MACO
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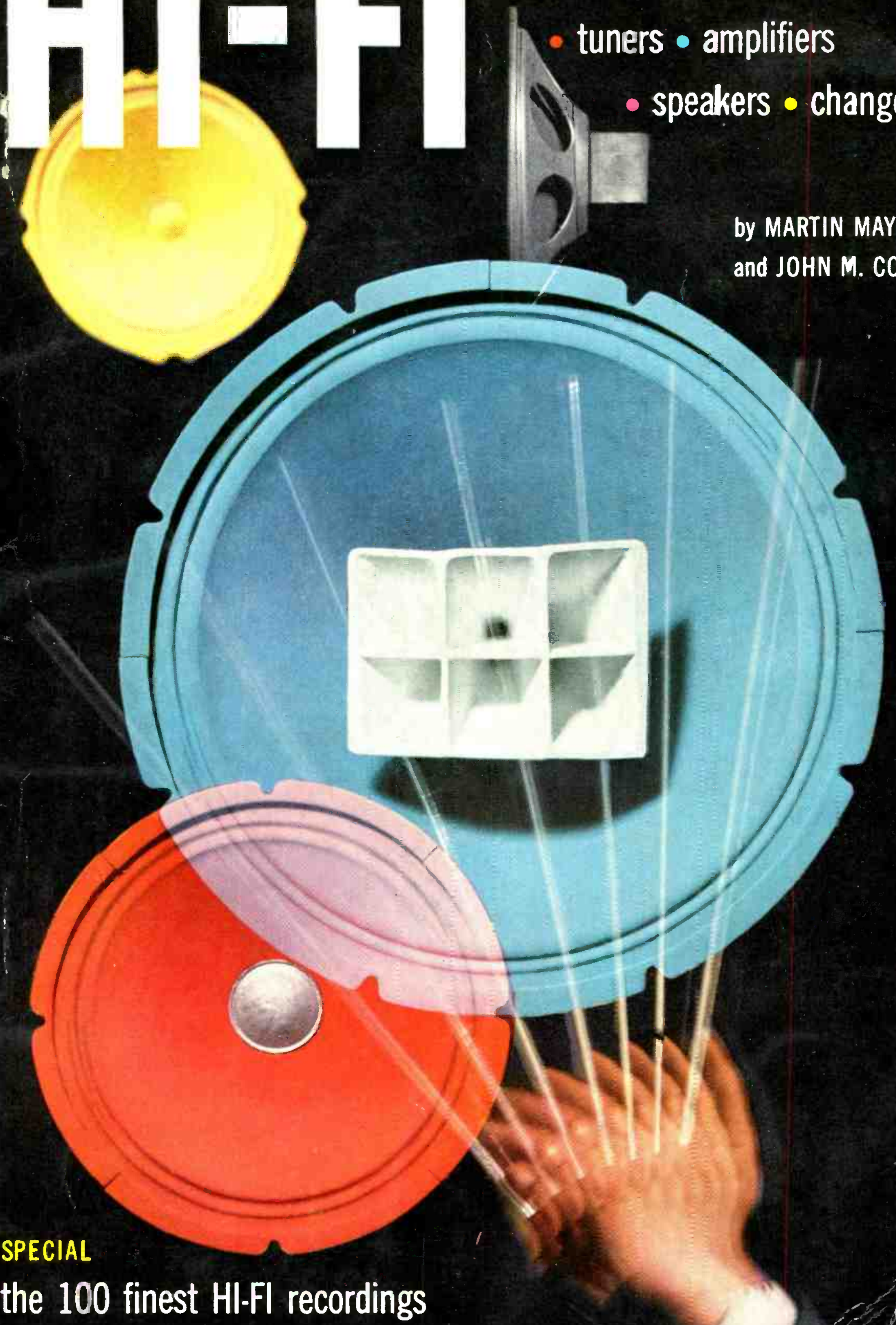
HI-FI

how to pick the best components for every budget

- tuners
- amplifiers
- speakers
- changers

by MARTIN MAYER
and JOHN M. CONLY



SPECIAL
the 100 finest HI-FI recordings

INTRODUCTION

Everything you want to know—or should know—about hi-fi is here, from the way a record is made to the price of the newest tweeters. Every component is covered separately: turntables, tone arms, changers, pickups, styli, amps, preamps, speakers, enclosures. In words and pictures you're shown how they work and what the best buys are.

There's more: a chapter on tuners, tape and TV—the latest facts on the new binaural sound—an invaluable section on maintenance and repair. And the authors, after careful listening, have created a list of the 100 finest high-fidelity recordings you can buy today. Nothing's been left out—because this is the basic high-fidelity book.

the editors

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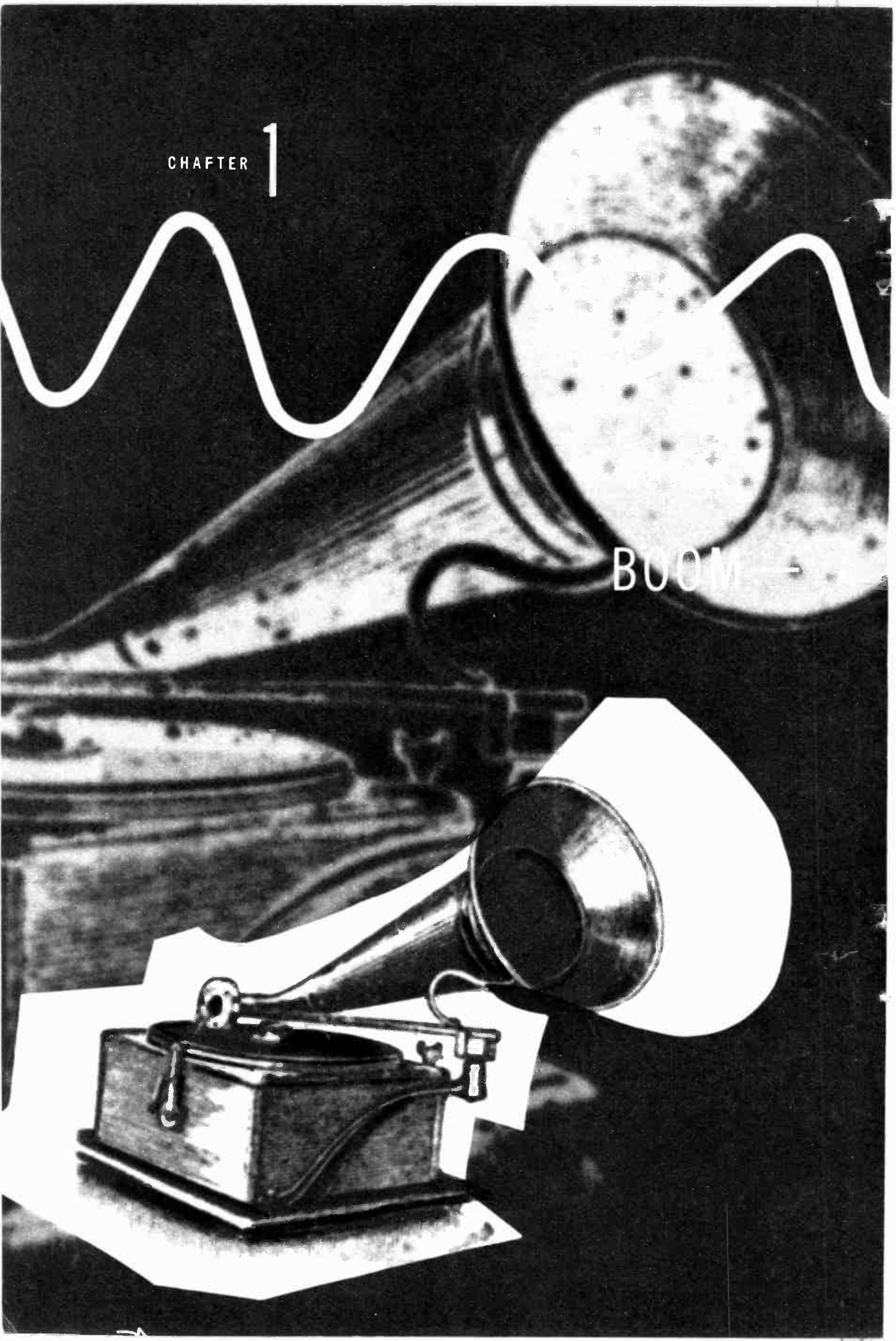
CHAPTER 1



BOOM —

Until you've listened to high fidelity, you don't know how life-like recorded music can sound. It's come a long way since Edison's talking machine

RECORDED SOUND

Brown Bros.

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 predicted 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. 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. To sell their feeble and essentially mispitched devices, the proprietors of the new invention hired Tamagno and De Reszke and Patti, Joachim and Sarasate, Busoni and D'Albert. They then had to convince the public that these artists actually sang or played in just this way, that the recording available in the stores was a genuine facsimile of a great live performance. Sloganeering began almost immediately, and though the actual phrase "high fidelity" had to wait 50 years, the general idea was present from the start.

THE EARLY PHONOGRAPH

The early phonograph, mind you, was an entirely mechanical device. The turntable (or revolving cylinder, in the early 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 crushing 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 see now what else about it could be treasured.

These facts are raked over not for the sake of a laugh at our ancestors, who were doing the best they could, but as a warning to anyone who expects perfection in a phonograph. Today's high-fidelity music systems for the home are infinitely better than the best machines known in the 1920's, and worlds better than even the best console radio-phonographs commercially manufactured as recently as five or six years ago. Musicians find them intensely satisfying and believe that the defects of the recording process we know are only minor flaws. In 30 years, however, wiseacres may be laughing at us the way we laugh at our predecessors.

As a practical matter, phonographs today are an interesting substitute for concerts—but we are still some distance away from the time when the musical experience to be got from a loudspeaker will rival that to be gained in a concert hall. The synthetic is nourishing, and you want the best synthetic you can buy, of course. But the easiest way to be unhappy with high fidelity is to forget that it's make-believe.

HOW HI-FI STARTED

The theory of high fidelity is not particularly new. Today's systems are the result of tinkerings by visionary idealists in the 1930's. Their ideas for the improvement of phonographs were not suited to mass-production techniques, and the commercial manufacturers ignored them. Even after World War II had shot electronics up from a sideshow attraction to an industry, the makers of commercial radio-phonographs were content to return to the production of limited-range, dull-sounding machines for a mass market.

A good piece of that market, however, had got the notion—from reading or talking to engineers or tinkering with electronics equipment while in service—that a better phonograph could be put together, and by amateurs, too. They went hunting for places where they could buy electronics equipment.

Generally speaking, there was only one place: the radio-supply wholesale house, which sold parts to radio repairmen and public-address systems to movie theaters, schools, skating rinks and the like. Some of them also sold record-playing equipment to broadcasting stations. Here, in limited selection, the budding "audiophile" found all he would need to build a sound system of his own.

For the ambitious, there was a limited selection of 16-inch transcription turntables with long tone arms and the General Electric or Pickering cartridge, all standard equipment in a broadcasting station. Others could pick up a Webster-Chicago (now Webcor) record changer, an item which radio repairmen were rapidly installing in old, manual-play radio-phonographs.

The really knowledgeable could buy a chassis and tubes and wires, and put together their own amplifiers. Others could purchase a public-address amplifier already put together—which, with all its many faults, was still better than anything available in an ordinary commercial phonograph. Public-address loudspeakers, or speakers made as replacements for those in commercial phonographs, were sitting on the shelves. Most important of all, there were enclosed cabinets for these speakers, or patterns for such cabinets, designed to improve the performance of the speaker. And, most tempting, all these items cost 40% less at the radio-supply wholesale houses than they did at your neighborhood store.

A NEW BUSINESS

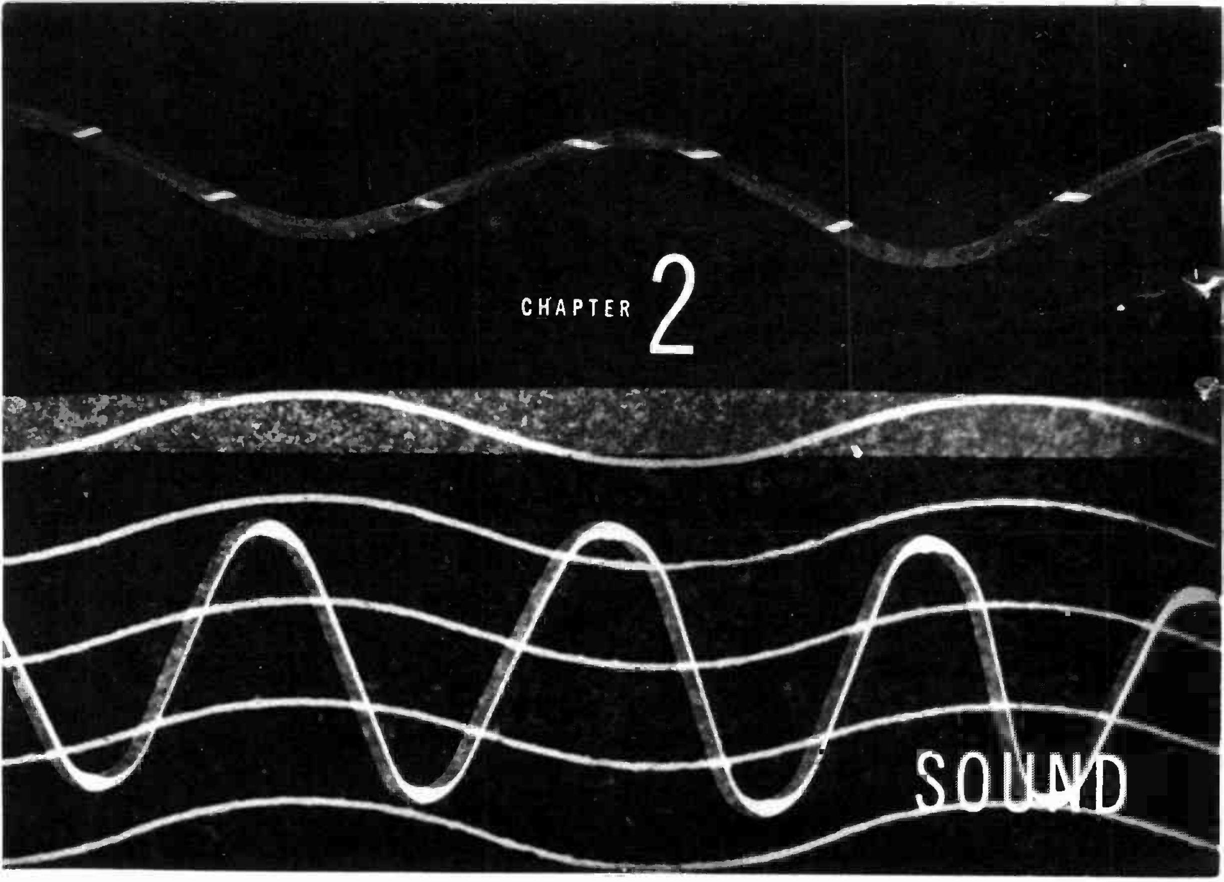
The first wave of new, amateur audiophiles caught the professional supply stores unprepared, and the salesmen were often embarrassed and annoyed at all the elementary questions. By the time the second wave came around, however, dozens of small companies had been formed to manufacture "high-fidelity components" and to market them on a wholesale net-price basis. Altec Lansing, Bogen and Bell packaged amplifiers. Altec, Jim Lansing, Jensen, and University modified their public-address speaker systems for home high-fidelity use. And the imported British Garrard changer joined the Webster-Chicago on dealers' shelves.

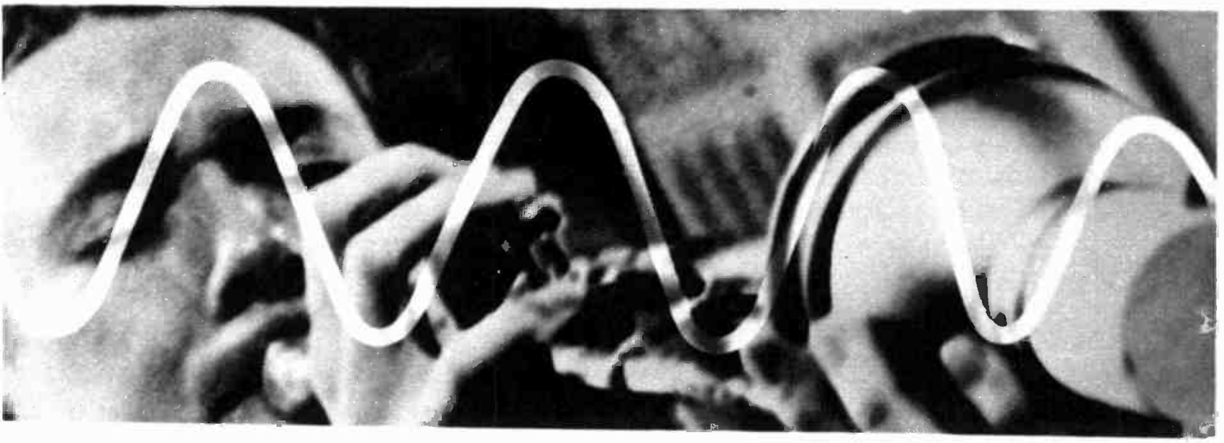
Even today, the high-fidelity components business is dominated by small companies. If you go to an audio show and step into an exhibit room, the chances are you'll meet a high executive officer of the company that made the exhibit. One mass-producer of commercial phonographs went in and then out of the hi-fi components field almost overnight. It found that it couldn't compete in quality and price with the basically hand-crafted products already on the market. Of the four larger companies which now have full lines of components in the stores, three – Avery Fisher, Magnavox and Stromberg-Carlson – were manufacturing limited quantities of top-quality phonographs before the boom. And the fourth, General Electric, developed its hi-fi components in its electronics, rather than its phonograph-manufacturing, division.

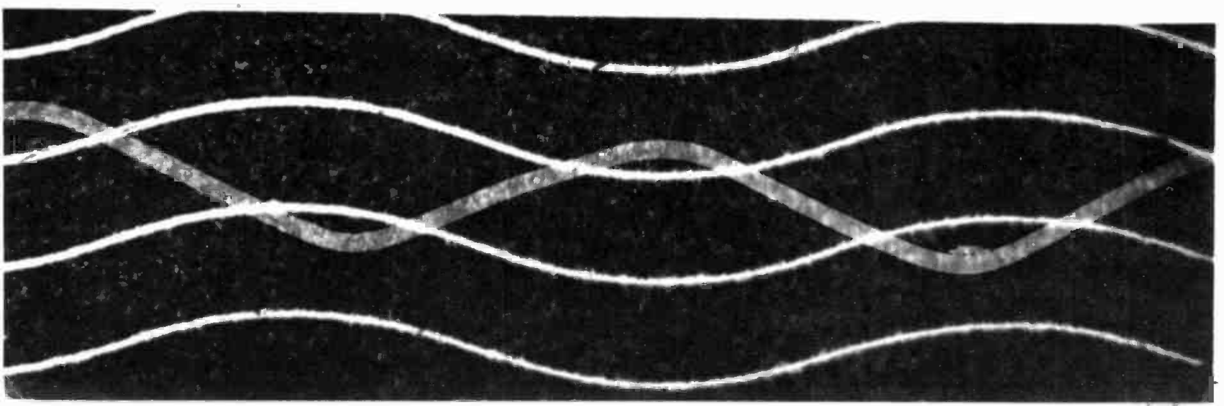
Almost everything which a hi-fi salesman will shove your way is good equipment—far better than you could hope to get in a commercial phonograph that would cost you more. But components come in dazzling variety, and to pick the ones that fill your needs can be a tricky job indeed.

