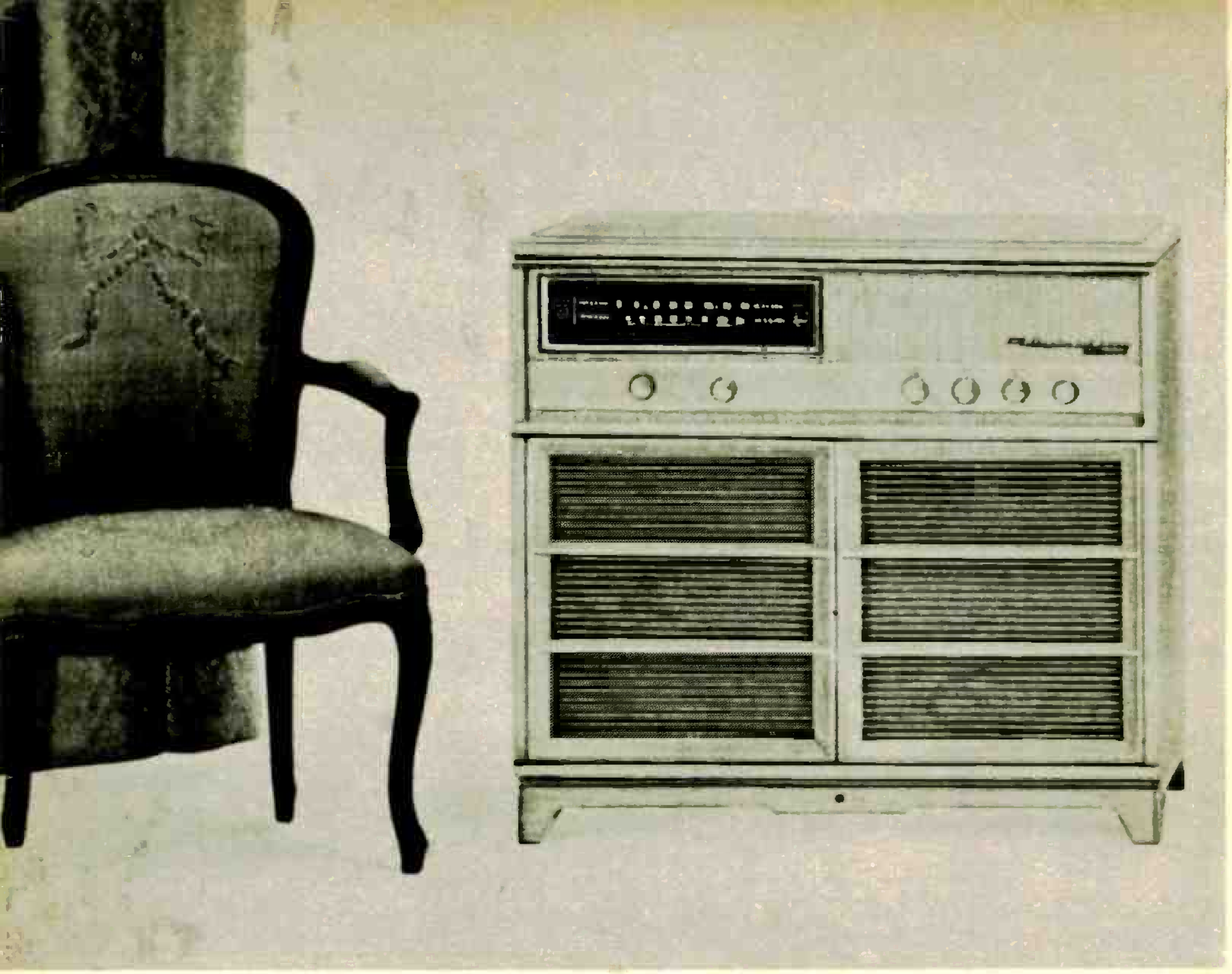
THE MAGNETIC PICKUP

Magnetic pickups are available in a number of different designs. A typical one has the stylus set in the end of a cantilever spring connected at its other end to a small permanent magnet. The stylus end vibrates between two iron pole pieces which extend up into the pickup chassis and form the cores of two small copper-wire coils. The pole pieces are yoked together at the top, near the permanent magnet. This creates a complete magnetic circuit—magnet through stylus bar to pole pieces and back to magnet. As the stylus vibrates, it feeds this magnetic-flux circuit alternately through the two pole pieces, inducing an electric voltage in the copper-wire coils. This induced voltage is led off to the preamplifier and the amplifier and then emerges from the loudspeaker as musical sound.

Another type of magnetic pickup has the stylus directly attached to a light steel tube, and there are no other moving parts. Around the tube is positioned a coil of wire, and the works sits within a magnetic field. The side-to-side motions of the tube, corresponding to the recorded wiggles, change the patterns of the magnetic



Moving-coil magnetic pickup is often chosen for high-fidelity phonographs, even though it produces a smaller voltage than the ceramic, because it lends itself to the design of high-quality pickups which incorporate transistor circuits

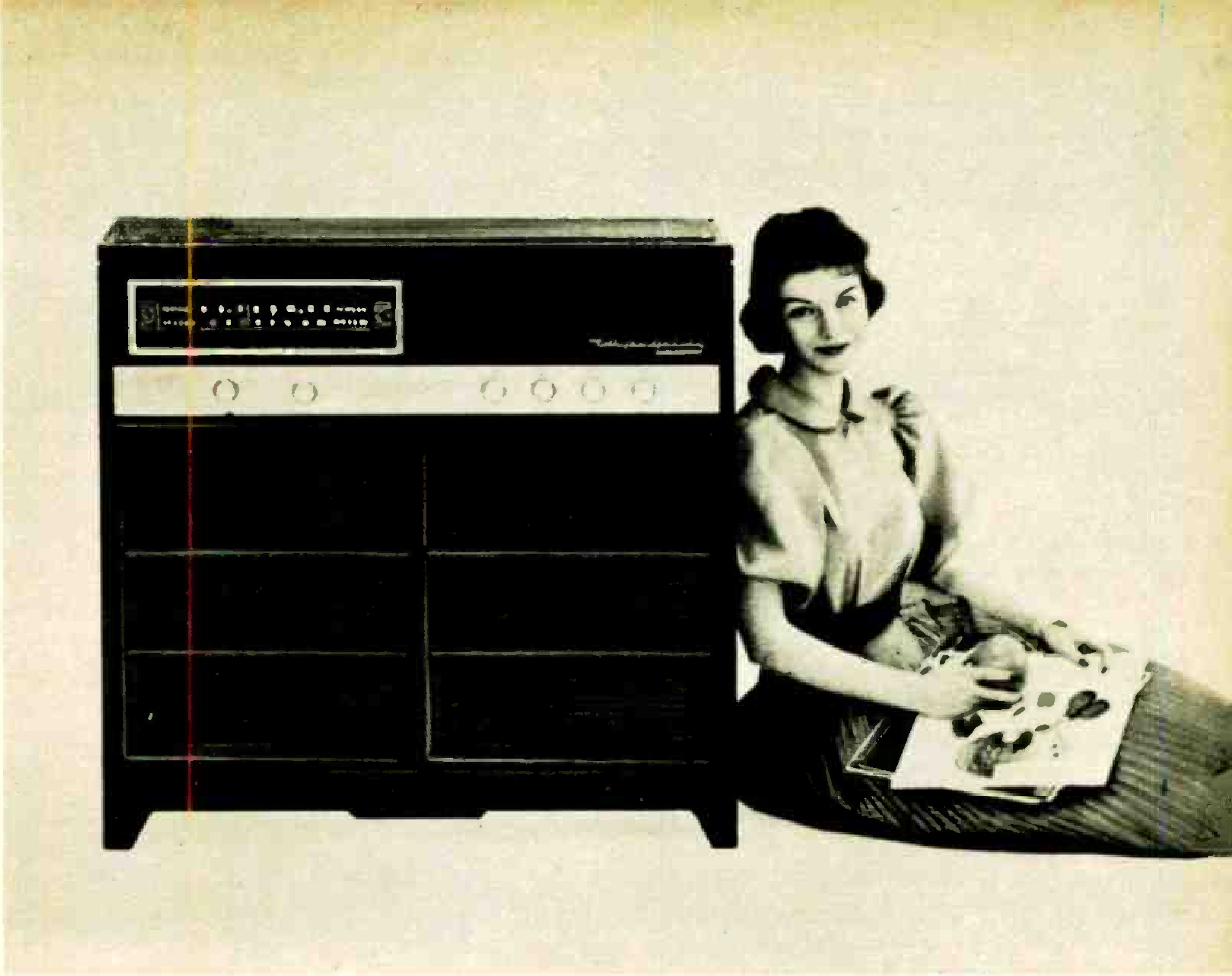


lines of force—and the wire coil puts out a relatively small voltage. Unwanted vibrations are minimized by damping materials.

In another form of magnetic pickup, often known as a "dynamic" pickup, a wire coil, set between the pole pieces of a magnet, is moved within the magnetic field by the action of the stylus. This system lends itself well to the practical design of a good high-quality pickup.

THE CAPACITY PICKUP

The third type of pickup, the capacity, consists of a fixed metal plate, onto which is fed a very rapidly oscillating charge, and a movable plate which in rest position stands parallel to its neighbor, a tiny air gap away. The floating plate is attached to the stylus. As the stylus traces the wiggles in the groove of a spinning record, it causes the moving plate to flutter toward and away from the charged plate. As the air gap expands and contracts, the oscillating current is modulated by the frequency of the vibration of the stylus.



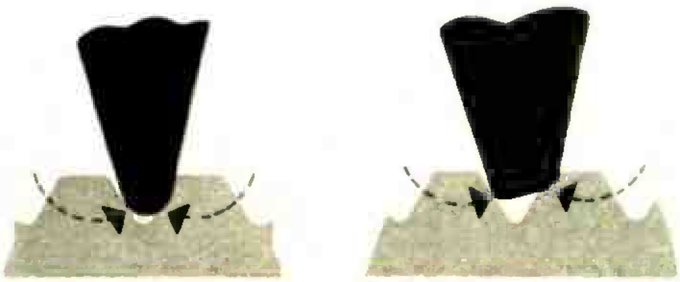
The Mark III uses a turnover, improved ceramic pickup. Styli are two synthetic sapphires, system of three loudspeakers is angled for full dispersion of sound. Available in finishes of mahogany, maple and light rift oak

The theoretical advantages of the capacity pickup are great: it can be made to track at very low pressures and therefore wears both records and styli much more slowly than either of the other two types. But, in most households, all this is balanced by an overwhelming disadvantage: it is very fragile, suitable only for bachelors or people with unnaturally good control over children.

Returning to our discussion of crystal and magnetic pickups, let it be said that neither is necessarily superior to the other. The crystal and ceramic pickups give off a much larger voltage than the magnetic, which means they can be used without a preamplifier. They are also entirely free from magnetic hum. High temperatures and humidity sometimes cause variations and deterioration in crystal pickups but do not affect the ceramic type. Properly designed into a high-fidelity system, crystal or ceramic pickups provide outstanding results.

The situation is a little different when it comes to magnetic pickups. There have been many good designs available for several years, ones designed primarily for high-fidelity work. Also, a satisfactory magnetic pickup is easier to design than a satisfactory crystal or ceramic. The stylus in a magnetic pickup need push only a light coil of wire or an equally light metal tube, while the stylus in the crystal pickup must bend a crystal. In every pickup, the stylus moves at the same speed. If it is to do more work, it must have greater mass.

We don't want to confuse you with this crystal and ceramic vs. magnetic pickup discussion. The point for you to remember is that any one, if well designed and, above all, if used with the right components, will give satisfactory performance.