We've written this book not to sell you anything, but to make your job easier.

CHAPTER 2
SOUND







In the tiny grooves of a record are a million microscopic wiggles, containing the sound and color of a musical performance. Here's how it's done

INTO WIGGLES

The phenomenon that we call sound is a shock wave in the air, pulsing at a certain speed. The wave hits against the eardrum, pushing it and then 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 (that wonderful electronic device) into the sensation we describe as sound.

Before this auditory system can be set in motion, the shock wave must have a certain minimum intensity. A solitary bassoon player, standing on home plate in Yankee Stadium, would be inaudible in the bleachers, even though the pressure wave from the mouth of the bassoon would still be in the air. Everybody has had the experience of seeing a crowd or a brass band in the distance, too far away to be heard. The shock wave had been dissipated—lengthways, sideways and up and down—in the open air. It is three-dimensional, and spreads out in all directions, with rapidly diminishing force, from its point of origin.

Not every shock 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 in the kneecap, if it is strong enough, but it will not be recognized by the ear. Pulsations more rapid than 15,000 times a second—those caused, for example, by the love song of a bat—are also "supersonic."

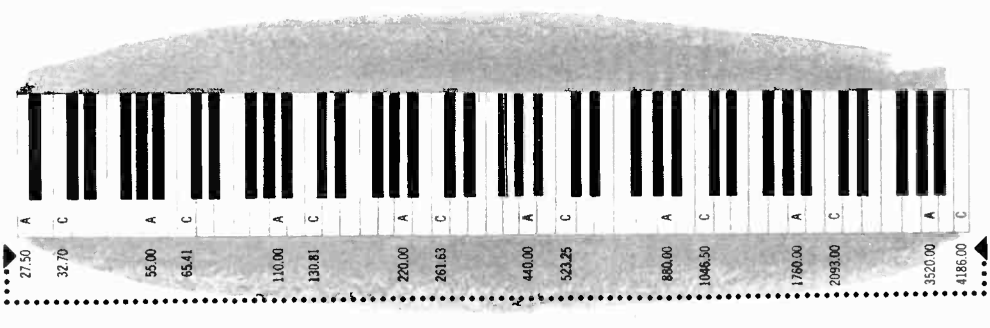
Since each pressure wave gradually increases and decreases in intensity, with a recognized crest and a recognized trough in every wave, the pulsations are described as cycles. Thus the abbreviation, which you will find in every piece of hi-fi literature, "cps": cycles per second. The number of cycles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

FREQUENCY RANGE OF MUSIC

Generally speaking, youngsters will hear a wider range of frequencies than oldsters. Otherwise there are no rules—hearing is a highly individual matter. Some television sets emit a squeak at 17,000 cps when in operation; dogs and a few people can hear it. The biggest pipe on the biggest organs sounds a fundamental note of 16 cps, and a few people can hear that, too (most people merely feel the vibration). Simple hearing ability, of course, has nothing to do with musical talents—Beethoven was stone deaf in his last period. And you'll find a great proportion of the tone deaf among people who can hear 20,000 cps.

A musical sound is distinguished from mere noise by its complexity and by the fact that it continues throughout its individual duration at the same frequency. 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 that pipe-organ 16 cps, 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, but this becomes show-off stuff.

The note that the oboe sounds to tune up the orchestra is an *a*, which is 440 cps. The *a* an octave lower will sound at one-half that frequency, or 220 cps. The *a* an octave higher is twice that frequency—880 cps. Note that the ratio is



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 orchestral instruments are tuned geometric—every octave up doubles the frequency. From 30 to 120 cycles per second is an aural distance of two full octaves, and the same aural distance is represented by the jump from 4,000 to 16,000 cps.

Now almost every musical note that any composer has ever written onto 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 20,000 cps—and even the most conservative musician will demand at least 12,000 cps. The reason is the complexity of the musical sound, which creates vibrations in the air far above the frequency of the note written on the page.

HARMONICS

A violin string, properly stroked to sound our standard *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 struck 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 for the fifth, seventh, eleventh and thirteenth, which are objectionable, probably inaudible, and rare in decent instruments).

But all these harmonics emerge from the instrument simultaneously, so that the actual sound of a fiddle playing *a* becomes an extremely complicated set of pressure 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 any 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 cello in its upper register from sounding like an oboe.) Each instrument makes its own pattern of harmonics, and this pattern produces its characteristic sound. The watery tones of the bassoon, for example, trace from the great relative strength of its second harmonic. The apparent purity of a Stradivarius comes from the very slight strength of all the lower harmonics.

When two different musical notes are sounded at the same time, they will "modulate" against each other to produce still a third note lower than either—a "resultant tone." 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 resultant tones, from the interaction of the notes and their respective harmonics at varying strengths. Imagine, then, the enormous complexity of pressure waves in the air that results from the united attack of a 100-man symphony orchestra.

I

THE RECORDING PROCESS

Even to students of this subject it seems miraculous that a musical sound of this complexity can be adequately caught in a groove only .0025 inch wide.

Until the middle 1920's, all records were made by the "acoustical" method. A pressure 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 at 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 asked this contraption to reproduce a sound so complex as the attack of a symphony orchestra, however, the best it could give you back sounded remarkably like a horse laugh. And fair enough, too.

electrical recordings

In the 1920's the gradual development of radio 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. And in the case of the microphone, which is not a highly efficient translating device, considerable "amplification" of the original electrical signal was necessary to make it strong enough to drive the needle. These two problems—making a microphone sensitive to all the sounds of the musical spectrum, and making an amplifier that would enlarge the microphone's signal with exact accuracy—bemused the record business through the first decade of electrical recording.

Essentially, however, even the earliest electrical discs were far superior to the best that could be made by acoustical recording. Though the parchment diaphragm did respond to a certain extent to the pressure waves from the complex harmonics, it always exaggerated the importance of the strongest waves that hit it. Moreover, it was highly insensitive. Only those sound waves which were strong enough to push the needle would produce any result at all.

The early microphones used as a diaphragm a very thin, charged metal plate, which would move in response to quite minor sound waves and which started an electric signal every time it moved. It was necessary to use several microphones to pick up all the instruments of an orchestra, but the electrical signals from the various microphones could be "mixed" successfully to produce a sound that would recall the concert hall even to an unimaginative listener.

The sound usually cut off at 5,000 cps, eliminating most violin harmonics and similarly rich musical sounds. It was not possible then to design a motor 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 Columbia Records had to junk a fine first "take" of the Beethoven *Third Piano Concerto* because you could hear the keys jangling in pianist Rudolf Serkin's pocket. Amplifiers, when watched by record-company technicians, are practically perfect. And the magnetic-coil cutting needles can wiggle as fast as 25,000 times a second.

recording on tape

The cutting needle, however, is no longer present at the recording session. Instead of going directly into the physical wiggles on a disc, the signals from the microphones are magnetized into a plastic and iron-oxide tape, which spins past the recording head of a tape machine at the rate of 30 inches per second.

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. By this method it was possible to put Irmgard Seefried's high *c* into a role otherwise sung by the aging Kirsten Flagstad.

Bruno Walter conducts the New York Philharmonic Orchestra at a recording session in Columbia Records' studio—a converted church. Note the screens, which are used for acoustical effect

In the old days, with 78-rpm records cut in the studio at the moment of performance, 3½ or four minutes of music (the length of a record) had to be redone to make a correction. Moreover, the record that left the studio in the old days was essentially the same as the record that would appear on the counter in the store. Today a great deal of trickery can be accomplished on the tape before the disc is even cut. Most engineers figure on two or three hours of playing with the tape (boosting this range or that, adding echo effects or "presence") for every 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 10.

The electrical impulses imprisoned on the tape are transformed into side-to-side wiggles on a disc by a Rube Goldbergian machine. Its heart is a very heavy turntable which rotates at exactly 33⅓ rpm. Above the turntable is a steel bar which runs from the circumference of the disc to the spindle at its center. A "bug" crawls along this bar. The bug contains the motor that drives the cutting stylus (we will now drop the antiquated word, "needle") and the stylus itself.

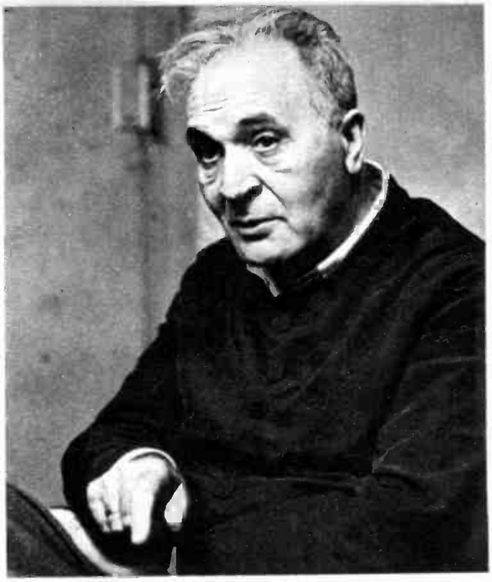
PRESSING A RECORD

Once this "master" record is cut, production reverts to methods that were in common use nearly 50 years ago. The master is sprayed with a silver solution and then plunged into an electroplating jar with a bar of nickel or copper at the negative pole. The resulting nickel or copper electroplate is an unplayable mirror image of the master (with ridges where the master has grooves). Another pair of electroplating processes produces an iron "stamper," an identical mirror image of the master, which presses the actual records. The device in which the records are pressed is like an elaborate waffle iron, with stampers at top and bottom. The waffle is a "biscuit" of vinylite, and the heating source is live steam. It usually takes about 40 seconds for the vinylite waffle to cook. Because of the high pressures involved, each stamper gives satisfactory results for only a thousand or so records. If you get a fuzzy-sounding disc, it's probably because the stamper was used after it had worn down. Recently, the manufacturing companies have been experimenting with an injection-molding machine, which mechanically shoots hot styrene plastic between two emplaced stampers. This process would save a good deal of money. Unfortunately, a considerable proportion of the records so far produced by these machines—when they have been set to work on wide-range recordings—have turned out defective in one way or another.

PLAYBACK PROBLEMS

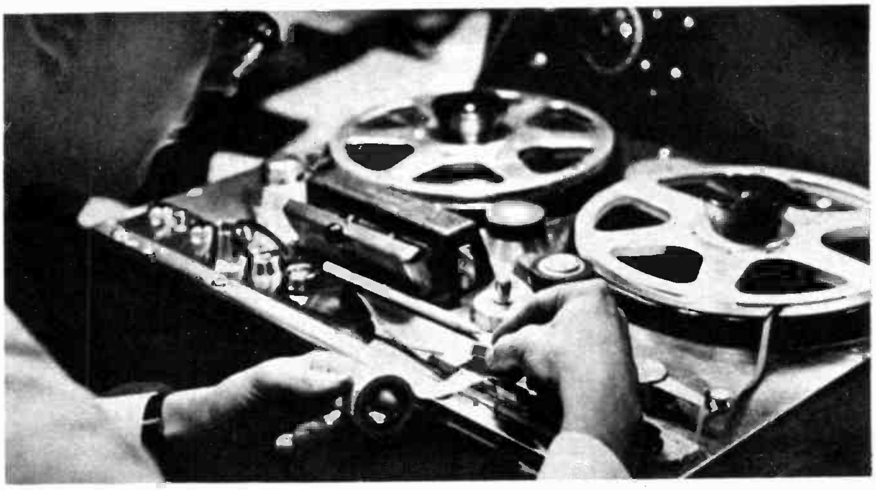
We now have a record. It looks simple, but it is actually an immensely complicated piece of vinylite, and solving the problems which it presents is what makes hi-fi expensive. Since even the best phonograph system is limited in its fidelity by the accuracy with which the wiggles on the record reproduce the sounds of the original performance, let us look at the record.

Until now, in discussing the accuracy of the recording, we have been looking



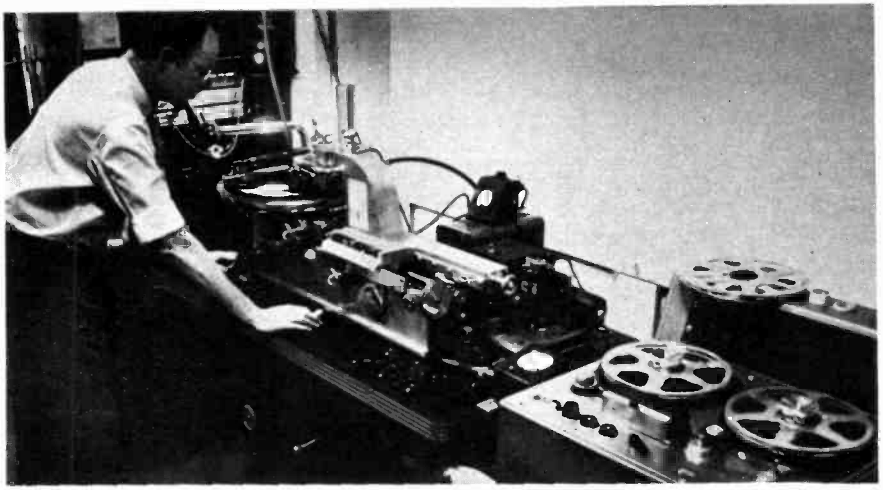
Walter, wearing almost monastic gown which is the trademark of his personal style, listens to playback of performance

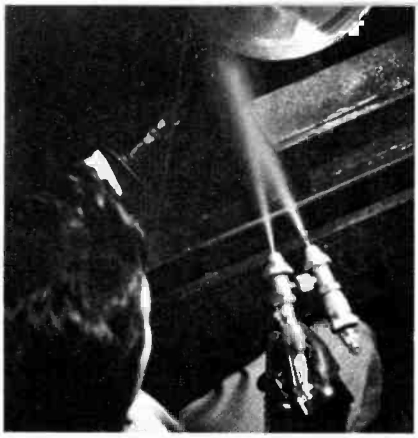
An engineer splices two ends of tape. Since professional recorders spin tape at 30 inches per second, there is space to splice between notes even in a fast piano run



Photos courtesy Columbia Records

Another engineer supervises the cutting of a master record. Electrical impulses from the tape, when amplified, drive a chisel-shaped cutting stylus into the surface of a disc

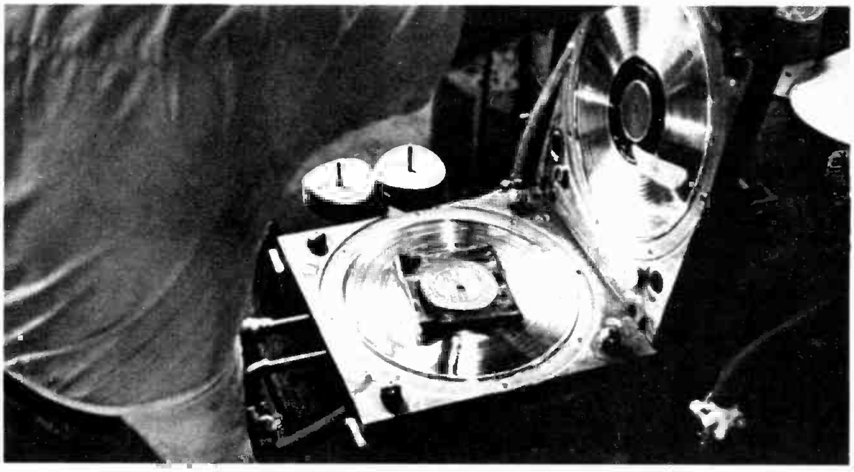




Master record is coated with a silver solution to make it an electrical conductor and prepare it for the electroplating vat

The resulting electroplate, peeled from the master, is a mirror image of the original, with ridges where the master has grooves

Biscuit of warmed vinylite is placed between two "stampers," the results of the electroplating process. Labels are placed below and above, the stampers are closed, and live steam melts the biscuit



Forty seconds later a finished record emerges. The rough edge of surplus vinylite will be sliced away later by an automatic knife while the next record is being pressed

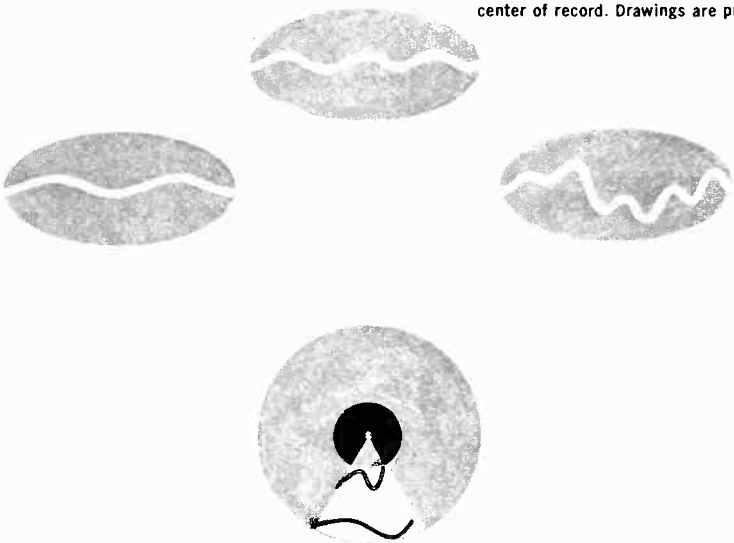
at single frequencies: does it go up to 15,000 cps? Actually, however, a piece of real music involves at least half a dozen frequencies, all going at the same time. All this musical intelligence must be carried inside a single groove, .0025 inch across at its widest.

An LP record spins at 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 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. Pretty delicate. Fifteen thousand cps would be a bad individual note 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. So the wiggle on the record becomes very complex, indeed.

That's at the edge, with the groove whizzing by the stylus at the rate of 20 inches per second. Move in three inches now, as you play the record, to a point where the stylus is only three inches from the center spindle. At the point where the stylus is now, the circumference of the record is only 18 inches, as compared

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



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.