New stylus rides on only two points at its rounded tip. Flats wear on the two points, and a badly worn stylus will not track properly, resulting in distortion and record wear. Drawing is exaggerated

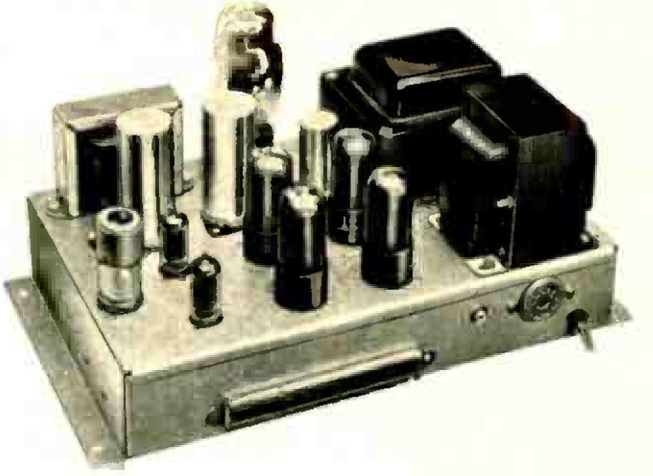
STYLI

The old-fashioned phonograph needle has come a long way. Its modern name, stylus, is the least of the changes that time has brought to it.

Styli are made with tips of osmium, sapphire (synthetic or natural) or diamond. Assuming that the shape of the stylus is initially correct, the most important aspect of its quality is the ability of the tip to maintain its shape. Osmium, because it is the softest of the three, lasts only a short time—long enough to play a probable maximum of 10 LP records without undue wear. Of course, osmium needles are also the cheapest, but because of their relatively short life they are rarely used in high-fidelity phonographs.

Either synthetic or natural sapphires are somewhat more expensive and considerably more satisfactory; and diamond styli—more expensive yet—show the least wear with time. A word of caution, however, about diamond styli, for all are not necessarily of high quality. Diamond, an extremely hard material, is correspondingly difficult to shape and grind to a smooth finish. Although satisfactorily ground diamond styli are available, the best of them may not be as smooth as the sapphire versions made by the same companies. In short, although diamond styli, when well made, are unquestionably longer lived, sapphires are capable of giving completely satisfactory performance and are by far the most generally used.

Whether you prefer a diamond or a sapphire, don't cut corners on the cost for that particular type of stylus. When you buy a stylus you do not buy just a tip, but



The amplifier accurately steps up relatively small voltage of signals from pickup, makes them strong enough to activate the loudspeaker

a complete assembly which is a vital part of your pickup. It doesn't pay to save two dollars on a stylus and distort the performance of the entire machine.

AMPLIFIERS

The turntable, tone arm and pickup with stylus have performed the first step in getting the music out of your phonograph record—they have taken the electric impulse out of the record's wiggles. Now that impulse has to be made strong enough to be of some use. If the tiny signal in the pickup were converted directly into sound, nobody would hear it. Hence the amplifier, which is an electronic device for magnifying and controlling electric signals.

HOW MUCH WATTAGE?

Almost any amplifier will deliver huge jolts of signal strength to a loudspeaker, if called on to exert itself. But the result may sound terrible. All the designing of an amplifier, all the rigging together of tubes and resistors and condensers, is done with a certain maximum power output in mind. An amplifier rated at 10 watts will pour out more power to meet a peak in the music, but the increased output may arrive with high distortion, and what you will hear is a shattering blast of noise.

The power output capabilities of amplifiers receive a considerable share of attention from those interested in high fidelity. A huge variety of rated outputs appear on the market, and it is sometimes difficult to determine one's needs. However, it is evident that the high-power units will be satisfactory under almost all conditions, but considerations of economy and actual power required indicate the usefulness of the lower-powered instruments. The mere consideration of amplifier output power is not the entire story. Closely tied in is the efficiency of the loudspeaker system, and proper evaluation must concern the entire system rather than a figure referenced to only one part. It is the undistorted acoustic output which is of prime importance, and even the lower-powered amplifiers can be matched into a system which is completely satisfactory to the listener.

HOW AN AMPLIFIER WORKS

The essential part of an amplifier is the vacuum tube. In its simple form this tube consists of a negative and a positive pole with a grid in between. When the negative pole is heated, electrons are thermally shaken loose and flow through the interstices of the grid to the positive pole—assuming that the grid is neutral. A very small voltage fed into the grid can control the flow of electrons, frustrating their flight or drawing them across in greater quantities. This description is cruder than the process really is, but it isn't inaccurate.

Now, there is a limit to the size of the current (the volume of electrons jumping the vacuum gap) that can be controlled by a small voltage on the grid. You cannot simply feed in the tiny signal from a phonograph pickup (or radio tuner or tape machine) and ask one tube to put out a replica of that signal powerful enough to run a loudspeaker. The process must be carried forward gradually, in several stages. Most modern vacuum tubes are designed to give a very high ratio of output to input voltage, permitting a considerable gain in voltage at each stage—with, of course, a proportionate risk of distortion. Others will put out a lesser multiple of the signal voltage on the grid. The output from each stage of amplification consists of a high-voltage DC current with an audio-frequency wiggle up top. The DC is eliminated by a condenser and the audio-frequency wiggle is passed on to the grid of the next tube.

In the final or output stage of the amplifier, "beam power" two-grid tubes are now almost universally used. Their high efficiency in conjunction with modern circuitry makes practical low distortion at reasonable cost. These output tubes feed power to the loudspeaker, but cannot be connected directly, since their impedance is very high compared with that of a speaker. Therefore, it is necessary to match these components by inserting an "output transformer" between them.

THE OUTPUT TRANSFORMER

The transformer is basically made up of three parts—a high-impedance coil of wire, a heavy piece of iron and a low-impedance coil of wire. The current goes through the first coil, and its alternations induce a matching magnetic fluctuation in the iron. This magnetic fluctuation induces the identical current in the low-impedance coil, which feeds the speaker. It is important that all the fluctuating current from the output tube go into that final wire—as little as possible should be wasted in heat. To handle high power, an output transformer must have lots of wire and a heavy iron core, for if more current is sent through than can easily be transferred, the transformer will heat up, waste power and (most important) distort the relative strength of the signal at different frequencies.

Amplifiers are designed so that the current that emerges from the output transformer will be, as closely as possible, an exact enlargement of the current fed in from the phonograph pickup.

PREAMPLIFIERS

Phonograph amplifiers are generally divided into two parts: the power amplifier and the preamplifier. The power amplifier contains the output and other associated tubes, the output transformer, and generally a power supply .The preamplifier contains all other tubes, controls, input jacks, etc., and may or may not be built on the same chassis as the power amplifier. The complexity of a preamplifier is determined by the functions it is to perform. For instance, one used with a magnetic

RCA Victor's Mark IIID is a complete home high-fidelity entertainment center. It has 4-speed record changer on roll-out drawer, AM-FM radio and tape recorder conveniently under lift lid

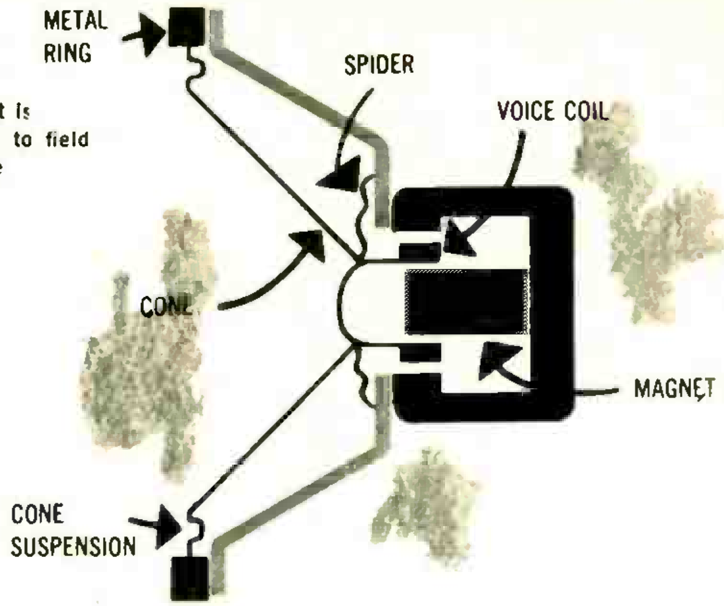
pickup requires more amplification and, therefore, more tubes than one used with a crystal or ceramic pickup, because magnetic pickups generate less voltage.

LOUDSPEAKERS

Now we're ready to listen to the music. The electric signal has been picked up from the record and amplified and fed into a loudspeaker, which will transform it into sound.

There are several basic loudspeaker designs, but only two are significant today. These are the electrostatic and the magnetic, or moving-coil, systems. The electrostatics are just coming into high-fidelity use and are not yet commercially significant, which leaves, for all practical purposes, the magnetic speaker.

The magnetic loudspeaker: Fluctuating current is fed to voice coil which oscillates in reaction to field of magnet. This oscillation drives paper cone



In the old days magnetic or moving-coil speakers involved an electromagnet, with high-voltage lines arriving at the speaker together with the low-voltage signal wires from the amplifier. Modern speakers, however, use a strong permanent magnet. This magnet and a coil of wire, called a "voice coil," form the heart of every magnetic speaker. A fluctuating electric current is fed through the coil, and sets up an electromagnetic field around the coil. The interaction of this electrically induced field with the permanent field of the magnet pulls the coil to and fro, just as the stroke of the bow sets the violin string to vibrating. A voice coil oscillating in the air, however, would make very little sound—no more, in fact, than a violin string vibrating alone in space. The violin string agitates the air in the violin sound box to set up the full and characteristic sound of the instrument. The voice coil, in the most common sort of loudspeaker, drives the narrow end of a paper cone which is held relatively stationary at the wide end. The cone, in critic Edward Tatnall Canby's fine phrase, "grabs the air" to set up strong sound waves.

THE MAGNET

Almost every modern magnetic loudspeaker uses an Alnico V permanent magnet. Alnico V is an alloy of *al*uminum, *ni*ckel and *co*balt with steel, which can be magnetized easily and powerfully. The larger the magnet, the stronger will be the lines of force around it. Top-quality high-fidelity loudspeakers may have magnets as heavy as 11 pounds. Cheaper, smaller speakers may have magnets as light as one ounce. If the air gap around the voice coil between the poles of the magnet remains the same size, an increase in the size of the magnet will give greater control over the vibrations of the voice coil.

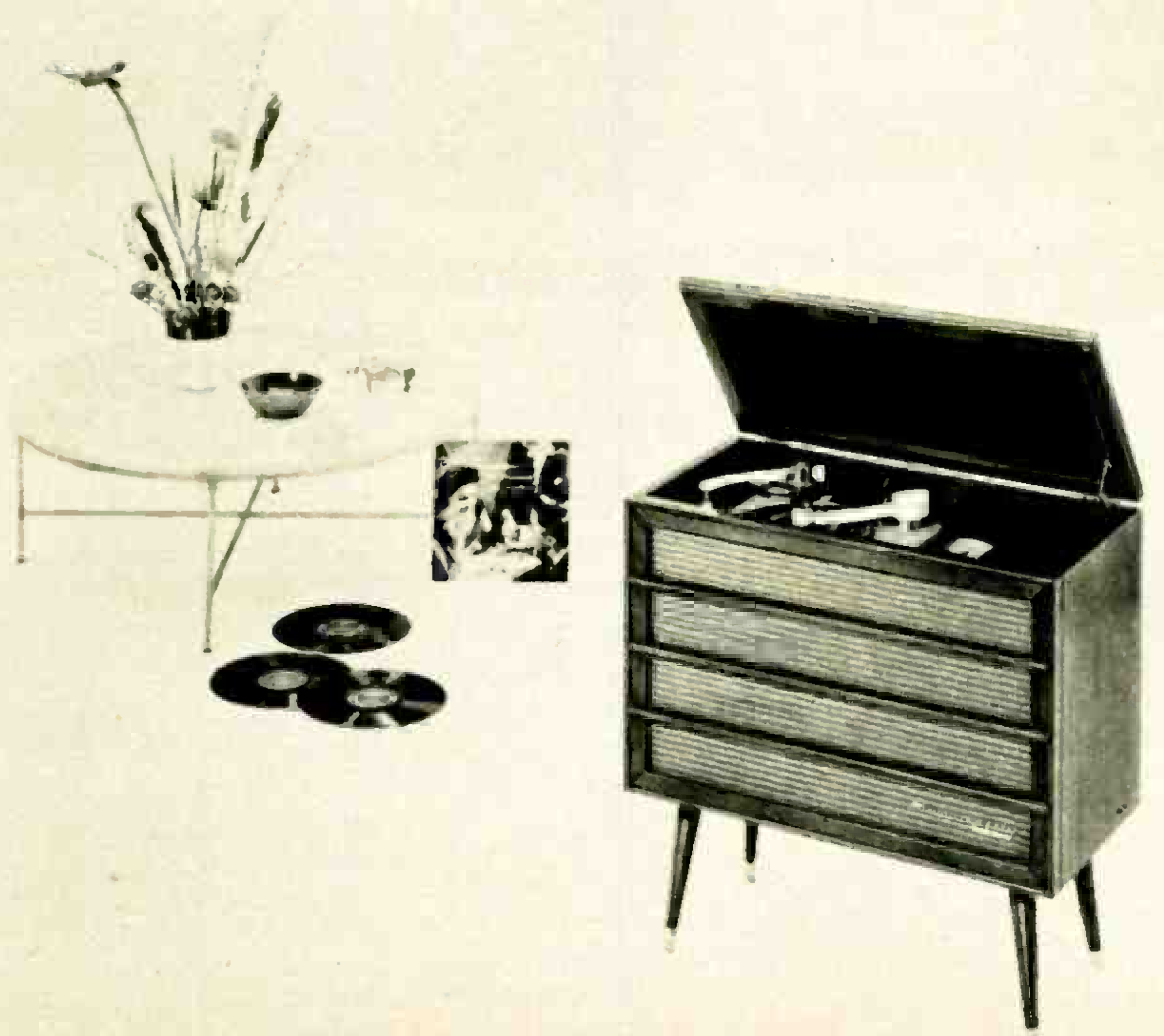
THE CONE

The composition and the size of the cone are fundamental to a speaker's efficiency and accuracy. Most cones are made from a chemical pulp which includes wood, textiles and also paper in various quantities. The cone must be stiff enough to move as a unit when the voice coil pushes it—a really soft cone would simply ripple toward its edge. At the same time, a taut cone, like a taut fiddle string, will have a fundamental resonance, a frequency at which it will vibrate by itself with no driving force other than a sound wave. This is fine with a fiddle string, which is supposed to sound *g* when stroked, but a speaker is supposed to be able to sound any note. The softer the composition of the cone, the lower the fundamental resonance. For this reason, speaker manufacturers make the cones as soft as they possibly can be—and still work effectively.

"WOOFER" vs. "TWEETER"

When the violinist wants to play an *a* on the *g*-string, he shortens the string by pressing it down with his finger. All other things being equal, a short object will vibrate more quickly (at a greater frequency) than a long object. Although speakers are measured according to the diameter of the cone at its open end, not by the length of the walls of the cone, a 15-inch speaker (or "woofer") will have much

The Mark IV, in space-saving cabinet, still has the full Panoramic Speaker System of larger models. Pickup is a turnover ceramic unit with twin synthetic-sapphire styli



The large "woofer" in a loudspeaker system has long walls, therefore is most efficient reproducing sounds at low frequencies

"Tweeter," shown with directional plastic cone used in RCA Victor sets, creates high-frequency sounds

longer walls than a 3½-inch speaker (or "tweeter"). Its fundamental resonance will tend to be lower, its bass response more accurate.

The tautness of a vibrating object will also help determine its speed of vibration; thus the violinist winds the string to just the right point to tune it correctly. In the same way, the paper cone of a loudspeaker cannot be allowed to flap around loose at its open end. It must be held, more or less tautly, by a metal ring.

At 100 cycles per second the relatively soft 15-inch cone will vibrate as a unit, pulsing in and out over its entire area. At some point between 2,000 and 3,000 cps, however, the big cone will find that matters have got out of hand. The effect of the last movement of the voice coil does not reach the edge of the cone before the next movement begins. Instead of driving the speaker, the voice coil merely agitates it—"flaps" it.

Usually, the inside of the cone—the part nearest the vibrating voice coil—will continue to pulse properly at the higher frequencies, while the edges simply quit. The cone's function is to grab the air, and the more air the cone grabs, the louder the sound. A 15-inch speaker will grab far more air at 100 cps than at 10,000 cps, because friction in the particles of paper at high frequencies tends to attenuate the sound waves. Asked to reproduce the entire range, this 15-inch speaker will sound boomy, accented toward the bass—we say that the treble response falls off. Generally speaking, although size is not the only criterion of frequency response, the smaller the speaker, the smaller the problem it has in reproducing higher frequencies.

Various devices are used to improve the treble response of a large speaker. The center section of the cone may be stiffened, or backed with a thin plastic coating, to improve efficiency at high frequencies. In some speakers a metal diaphragm is inserted, three inches or so from the voice coil, for relatively separate reproduction at the treble range.

Because large speakers are best at low frequencies and small speakers best at high frequencies, audio engineers designed a device consisting of two or more speakers instead of one: a large woofer for the low and low-middle frequencies, and small tweeters for the high-middle and high frequencies. The output signal from the amplifier is divided by a crossover network, so that only the higher-frequency impulses go to the tweeters.

In general, low frequencies are nondirectional; that is, they do not confine themselves to a narrow beam. Very high frequencies are directional, and provisions must be made for adequate distribution. This is most often done by placing several high-frequency reproducers in the system at various angles to give uniform distribution of these sounds throughout the room. The little speaker may be mounted concentrically inside the big speaker, or it may be mounted just off the axis of the big one.

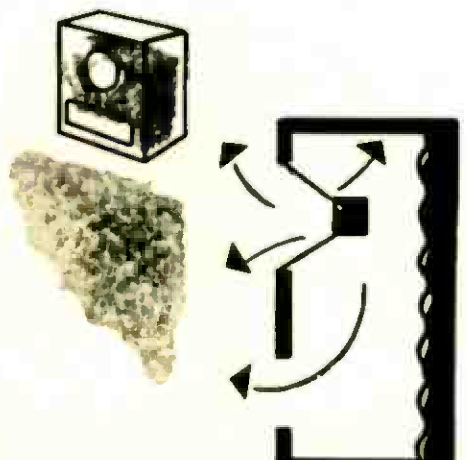
SPEAKER ENCLOSURES

A loudspeaker hanging on a string in the open air would reproduce high frequencies correctly, but all the low frequencies would be lost. So, just as the tendency of high-frequency waves to shoot out in a straight line led engineers to design tweeter systems which distribute their sounds over a wide area, the tendency of low-frequency waves to spread out lazily in all directions led engineers to design "baffles" for the best bass response from a speaker.

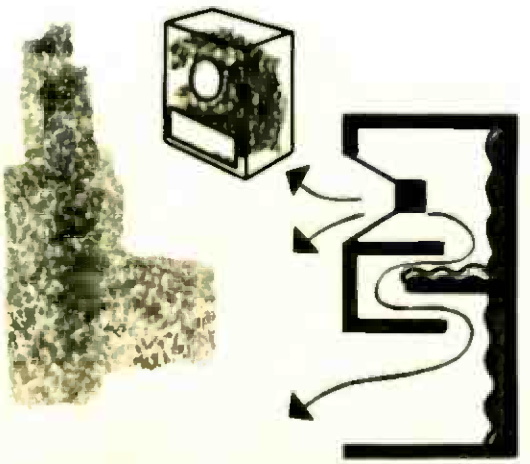
Any vibrating object moves in a complete cycle: rest position, push to forward, push past rest position to back, push forward again. The low-frequency sound wave, pushed back, seeps around the front and cancels out the effect of the forward push. If the speaker is mounted on a board, with a hole cut to the diameter of the cone, the back waves will be "baffled" in their attempt to come around. If the baffle is a wall of the room into which the speaker is facing, it is said to be "infinite"—the back waves can never come around. For the same reason, a totally enclosed box, with just the hole for the speaker, is infinite.

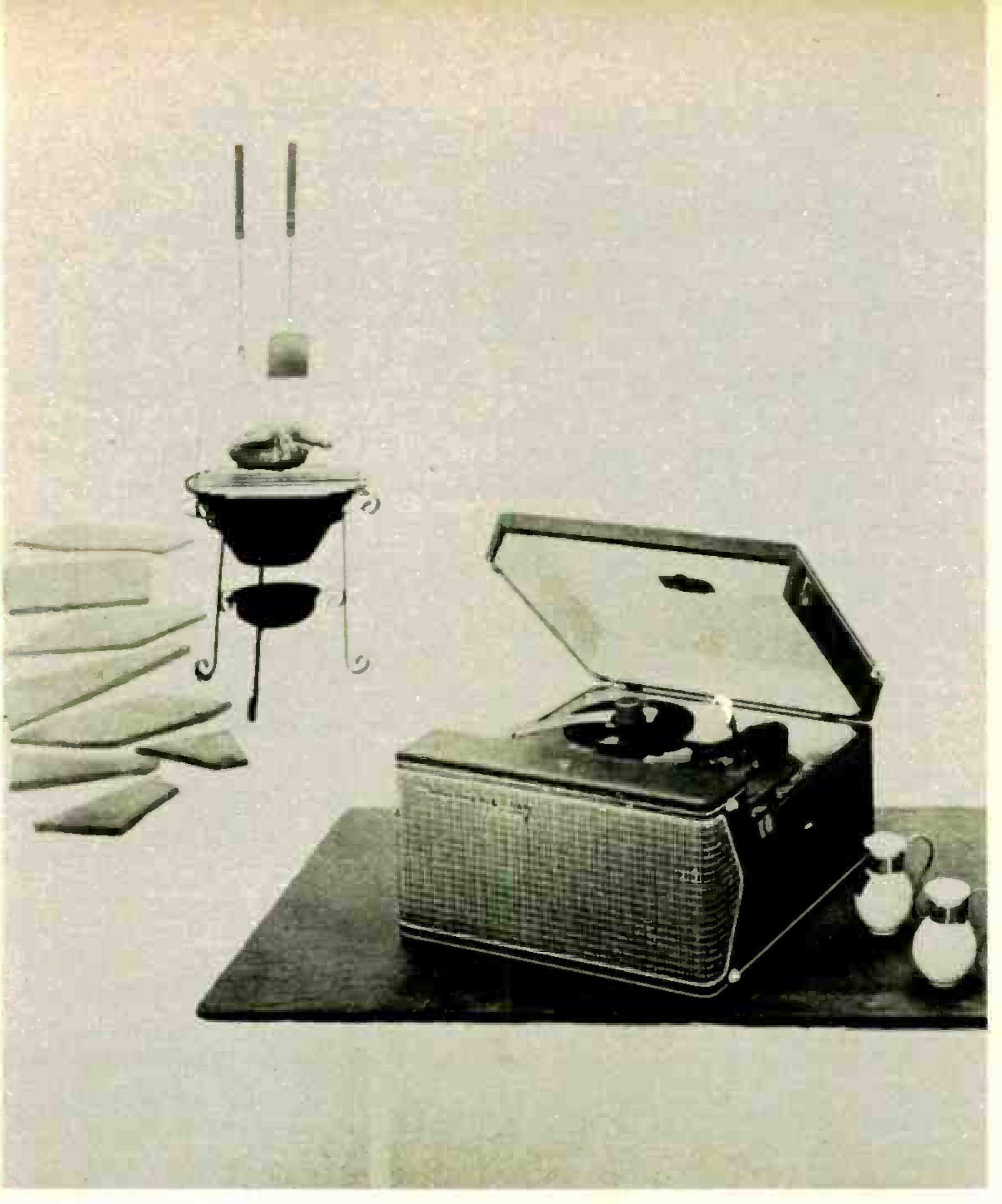
The trouble with a small, totally enclosed box is that it probably will reinforce the natural resonance of the speaker or even raise it slightly. Bass response will peak sharply there and drop off, just as sharply, below. Since this is basically the result of air's resistance to compression in a confined space, it is less acute when

Bass-reflex box, most common kind of enclosure, brings rear waves around through port to reinforce bass sounds from the front



Acoustic-labyrinth enclosure lengthens the column of air inside the box, brings forward reinforced sounds at still lower frequencies





All space problems vanish with the portable Mark VII high-fidelity phonograph. Featuring RCA Victor's 4-speed changer and Panoramic Speaker System, it's styled in brown simulated leather with contrasting grill cloth

confinement is relaxed—that is, when the enclosure is bigger. The wall of a closet full of clothes (which will absorb the backward sound waves) or of a great big room makes a fine infinite baffle, with no effect whatever on the operation of the speaker. The low-frequency sounds come out the front of the speaker just as they are.