Moreover, the cutting stylus is a sharp, chisel-shaped instrument driven by a motor, while the playback stylus has a spherical tip (it seems sharp when you jab it into your finger, but when you put it under a microscope you see the spherical tip), and it must be driven by the turning groove itself. Now, 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 stylus pressure is only eight grams, the effective pressure on these two points can be as great as 26 *tons* per square inch. This pressure, mind you, on vinylite, which bends easily in the hand.

cutting stylus vs. playback stylus

This is just the sort of situation that makes problems. Problem one, inescapable and 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 mean that reproduction by disc recording can never be absolutely perfect. The point is worth keeping in mind, because salesmen may tell you that such-and-such a rig, costing a fantastic figure, is literally perfect. It isn't.

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 but also to ignore it electrically, because all the music is contained in the side-to-side wiggles. This flexibility of the pickup also comes in handy when the record warps (which all vinylite records will, to some extent), and thrusts the stylus hard to the heavens each time the bump spins around.

playback loss

Using a soft material such as vinylite to drive the playback stylus causes other difficulties, the most obvious being the phenomenon known as "playback loss." A motor drives the cutting stylus 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 pressed 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 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 eight or so inches per second, and pressing on that groove at two points is a weight as considerable as 26 tons per square inch. The result is friction, which translates itself inside the pickup to a high-frequency hiss—surface noise, needle scratch. Shellac, being a rather thick-grained substance, produces more of this scratch than vinylite, which was one of the reasons that record companies switched to vinylite as they began to make records with high-frequency content. Even vinylite, however, produces considerable surface noise, most of it concentrated in the upper ranges.

The way to get rid of surface noise is to make the music at the noise-ridden frequencies so loud that it "masks" the noise. The noise level, of course, remains constant. Inside the phonograph, when the record is played, the strength of the high-frequency signals must then be electrically reduced—and the surface noise will disappear. Very clever. But here we have left the area in which record companies are taking care of difficulties inherent to the process. Now they are 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 have now entered the realm encompassed by the words "equalization" or "compensation."

bass boost

Also in this realm is the "bass boost," by which your phonograph must increase 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—$\frac{1}{20}$ to $\frac{1}{8}$ of a second. To drive the stylus at the same speed when there are only 50 wiggles in an inch, the wiggles would have to be 20 times as wide from bend to bend. Loud bass notes would thus demand a very wide, rambling groove, vastly limiting the amount of music that could be put on a record.

The record companies get around this problem very simply. In cutting a disc, they reduce the level of low-frequency sounds. Once again, your phonograph must compensate for an artificial change in the true sound. It must boost the bass to the extent that the record company has cut it.

This, then, is the phonograph record—a series of complex wave-form wiggles pressed onto vinylite, the high-pitched sounds accentuated all over the disc but especially toward its center, the low-pitched sounds de-emphasized everywhere. The idea now is to turn this disc into a replica of the sounds made in the studio.

The record is a given quantity. You are at the mercy of the recording engineers and technicians who handled the session. Their placement of the microphones, and the tricks they later played with the tape, are enshrined forever in your record. If they made miscalculations, there is little you can do about it. The vast majority of records that come out today, however, are pretty good. If your phonograph can reproduce them accurately, you have a musical experience ahead of you.

CHAPTER 3

WIGGLES

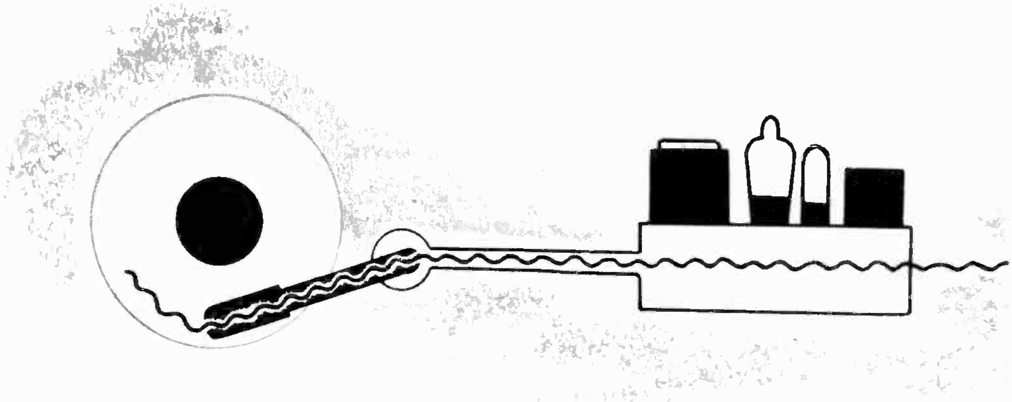
This is where you and your own equipment come in. The playback process is essentially recording in reverse—with a few problems all its own

INTO SOUND

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 electrical signal. This signal is fed into an amplifier, from which it emerges magnified about one million times.

The resulting current is put to work. It is fed into a firm coil of wire suspended between the poles of a heavy permanent magnet. As the current ebbs and flows it creates magnetic fields of various kinds and intensities around the coil. The new and changing fields interact 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 shock waves we call sound. This is the way a phonograph turns the wiggles on a record into sounds.

We are dealing here with minute physical movements and minute electrical signals. Every part of the operation requires precision tools, or the result will be a highly distorted sound. In later chapters we shall examine the various "components" that make up a complete audio system, and watch them work both in sickness and in health. To make sense rather than jargon out of this kind of analysis, however, we must first look into the question of what a phonograph ought to do and where it is likely to fall down.



WIGGLES INTO SOUND

I

PROBLEMS OF THE PHONOGRAPH

Let us assume a perfect recording, properly equalized. The purpose of the phonograph is to get from this recording exactly what is on it, no less and no more. Both sides of this coin are slippery. The average phonograph will not respond properly to every signal on a record and will also add some noises of its own.

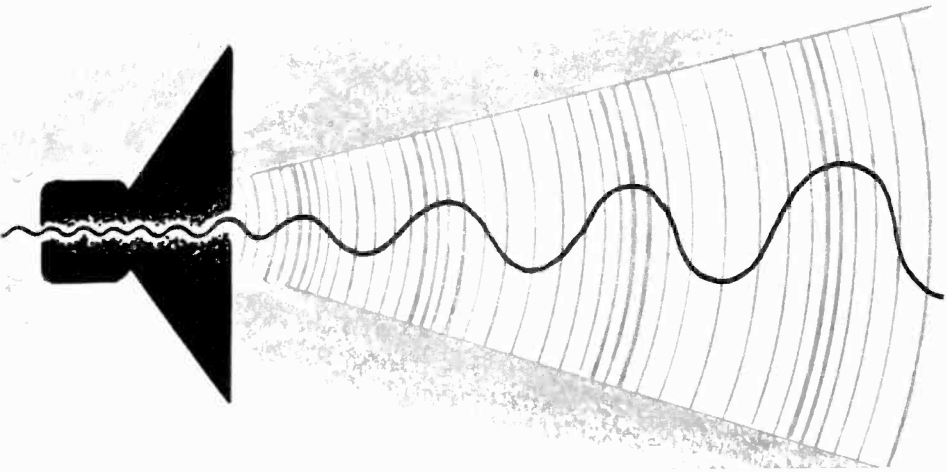
frequency response

A perfect recording will contain wiggles at frequencies from 20 cps to 20,000 cps. The first problem, and the one to which hi-fi equipment manufacturers generally devote most advertising space, is that many phonographs will not respond at all near the extremes of this range. Some part of the music is cut off, with the result that the sound is less "live." It cannot be too strongly stressed that frequency response *alone* is a poor test of a phonograph's performance. Lots of wretched machines will make sounds all over the range, while some highly satisfactory machines will cover only the range of 40 to 12,000 cycles. A phonograph is a musical instrument, and the musicality of its sounds is far more important than their range—but of course it's better to have both.

linearity

More important than frequency range is the phonograph's "linearity" within its range. If the record demands sounds of equal intensity at 70 and 9,000 cps, the phonograph should put out sounds of identical loudness at both frequencies. If a 4,000-cps tone is recorded at an intensity of $2x$, that sound should be twice as loud as those of x intensity. If the phonograph gives an x sound for the 70-cps wiggle, a $1\frac{1}{2}x$ sound for the 9,000-cps wiggle and a $1\frac{3}{4}x$ sound for the 4,000 cps wiggle—all recorded at $1\frac{1}{2}x$—it will distort the texture of the music.

This "smoothness" of response is a primary requirement for a phonograph that is also a musical instrument—and inside each of the components is a gremlin



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

conspiring to make the "response curve" jagged, too loud at certain frequencies and too weak at others. The "peaks" in the curve—the places where the phonograph responds too loudly—are far more important than the dips, because the ear will fill in missing sounds rather easily but can't ignore the booming peak.

hum

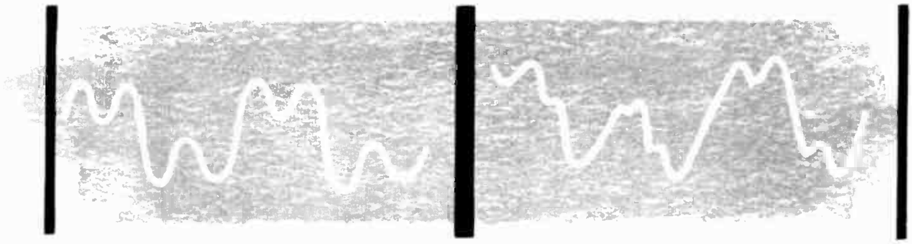
This matter of added sounds crops up all over the instrument. Hi-fi phonographs operate on AC current, which oscillates at the rate of 60 cycles per second: *b*-flat. AC current is fed into most hi-fi rigs at three places—the turntable motor, the pre-amplifier and the power amplifier. Thus the chances of picking up some added strength at 60 cps are just dandy. This particular added sound is so common that it has graduated from the status of a musical note to that of a cant phrase—"hum." 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 costs money in transformers, shielding and precision parts.

harmonic distortion

Less annoying is "harmonic distortion," the tendency of a phonograph to add new harmonics to the music being played. Harmonics are musical sounds. A few of them (but only a few) are not present in good musical instruments and sound out of place—wrong—when added by an amplifier. But, since harmonics are musical sounds and their strength and their relationship to each other determine the individual sound of an individual instrument, harmonic distortion is hard to spot by ear. Tests with musicians have shown that harmonic distortion up to 30% can get by without anybody's making nasty remarks.

intermodulation distortion

What you should worry about is "intermodulation distortion" (IM). 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 tones in such a way that a "sum" or a "difference" tone is produced, harsh, unresonant and unmusical. The stylus, for example, is being driven in a wide arc to produce a loud 100-cycle tone, and 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 is nasty to hear. There's an "edge" on the music that will rapidly tire the ear.

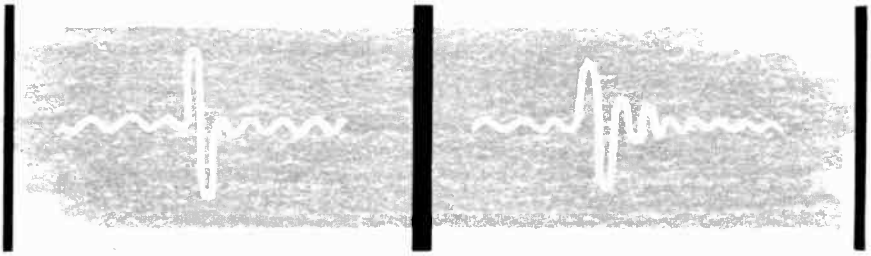


Here, graphically shown, is intermodulation distortion. At left is the correct pattern. At right is the uneven pattern produced when two frequencies, fed simultaneously into the system, distort each other

transient troubles

A different kind of trouble arises from the inability of most phonograph components 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.

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



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. The effects have been mitigated, but the problems themselves haven't been solved.

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 shock waves that will start it shaking all by itself. The most popular example is the water glass and the tenor who shatters it with his high *c, fortissimo.*

This is a basic problem with loudspeakers and their enclosures, and it can also crop up in the bars that hold 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 phonographs always crop up in the frequency-response charts. The resonance of the stylus against the groove, moreover, occurs at high frequency, makes an annoying peak at that frequency and inhibits the proper motion of the stylus at all higher frequencies. Designing equipment in such a way that these resonances will occur outside the range of audible frequencies, and those that occur within hearing range will be damped, is the job that drives audio engineers out of their minds.

MISMATCHED COMPONENTS

Pops, rumbles and squeaks of all kinds may arise when audio components of vastly different quality are hooked together in a single system. A $30 record player, $50 amplifier and $50 speaker system may make pleasant music in your living room. Hook the $30 player into $200 worth of amplifiers and $300 worth of speaker system, though, and you'll get turntable rumble. It is possible to improve a given hi-fi rig part by part as the money becomes available, but you'd better improve the speaker last. A good speaker will expose the shortcomings of a bad amplifier; a good amplifier will expose those of a bad pickup or record-changer. It's worth noting, as a qualification of the above, that an amplifier is usually better than speakers or other components in the same price category.

I

PACKAGE PHONOGRAPHS

The problems we've been talking about arise in components which are carefully designed and manufactured to give the best possible sound per dollar of cost. Ordinary package phonographs are designed and manufactured with other goals in view. In such machines the question of intermodulation is a subtlety—there is so much IM already that you would scarcely notice a 5% increase. Such phonographs will not make musical sounds at high volumes. Their frequency response is so restricted that you can rarely tell a woodwind from a string instrument playing the same note: no harmonics. Their open-back cabinets give a separate, spurious resonance to the sounds from the loudspeaker, blurring all sounds that occur in the bass octaves. The ear is a wonderful instrument and can adjust to the appreciation of muddy, essentially unmusical noises—but a good phonograph will give a much greater degree of pleasure.

In the last few years a few manufacturers of commercial machines have been making determined efforts to improve the sound quality of their goods. In a small room (10 by 12, say) reasonably full enjoyment can now be secured from certain table-model phonographs which sell at prices between $150 and $200. A few of the new prepackaged consoles will give equivalent enjoyment in larger rooms. These, however, run $700 to $800. In every price range you can get better and cheaper equipment by buying components and putting them together yourself. For $135 you can buy components that will make the $170 table-model sound

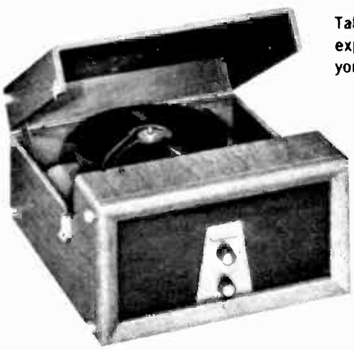
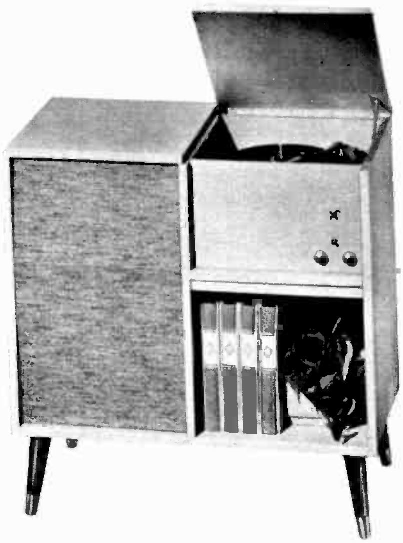
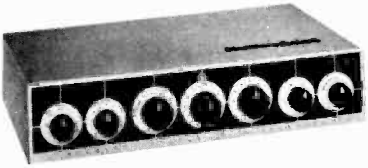
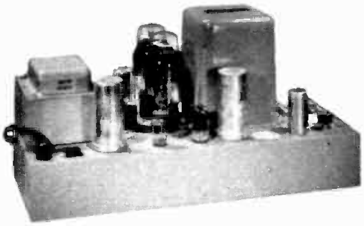
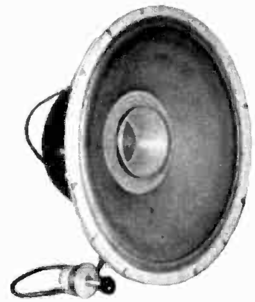


Table-model Mitchell, at $200, is the least expensive package phonograph to give you variable equalization for records made before 1954

V-M, at $200, has little to boast about in record player or amplifier, but the speakers are adequately baffled in a bass-reflex box



First table-model designed for optimum baffling of small speaker, the Columbia 360K is now improved with electrostatic tweeter for the highs

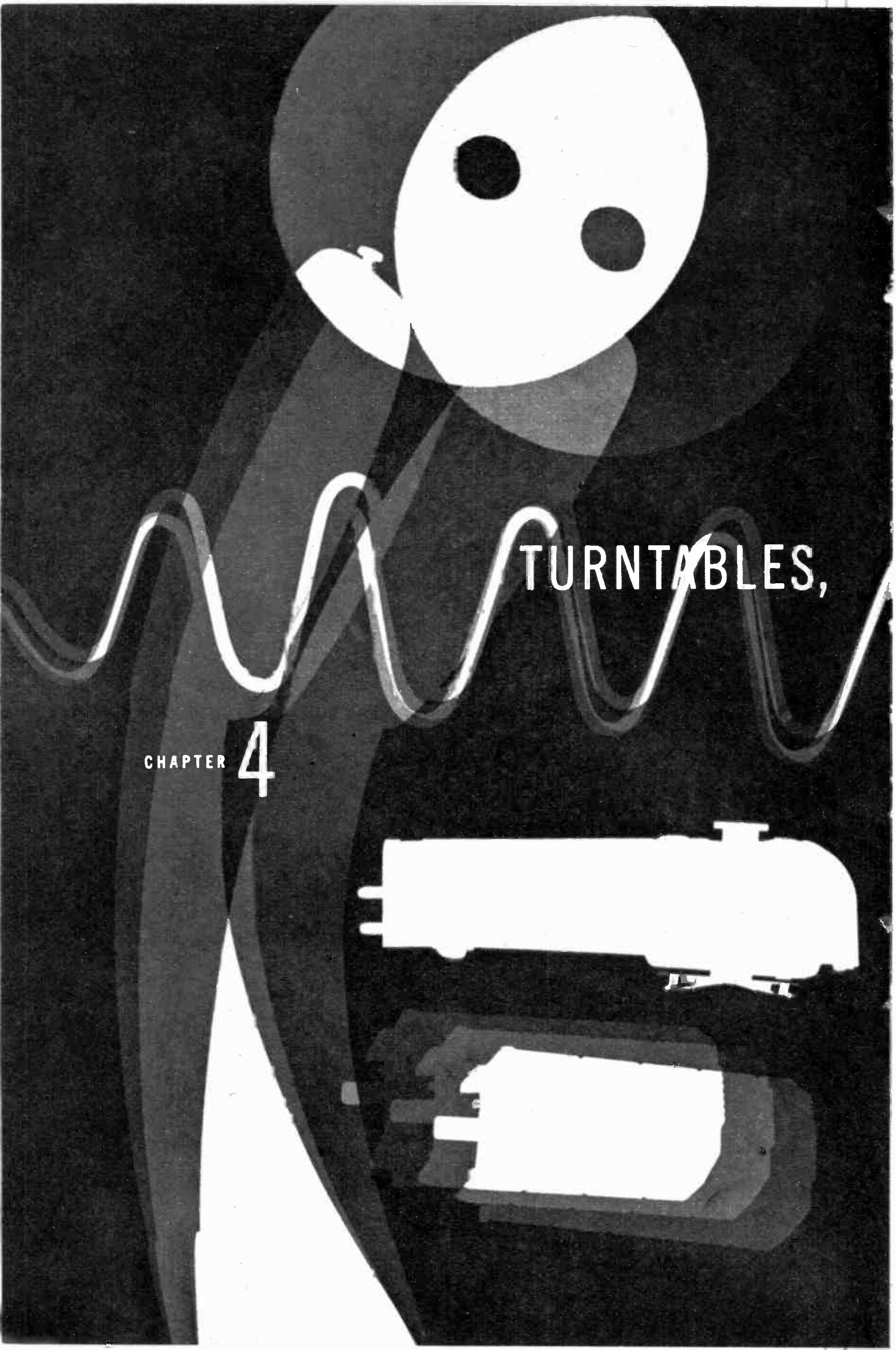
Stromberg-Carlson, once a console maker, now sells components, lets dealer assemble into console. Above: Model 426 preamp, 428 25-watt amplifier, 465 15-inch speaker—each $100. Equipment cabinet, below, features tilt-out controls; excellent speaker enclosure is separate. Package costs half again as much as parts


Above is the unusually handsome Kingsway Apollo, manufactured in England to American design. It's about $350 of hi-fi equipment for $950

extremely shallow, and for $350 you can buy components that will give you sound considerably superior to that of the best consoles. (Remember, this is a phonograph only—no tape, no FM.) How much you want to spend will depend on the size of your listening room and the fastidiousness of your taste in sound—$135 is the minimum (and a pretty bare minimum), and $750 or $800 should satisfy any but the most exacting taste in the very largest room. It is possible to spend $2,200, of course, but we have never seen any real reason to do so.