Just as they are: there's the rub. For the efficiency of speakers falls off at very low frequencies, especially below their individual fundamental resonance points. And even very fine woofers seldom have fundamental resonance points below 35 cps. So engineers began trying to design speaker enclosures that would actually improve the bass response of a speaker.

The earliest and still the most widely used solution of this problem is the "bass reflex" baffle, an enclosed box with a second hole cut in it. The back of the box is material, in order to deaden all back-pulsing high-frequency waves. The second hole, or "port," is cut just big enough so that the resonant frequency of the column of air inside the box will be slightly lower than the fundamental resonance of the speaker. The lower resonant frequency of the baffle extends the effective response of the speaker because the low-frequency sound waves from the rear of the speaker emerge from the port practically in phase with the front pulsations. In the infinite baffle the back waves are lost, but in the bass-reflex cabinet they come out and help swell the speaker's response at low frequencies.

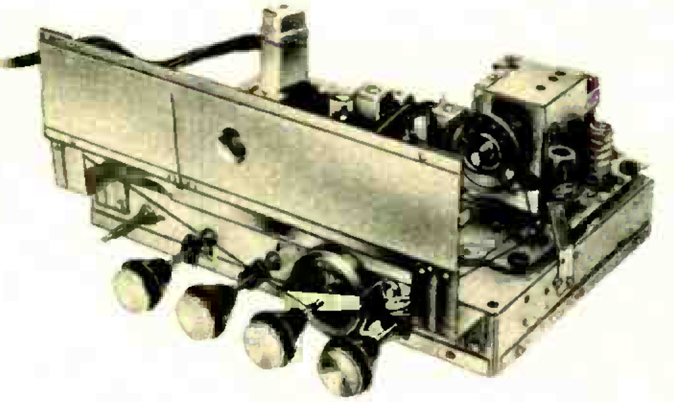
Another type of speaker enclosure is the "acoustic labyrinth"—essentially a bass-reflex enclosure in which the back pulsations are bounced through a maze of small internal boxes—back wall to front to back again, and then out. This device sends the back wave on a much longer path. Since the resonant frequency becomes lower as a column of air increases in length, the acoustic labyrinth extends a speaker's bass response. It is a large enclosure and requires more space than the bass-reflex.

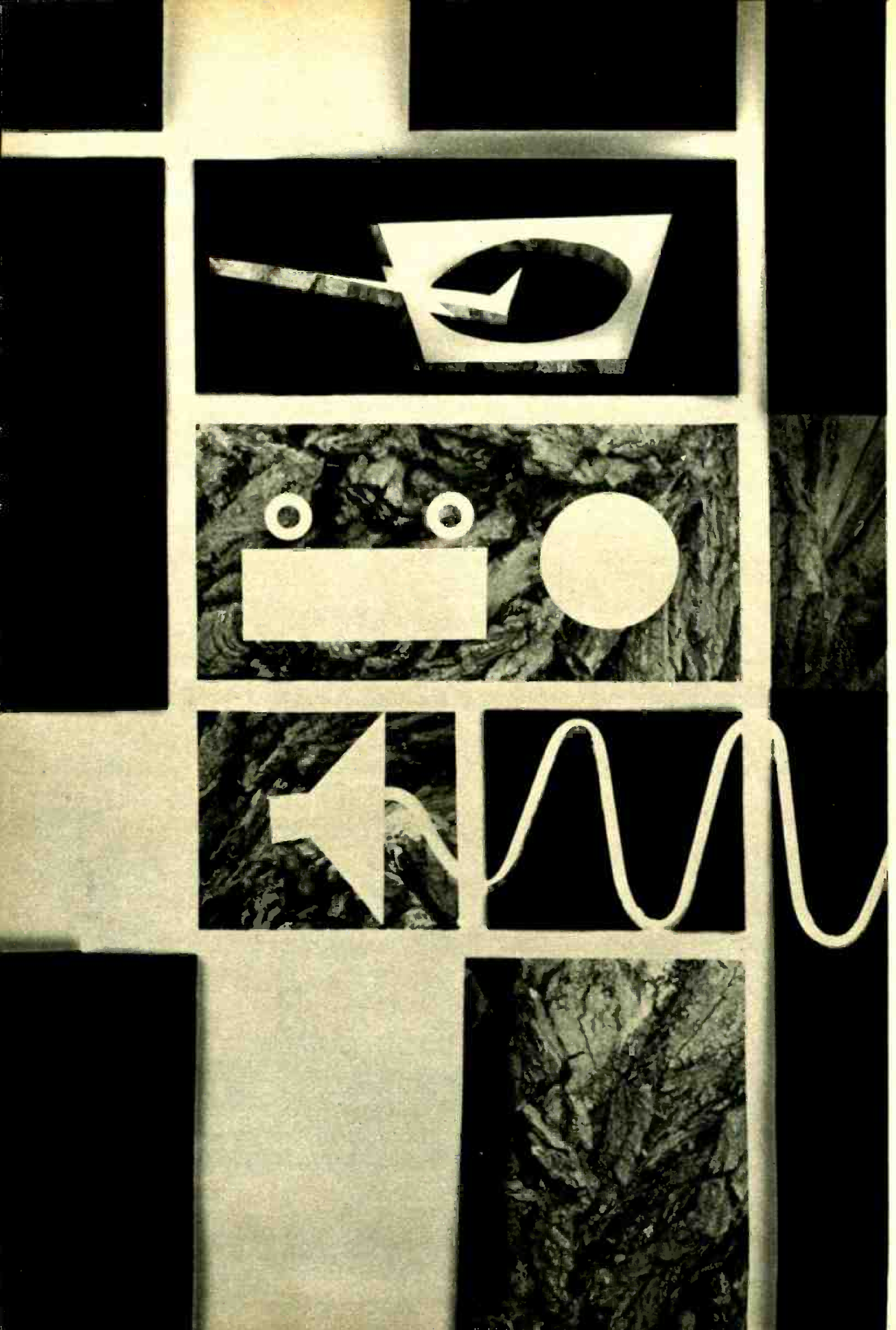
TUNERS

These, then, are the components of your hi-fi set—turntable, tone arm, pickup and stylus, amplifier and perhaps preamplifier, and loudspeaker. There is one more component, not part of the phonograph but nonetheless essential to the music-lover: a radio tuner. The type usually preferred is an AM-FM tuner.

A radio tuner is a radio with the amplifier and speaker left out—you use the ones on your phonograph. A simple AM tuner will need only a loop antenna, unless you live in a deep valley. A tuner for the FM band will need a more elaborate antenna, unless it is operated very close to the transmitting station. But since the FM band is right in the middle of the frequencies allotted to TV, any TV antenna will work fine as an FM aerial too.

Many people find an AM-FM tuner an indispensable adjunct to their high-fidelity set. This feature is available on many RCA Victor hi-fi systems





CHAPTER **4**

WHERE TO PLACE YOUR SET

Your high-fidelity set can sound wonderful, or

it can be a big disappointment. Where you place it can

be almost as important as the quality of the set

Setting up a high-fidelity phonograph in your living room does not require an expert's knowledge of acoustical engineering—merely the avoidance of certain mistakes. The fact that the problem is easily solved, however, does not make it unimportant. The very finest set made can sound poor in the wrong room.

There are three major factors that affect the acoustics of a room. First, the size; second, sound-reflecting and sound-absorbing characteristics; and third, the noise level of the area itself.

The size of the room largely determines what engineers call its "reverberation period." For, you see, a room is an air space enclosed by walls. Sound released in that room does not travel out and away. As the waves reach the walls they bounce back and meet other sound waves bouncing off opposite walls. If the bouncing waves meet in such a way that their crests and troughs coincide, a "standing wave" is created, and you get a big bass boom in some parts of the room and little bass response in others. Or you will get excessive reverberation and reflection of sound—the bouncing back and forth of sound between two parallel walls.

But on further consideration, your living room is not just four walls, a floor and a ceiling. It contains furniture placed in a certain way, draperies hung over or beside the windows, and rugs or carpets on the floor. One or more doors, open or shut, affect the movement of the sound waves from your phonograph. The walls themselves may be of plaster, brick, wood or some other substance. All of these special characteristics of your room will affect, for better or for worse, the quality of sound you hear from the high-fidelity phonograph.

"DEAD" ROOMS AND "LIVE" ROOMS

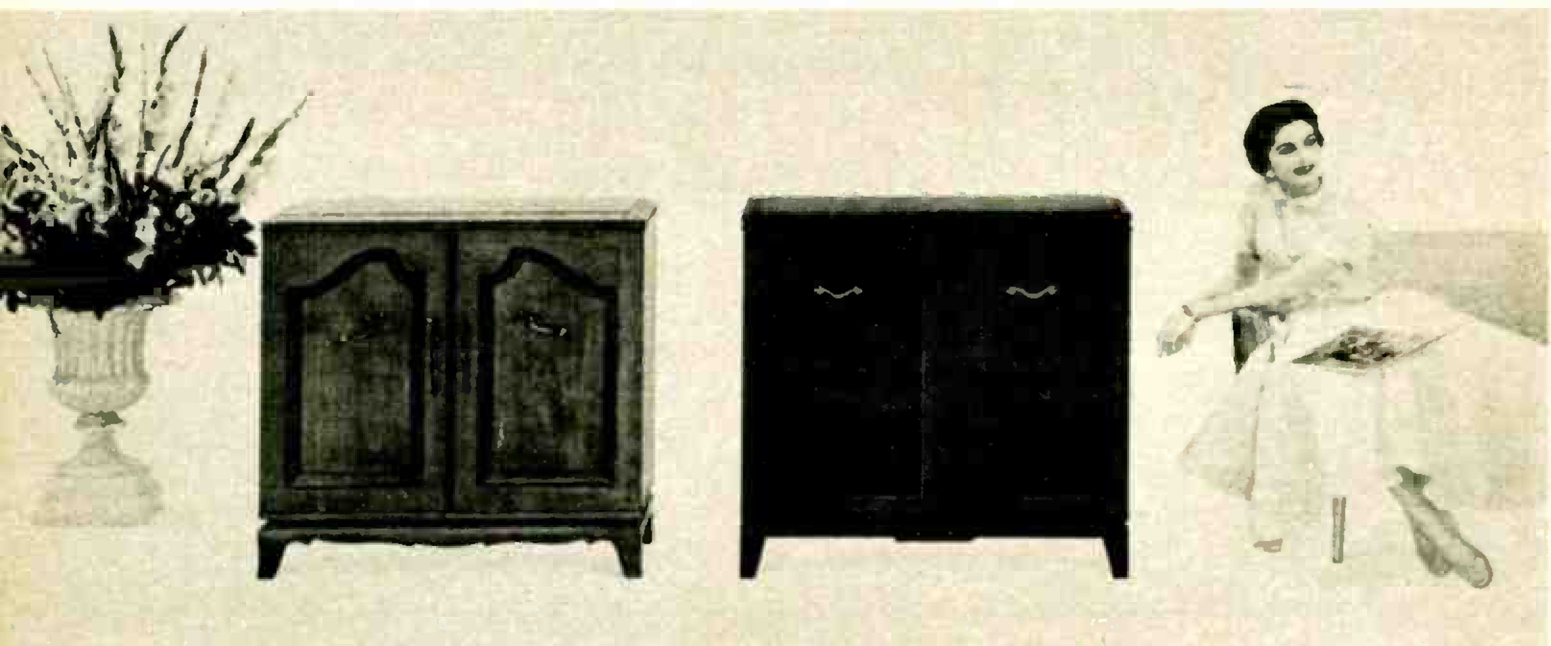
Heavy draperies, upholstered furniture, rugs on the floor and tapestries on the wall—all these absorb high-frequency sound waves. A room in which all such waves are absorbed is said to be "dead." A relatively barren room—one without draperies or rugs, and with molded-plywood furniture—will let the high frequencies bounce back. This is a "live" room. Your room must be neither too dead nor too live—that is, it must let you hear the treble sounds, but not exaggerate them to an extent where they become painful.

The typical American living room generally fulfills these qualifications for good listening. Its walls are apt to be of plaster or plaster-board or some other hard, non-sound-absorbing material. If there is a heavy rug on the floor, the ceiling is almost always bare. We don't use wall hangings, and window draperies are usually light and airy.

Still it may be necessary to do a bit of experimenting in placing your set and the furniture surrounding it to get the maximum performance from the phonograph. For instance, if your set is aimed at some sound-absorbing surface—a wall of filled bookshelves—you may be losing some of the high-frequency sounds. Aim it instead at a hard wall surface.

Or, conversely, if you are losing the lower frequencies, the trouble can be corrected by putting the set in a corner, facing out. Then the low-frequency bass

Across bottom of page: Here is a good example of how cabinets of each RCA Victor set are designed to fit into the decor of any living room—provincial, traditional or modern. The latter is shown both opened and closed



sounds will curve off the two corner walls toward the listening area, instead of spreading out as they would if the set were placed flat against one wall. The treble sounds have not been diminished, but the bass sounds have been accentuated, bringing the *total* sound nearer to the proper balance.

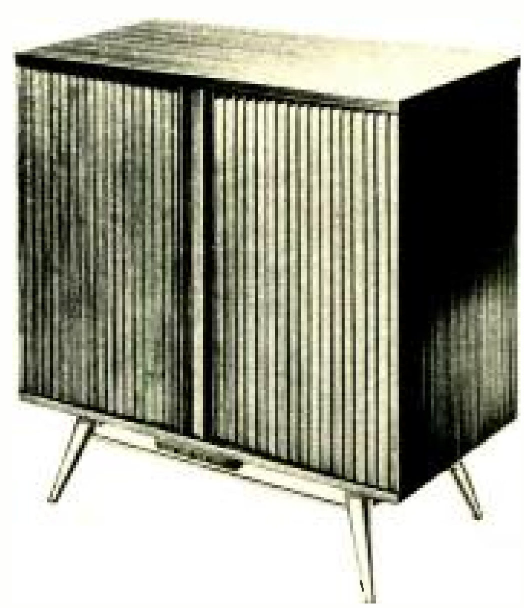
One manufacturer of high-fidelity sets has taken the deficiencies of the average listening room into consideration and has designed into its players a multiple-speaker system providing directional plastic cones for angled tweeters. This acoustically balanced speaker system minimizes most living-room problems. For the average individual it is significantly simpler to select a high-fidelity player that does minimize home placement problems.

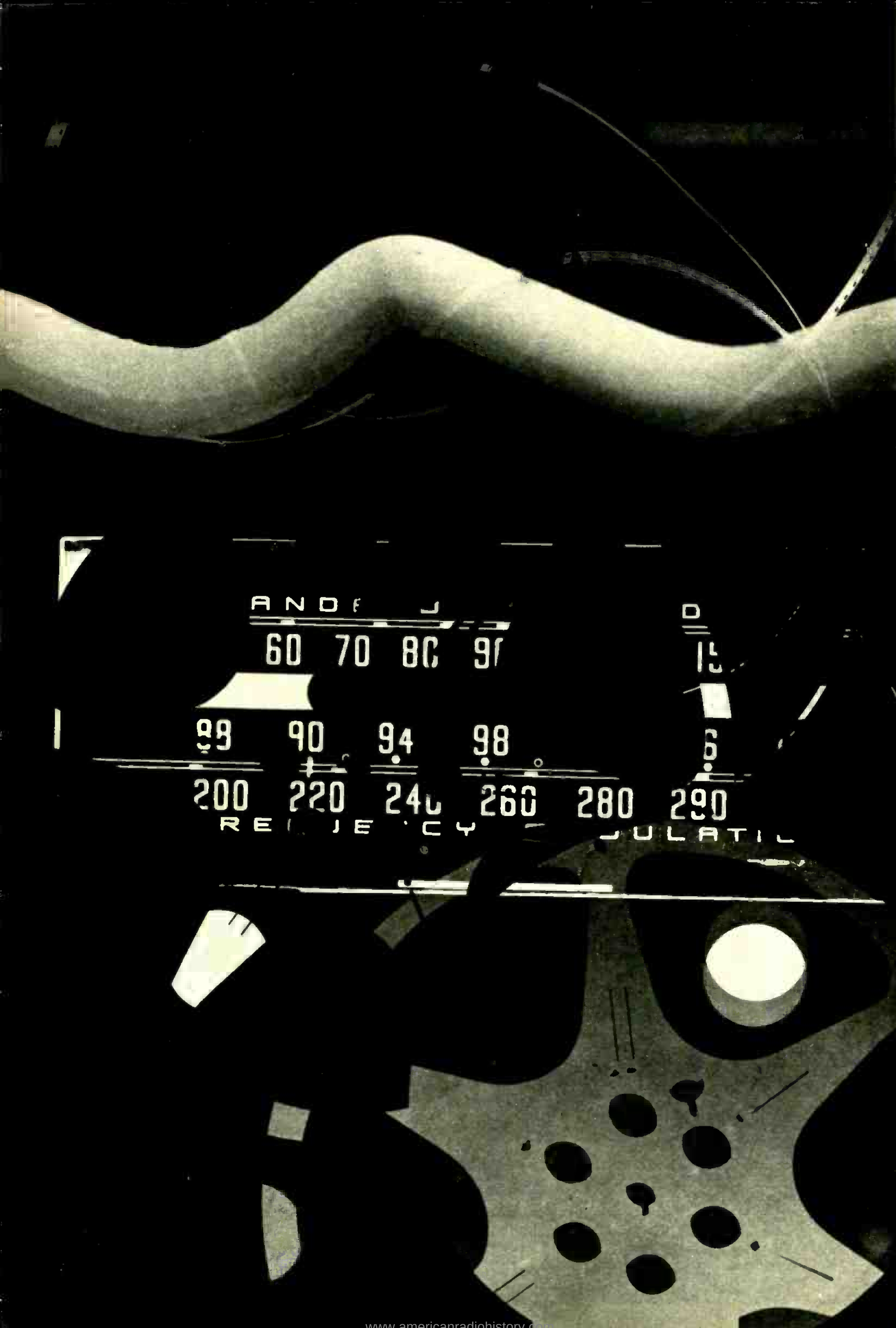
THE NOISE LEVEL OF A ROOM

The third important factor in placement of your set is the noise level of the listening room. Noises created by running equipment causing mechanical vibrations must be stopped or greatly silenced. Trial and error will teach you where your set should be placed to give you the best sound.

But the quality of sound is not the only thing you will want to consider in selecting and placing a high-fidelity set. Your phonograph is primarily a musical instrument, true enough, but it is also a piece of furniture, part of the decor of your home. It deserves a beautiful cabinet. Packaged high-fidelity systems are housed in cabinets carefully designed to harmonize with all types of rooms, modern or traditional. Properly placed in relation to the other furniture in the room, one of these sets is a joy to the eye as well as to the ear.

Below: Doors of modern cabinet of RCA Victor Mark II are folded back to reveal the record player with four-speed changer in convenient roll-out drawer, the control panel and tuning dial

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CHAPTER **5**

TAPE RECORDING AND HIGH FIDELITY

With high fidelity you're not limited to sound

on records. You can buy prerecorded tapes or make up your

own library of favorite music and family events

Up to this point, we've talked about only one kind of phonograph record—the disc. There's another kind, growing in popularity by leaps and bounds—the reel of thin plastic tape which carries on its surface either sounds which have been produced professionally in recording studios, or sounds you have made and recorded yourself.

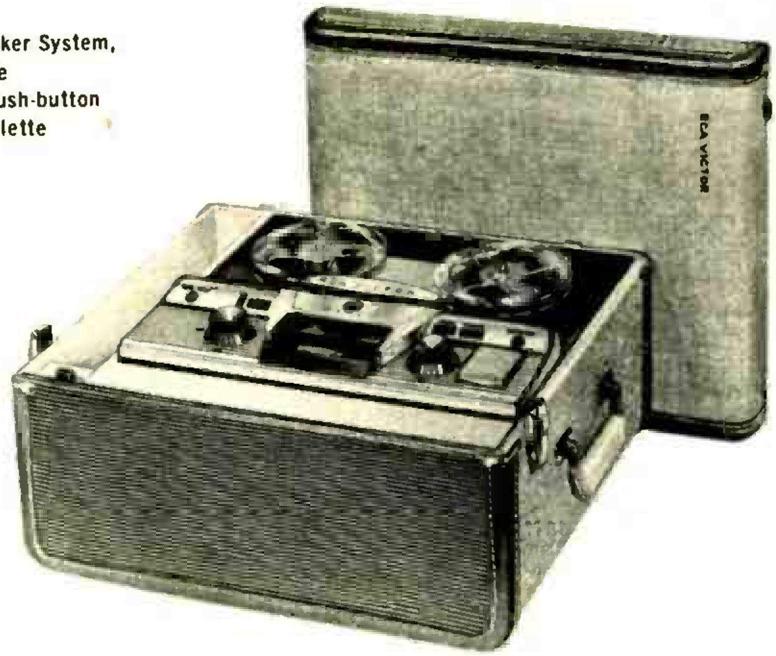
First, let's consider the difference between tape and disc recordings. On a vinylite disc, sounds are preserved by means of *physical* wiggles. Getting the wiggles off the record and into the form of electrical impulses is, as we have seen, a complex process with some risk of distortion in the resultant sounds. Tape eliminates this process and minimizes distortion risk—because on tape sounds are preserved and easily converted into electrical signals *without* being physically transferred.

In a tape-recording session, audio frequencies (sounds) magnetize an iron-oxide coating on a moving strip of plastic tape. In the playback process the tape moves past an electromagnet, a ferrous ring with a gap, wound around with a coil of wire. The irregular pattern of the magnetized areas on the tape sets up a tiny voltage similar to that created inside the magnetic pickup in a regular disc phonograph.

ADVANTAGES OF TAPE

But the sound generation is all electric, and the physical rub of the tape against the playback head has very little effect on the music you hear. Further, the rub does not damage the tape in any way. Tapes, when properly handled, may be played an

The RCA Victor "Judicial" High Fidelity Tape Recorder features Panoramic 3-Speaker System, two-speed operation, provision for remote control, voice-music switch, simplified push-button controls. Other models include a consolette on roll-around clear-plastic wheels



TAPE RECORDING AND HIGH FIDELITY

indefinite number of times and may be preserved an indefinite number of years.

Disc records, on the other hand, do deteriorate. Playing them involves pressure, and pressure means friction. Sooner or later, even if played on the best machine, a disc will wear out. Similarly, because of the friction of the stylus against the grooves of the disc, there will always be a certain amount of surface noise.

Tape is noisy, but for different reasons. The noise on tape is produced by electrical phenomena, not mechanical, and will not increase with time and use. At present, engineers are working on ways to eliminate this noise completely.

Tape has other advantages. With it, you can make your own sounds and play them right back, then keep them to listen to years later. Baby's first word, Junior's prize-winning speech at school, the lines of a wedding ceremony—these are moments you can keep. Or you can record a special broadcast direct from your radio.

You can keep the sounds you put on tape, or erase them and use the tape over again. You can cut and splice tape to eliminate unwanted portions. You can buy recorded tape just as you buy discs; the same performances are, in many cases, available in either form.

On the other hand, tape *is* expensive. Current prices of prerecorded tapes are roughly four times the cost of discs playing the same length of time. A good tape recorder and player is about as expensive as a good hi-fi disc phonograph—and, of course, it won't play the record you pick up casually that is currently popular and costs less than a dollar.

Even blank tape is rather expensive—although this drawback is balanced to some extent by the fact that you can erase it and use it over and over again.

With this warning—that tape will cost you more—out of the way, it's quite possible that you will want to investigate this type of recording, either by itself or as a supplement to your disc hi-fi set. You may even find, if you own both types of equipment, that your tape recorder will in the long run save you some money. You can tape-record your discs when they are new and play the tape during the early months. Then, when you've become a little tired of that record, just erase the tape and use it over to lessen the wear and tear on a later favorite disc. The discs themselves will then remain in almost-new condition for better listening years later.