WHAT HI-FI OFFERS

What you buy in a hi-fi rig is probably best considered as "presence"—a feeling of life and nearness in the music. As you spend more money, you get greater presence. You might keep in mind that you also get greater fragility. When something goes wrong in a $1,000 outfit it produces more clearly perceptible distortion, and it costs more to repair. In the coming chapters we shall discuss various classes and brands of the various components, explaining how well each of them solves its part of the problem of reproducing recorded sound. You take it from there.



CHAPTER 4

TURNTABLES,

Playback starts when the turntable spins

the record. Keeping the speed constant and the stylus

centered in the groove is hi-fi's first step

TONE ARMS, CHANGERS

The work of a phonograph breaks naturally into three equally important divisions: getting electrical signals off the disc, amplifying the signals and turning them into sound.

The first division, in its parts, as a player or as a changer, needs a turntable spinning at exactly the right speed and introducing no noises of its own, and a tone arm swinging freely, side-to-side, over the turntable. The tone arm holds at its head a pickup cartridge, which in turn holds the stylus in the spinning groove.

What we want from the turntable sounds simple, but it isn't. In the first place, there are three speeds—78.26 rpm for the old-fashioned standard shellac records, 45 rpm for the little seven-inchers 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 this speed. If the turntable is slow, the pitch drops; if 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," also expressive. Both are highly annoying, especially in recordings of single instruments.

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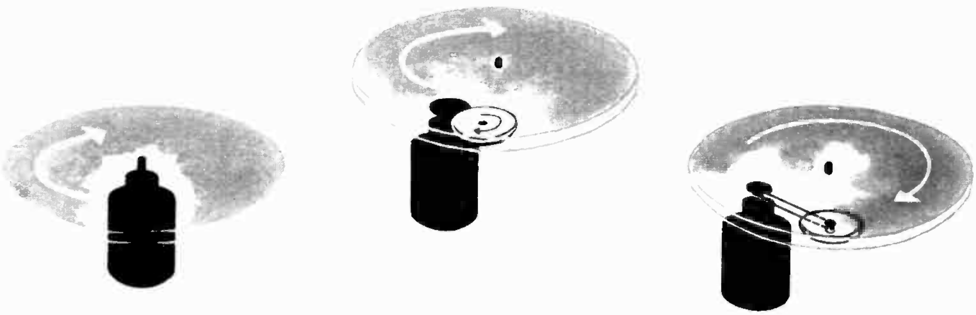
HOW TURNTABLES WORK

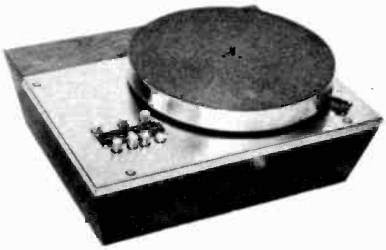
The ordinary shaded-pole motor, which runs your electric drill or power saw, is no good for such precision work, because any variation in the voltage of your house current will change its speed. Most turntables use a specially designed "induction" motor which is fairly stable in feed, though extreme changes in line voltage may disturb it. (Look for a tag stating its requirements: "95-130 volts" means disaster-proof). Even this isn't absolutely steady. The 60-cycle alternation of AC electric supply, however, is invariable (an electric clock practically never goes wrong), and thus a "synchronous" motor, which decides its speed by the frequency of alternating current, can keep a constant rpm under any circumstances short of a complete power failure.



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

Getting this constant speed of the motor up to the turntable (in three different varieties) takes considerable ingenuity. Today's best and most expensive turntables–the Rek-O-Kut B-12H ($125), the British Garrard ($87) and the Scott "Stroboscope" turntables ($125), the British Sugden "Connoisseur" (not yet imported to this country) and the Components Corporation at $85–use one of three different methods to translate motor speed into turntable rotation.

On the Rek-O-Kut and the Garrard the power gets to the turntable by means of a "rim drive"; that is, the final agent is a hard-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. Usually the spindle, the upward-protruding end of the motor shaft, is 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–and so on. A conical or tapered spindle may be used to give continuously variable speed, anywhere from 25, say, to 100 revolutions per minute.



A built-in stroboscopic disc, attached to bottom of the turntable, tells the owner of this H. H. Scott whether or not he must adjust the speed control

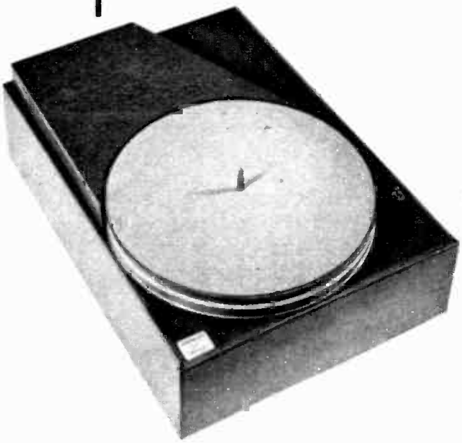
The Rek-O-Kut B-12H and B-16H feature hysteresis motors which govern the speed by the frequency of an alternating current rather than by line voltage

On the Scott the turntable drive is direct; that is, the drive shaft of the motor locks into one of three gears on another drive shaft, which in turn is geared to the center of the turntable. The Components Corporation uses a linen belt which fits directly onto the drive shaft (at one of three diameters) and then fits around the circumference of the turntable. Still another method, in the D & R 12-A ($87), applies an idler wheel to the outer rather than inner rim of the turntable.

There are arguments for and against each of these methods. The Components Corporation gets the motor farthest from the turntable and the pickup, thus minimizing the danger of noise from the motor. For the same reason, though, it is the bulkiest and ugliest, and it requires the most elaborate mounting. Direct drive uses metal parts only and can thus be machined to the closest tolerances. It also lasts longest, at least in theory—but not necessarily in practice. And when something goes wrong, the repair may be expensive. Rim drive requires occasional replacement of the rubber-tired idler wheels and drive spindle-tops (which wear a bit unevenly, producing wow and flutter). It is, however, the easiest to repair.

A lot less money will buy you a turntable almost imperceptibly less accurate: the Thorens E-53 PA (direct drive made in Switzerland; $60), the Rek-O-Kut B-12 (rim drive; $75) or L-34 (two speeds only; $50). Rek-O-Kut and Bogen (made by Lenco in Switzerland, but marketed here by Bogen) also offer turntables with continuously variable speed, which are useful if you have a quantity of the very old records made at 80 rpm. Otherwise the continuously variable turntable is a greater nuisance to operate, and it's an old saying that what you don't put into a gadget can't go wrong. Scott and Garrard offer limited flexibility around the three generally useful speeds. Thorens gives you a governor which automatically corrects to the right rpm.

Garrard's Model 301, an English import, has a pressure lubrication system, with a control which allows for slight variations in record speed



Components Corporation isolates motor from the record, conveys the necessary power by means of belt around the turntable

Thorens E-53 PA, a direct-drive turntable made in Switzerland, has built-in governor to keep turntable speed steady at 33, 45 or 78 rpm

We are still not entirely out of the woods, however. The induction motor previously described, while it will average the correct speed in each revolution, will not necessarily spin smoothly. A two-pole motor (still used in some cheap record changers) is altogether too rough for high-fidelity reproduction and extrudes a magnetic field likely to produce pickup hum. Four-pole motors, which are standard equipment in all hi-fi changers and most turntables, are twice as good. But even here there is some danger of irregularity. For this reason high-fidelity turntables are heavy, so that they will act as flywheels and maintain an even speed. For normal use the four-pole motor is fine, but exceptionally good amplifiers and loudspeakers may detect a very low-frequency rumble in its operation. To combat this, the expensive Rek-O-Kut B-12H features a "hysteresis synchronous" motor (known to the irreverent as the hysterical motor), which is roughly the equivalent of a 16-pole motor. No rumble, no hum.

TONE ARMS

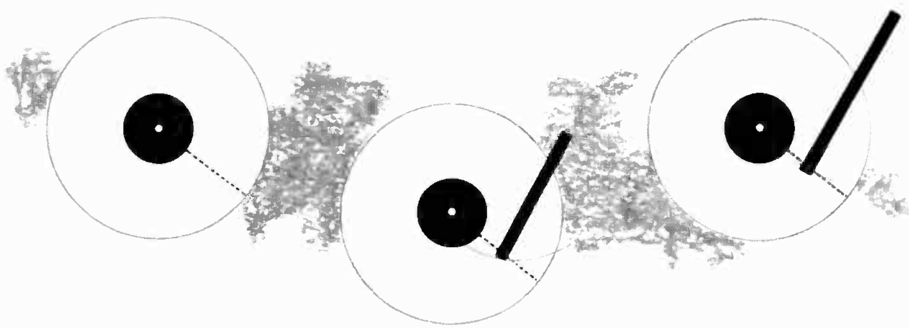
A turntable does not become a record player until you add a tone arm, which must be separately purchased and mounted. Like the custom turntable, the separate tone arm solves a multitude of problems.

You will recall that the cutting stylus rides across the record on a bar from circumference to 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, making a curved rather than a straight track across the record. In a really bad tone arm, the playback stylus will sometimes be off as much as 10 or 15 degrees. The message of the wiggles is distorted, and the record wears unevenly and more quickly, as does the pickup itself. This is known, ominously, as "tracking error."

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.)

Although many hi-fi authorities will still insist on the long arm (which requires a very large installation space), a recent tracking-error test came up with the tiny Ferranti arm as the most accurate tracker in the business. The new Burne-Jones arm, another British import, is really two arms attached to a single pickup and swinging separately so that the pickup is always aligned with the groove. As this was written, no commercial B-J could be found to work properly. One or another of the four bearings at the ends of the arms was too stiff, and the stylus kept sticking in the same groove. Check on developments in this arm before buying.

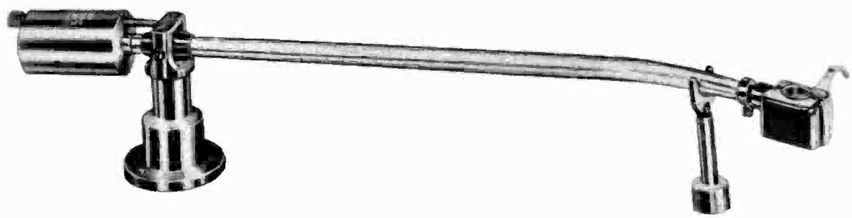


Here's what causes tracking error. At left, cutting stylus travels across record on a bar, making straight line. Center, short tone arm traces a wide arc, holding stylus at wrong angle to groove. Longer arm improves arc

tracking weight

The vertical pressure of the playback stylus on the record will be a key factor in both stylus and record wear, and the various tone arms employ various methods to get the right "tracking weight." Some use springs at the rear end of the arm. In some the nonbusiness end will extend some distance beyond the pivot, counterbalancing the weight of the rest of the arm and the pickup. This means bigger installation space. The GE Baton arm ($32) features a head attached to the arm itself by a swivel. A moveable counterweight balances the head.

Most pickups are made to respond best at a tracking weight of six to eight grams, but the pickups themselves are not all the same weight. The viscous-damped Gray 108-B ($56) adjusts any pickup to six or eight grams of vertical pressure. The GE balancing bar is calibrated and has a moving screw, giving a choice of tracking weights. Both the spring and the counterbalanced arms often have some mechanism by which the tracking weight of the stylus can be increased or decreased. But none of these measurements will do you much good unless you know the actual weight of the pickup you are using and the weight of the pickup for which this particular arm was designed. You can measure the final vertical pressure of any arm and pickup on any one of a dozen gauges—preferably the Audak ($4), which is most accurate because it is a balance, with replaceable weights, and has no springs. But even an accurate measurement (which should be made, with all arms) does not tell you what will happen on warped records.

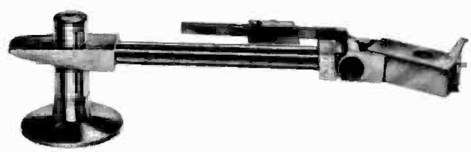


Electro-Sonic tone arm, made to be used with the same manufacturer's pickup, is one of the longest in the stores. Tracking weight is adjusted by means of a spring balance in the cylinder at the rear

tone arms for warped records

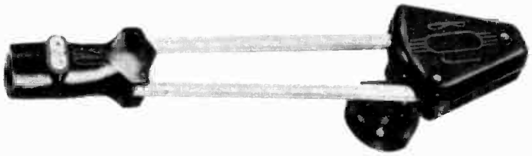
If many of your records are warped, certain precautions are indicated. In general, the lower the mass of the arm-and-cartridge assembly which has to take the jouncing from a warped disc, the better the results. The GE Baton arm ($32) and the Pickering ($31.50) have heads which swing freely up and down on their own pivots, and thus meet the problem ideally (the Pickering's vertical swing is limited). The short, lightweight Ferranti and Weathers arms are also engineered to operate well on a warped disc.

Right: Clever pivot for the business end of the arm eliminates arm resonance and allows very precise weight adjustment in this GE



Left: Ferranti, smallest arm, had least tracking error in laboratory test, proving value of careful design. It holds Ferranti pickup only

Above: The Livingston, simplest and least expensive of all tone arms, is highly recommended for all installations on a budget



B-J arm, a British invention, is light, made entirely of plastic. Two separate arms hold the triangular head, pivot independently to assure correct tracking. Early models are stiff

matching arm to pickup

The functioning of the pickup, however, is more important than the perfection of the arm. Most pickups operate best in arms made by the same manufacturer. In some cases no other arm will do. The Ferranti and the Weathers will scarcely work at all in another maker's arm. The Audak, which is very heavy, and the Pickering, which is rather fragile, are best installed in the arms specifically designed to hold them. With the GE and Fairchild pickups you have a choice of arms, because these are the most popular in the business and every arm is more or less prepared to hold them. And with those pickups which do not have matching arms you are, of course, on your own.

For those who want to buy an arm independent of any other component in their system, the Livingston ($13) is not notably inferior to other arms and is a good deal less expensive. Swanky installations may be happiest with the viscous-damped Gray, because few sights in the hi-fi business are so inspiring to your friends as that of the Gray being lifted up and casually dropped, falling oh-so-gently onto its bed of ooze.

Shorter than the same company's 202, but still very large, the Fairchild 280 and 281 models are neat and simple, eliminate the need for an arm rest

I

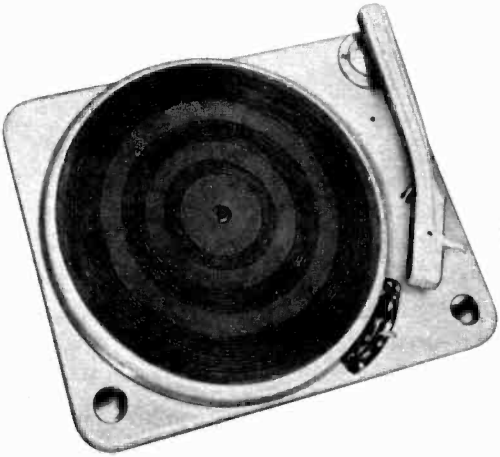
MANUAL PLAYERS

The cheapest recommended turntable and the cheapest separate arm will cost you, between them, about $70. For half this money you can buy the German-made Miraphon record player, with an excellent four-pole motor, a solid turntable and a very decent arm. It will not track quite so well as the separate arms, and the turntable is not so well weighted for the avoidance of wow and flutter. But you'll have to be pretty good to catch the difference, and the price is right. For a few dollars less you can buy the Garrard Model T or the Collaro manual player. For no reason anybody can figure out, however, the manual players made by these companies have not been nearly so satisfactory as their record changers.

Miraphon record player, from West Germany, provides an extremely inexpensive answer to the problem of turning the record and holding the pickup

More luxurious turntable-and-arm combinations include the Bogen B50-4 (about $40) with the Lenco Swiss continuously variable speed control and a turntable 11¾ inches in diameter. The all-Swiss Thorens, using the same driving mechanism and governor as on the separate turntable, presents a variety of models from $53 to $68. The turntable here is cast iron rather than cast aluminum, which disturbs some magnetic pickups (especially the Pickering and Fairchild).

If you want this unit and a Pickering or Fairchild, Thorens will sell you (for $7.50) a nonmagnetic brass turntable to replace the standard issue. This player demonstrates the flexibility of hi-fi as a whole. It comes with a push-button control system that picks up the tone arm and puts it down on the record (never touched by human hands), then picks it up again at the end and returns it to the *off* position, like a record changer. And it also comes (for $49) without any tone arm at all, but with holes drilled in the right place for installation of the GE Baton arm. This latter arrangement, however, is not recommended. For only four dollars more you can buy the Thorens transcription turntable, which is cast aluminum and more carefully machined, and drill into your own mounting board the four holes which the GE requires—and you'll have a considerably better player.



Manufactured in Switzerland for Bogen, this Lenco player gives continuously variable speed from 29 to 86 revolutions per minute

Thorens luxury player has push-button control of tone arm, and governor system identical to that on the same company's E-53 turntable

CHANGERS

If you have a large quantity of 78-rpm or 45-rpm records, you will probably want a record changer. Getting up to change records every four to six minutes is unquestionably a nuisance, and it diminishes the pleasure of a phonograph. Since the argument for high fidelity is an increase in pleasure, there is no practical sense to the purist argument which rules out the record changer from all high-fidelity installations.

No practical sense to it, but sound theoretical reasons behind it. Neither of the authors of this book is a hi-fi purist, and both of us have considerable collections of old 78-rpm records. But we both have given up the comfortable record changer.

The reasons are best summarized. The motor of a turntable has one job, turning the table. The motor of a changer must also work, through intricate gears, to lift and move a tone arm out of harm's way and to push records one on top of the other. It does its basic job less efficiently because it has too many other things to do. The tone arm of a separate installation merely holds the stylus on the groove, and swings in as the record plays. The tone arm of a record changer must also trip a mechanism which starts the changing cycle. As it leans against this switch, toward the end of a record, it drags the stylus against the outside edge of the grooves, distorting the eventual sound and (more serious) wearing out the shorter grooves which tend to wear more quickly, anyway.

Since record changers do not have heavily weighted turntables, they lack the flywheel effect which makes for constant speed on precision instruments. The turntables are rarely a full 12 inches in diameter. This means that the vinylite record sags slightly as the stylus plays its outer area—and the stylus wears more heavily against the outside of the groove.

Pickups are made to perform most accurately when the stylus is directly perpendicular to the flat record. A tone arm can be adjusted to hold the stylus in this position if there is to be exactly one record on the turntable. A changer, however, plays stacks of records, and the tone arm will hold the stylus perpendicular to only one of the records. The stack problem has other aspects, too. It increases the weight of the turntable which the motor is turning, and the turntable is likely to run slow as the stack builds up. Moreover, it never did any record any good to be dropped, and then to be gripped in the grooves of another record.

Nevertheless, except in the very best systems (which will pick up the changer's characteristic low-frequency rumble) the record changer is an adequate way of playing records. Those with an all-LP collection will not want it (the man who is too lazy to change records every 25 minutes is too lazy to live), but others are likely to find that its convenience outweighs its defects. It is by no means uncommon for a hi-fi family to own *both* a changer and a precision turntable. The former accompanies Madame's housework with continuous music; the latter is for more serious and attentive listening.

Record changers come in all varieties. The ultra-fancy kind, which turns records over, has not been made for hi-fi use—it takes a special and pretty poor cartridge. But the Thorens CD43 is eminently hi-fi goods, and (at $94) pretty luxurious, too. It has the same direct drive and governor motor system as the Thorens transcription turntable, and a highly complicated rim-push changer system that intermixes sevens, 10's and 12's. You can make a record repeat, or you can introduce pauses between records by turning a button which slows the changing cycle, and the machine shuts itself off after the last record. You can also handle the tone arm manually without upsetting the whole instrument.

One class down are the Miracord XA-100 (a German import at $68) and the Garrard RC-90 (also $68). Both of these are rim drive and are rim push for

Newest of the changer designs, Miracord "magic wand" features a pause control which allows listener to introduce delay between records

Thorens makes the most elaborate and most expensive high-fidelity record changer, incorporates pause control, speed governor

Garrard RC-90, an improvement in detail over the heavy-duty RC-80 long hi-fi's best seller, allows for manual playing when you want it dropping records. Both will play manually if desired. The Garrard has a control for varying turntable speed around the three basic rpm's. The Miracord is a push-button affair and has a pause control similar to that on the Thorens.

For $20 less you can buy the Garrard RC-80, which for some years has been the best buy in the changer field. It's a pain in the neck to operate, though: if it isn't allowed to operate automatically, on its own cycle, it won't work at all. Manual playing of records is impossible, and you can't lift the tone arm off or set it on in the middle of the record. However, its drive wheel is insulated from the motor by belt-pulleys, which minimizes vibration in the turntable.

In Class 3 are the British-made Collaro ($46) and the Webcor series 1631 (about five dollars less). In these changers the turntable is not so heavy and the motor not quite so noiseless. The new Webcor models are considerably improved over those of four or five years ago. Both changers are easy to use manually, and both now sell big spindles which clip over the regulation spindle to allow automatic changing with 45-rpm records. The Collaro tone arm tracks remarkably well. Webcor also markets a series 1641 changer (same motor and changing mechanism as the 1631, but lighter turntable). At $34, it gives minimum hi-fi.

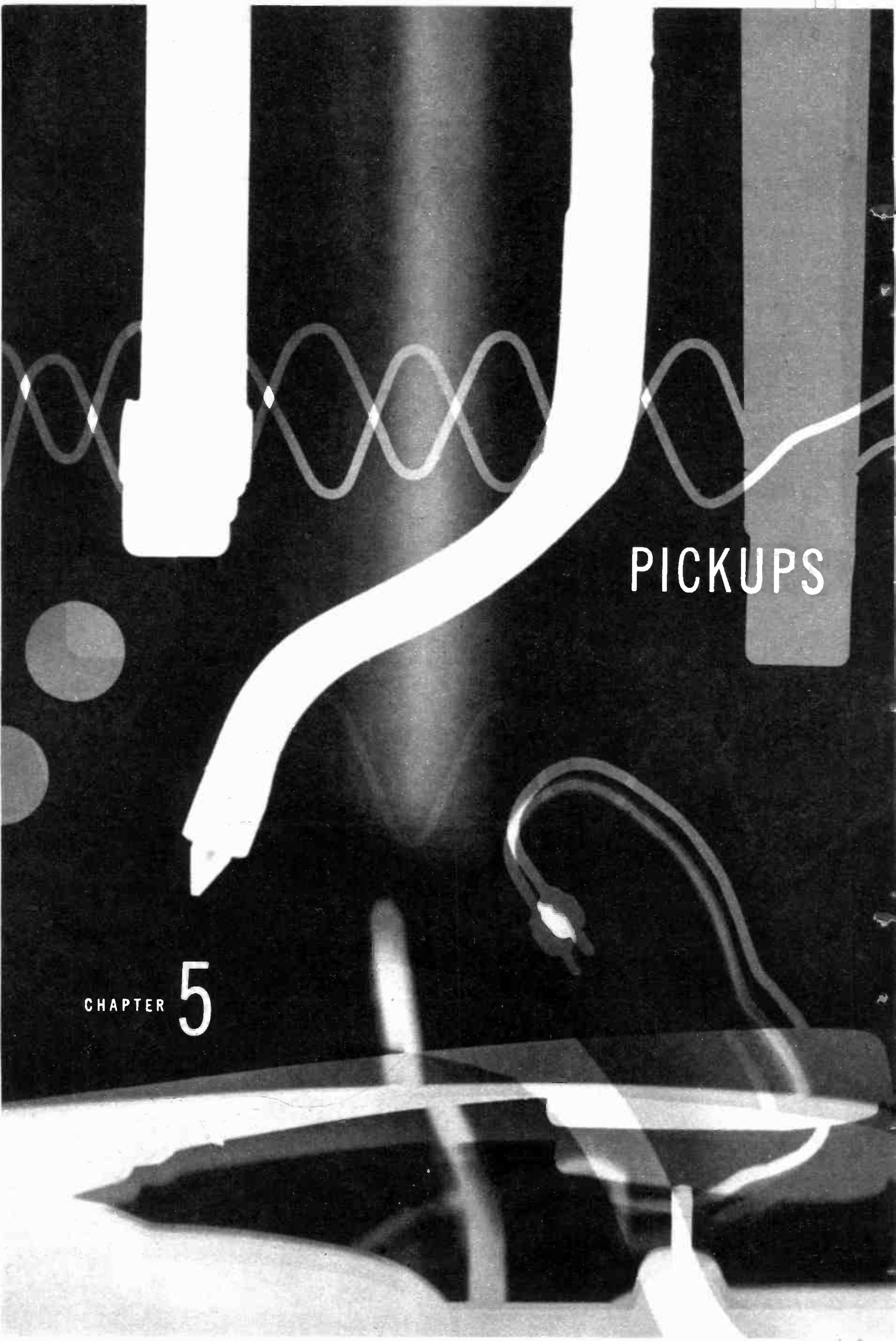
Lesser changers (the domestic or the imported) are not recommended, because they have a center-push system of dropping records. On a modern changer the stack of records to be played always rests on a shelf cut into the bend of a spindle. Rim push means what it says: the disc is pushed from its edge, over the shelf and down. Center-push changing involves a metal fist that punches out from the spindle shelf, knocking the bottom record off and down. This process tends to widen the record's center hole, which must fit neatly over the spindle on the turntable to keep the record turning in a perfect circle. A record that spins eccentrically will produce the same result as an erratic turntable: wow.

RECOMMENDATIONS: Any one of five turntables – the Rek-O-Kut B-12H ($120), the Garrard Model 301 ($87), the Scott ($125), the Sugden Connoisseur ($85) or the Components Corporation ($85) – is recommended for the highest-quality installations. For similar installations on a budget, the recommendation is the Thorens ($60).

Generally speaking, it is wise to buy the tone arm made by the manufacturer of your pickup. Those who own a quantity of warped records will find the GE arm ($32) the most satisfactory. If budgetary considerations are primary, the GE pickup (see Chapter 5) in the Livingston arm ($13) is recommended.

Among complete record players the aristocrats are the Thorens ($53 to $68) and Bogen-Lenco ($40). Budget choice is the Miraphon ($35).

Thorens makes the most de luxe of hi-fi record changers ($94). The Miracord ($68) and Garrard 90 ($68) are almost as elaborate, and are excellent. The Garrard 80 ($49), despite its inconvenience of operation, remains the best buy, in terms of value for money. The Webcor 1641 ($34) is the lowest-priced satisfactory hi-fi changer.



CHAPTER 5

PICKUPS

No matter how expensive your record player, its performance is only as good as the pickup— an ingenious gadget the size of a wristwatch

AND STYLI

The conversion of mechanical motion to electrical energy is one of the fundamental techniques of modern civilization. The water goes into a turbine instead of down the waterfall, and the dynamo makes current. But this is high-voltage, crude, quantity output. The phonograph pickup substitutes tiny motions of a stylus for the ferocious rush of water, puts out as little as *three or four one-thousandths of a volt* in electric current and must set up in that tiny current patterns which correspond exactly to the wavings of the wiggle on a record.

A pickup is considerably smaller than a man's pocket watch and must be machined to nearly the same standards of tolerance. For the pickup presents an absolute limit to the accuracy of any phonograph. The best your amplifier and loudspeaker can do is give you exactly what comes out of your pickup. And any distortion in the output of the pickup will be magnified a million times before the amplifier is through with it.

Most pickups are relatively distortion-free in their creation of an electric signal, but nearly all of them have some mechanical trouble. The pickup must hold the stylus tightly enough to make it stay in the groove even when it is jolted hard by 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.

I

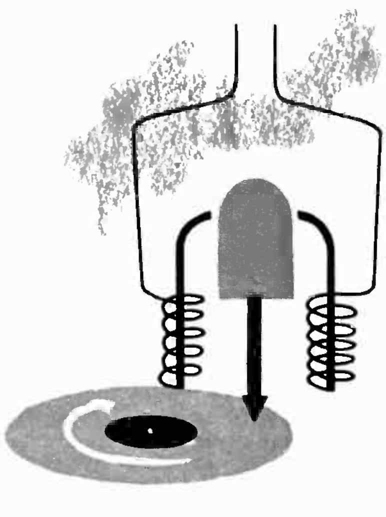
PICKUPS: THE FOUR BASIC TYPES

Pickups embody various mechanical designs, and use different means of translating stylus motion into electrical energy. The four basic methods are called "magnetic," "dynamic," "piezo-electric" and "capacitance." The first two work by a "constant velocity" response, which means that the power of the signal created depends on the speed with which the needle whips around the wiggles. This is the exact reverse of the process by which the cutting head and stylus cut the record. Piezo-electric (crystal and ceramic) pickups and capacitance pickups have a "constant amplitude" response. This means that the power of the signal depends on the width of the wiggle from its crest to its trough, the degree to which the stylus is displaced from its center or rest position. Neither method is necessarily superior to the other, but the fact is that a majority of the satisfactory high-fidelity pickups are constant velocity—magnetic or dynamic.

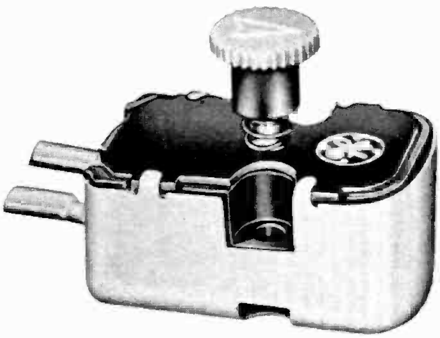
magnetic pickups

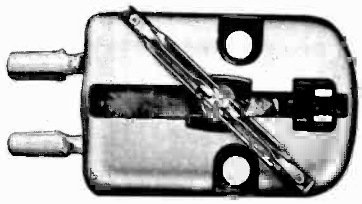
The most popular magnetic pickup made—also one of the best and one of the cheapest—is the General Electric "variable reluctance" cartridge, in which the stylus is set in the end of a cantilever spring connected at its other end to a small permanent magnet. The stylus end vibrates between two iron pole 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 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 voltage is led off to your preamplifier and emerges from the loudspeaker as musical sound.

Early GE cantilever stylus assemblies were too massive to transmit very-high-frequency vibrations. New GE stylus assemblies, which fit the old cartridges,

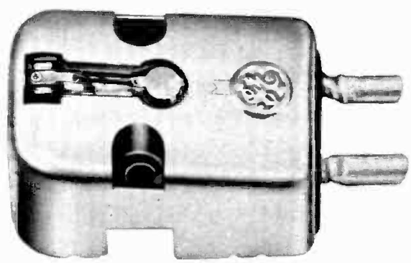


Here's a simple schematic of a magnetic pickup. The wires from the coils in which the current is induced lead directly to necessary preamplifier





GE Triple Play is the most popular magnetic pickup. The same magnet services two separate stylus assemblies. The knob lets you swing one or the other into play



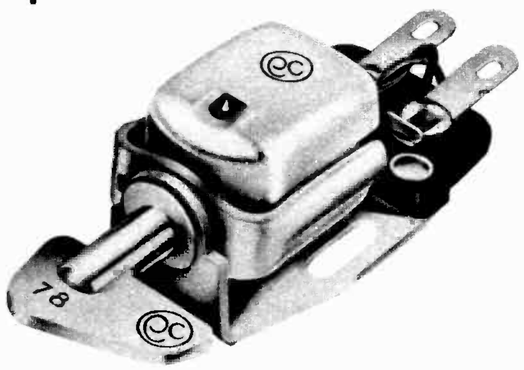
This is GE single cartridge. Note pole pieces to either side of the stylus, and flexible bar running to magnet

solve the problem. Extraneous vibrations of the stylus and the lever are damped pretty effectively by tiny elastic binding blocks.

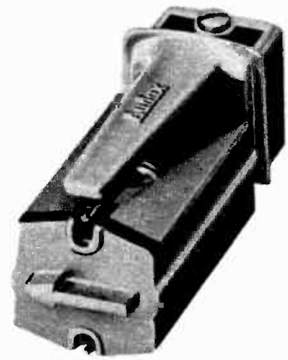
The GE comes equipped with one stylus (for 78 *or* microgroove) or two styli (one for each type of record) in a single cartridge. Anyone can take out the old stylus and put in a new one on the GE pickup, and the new two-stylus assembly is made in such a way that either stylus can be replaced separately. The price is satisfyingly low—$6 with a sapphire or $20 with a diamond stylus for the single-play models, $23 for the triple-play with diamond microgroove and sapphire 78 stylus, $34 with diamonds all around. And maintenance is simple—just clean away the dust that gathers in the gap around the stylus.

Another variable-reluctance magnetic pickup is the Pickering, in which the stylus is directly attached to a light steel tube and nothing else moves. Around the tube is positioned a coil of wire, and the works sits within a magnetic field. Magnetic lines of force will go through air if they have to, but they would rather go through steel. The side-to-side motions of the tube, corresponding to the recorded wiggles, change the patterns of the lines of force—and the wire coil puts out a tiny current. Unwanted vibrations are damped by a silicone grease rather than by rubber blocks as in the GE. However, this grease may pack away from the stylus bar, which can be a nuisance.

When the stylus wore out on Pickerings made before 1956, the pickup had



Most expensive of the magnetics, the viscous-damped Pickering comes in double mountings (as shown) or single cartridges



Audak costs more than GE, gives higher output, has stylus bar of harder metal. It's available in triple-play models only

to be returned to the manufacturer, who installed a new stylus. This had obvious disadvantages in the time lost, but a considerable advantage in that the cartridge would be inspected and if necessary repaired. The newest Pickerings have detachable styli. Model for model, the Pickering costs about twice as much as the GE—$38, with diamond, for LP alone; $60 with a double diamond.

Somewhere between the GE and the Pickering falls the Audak, third of the Big Three magnetic pickups, and very similar in principle to the GE. Main difference: The GE's cantilever stylus bar is made of soft metal, and sometimes bends and lodges against one pole piece; the Audak stylus bar is made of tempered metal, proof against this. Audak also has the highest output of any magnetic cartridge, and it is about the sturdiest—nothing ever happens to it. But it is unusually heavy, and you must counterweight the arm in which you use it unless you buy the Audak arm. This pickup is not made in a single-play model. Rou must buy a turnover, with separate 78 and microgroove styli, even if you don't own a single 78-rpm record. When a stylus wears out you can change it by yourself and need not send the cartridge back to the factory. Prices range from $20 for a double sapphire to $56 for a double diamond.

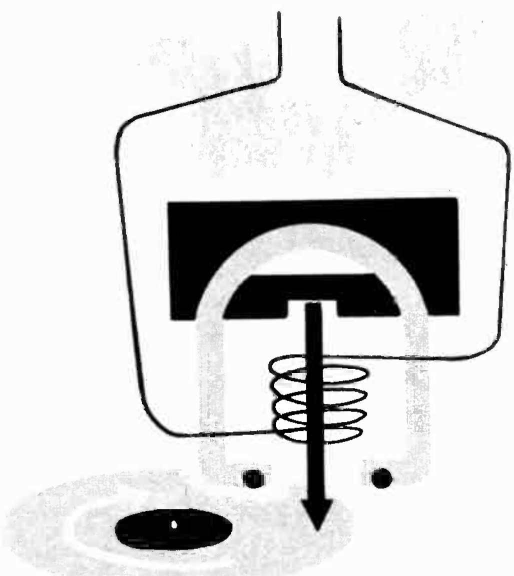
dynamic pickups

In magnetic pickups the voltage which corresponds to the motion of the stylus is induced in a stationary coil by a "moving iron" element. In dynamic pickups the coil itself moves. Generally speaking, this design produces an even smaller voltage than the variable-reluctance magnetic design. Thus dynamic pickups give extremely low output and require either a top-quality preamplifier or a separate booster transformer.