HOW TO BUY TAPE

Considering the relatively higher cost of tape, its selection and care is of even more importance than the selection and care of discs. The best tape, fortunately, costs only a few pennies per reel more than tape of inferior quality.

Good tape is, first of all, smooth. A smooth surface is essential to insure close contact between the tape and the recording head. The smoother the surface, the closer the contact, and the closer the contact, the better the frequency response—which is just another way of saying the better the quality of the sound you will hear. You can't tell how smooth a tape is by looking at it—you'd need a microscope.

The tape should also be thoroughly impregnated with iron oxide, not merely covered with it. Iron oxide is somewhat abrasive and if too much of it is deposited as dust on the recording head of your machine, it will scratch subsequent tapes passing over the head, causing them to lose still more oxide. Since the magnetized oxide is the part of the tape that carries the sound, pretty soon your tapes will be useless. You can't tell by looking at the tape how thoroughly impregnated it is.

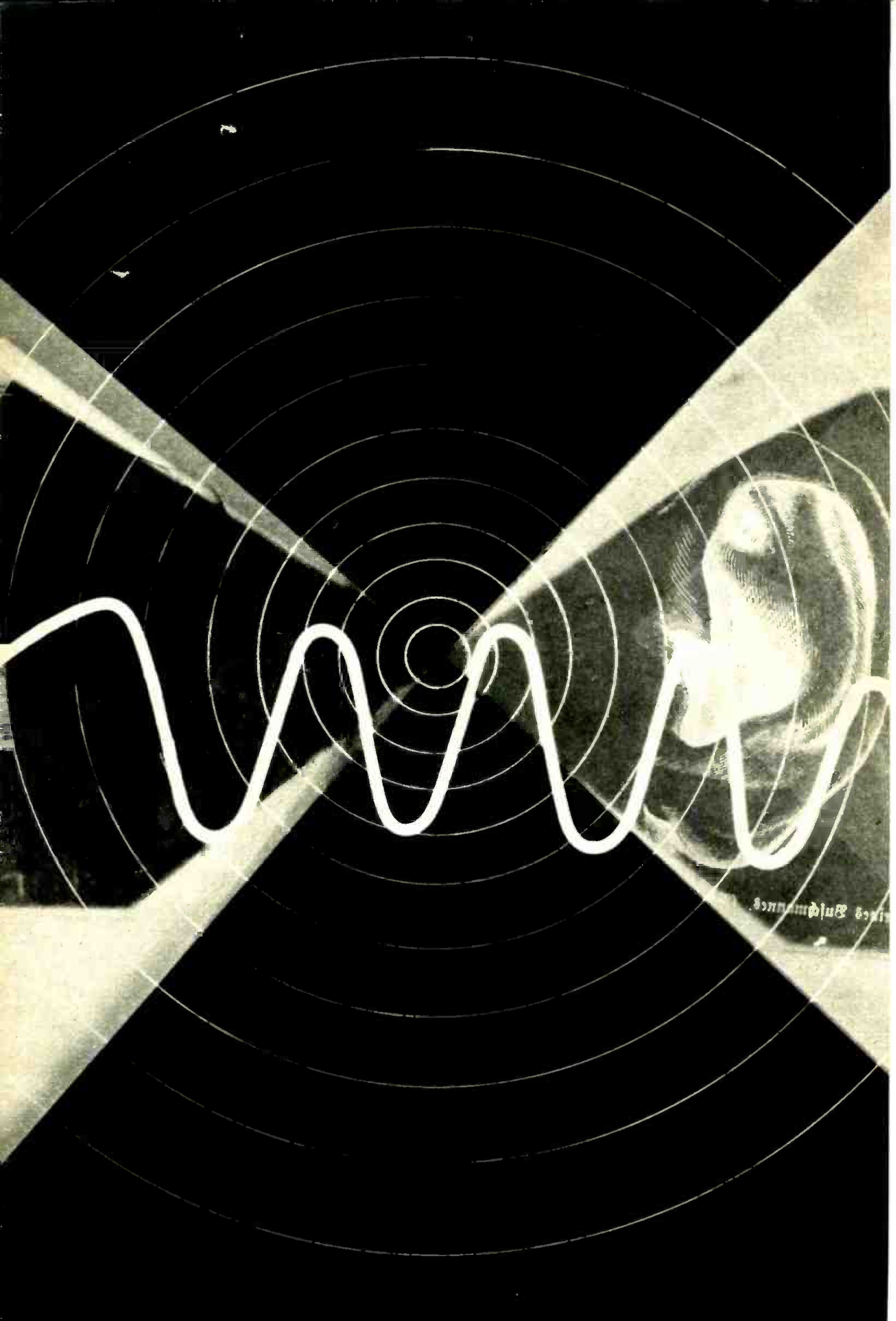
The best rule in buying tapes is to choose a well-known brand. Some experimenting may be necessary before you've found the brand you like best—but once you've found it, stick to it.

CARE OF TAPE

Inadvertent erasure of your recorded tapes is a real danger. The sounds on your tape were put there by magnetic force, and magnetic force (but nothing else) can take them off. Never, then, put a reel of tape near a source of very strong magnetism—an electric iron, the transformer of a toy train set. If you do, the sounds on it may be partially or completely erased. And be careful not to press the "Record" button while you're playing a recorded tape. That will start the machine erasing.

The plastic material of tapes remains at peak pliancy and strength only as long as they are not exposed to unusual humidity or dryness. If you live in a very damp or very dry climate, it's a good idea to play the tapes occasionally, or just rewind them. In any climate, if they aren't going to be used for a couple of years, they should be stored in tightly fitting metal cases of the kind used for movie film.

Treat your tapes right, and it is entirely possible that your great-grandchildren will be listening to them some day.



CHAPTER **6**

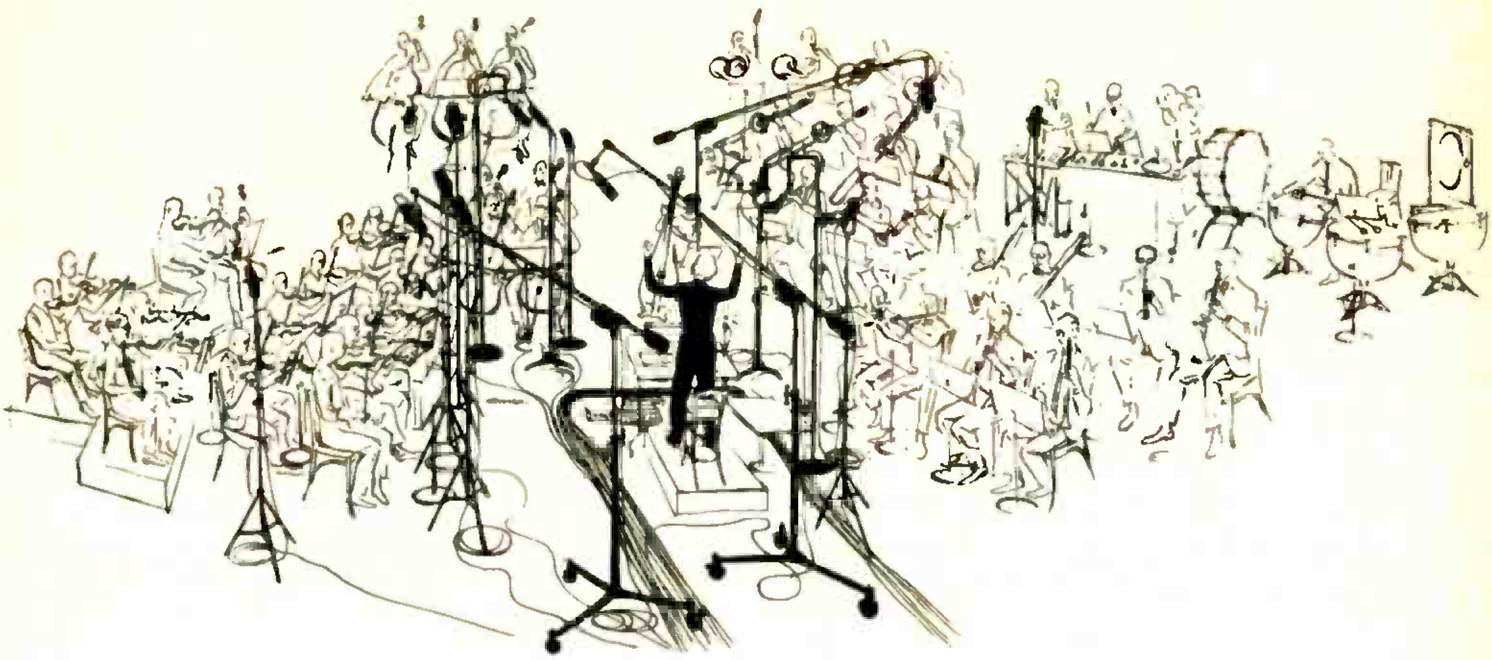
A NEW DIMENSION IN SOUND

Three-dimensional sound is the newest thing in the audio world. By literally surrounding you with music, it comes closest to duplicating a live performance

Chances are you've read motion-picture ads which mentioned "stereophonic sound." Maybe you've sat in a theatre watching and listening to a picture which featured that kind of sound. But unless you're well up on latest developments in the art and science of recording, you're not likely to know exactly what stereophonic sound is, nor that it is something you can enjoy in your own home as well as in a theatre.

The best way to describe stereophonic (sometimes incorrectly called binaural) sound is to say that it is three-dimensional. It has depth, realism and direction exceeded only by a live performance. It is hi-fi plus. As to the name—well, are you old enough to remember the stereoscope that used to be standard equipment in every parlor? It was a viewing instrument with two lenses, one for each eye. You held it up and looked through those lenses at a picture which was really two nearly identical pictures, pasted side by side on a card. The only difference between the two pictures was that they were photographed by cameras set slightly apart—about as far apart as the distance between one's two eyes. When seen through the viewer, the two pictures blended into one—and that one had depth as well as width and height; it was, or seemed to be, three-dimensional. The same principle was employed a few years ago by the makers of 3-D movies. Adapted to the ear, it is the principle of stereophonic sound.

When you sit in a concert hall you hear music not only from directly ahead of you, but from both sides, overhead and even below. Because one ear is usually



Here is an artist's impression of an RCA Victor sterephonic-sound recording session at New York City's Manhattan Center. The conductor is Leopold Stokowski; the orchestra, a free-lance aggregation of his own choosing. The performance is recorded on two tracks, which are then played back simultaneously over two separate loudspeaker systems. The results of this session will be issued on tape

slightly farther away from any sound than is the other, you don't hear *quite* the same sounds at *quite* the same time in both ears. Your brain mixes the sounds and at the same time differentiates between them. Close your eyes during a passage involving the strings and the woodwinds—you'll hear them both, but your sensitive ears will tell you that the strings are on the left and the woodwinds on the right.

Commercial phonograph records are single-track sound—that is, you hear them from one source no matter how many microphones were used in the recording or how many different loudspeakers are in the phonograph—because the record itself uses a single track for the sound.

RECORDING STEREOPHONIC SOUND

Stereophonic sound for the home phonograph is recorded on *two* tracks, which are to be played simultaneously over two separate loudspeaker systems. During the recording, two microphones or groups of microphones are used, placed usually from 8 to 20 feet apart. Ideally, the playback loudspeakers should be the same distance apart. The listener gets the illusion of sound coming from a wide area, truly as if a full orchestra were there. It is a listening experience almost beyond description. However, stereophonic sound *must* be played back on high-fidelity equipment to achieve this realism. And it must be heard to be appreciated.

For stereophonic sound recording and playback, tape is ideal. Discs can and have been used, but they do have certain disadvantages. The most important is that it is very hard to get two pickups into precisely the correct matching grooves—for, of course, you need a double-headed tone-arm with two pickups, as well as two ampli-

"Victrola" Stereotape Player features New Orthophonic High Fidelity Sound. Master unit (front) contains tape transport, two-channel amplifier and Panoramic 3-Speaker System. (Several RCA Victor high-fidelity "Victrolas" have stereojacks to function with this unit.) Companion unit (rear) contains a second Panoramic 3-Speaker System. RCA Victor also offers a portable "Victrola" Stereotape Player

fier and two loudspeaker systems, to accurately reproduce stereophonic sound.

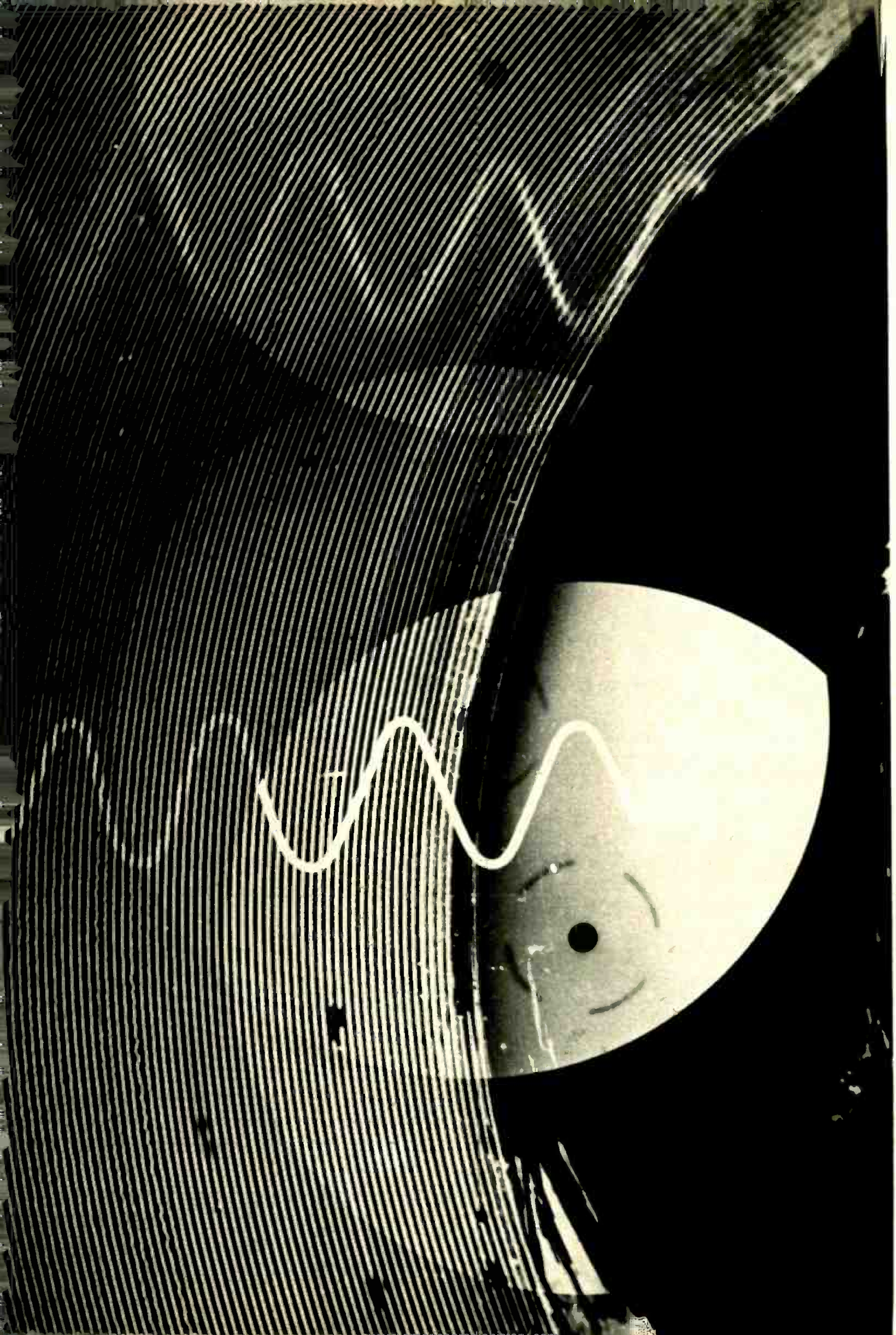
Not all stereophonic systems are high fidelity. Two-track recordings simultaneously played back through dual speakers can be as deficient in high and low frequencies as an inexpensive record player. Buyers of stereophonic sound check carefully to see that they get balanced twin-speaker systems and that the over-all characteristics of the player being considered give a true high-fidelity response.

STEREOPHONIC TAPES

On tape, stereophonic sound recording is much simpler and more satisfactory. A strip of tape has two edges, one for each sound track. It can be threaded to pass over dual playing heads, each hooked up to its own amplifier and loudspeaker. There is no loss of playing time, and the setup is far less bulky and complicated.

Some stereophonic machines have one head directly on top of the other (called "in-line" or "stacked" heads) while others have the heads a short distance apart ("staggered" or "displaced" heads). The in-line heads are the most widely used today. Stereophonic recorded tapes designed for use on machines with in-line heads should not be played on machines with staggered heads, and vice versa. Get tapes made for your particular machine. Most manufacturers of stereophonic tapes, however, produce both.

As to stereophonic recordings presently available—the magic of this sound technique is such that the companies are making and issuing new releases at a steady rate. At least one major manufacturer is releasing stereophonic tapes almost every day of the week.



CHAPTER 7

YOUR MUSIC LIBRARY

Here's some advice about buying records and

taking care of them, plus some carefully chosen starter

collections at different price levels

The widely known "The Music You Want When You Want It" is an RCA Victor slogan and trademark—but it is more than that. It is an expression of the phonograph's unique advantage over radio or television—even over the concert hall and opera house. The owner of a high-fidelity set has his personal choice of great music, that he can listen to at his own convenience in his own home.

But, of course, this advantage is entirely dependent upon wise selection of records and prerecorded tapes and proper care of them once they have been acquired. The best high-fidelity set in the world won't give anyone any pleasure if it is put to work playing records of poor quality, records that are scratched and worn, or even recordings of music which have little or no interest for the listener at that particular moment of his life.

Once you have your set, the selection and care of your record library are of prime importance. An almost unlimited assortment of records is available. They can be bought by mail or in person at any of the thousands of stores in the United States. They are made by a dozen or so different companies, here and abroad. They come in the form of discs—33⅓ rpm, 45 rpm, and 78 rpm—or as electrically recorded tape. You can buy symphonies, concertos, choral works, solos, chamber music, whole operas, jazz classics or the latest release of your favorite popular singer or dance band. How do you choose?

You will, of course, want records that you can live with and enjoy a year or 10 years from now as much as you did on the day they were purchased. This consideration doesn't rule out the pop records, but it does lay upon you the obligation to select with great care. Today's best-selling platter won't necessarily be the record you'll want to hear in 1966.

Not all phonographs made and sold today are hi-fi, but most phonograph records are. Exceptions are the "collector's items"—repressings of records cut years ago by famous artists such as Caruso, or of early Benny Goodman, Glenn Miller or Bing Crosby recordings. In other words, you don't have to buy special records for your hi-fi set. Since 1952, recording techniques have been such that the releases of all the major companies after that date are virtually perfect. The music is there, in the record—all it needs is the proper system to bring it out.

CARE OF RECORDS

You will invest time, thought and money in your record library. You will want to protect that investment with adequate care. Taking care of a record collection is not nearly so difficult as some experts might have you think. Records should be handled only by their edges, or by one edge and the center label. You should stack them in an upright position—not flat on their backs—and remember it's not wise to rub the discs against their cardboard jackets when taking them out or replacing them; squeeze lightly on one edge of the jacket and it will pop open, allowing the record to move freely. Of course the records must be in their jackets whenever they are not in use. Most new records come in protective paper or plastic shields—the latter are more efficient than paper or cardboard. Keep the shields, and keep the records in them.

To avoid warping, store the records away from extremes of heat or cold. When your phonograph is not being used, no records should be on the turntable or changer. No matter how good a housekeeper your wife is, dust will settle on records left exposed to the air, to their great detriment.

A sharp ear on the stylus is an important part of record care. A worn stylus will ruin any record but, fortunately, there is an unmistakable sign of stylus wear: the high-frequency sections of the music will sound fuzzy. No matter what the stylus manufacturer has said about playing hours, when you hear fuzziness either change your stylus immediately or take it to your local record store to be examined under a microscope for flats or nicks.

YOUR HI-FI LIBRARY

Part of the fun of hi-fi is in selecting your own records—but, on the other hand, it isn't always possible to record-shop by ear; either the store has no facilities for letting you listen to a recording before you buy it, or your own time-schedule is too crowded. So we've selected a basic library of fine RCA Victor 45 rpm Extended Play recordings at each of three price levels—$25, $50 and $100—for your guidance, plus a group of recommended RCA Victor Stereo-Orthophonic prerecorded tapes which run to about $100.

BASIC LIBRARIES OF RCA VICTOR HI-FI MUSIC

A beginning for about $25 ● 45 rpm Extended Play recordings

BIZET *Carmen* (excerpts) RCA Victor Orchestra, Fritz Reiner, conductor; Robert Shaw Chorale, Robert Shaw, conductor ERA-45
DELIBES *Highlights from "Coppelia"* Members of the Boston Symphony, Pierre Monteux, conductor; Manuel Valerio, clarinet ERA-253
DELIBES *Highlights from "Sylvia"* Members of the Boston Symphony, Pierre Monteux, conductor ERA-252
FRIML Music from *"The Vagabond King"* Oreste and Jean Fenn; Henri Renee, musical director ERB-2004
Getting Friendly with Music Boston Pops, Arthur Fiedler, conductor ERB-1995
GROFE *Grand Canyon Suite* (excerpts) Boston Pops, Arthur Fiedler, conductor ERB-66
KERN *Showboat* Roberta Peters, Risë Stevens, sopranos; Robert Merrill, baritone; Lehman Engel, conductor ERC-2008
RIMSKY-KORSAKOFF *Scheherazade* Morton Gould and his Orchestra ERC-1956
TCHAIKOVSKY *Concerto No. 1* Emil Gilels, piano; Chicago Symphony, Fritz Reiner, conductor ERC-1969

A moderate collection for about $50 ● 45 rpm Extended Play recordings

CHOPIN *Les Sylphides* Boston Pops, Arthur Fiedler, conductor ERB-1919
CHOPIN *Three Ecossaises, Op. 72;* MENDELSSOHN *Songs Without Words, Andante and Rondo Capriccioso, Op. 14* Ania Dorfmann, piano ERA-238
Music for Summertime Morton Gould and his Orchestra ERC-2006
Music from "Picnic" Boston Pops, Arthur Fiedler, conductor ERB-270
Music from "Serenade" Mario Lanza, tenor RCA Victor Orchestra ERB-70
My True Love Sings Robert Shaw Chorale, Robert Shaw, conductor ERB-1998
RODGERS *Carousel Suite* Morton Gould and his Orchestra ERA-234
RODGERS *Oklahoma! Suite* Morton Gould and his Orchestra ERA-235
STRAUSS, J. *Graduation Ball* (Music for the Ballet) Boston Pops, Arthur Fiedler, conductor ERB-64
TCHAIKOVSKY *Romeo and Juliet Overture* NBC Symphony, Arturo Toscanini, conductor ERB-22
Plus those albums listed in category one.