The most popular of them is the Fairchild, in which the wire coil is wound directly onto the duralumin bar that holds the stylus. It is an extremely accurate pickup, and the least fragile of the low-output dynamics. Fairchild makes only single-play cartridges, which means that you must buy two if you have both microgroove and 78-rpm records. Two Fairchilds cost $75 (with diamond styli). The cartridge must be returned to the factory for stylus replacement.

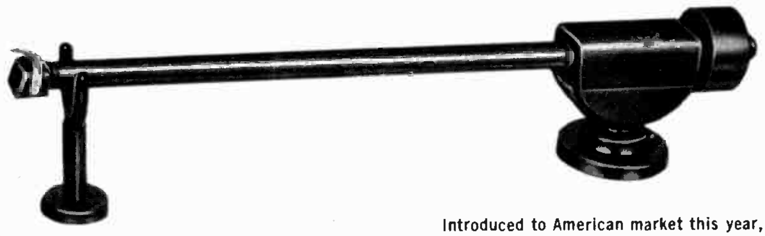
About the only disadvantage of the Fairchild (except for its price) is that the magnetic field extends some distance beyond the cartridge itself. If your record player has an iron turntable, the magnetic pull will increase the effective tracking weight of the stylus, speeding up both record wear and stylus wear. Most people who want to spend $75 for their pickups will also want to spend the necessary money for a machined-aluminum custom turntable. For those who use this pickup with a record changer, however, Fairchild makes a pad which sits on the turntable and keeps the cartridge safely away from the pull of the steel turntable.

Many experts feel that the new Electro-Sonic Laboratories cartridge, especially in its imported Danish version (the American model is built to a Danish pattern) is or ought to be inherently the cleanest dynamic pickup, perhaps because of the appealing logic of its design. It is, however, extremely expensive (up to $100 for a single-play cartridge and balanced arm; no dual-stylus model is made), and terribly temperamental about working conditions. Some samples have shown a serious resonant peak (an increased output not called for by the record) in the region of 12,000 to 13,000 cycles. Like all pickups using magnets it gathers dust, and cleaning it requires elementary knowledge of mechanics. In short, the ESL

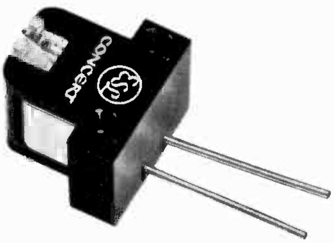


Above is schematic of dynamic pickup. As the stylus swings back and forth between the magnetic poles, the moving coil feeds out an alternating current

Below: Fairchild is most popular, sturdiest dynamic pickup. Its output is very low, requiring an excellent preamp or a step-up transformer



Introduced to American market this year, the Leak moving-coil pickup with matching arm comes highly recommended by English audiophiles



Electro-Sonic pickup is made in America according to extremely logical designs by Danish engineers. It is excellent but fragile

(as it is affectionately known in the catalogues) is for hobbyists and specialists rather than the average listener. Even here, it is seriously challenged now by the splendid British Leak (about $65 with arm), which knowledgeable people say measures "flatter" than any other pickup. But it has almost no vertical compliance —which means that it won't play warped records (neither will the Ferranti, which we shall come to in a moment).

All the other magnetic pickups on the American market at this writing suffer from gremlins of one sort or another. The Recoton, which sells at a price competitive with the GE, is sometimes good, sometimes bad, depending on the particular unit you buy. A recent report in a consumer's magazine rated it the best pickup made. But check carefully before you buy one. The British-made Ferranti is brilliant in design. But the damping is viscous (that is, grease), and the grease is not homogeneous. Sometimes it separates, leaving the stylus bar quivering unrestrained in thin "soup." A gifted amateur can dissect a Pickering at home and stir its damping grease back into place. But anyone who can do this to a Ferranti has missed his calling—he belongs on the staff of the Mayo Clinic.

piezo-electric pickups

Crystal and ceramic pickups operate on an entirely different principle, first discovered by an Italian scientist named Piezo. His experiments showed that a crystal made of Rochelle salts would bend without breaking, and 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 (a synthetic crystal). Its side-to-side swing bends the crystal, and the result is a fairly sizable electric signal.

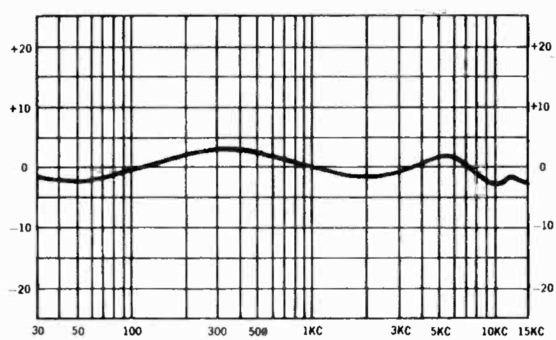
The piezo-electric pickup has certain advantages over the magnetic. It gives off a much larger voltage, which means that it can be used without a preamplifier. Moreover, any extraneous noises that enter the system through the pickup will be far less important, because the intrinsic musical sounds are coming through with six to seven times the strength they would receive from a magnetic cartridge.

The induction coil that makes the electrical signal in the magnetic pickup may in its wanderings come within the field of the turntable motor and transmit a dose of 60-cycle hum, while the piezo-electric pickup is impervious to stray magnetism. Finally, the magnetic is unsatisfactory in moist climates, because condensation forms between the poles of the magnet, eventually corroding the guts of the pick-up, while the ceramic (not the crystal) is impervious to weather.

Nevertheless, 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 piezo-electric pickup must bend a crystal. A baseball which hits a heavy wire screen at 60 miles an hour may dent the screen; a locomotive which hits the screen at that speed will go right through it. In every pickup, the stylus moves at the same speed. If it is to do more work, it must have greater mass.

The greater the effective mass of the stylus, the less responsive it will be to the back-and-forth push given by the moving wiggle on the phonograph record. It will have greater inertia, greater tendency to keep traveling in whatever direction it has been pushed. The strong low-frequency pushes, therefore, will tend to drive the stylus right out of the groove. Keeping the stylus in the groove will demand more stiffness inside the pickup, more resistance to the free motion of the stylus. Most piezo-electric pickups are therefore inaccurate at the lower frequencies.

And the piezo-electric pickup is a constant-*amplitude* device. The electric signal is caused by the bending of a crystal: the greater the degree of bending, the greater the signal. Records are cut, however, by a constant-*velocity* cutter,



Records are cut with treble boost and bass de-emphasis—a line running up on the graph from left to right. Sonotone pickup equalizes by constant-amplitude response, to produce almost level response line, as shown

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which makes the strength of the recorded signal proportionate to the speed with which the stylus whips around the wiggles. Low-frequency signals become wiggles of considerable amplitude, and high-frequency signals wiggles of infinitesimal amplitude.

Thus the piezo-electric pickup distorts the recorded signal by giving a loud voltage to the low-frequency notes and a soft voltage to the high-frequency notes. Moreover, there may come a time, at very high frequencies, when the amplitude of the wiggle is not sufficient to make the crystal bend, and the piezo-electric pickup will not respond at all.

None of this is quite as bad as it looks. As explained previously, high-frequency signals are boosted when records are made, to mask surface noise; low-frequency signals are attenuated, so that grooves can be kept narrow and lots of grooves cut into a single disc. The piezo-electric pickup, in boosting the bass signals and diminishing the treble signals, acts to equalize the distortion built into the phonograph record. While it will not boost or diminish on a curve that exactly matches the "recording characteristic" of the record, it will do a fair-enough job. And by eliminating the equalizer as well as the preamplifier, it enables a big cost corner to be snipped off.

No piezo-electric pickup yet produced commercially will respond throughout the audible range, but a few of the new designs fit the stylus so closely into the ceramic that an electric signal will be produced by wiggles as narrow as 14,000 cycles. From 14,000 cps to 17,000 cps, which is the utter limit of normal hearing, represents a range of less than two whole tones in the musical scale, so a pickup which responds to 14,000 cps is quite adequate even for very high fidelity.

The lack of good quality control is a more serious objection. It is not possible for a manufacturer to maintain a given quality throughout a large production of piezo-electric pickups. Unlike small permanent magnets and coils of copper wire, which are mass-produced for a number of purposes and are standardized to very close limits of tolerance, chemical-electrical crystals and ceramics vary from batch to batch. No manufacturer has yet been able to establish a response characteristic that will hold true for every one of his pickups.

One piezo-electric pickup is made for installation in a full high-fidelity rig: the Electro-Voice Ultra-Linear. This cartridge can be purchased with a special transformer which decreases its power to the point where it can safely be plugged into a preamplifier. Electro-Voice also sells an equalizer, which enables the customer to adjust his playback curves to the recording characteristics of the various record companies. There is nothing particularly wrong with this pickup, except that it costs more than the GE, and except in climates where a magnetic pickup is risky it is not superior to the GE.

Among all the other piezo-electric pickups, the experts have good words only for some Asiatic crystals, the Sonotone, the British-made Collaro and the Dutch-designed Ronette ceramics. These would be adequate for low-cost hi-fi machines, except that even the minimum hi-fi amplifiers now include preamplifiers and are built for use with magnetic pickups. Most of the straight amplifiers presently on the market do not even have an on-off switch, let alone such refinements as a volume control. They are meant to be used only with a separate preamplifier control unit.

So the crystal or ceramic cartridge fades away as a possible buy for anyone building a set from individual components. Where it is still important is in the packaged machine, usually portable or table-top, which uses the stronger voltages from the piezo-electric pickup to sidestep the expense of a preamplier, and thus gives value for money in the $125-$175 price range. Anything that costs more than $175 should give some choice of equalization for the different brands and kinds of records that a phonograph will play.

capacitance or FM pickups

The less work the stylus must do, the more accurate the pickup can be. In magnetic, dynamic and piezo-electric pickups the electric signal is generated by the motion of the stylus itself. Even with the most careful engineering a vertical pressure of four to eight grams is necessary to make such pickups work properly, and the moving mass of the stylus must remain a measurable quantity. If you could design a pickup, though, in which the signal voltage was already there, and the motion of the stylus would merely modify it, then . . .

Then you would approach the perfect pickup. Literally hundreds of patent applications have been filed on such designs, and a few such pickups have actually been manufactured. The most successful of them is the Weathers, which is called a "capacitance" pickup because engineers enjoy using such words, or an "FM" pickup because it works on a system somewhat similar to FM broadcasting.

Briefly, the works of the Weathers pickup consist of a fixed metal plate, onto which is fed a very rapidly oscillating charge, and a free-floating 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

Lightweight Weathers has built-in record brush, lessens wear on both record and stylus. Exceedingly delicate, it tends toward IM distortion unless handled with extreme care

record, it causes the floating 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 Weathers pickup cannot be bought alone. You also need the Weathers box with the oscillator which feeds the unmodulated and detects the modulated current, the way a radio tuner detects an FM radio broadcast. The combination costs $40 with a sapphire or $55 with a diamond stylus. Since the Weathers will not operate properly in any tone arm but its own, you had better add $15 for the arm and buy the package.

This package is expensive, but Weathers offers it also in combination with other elements of a record player, and in combination it is a bargain. The "Debonair" unit comes completely mounted with oscillator, turntable and pre-

Weathers K-700 has complete player, pickup, preamp, all for $125. Low tracking weight of Weathers permits turntable with a raised center. Only the label touches a dusty surface

amplifier—decent turntable and good preamplifier—for only $125. The same mounting, with oscillator but without preamplifier, costs $83. The 12-inch arm, with pickup, oscillator and preamplifier (no turntable, no cabinet) runs $77, and can be set up with the turntable of your choice. All these prices are with sapphire stylus; with diamond stylus, prices are about $15 more. A turnover cartridge, with separate styli for 78 and microgroove, runs about $7 more than the single-stylus models for sapphire, $22 more for diamonds.

The advantages of the Weathers are numerous. Since it tracks at a pressure of only one gram, it wears both records and styli much more slowly than any other pickup. A stylus will last about 20 times its normal life in a Weathers pickup. The moving mass of the stylus has been reduced to the point where it is scarcely measurable, which means that the frequency response is practically unlimited: the Weathers has tested out to 30,000 cycles. Because the vertical pressure is so low, the record can safely be played while resting on a center cushion no wider than the label. The grooves never touch the turntable, and thus they pick up much less surface dust.

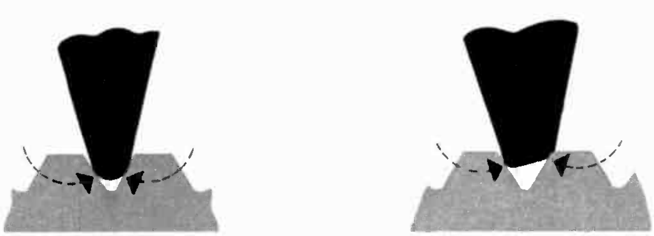
But all this is balanced, in most households, by the Weathers' one overwhelming disability: it is disgustingly fragile. A cross look can give it a case of intermodulation distortion. It must be fixed in place and left alone, and it is not recommended for any household in which more than one person has access to the phonograph. For bachelors, or people with unnaturally good control over the spouse and children, the Weathers is excellent. For others, it is just too dainty.

STYLI

The Weathers pickup can be purchased with any of five styli: a 78 diamond or sapphire, a microgroove diamond or sapphire, or a "truncated" sapphire which will play all kinds of records. Because of its exceedingly low tracking weight, the Weathers can use an all-purpose needle without ruining records. No other pickup today can make this claim. Many of the cheap crystal pickups come with a single all-purpose stylus, but they invariably chew up both vinylite and shellac records in a very few playings.

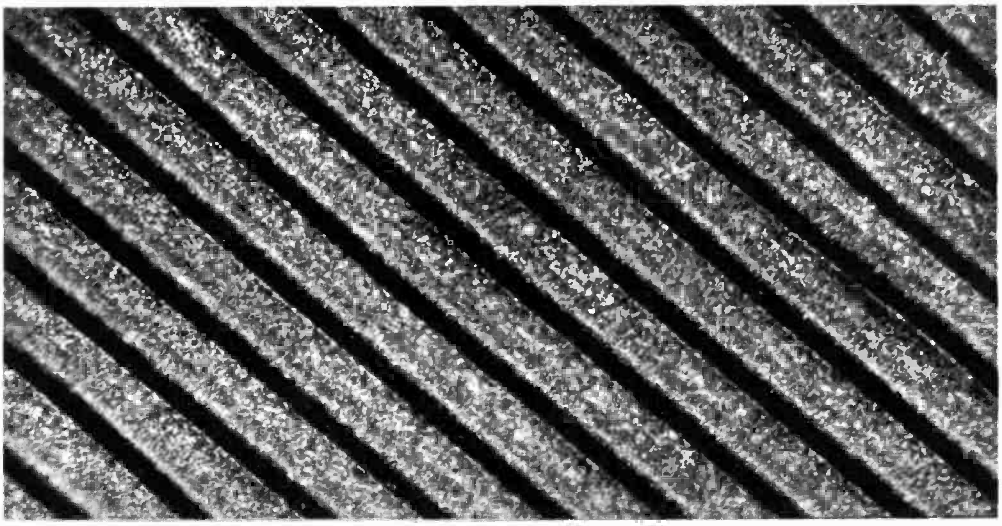
A new and correctly shaped stylus will ride in the grooves of a record with its weight on two points at the sides of the groove. As the stylus wears, it will develop "flats" at these two points. Now a 10,000-cycle wiggle, halfway through a long-playing record, has a length of about .001 inch. If the flat on the stylus has a length of .001 inch, the stylus will simply ignore the 10,000-cycle wiggle. A worn stylus will therefore cut the frequency response of the phonograph, regardless of the spanking-new expensiveness of every other element in the system.

Worse, it will cut the record. A sharp edge forms at the point where the hemisphere tip of the stylus begins to flatten, and the edge gouges away the wiggles in the record groove. At six grams of vertical pressure the stylus presses on its two resting points with a weight of nearly 26 tons per square inch, and a sharp edge with such a weight behind it will ruin a record very quickly.

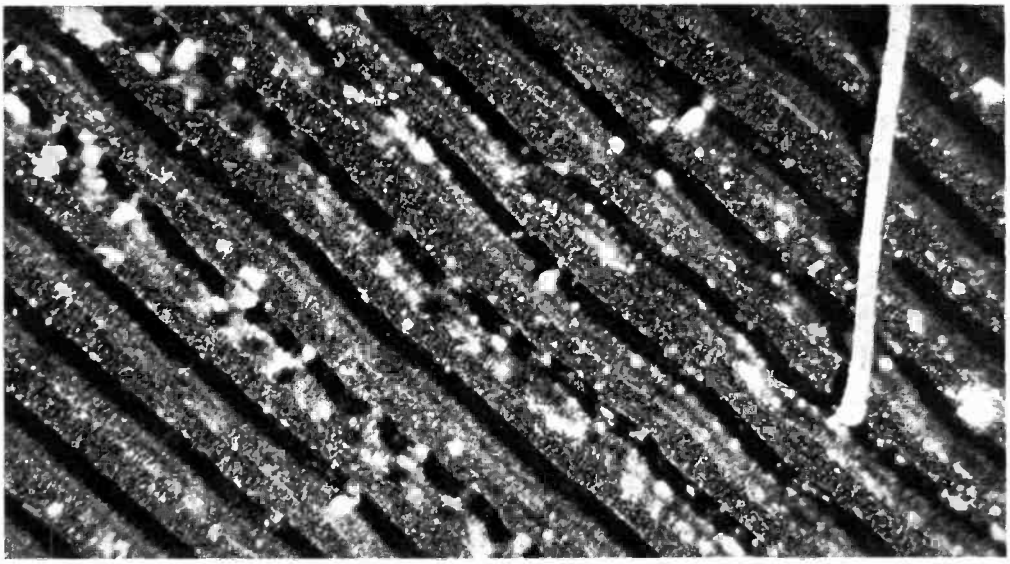


New stylus rides on only two points at its rounded tip. Flats wear on the two points, and eventually the shape of the tip changes. A badly worn stylus will present two chisel-sharp edges to the soft vinylite, hacking away the recorded sound

Tetrad Corp.



Here's a new record, as it appears through a microscope. Grooves seem straight because of the great enlargement necessary to obtain a readable picture of an item that's only .002 inch wide



Here is an old and mistreated record, seen through same microscope. Note the dust on the surface of the grooves, and the chipping away on the walls of high-frequency wiggles

osmium

An osmium stylus, which is standard equipment on crystals and ceramics of the second grade, will develop slight flats after playing only two or three LPs, and may begin to damage vinylite records after as few as 10 playings. (The wider groove of the old 78 does less damage to the stylus and, generally speaking, a 78 stylus will be good for three times as many plays as a microgroove stylus.) Few people are willing to change needles that often, and even if they were the expense would be enormous. No need for it: the sapphire is much cheaper.

sapphire

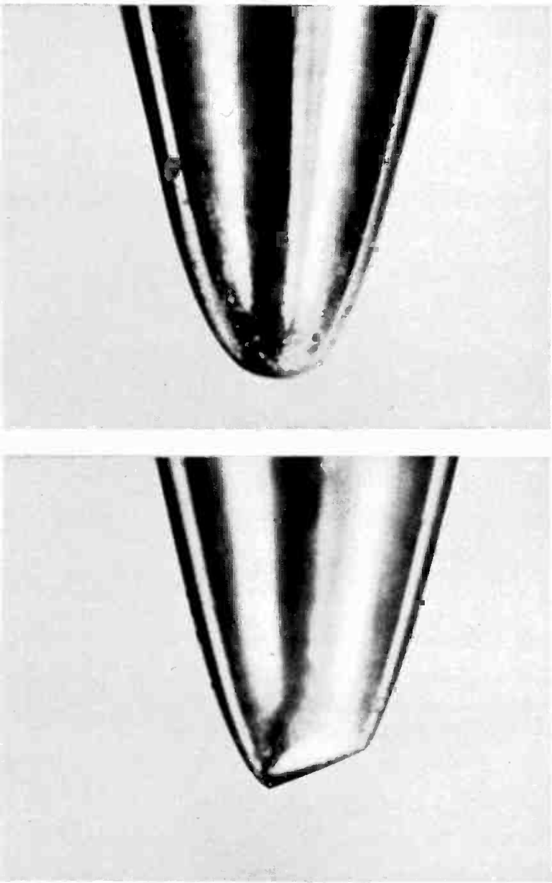
An average sapphire stylus will give about 35 or 40 long plays before it begins to scratch records. With luck, it may go to 75 plays in safe condition. Since an LP plays almost an hour, this is not an insignificant amount of music, and in the average home would mean that the stylus would need to be replaced every two months or so. For most pickups the replacement cost is about $2. Pickups that must be sent to the factory for stylus replacement should not, however, be bought with sapphire styli. The replacement charge is usually somewhat higher.

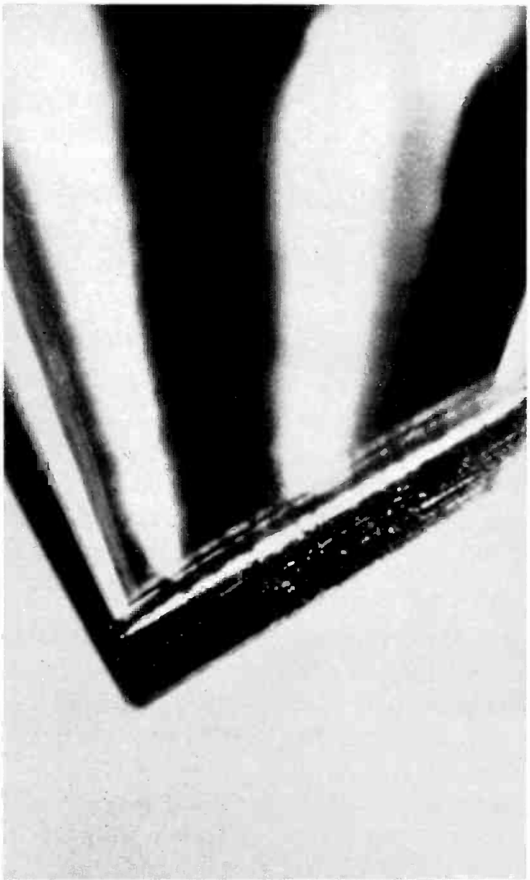
diamond

For LPs the recommendation is always the diamond. The purchase cost of the stylus will run somewhere between $12 and $20, but the diamond will last from eight to 30 times as long as a sapphire, which means that it costs much less over the long run. It also gives you fewer worries about what is happening to your records. A worn stylus will ruin records long before it begins to sound bad, and the man with a sapphire usually loses part of the fun of his phonograph because he is listening for that first sign of wear. A diamond should be good for at least 300 hours, and it may give 1,000 hours of listening before it goes sour. There is a considerable difference between 300 and 1,000, and the man who lives far from the madding crowd may find it difficult to decide when his stylus wants replacement. In most larger cities, however, a record store or hi-fi shop will have a 150-power microscope set up for the purpose of examining styli—and you can see for yourself whether or not the tip is dangerously worn.

buying a stylus

It is dangerous to try cutting corners on the cost of a new stylus. When you buy a stylus you do not buy just a tip, but a complete assembly which is a vital part of your pickup. A "retip" soldered onto the old assembly is likely to change the very delicate balance within the pickup and produce distortion in the final sound. For the more common pickups—notably the GE and the Audak—stylus manufacturers such as Walco and Tetrad produce perfectly good stylus assemblies which will work as well as the manufacturer's own. For other pickups, however, it is advisable to buy the stylus made by the company that makes the cartridge. You have put a lot of money into a phonograph, and the sound of that phonograph depends initially on the accuracy of its pickup. It doesn't pay to save two bucks on a stylus and distort the performance of the machine as a whole.

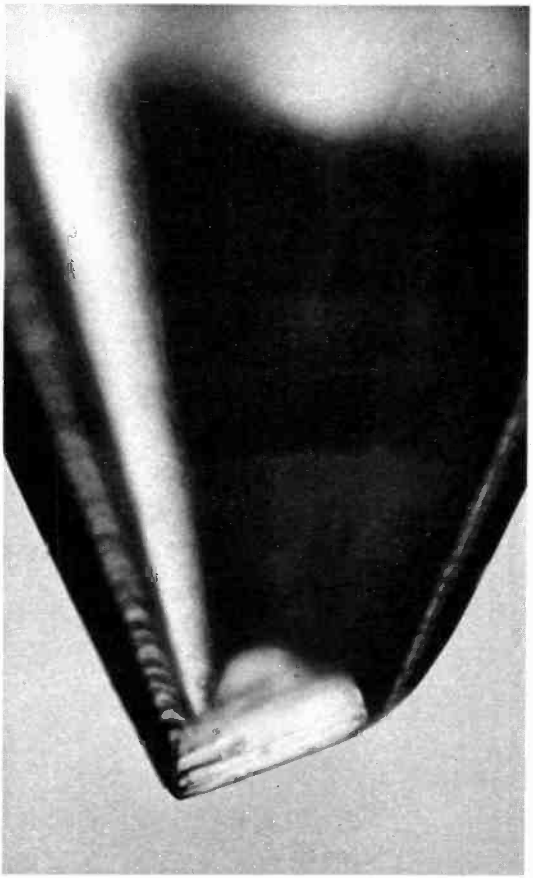




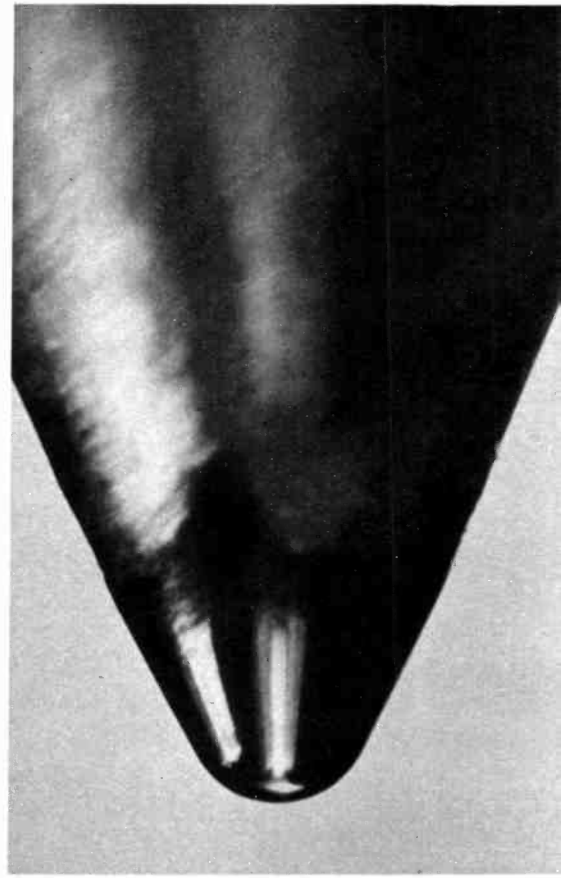
At top is a new steel needle, carefully polished to the correct shape. At bottom is same needle after one play

This osmium needle, shown after 50 hours of use, would cut glass, let alone a substance as soft as vinylite

Tetrad Corp.



Sapphire stylus after 50 hours has lost its
rounded tip and developed first tooth
of its cutting edge. It will now damage records

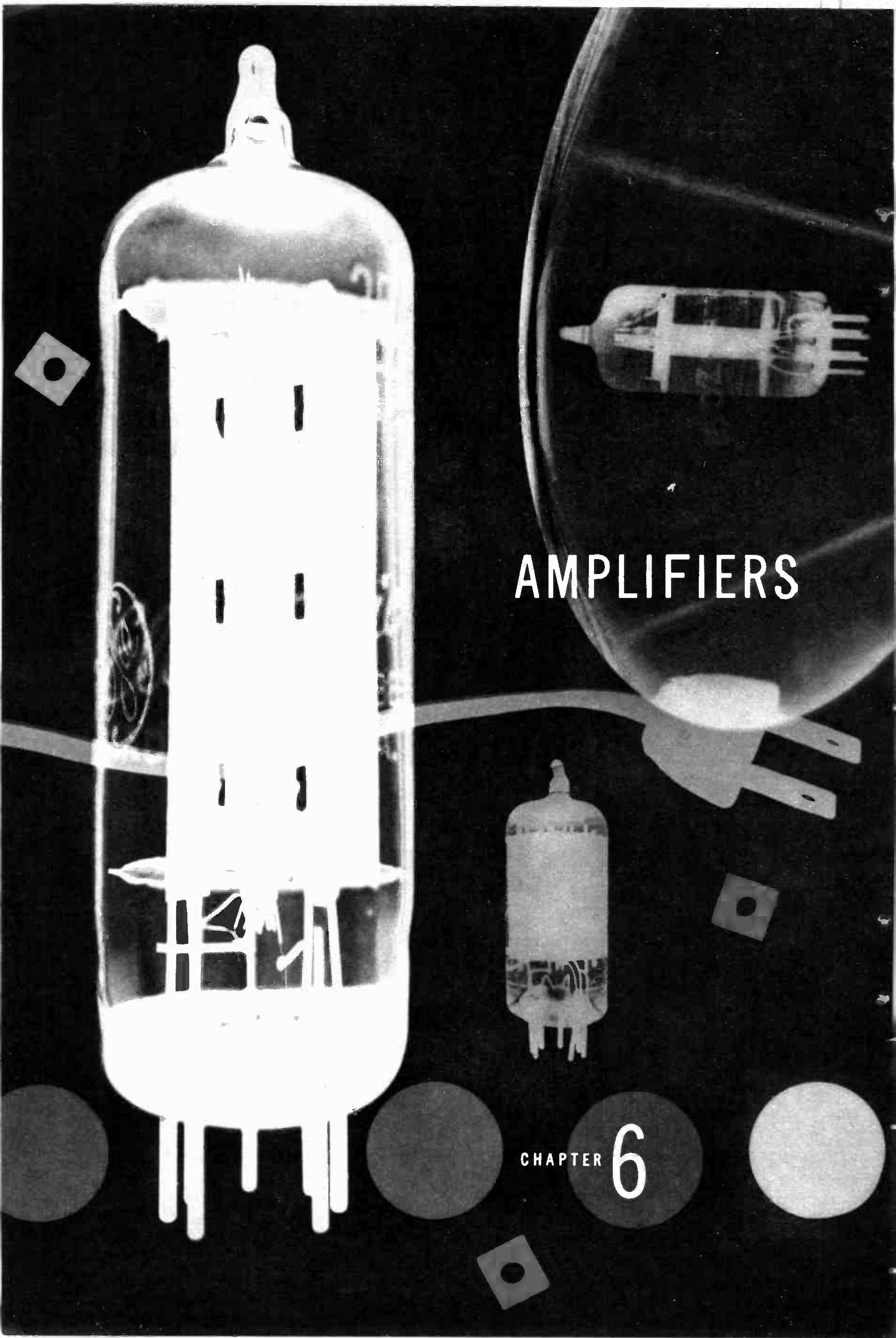


Diamond stylus, after 478 hours of play,
is still correctly shaped, merely
rubbed. This is why diamonds are the best

RECOMMENDATIONS: Among the very highest quality pickups, the Electro-Sonic ($100 with arm) is for hi-fi hobbyists and the Weathers ($55) for bachelors; the Leak ($65 with arm) or Fairchild ($38) for audio purists with a family and without technical accomplishments.

The GE ($20), the Audak ($56 for double diamond stylus) and the Pickering ($38) are recommended for any installation. (All pickup prices except the Audak are for pickups with single diamond stylus.)

Replacement styli for the GE and Audak, the best-selling pickups, can safely be bought from Tetrad or Walco as well as from the makers. For all other pickups, only the pickup maker's styli should be bought.



CHAPTER 6
AMPLIFIERS

This stage is purely electronic—the tiny impulse must be magnified a million times. Engineers have designed equipment that does an almost perfect job

AND PREAMPLIFIERS

There is music in a pickup and, obviously, music in a loudspeaker—but nothing of the sort in an amplifier. Like any sound, music is a physical phenomenon, a vibration in the air. And the phonograph amplifier is a purely electronic device, magnifying and controlling an electric current. Its purpose is to put out an electric signal that is an exact, million-fold enlargement of the signal put into it. No part of the amplifier actually moves, and a properly working amplifier will be as silent as the grave. If you can hear it, there is something wrong.

Physical problems, such as those posed by motion and friction, are basically beyond solution. Pickups and loudspeakers can be designed to minimize the obstacles which nature has placed in the path of their optimum performance, but the obstacles themselves will always exist. Electrical problems, however, can be mapped out on a piece of paper, and the answers can be put into production.

Engineers and hi-fi enthusiasts therefore love to talk about amplifiers—the tiny differences between one brand and another, the trick circuits that will, perhaps, improve on perfection. For anyone who merely wishes to *buy* equipment, though, the talk is largely unprofitable. To buy the amplifier that best meets your own requirements, you need merely answer three simple questions:

1. How much power do you need in your living room?
2. How much flexibility do you want for the future?
3. How good is the rest of your equipment?

I

HOW MUCH POWER?

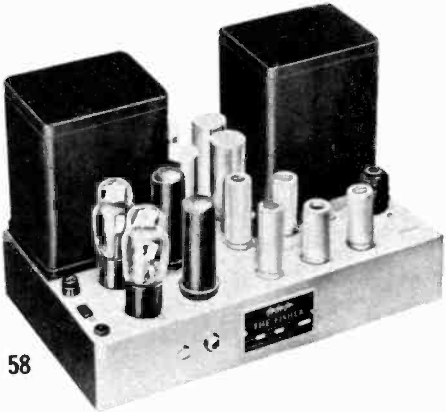
Almost any amplifier will deliver huge jolts of signal strength to a loudspeaker, if called on to exert itself. But the result will sound terrible. All the designing of an amplifier, all the rigging together of tubes and resistors and condensers, is done with a certain maximum power output in mind. A 10-watt amplifier will put out 17 watts to meet a peak in the music, but the 17 watts may arrive with 40% intermodulation distortion, and what you will hear is a shattered blast of noise.

The amount of power you need from your amplifier will depend on the efficiency of your loudspeaker unit (see next chapter) and the size of your room. For the average piece of music, played on an average loudspeaker in an average living room, the amplifier rarely will be called on to deliver more than five watts of power. Considerably less than five watts will be in use during pianissimo passages in, say, a string section—but considerably more when Bach's organ thunders or Verdi shouts on the kettledrums. From the softest to the loudest sound in a symphony may be a difference in intensity on the order of one to 600.

50-watt amplifiers

The customer with a large living room and inefficient speakers may need as much as 50 watts of undistorted power. Without such an amplifier the music will be too soft, with a resulting loss of presence, or loud enough but fuzzy and harsh. There are several amplifiers which are relatively distortion-free at 50 watts. The best-known are the McIntosh ($250), Scott ($200) and 40-watt Fisher ($160). All three are perfectly magnificent, as they should be. Their immense undistorted output will be called into play at extremely rare peaks, but it will guarantee that every blow on the tympani will be crisp, individual and accurate.

Fisher 50-A is a conservative, all-triode design, with pentodes used as triodes in the output stage. It provides 40 watts of undistorted power



Revolutionary McIntosh 65-watt amplifier boasts high-gain pentodes. Inherent distortion is corrected by design factors at every stage

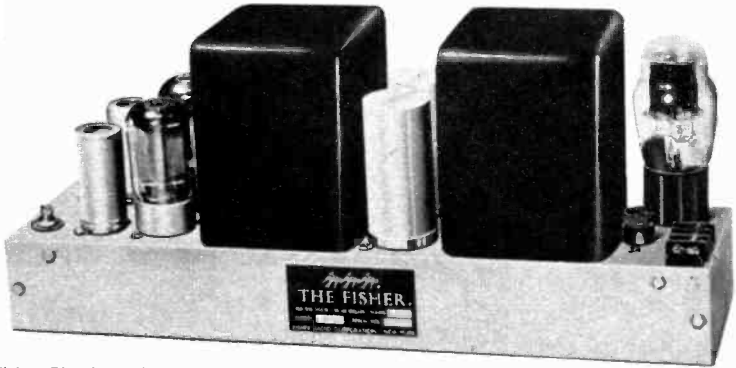
Big Scott 265 rivals heavy-power Fisher
and McIntosh. It provides a "snubber circuit"
to avoid overpowering loudspeaker

30-watt amplifiers

Very few people will require such enormous amplification as 50 watts. All but the most demanding loudspeakers will work as well as you wish on 30 watts of clean power. Most hi-fi experts seem to regard 30 watts as optimum, and as a result there are literally dozens of power amplifiers advertised as 30 watts at 1% harmonic distortion or less. Again the McIntosh is the most expensive, at $144. Almost all the others are within $10 of $100. Here Bogen, Pilot, Electro-Voice, Bell, Regency, Grommes, Stromberg, Interelectronics, Brociner. Newcomb, Pederson and many others join the parade with power amplifiers that are, in operation, virtually indistinguishable from one another.