Greater variety for about $100 ● 45 rpm Extended Play recordings

BEETHOVEN *Symphony No. 5, in C Minor, Op. 67* Boston Symphony, Charles Munch, conductor ERB-60
BERLIOZ *The Damnation of Faust* (excerpts) Boston Symphony, Charles Munch, conductor ERA-250
BRAHMS *Concerto No. 1, in D Minor, Op. 15* Artur Rubinstein, piano; Chicago Symphony, Fritz Reiner, conductor ERD-1831
CHOPIN *Nocturne No. 19, in E Minor; Impromptu No. 1, in A Flat; Etude No. 3, in E; Mazurka in F Minor* Vladimir Horowitz, piano ERA-241
CHOPIN *Waltzes* Artur Rubinstein, piano ERB-1892
DEBUSSY *La Mer; Nocturnes* Boston Symphony, Pierre Monteux, conductor ERC-1939
DEBUSSY *Prelude to the Afternoon of a Faun;* RAVEL *Rapsodie Espagnole; Bolero; La Valse* Boston Symphony, Charles Munch, conductor EPV-1984
The Family All Together Boston Pops, Arthur Fiedler, conductor ERB 54
FRANCK *Symphony in D Minor* NBC Symphony, Guido Cantelli, conductor ERC-1852
GOULD *Dance Variations* Arthur Whittemore, Jack Lowe, duo-pianists; San Francisco Symphony, Leopold Stokowski, conductor ERB-55
GOUNOD *Highlights from "Faust"* Victoria de los Angeles, Martha Angelici, sopranos; Nicolai Gedda, tenor; Jean Borthayre, Robert Jeantet, baritones; Boris Christoff, bass. Orchestra and Chorus of the Théâtre National de l'Opéra. André Cluytens, conductor ERB-36
GRIEG *Piano Selections* Artur Rubinstein, piano ERB-50
MASCAGNI *Highlights from "Cavalleria Rusticana";* LEONCAVALLO *Highlights from "Pagliacci"* Victoria de los Angeles, Zinka Milanov, sopranos; Margaret Roggero, mezzo-soprano; Jussi Bjoerling, Paul Franke, tenors; Robert Merrill, Leonard Warren, baritones; Robert Shaw Chorale, Robert Shaw, conductor. RCA Victor Orchestra, Renato Cellini, conductor ERB-38
RESPIGHI *Pines of Rome* NBC Symphony, Arturo Toscanini, conductor ERB-58
SCHUBERT *Symphony No. 8, in B Minor* ("Unfinished") Boston Symphony, Charles Munch, conductor ERB-61
SIBELIUS *Symphony No. 2, in D, Op. 43* Members of the NBC Symphony, Leopold Stokowski, conductor ERC-1851
Plus those albums listed in categories one and two.

A basic library of stereo-orthophonic tapes for about $100

BERLIOZ *Symphonie Fantastique, Op. 14* Boston Symphony, Charles Munch, conductor GCS-6/GCSD-6
CHAUSSON *Poème, Op. 25;* SAINT-SAENS *Introduction and Rondo Capriccioso Op. 28* David Oistrakh, violin; Boston Symphony, Charles Munch, conductor CCS-16/CCSD-16
DEBUSSY *Nocturnes* Boston Symphony, Pierre Monteux, conductor CCS-12/CCSD-12
MOZART *Symphony No. 41, in C* ("Jupiter") Chicago Symphony, Fritz Reiner, conductor DCS-10/DCSD-10
SCHUBERT *Symphony No. 8, in B Minor* ("Unfinished") Boston Symphony, Charles Munch, conductor CCS-13/CCSD-13
TCHAIKOVSKY *Concerto No. 1, in B Flat Minor, Op. 23* Emil Gilels, piano; Chicago Symphony, Fritz Reiner, conductor ECS-8/ECSD-8
TCHAIKOVSKY *Symphony No. 6, in B Minor, Op. 74* ("Pathétique") Boston Symphony, Pierre Monteux, conductor GCS-5/GCSD-5

GLOSSARY

ACOUSTICAL RECORDING—a method in which the physical power of the sound waves themselves provides the recording force.

AMPLIFIER—an electronic device that magnifies the strength of electrical impulses, without (in the ideal case) changing their relation to each other.

AM—abbreviation for amplitude modulation. A method of radio broadcasting by which the strength of the transmitting frequency, or *carrier frequency*, is modulated, or constantly varied, by the audio frequencies to be broadcast.

BAFFLE—see *enclosure*

BASS BOOST—see *equalization*

BEAM POWER—a kind of tube in which the electron flow is concentrated for maximum power. Used only in the output stage.

CARRIER FREQUENCY—see *AM*

CARTRIDGE—see *pickup*

COAXIAL SPEAKER—two loudspeakers mounted together on the same axis, the small treble speaker inside the big bass speaker, so that a line running back from the midpoint at the mouth of the speaker unit will pass through the center of both speakers.

COMPENSATION—see *equalization*

CONSTANT AMPLITUDE—a relationship between recorded wiggles and electrical signals, by which the power of the signal is proportional to the width of the wiggle.

CONSTANT VELOCITY—a relationship between recorded wiggles and electrical signals, by which the power of the signal is proportional to the length of the wiggle within a given stretch of groove.

CPS—cycles per second. See *frequency*

CROSSOVER NETWORK—a device that separates the electrical signal from the amplifier into high-frequency impulses and low-frequency impulses, to run separate speakers in a speaker system.

CUTTING STYLUS—see *stylus*

DAMPING—in the audio context, a shutting off of vibrations. Both pickups and speakers are damped to prevent extraneous electrical signals and sounds. The output from an amplifier should control the speaker, and some amplifiers provide *variable damping,* which allows slightly more precise direction of speaker vibrations.

DECIBEL—a logarithmic measurement of relative intensity. If 1 is the basic strength, 10 will be 10 *db* over 1, and 100 will be 20 db over 1, and 1,000 will be 30 db over 1.

DISTORTION—the alteration, in any way, of a sound that is to be reproduced. *Harmonic distortion* alters the relationship of the sound to other sounds directly derived from it. *Intermodulation distortion* (*IM*) creates new and undesirable sounds from the interaction of two correct sounds.

ELECTRICAL RECORDING—a method in which the physical power of sound waves is translated into electrical energy and amplified to run a motor which provides the recording force.

ENCLOSURE—a loudspeaker mounting intended to prevent the rear waves of the speaker from interfering with the front waves, particularly in the bass range. Most good enclosures act to reinforce the bass response of the speaker.

EQUALIZATION—the correction of known distortions deliberately introduced into a phonograph record (or a tape, or a radio transmission) at the point of origin. Phonograph records are made with the bass frequencies attenuated and the treble frequencies accentuated. Phonograph reproducing equipment must *compensate* for the distortion. The bass must be *boosted*, and the treble *de-emphasized*. The bass attenuation is not even throughout the bass frequencies. It is greatest at the lowest frequencies, and less as the frequency rises, until a point is reached at which the record is *flat*, an exact reproduction of the sounds fed into the recording microphone. The point at which bass attenuation stops is called the *turnover*. Conversely, treble accentuation becomes greater as the frequencies climb, and the reproducing equipment must *roll off*, on an even steeper slide, to compensate correctly. Until 1954, each record company had its own way of distorting the true sound, so that a number of different equalization curves are necessary to play records made before midsummer, 1954. Almost all new records are equalized to the "New Orthophonic" or RIAA curve.

EXPONENTIAL HORN—a horn in which each increase in length is exactly matched by an increase in diameter.

FEEDBACK—essentially a graphic expression, exactly describing an existing phenomenon. *Acoustical feedback* occurs when the vibrations from the speaker cone influence the action of record player or amplifier. *Electrical feedback* is a circuit in the amplifier which takes impulses from a later stage and feeds them back into an earlier stage. *Negative feedback* decreases power and corrects distortion. *Positive feedback* would increase power and distortion.

FLUTTER—a rapid fluctuation in the speed of a turntable or a tape-moving mechanism, "fluttering" the true pitch of the sound to be reproduced.

FREQUENCY—rate of recurrence, usually in a fixed period of time. The *audio frequency* range is generally considered to be between 20 and 20,000 cycles per second. Since a sound wave represents a complete *cycle* of action—the air at rest, the air compressed, the air at rest, the air rarefied, the air at rest—audio frequencies are expressed in *cycles per second*.

FM—abbreviation for frequency modulation. A method of radio broadcasting, by which the radio carrier wave is constantly varied by the frequency of the sounds to be transmitted.

FRONT-LOADING—see *loading*.

FUNDAMENTAL RESONANCE—the lowest frequency which will induce sympathetic vibrations in an object floating in space.

GAIN—the degree of magnification of the input signal achieved in each stage of an amplifier.

HARMONIC DISTORTION—see *distortion*

HUM—the 60-cycle sound created by the leakage of ordinary alternating current into the audio sections of a phonograph.

HYSTERESIS-SYNCHRONOUS MOTOR—a motor in which the speed is proportional to the frequency of the alternating current which runs it.

IM—abbreviation for intermodulation. See *distortion*

LEVEL CONTROL—generally, a more technically accurate term for volume control. At the input of a preamplifier, a control which enables the use of various fractions or all of the electrical output from the signal source.

LINEARITY—the ability of a phonograph, or any of its parts, to reproduce every frequency at correct strength.

LOADING—a way of increasing the sound from a loudspeaker by coupling the sound-producing source more efficiently to the air. *Front-loading* couples by means of the waves from the front of the speaker; *rear-loading* couples by means of the waves from the rear of the speaker.

LOUDNESS CONTROL—a volume control which automatically compensates for the response characteristics of the ear.

LOUDSPEAKER—a device which transforms electrical impulses into sound waves.

PENTODE—a five-element tube. More powerful than the *triode*, but less accurate in its magnification of the signal.

PHASE—in acoustics, a part of the sound wave—increasing compression or rarefaction. Two sound sources are *in phase* when they are both compressing the air at the same time; *out of phase* when one is compressing, and one rarefying. Since the sound wave of each frequency has a different length, spatial considerations are important in determining phase relations.

PICKUP—a device which translates into electrical energy the physical motions of a stylus tracking the waving grooves of a turning phonograph record. *Magnetic* and *dynamic* pickups have a *constant-velocity* response; *crystal* and *capacity* pickups have a *constant-amplitude* response. See Chapter 3.

PREAMPLIFIER—a device which brings a very weak signal up to the strength necessary for its detection and amplification in an amplifier.

REAR LOADING—see *loading*

RECORD PLAYER—used in this book to mean the turntable and tone arm together.

RECORDING CHARACTERISTIC—see *equalization*

RESPONSE—the measurement of how a phonograph (or any of its parts) reproduces sound. The *response curve* measures the reproduction at all frequencies. A *flat response* indicates that it handles all frequencies alike, as it should.

ROLL-OFF—see *equalization*

SURFACE NOISE—sounds created by imperfections or dust on the surface of a record.

STYLUS—the projecting "needle," with a rounded point, that traces the groove pressed into the record. The *cutting stylus* cuts the groove.

TONE ARM—properly, pickup arm. The pivoting arm which holds the pickup over the record.

TRACKING ERROR—the difference between the arc made by a pivoting arm over a record, and the straight line of the bar which held the cutting stylus.

TRACKING WEIGHT—the effective downward pressure of the stylus on the record groove.

TRANSIENT RESPONSE—the ability of a phonograph to react instantly to the start or the end of a recorded sound.

TRIODE—a three-element tube, the basic amplification tube in almost every amplifier.

TUNER—a radio receiver without amplifier or speaker.

TURNOVER—see *equalization*

TURNTABLE—the disk on which the record sits while being played. Also used to indicate the disk together with the motor which turns it.

TWEETER—a loudspeaker designed to create high-frequency sounds only.

WOOFER—a loudspeaker designed to create low-frequency sounds only.

WOW—a relatively slow variation in the speed of a turntable or tape mechanism, causing an unpleasant fluctuation in the pitch of the sound to be reproduced.

can you answer these Questions?

What is high fidelity? *see page 9*

Is there any advantage to assembling components myself? *see page 27*

Do the size, shape and furnishings of my room affect my hi-fi system? *see page 47*

Can I get a set that fits the decor of my home? *see page 49*

What is frequency range? What should this range be for real high fidelity? *see page 11*

What is playback loss? What causes surface noise? *see page 20*

How is a performance recorded and made into a hi-fi record? *see page 13*

Can I play my old records? Should I now buy special records for my set? *see pages 14, 60*

Why do I need more than one speaker? *see page 42*

What is a "woofer"? What is a "tweeter"? What is a coaxial speaker? *see page 42*

How powerful an amplifier do I need for my home? *see page 37*

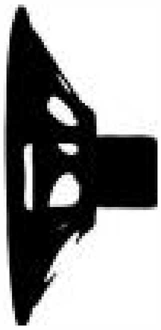
Should I have a record changer? *see page 31*

Is a diamond stylus worth the extra cost? *see page 36*

How can I get FM radio programs through my high-fidelity system? *see page 45*

What are the advantages of having a tape recorder? *see page 51*

What is stereophonic sound? *see page 55*



how to understand

HIGH FIDELITY

the first clear explanation of high fidelity—what it is, how it works, how you can best enjoy it in your own home