H. H. Scott 232 power
amplifier squeezes 32 watts of
undistorted power out of
very few stages of amplification,
incorporates separate
level control on chassis

The Grommes 220BA, a 20-watt power amplifier,
has a narrow chassis for easy installation. Cost is
only $58, performance fine within stated limits



Fisher 70, above, is a 25-watter. Like the Scott 232, it uses only two stages of amplification, plus the two matched beam-power output tubes

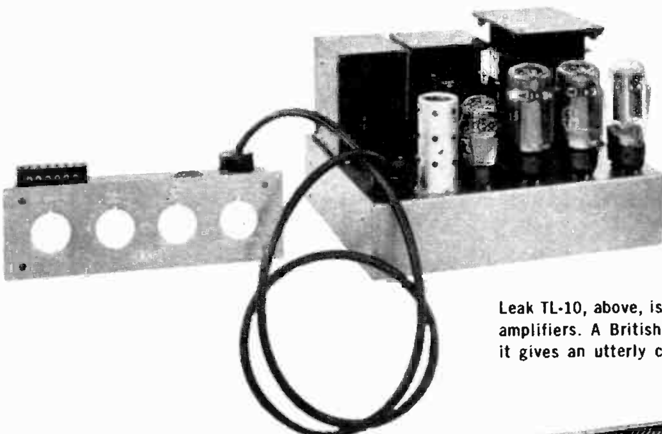
Forty dollars buys Heathkit W4-AM, a brilliant 20-watt amplifier once you've assembled it yourself. Instruction manual and all parts come with kit

20-watt or less

Separate power amplifiers are also available in 25, 20, 15, and 12-watt sizes, at prices ranging from $100 down to $50. Unless your speaker is particularly inefficient, 12 watts will fill your needs in a room 13 by 16, and 20 watts in a room 15 by 25. Among the cleanest of amplifiers at these power ratings are two British imports, the Leak and the Quad, which will deliver acceptable sound at peaks considerably above their announced power. The 15-watt Quad is generally regarded as the peer in performance of an American 30-watt amplifier—and it costs about the same, too.

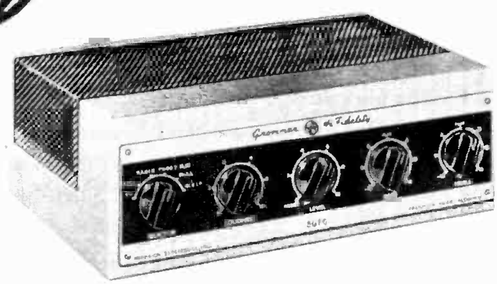
Most 10-watt amplifiers are complete in themselves, with preamplifiers and control units built onto the same chassis as the power units. Money can be saved in this way for both manufacturer and consumer, though at some cost in flexibility of installation. At less than $60, the Grommes 56PG, the Bogen DB110 and the Bell 2122-C give you fairly complete controls, preamplification and amplification at 12, 12 and 10 watts respectively. Several companies now make one-chassis 15, 20 and even 30-watt amplifiers, up to $160; but on most better amplifiers the control and preamplifier units are separate from the power amp.

Nationally known as the earliest cheap high-fidelity amplifier, the Bogen DB-110 gives 12 watts of power on a single chassis



Leak TL-10, above, is king of the smaller amplifiers. A British import, on two chassis, it gives an utterly clean, clear 10 watts

Little Grommes 56PG is one-tube preamp and 12-watt amplifier built on a single chassis, includes loudness and volume controls



HOW MUCH FLEXIBILITY?

Except for the radio tuning knob and the level control on the tape machine, if you have one, every control that you actually touch while operating your hi-fi rig should be on the panel of your preamplifier control unit. Here you will need an on-off switch, a switch that sets the machine to play from the different audio inputs (records, radio, tape, TV, what-have-you), a volume control, bass and treble controls, and switches or buttons for the proper equalization of various phonograph records.

In the operation of the phonograph the equalization controls and the preamplifier section of the unit are most important. Power amplifiers are built to work from an input of at least ½ volt, which is about what you get from a crystal or ceramic cartridge, a radio or a tape recorder. Magnetic pickups put out considerably less power—the GE, for example, gives only .01 volt. This tiny signal must be magnified before the main amplifier gets to work—and must be amplified with ferocious accuracy, because any extraneous noise or distortion that gets into the signal at this stage will be multiplied several hundreds of thousands of times by the power amplifier.

equalization controls

The equalizer section of the preamplifier is necessary to "compensate" for the distortions introduced into a phonograph record when it is cut. The bass signal is diminished at that time to save space on the record, and the treble signal boosted to mask surface noise. A piezo-electric pickup, by its method of operation, gives rough compensation for this deliberate distortion, boosting the strength of the lower frequencies and attenuating that of the higher frequencies. A magnetic cartridge, however, reproduces exactly what is on the record, and the compensation must be done electronically.

This problem would not be particularly severe, except that phonographs have generally used piezo-electric pick-ups—and the record companies until fairly recently kept guessing which "response curve" on the record would give the best result on the average inexpensive phonograph. Since each company likes to boast that its records will sound better on your machine than others will, each company kept its response curve a secret from the world at large. It was not until three or four years ago, with the growth of the hi-fi boom, that the major record companies condescended to tell the public how they were cutting records —and then it developed that everybody had his own scheme. To reproduce records accurately, a phonograph had to supply five or six compensation curves.

During 1954 the record industry finally agreed on one "recording characteristic"—the RIAA (Recording Industry Association of America) curve. Records made since the summer of 1954 should behave correctly on equalization fixed to the specifications of RIAA. To get accurate reproduction from the 10,000 LPs issued before the summer of 1954, however, you will need other curves. The basic minimum, on a single control switch, is five: RIAA, LP (or COL—the original Columbia LP curve), AES, good 78 and noisy 78. Better preamplifiers will have a greater choice of curves: LON (London), FLAT (bass boost but no treble roll-off), NAB and NARTB (similar to but not identical with RIAA), EUR (for European 78). RCA preamplifiers will label the RIAA curve ORTHO, for "orthophonic," an RCA trade-mark for 30 years.

On the most expensive preamplifiers the bass boost (or "turnover," which

Scott 120 preamp, self-powered or matched with the 232 amplifier, is the simplest to operate in high-quality, high-flexibility field

EQUALIZATION CHART

RECORD LABEL	TURNOVER: 400 AES (OLD)	TURNOVER: 500 RIAA RCA ORTHO NAB NARTB AES (NEW)	TURNOVER: 500 (MOD.) LP COL ORIG. LP LON	ROLL-OFF AT 10 KC.: 10.5-13.5 DB AES NARTB RCA ORTHO RIAA LON	ROLL-OFF AT 10 KC.: 16 DB NAB (OLD) COL LP ORIG. LP
ALLIED		●		●	
ANGEL		●		●	
AMER. REC. SOC.*		●		●	
BARTOK		●			●
BLUE NOTE JAZZ*	●			●	
BOSTON*			●		●
CAEDMON		●		●	
CANYON*	●			●	
CAPITOL*	●			●	
CAPITOL-CETRA	●			●	
CETRA-SORIA			●		●
COLOSSEUM*			●		●
COLUMBIA*			●		●
CONCERT HALL*	●			●	
CONTEMPORARY*	●			●	
DECCA*	●		●		●
EMS*	●			●	
ELEKTRA		●			●
EPIC*			●		●
ESOTERIC		●		●	
FOLKWAYS (MOST)		●			●
GOOD-TIME JAZZ*	●			●	
HAYDN SOC.*			●		●
L'OISEAU-LYRE*			●	●	
LONDON*			●	●	
MERCURY*	●			●	
MGM		●		●	
OCEANIC*		●			●
PACIFIC JAZZ		●		●	
PHILHARMONIA*	●			●	
POLYMUSIC*		●			●
RCA VICTOR		●		●	
REMINGTON*		●			●
RIVERSIDE		●		●	
ROMANY		●		●	
SAVOY		●		●	
TEMPO		●		●	
URANIA, MOST*		●			●
URANIA, SOME	●			●	
VANGUARD*			●		●
BACH GUILD*			●		●
VOX*			●		●
WALDEN		●		●	
WESTMINSTER		●			●

*Beginning sometime in 1954, records made from new masters require RIAA equalization for both bass and treble marks the frequency at which the boost ceases) and treble attenuation (or "roll-off," which means just what you would think) are handled by separate controls. The advantage here lies in the fact that many record companies established their own compromise among the various curves before the RIAA became standard —they took the AES bass boost, for example, and the LP roll-off. Exact accuracy, in many cases, thus depends on separate controls.

Somewhere around this point, however, many people will feel that they are being victimized by the law of diminishing returns—that the nuisance involved in setting two dials for every record is not matched by the slight gain in accuracy. The nuisance is at its worst when the two controls are "continuously variable," which means that you make up your own curves to suit the individual record. But it is true that such flexibility can be useful, because the record companies have been known to cheat on their own curves—to boost the treble just a little extra so that this particular record will sound that much brighter, that much more "hi-fi," to the uninitiated record-buyer. This trickery is sometimes employed on otherwise excellent records, and a little additional treble attenuation in the equalizer may be just what the purist requires.

Unless you are a hobbyist who *likes* to fiddle constantly with dials, though, you will probably find the treble and bass controls sufficient correction for any mistakes that a record company may have made or any distortions deliberately introduced into the published recording characteristic. This correction of mistakes should be the major function of bass and treble controls in a hi-fi rig. When the equalization control is properly set, a good record should play correctly with bass and treble at flat position.

control-unit inputs

The control unit should control everything in the rig. If you've got a lot of stuff, you'll need a lot of inputs. Practically every preamplifier made (including those built onto a single chassis with a power amplifier) will supply a low-level input for magnetic pickups, a high-level input for piezo-electric pickups and another high-level input for a radio tuner. (High-level inputs bypass the preamplification section of the control unit.)

Persons who want to plug the audio of a TV unit into their sound system will want still another input for that. Persons with tape machines will need an input marked TAPE, plus a second *output* in addition to the cable that goes to the power amplifier, so that records and broadcasts can be copied directly from the electrical signal. Those who want to make tapes of their own voices or musical performances will also need a microphone input, to be fed to the tape recorder. And people who want a record changer for social purposes plus a turntable-and-arm setup for serious listening will find it convenient to have an extra low-level input, so they can switch from changer to turntable by turning a dial.

Preferably, each of these inputs to the control unit should have a separate "level control," which determines how much power will come into the control unit from the sound source. Different brands of magnetic cartridge have different amounts of output; so do different tuners and different tape recorders. It is fairly important not to overload the preamplifier or the control circuits by feeding in too high a voltage, and the machine as a whole will work best when the strength of the signal input can be controlled.

Even more important is a correctly calculated "impedance load" on the magnetic-cartridge phono input. Too high a load will muffle the high frequencies, and too low a load (the most usual) will give you high-frequency distortion. Certain top-quality preamplifier control units have a variable load which you can adjust according to the instructions that come with your pickup. A few have separate input channels, labeled GE or Pickering or what have you. If the preamp you buy does not have a variable load, or an input matched to your pickup, make sure that a resistor of the proper value is inserted by the shop that sells you your machine.

Power amplifiers are nearly identical, but preamplifier control units vary vastly from brand to brand—mostly in the degree of flexibility, the number of

Fisher preamplifier is cut in the rear to allow easy changing of the three amplification tubes. Note the five inputs, each with its own level control, and the separate outputs to amplifier or tape recorder

controls, the number of inputs and outputs. Some preamplifier control units are self-powered, which means that you just plug them in as you would any other piece of electrical equipment. Others must draw their power supply from the main amplifier or from a separate power supply unit (which costs extra).

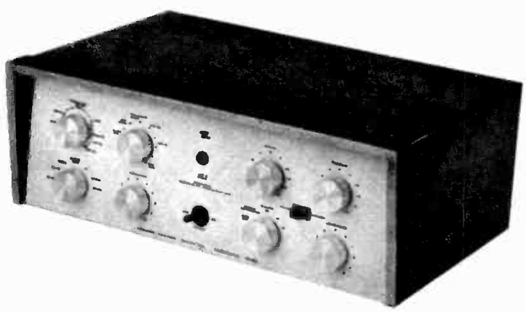
other controls

Various gimmicks are built into many preamplifier control units, and you may find some of them useful. The most common is the "loudness control," which substitutes for the volume control and compensates for "deficiencies" in the human hearing mechanism. According to exhaustive tests made at the New York nd San Francisco world's fairs of 1939-40, the average ear is relatively unresponsive to high and low frequencies when the sound is soft. A record played at low volume, therefore, will lose much of its brightness and depth—not because the full range is missing, but because you don't hear everything. If you boost the upper and lower frequencies as you attenuate the volume, however, you can compensate for the distortion introduced by the ear.

There are a few objections to this line of reasoning, the basic complaint being that the mind expects this fall-off in response when the music is very soft. If you live in a small city apartment with thin walls, however, you must play your phonograph more softly than the ear would normally desire. The loudness control gives you high-fidelity at low intensity.

To live happily with a loudness control you must have a good level control at the input to the preamplifier (so that the highs and lows are boosted *only* when the sound is quite soft). The control works according to the position of the volume knob, not according to actual sound or power quantities. And it is not advisable to buy an amplifier on which the loudness control is irrevocably built into the circuit. You should be able to turn it off and use a simple volume control whenever you wish.

Another popular gadget is the "variable damping" control, by which the amplifier, in theory, compensates for faults in the transient response of the loudspeaker. It is the output of the amplifier that drives the voice coil in the speaker, but a ringing-on of the speaker cone may keep the voice coil vibrating after the impulse from the loudspeaker has ceased. The damping control detects and halts these unwanted vibrations—or helps to halt them, anyway. Every amplifier has a built-in damping factor of some specified effectiveness; a variable control enables you to vary that factor in accordance with the actual behavior of your speaker. But for the same price you can buy a speaker with a heavier magnet,



The patented Dynaural Noise Suppressor is incorporated into the Scott 121, the most elaborate and expensive preamp on the market

McIntosh preamp, matched to big McIntosh amplifier, has push-button choice of turnover and roll-off curves, variable rumble filter

Push-button channel selector, volume controls for each input, up-down switches for turnover and roll-off are features of Fisher 80 panel design

Pilot PA-912, at $50, is the least expensive separate, self-powered preamplifier made. It offers four equalization curves, microphone input

which holds the voice coil more firmly and thus gives better transient response.

Finally, there are various devices which deal with the noises that creep into an audio system, especially surface noise from records and rumble from turntables. The sharp bass cut-off, which keeps turntable rumble out of the system, is worth having if you use a record changer. The sharp treble cut-off that eliminates all sounds over, say, 6,000 cycles is important if you have a large stock of old, scratchy 78's. Such cut-off filters do their job more effectively than it can be done by the treble and bass controls, and leave you the usable frequency band in unimpaired condition.

More debatable is the Scott "Dynaural Noise Suppressor," which makes the frequency response of the system dependent on the strength of the signal from the phonograph pickup. During loud passages, which will mask surface noise most effectively, the system operates at full frequency range. During soft passages, in which surface noise might be an annoyance, the Dynaural Noise Suppressor reduces the response at the high frequencies. Some people find this unique device a considerable aid to concentrated listening; others find that the constantly changing noise level is a worse nuisance than a steady scratch. Like most filters, the DNS is most valuable on old records.

In preamplifier control units, as in everything else, you pay for what you get. For $160 you can have eight inputs, noise suppressor, separate roll-off and turnover controls, loudness control, cut-off filters, self-powering and what have you: the Scott 121-A. Nothing on the market at the time of this writing approaches it in versatility, flexibility or price. No other preamplifier, in fact, nets for more than $130. The McIntosh and Fisher, matched to the most expensive power amplifiers, are less than $100. Self-powered preamplifiers go down as low as the Pilot PA-912, with three inputs and four equalization positions, at $50. Preamps that draw their power from a matched amplifier come for as little as $45.

GE preamp, self-powered, contains built-in scratch filter for noisy 78's, four positions on the equalizer

HOW GOOD IS THE REST OF YOUR EQUIPMENT?

If you are using a record changer or an inexpensive player, an amplifier which does not reproduce the lowest frequencies can be a positive advantage: it cuts off the noise. A speaker-and-enclosure with a fundamental resonance at 50 cps, for example, will boom when an amplifier feeds it a 50-cps signal. Why buy an amplifier that really puts out a considerable current at that frequency?

Most speakers below a certain price have a power-handling capacity of only 25 watts at most. You can hook such speakers into a 30-watt amplifier and get away with it most of the time, because 30-watt peaks are rare and you will seldom be playing such a machine at a volume which might produce a 30-watt peak. But the day may come when your amplifier will send its full strength to the speaker terminals, and the speaker will simply fold up under the pressure. This is senseless: you get no benefit from this extra power, and you may get damage.

Certain speakers, on the other hand, demand considerable power. The Acoustic Research AR-1, fully enclosed, is little bigger than a desk drawer—but it wants 50 watts at peaks. The GEC metal-cone speakers, though only eight inches across, require at least 12 watts apiece, and since they will be most commonly used in pairs, you will need 25 watts to run them. Most high-quality 15-inch coaxials and almost all the more elaborate speaker systems can take up to 50 watts and, in big rooms, should have at least 30 watts to draw on when necessary.

Wattage, of course, is not the only criterion, for you can buy a fairly crude 20 watts or a crystal-clear 10 watts for about the same money. A good small speaker or speaker system deserves the latter.

If you are improving an existing machine, the power amplifier is usually not a good place to start, but the control unit is. A good preamplifier–control unit will give you a complete command of the resources of your audio system, but it will not actually show up the weaknesses of the other parts. Those who have a sound old power amplifier, complete with controls, can vastly improve an existing system by replacing the old crystal cartridge with a magnetic and inserting a separate preamplifier-equalizer between the cartridge and the amplifier. The bargain here is the self-powered Fisher 50PRC, with separate turnover and roll-off controls, plus volume control and adequate preamplification—at $20.

WHAT THE AMPLIFIER DOES

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, however, 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 grid voltage, permitting a considerable "gain" in power 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.

Without getting into complications, it may be said that "triodes" (three-element tubes) amplify less powerfully but more accurately than "pentodes" (five-element tubes). The original Williamson circuit, a wiring diagram by a British engineer which inspired much—perhaps most—modern amplifier circuitry, used triodes only. The development of new circuits, plus certain modifications in the design of pentode tubes, has made it possible for pentodes to replace triodes, especially in the final stage, with little or no measurable increase in distortion.

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. If the condenser eliminates too much—or not enough—the result will be distortion. And condensers age with use. Generally speaking, the fewer condensers the better, and a virtue of the Williamson design is that it eliminated all but four.

In the final or output stage of the amplifier, "beam power" two-grid tubes are now almost universally used, because they make possible a more simple design. One problem with them, however, is that the "plate" of the tube, from which the actual output current is drawn, must necessarily have a very high "impedance" (resistance to the flow of an alternating current). High-frequency signals will not travel through a long high-impedance wire, and you cannot simply attach a low-impedance wire to a high-impedance source of current. The impedance must thus be stepped down in an "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 mere 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.

In all but a very few amplifier designs, the output transformer is the gate to the loudspeaker. As such, it must be good—which means, iron being what it is, good and heavy. Not the least accurate test of an amplifier's quality is its heft. If it weighs about 10 times as much as you thought it would when you looked at it, it's probably a pretty good amplifier.

DISTORTION

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 or other source. Precautions are taken to avoid distortion, and to eliminate distortion that creeps in despite precautions.

linearity

In the first category, the designer uses each individual vacuum tube well within the tube's capabilities—that is, he does not ask from the tube any greater amplification than the tube can furnish easily. A tube working well within its limits will be "linear"—in other words, it will enlarge the signal voltage on the grid in exact one-to-one correspondence. If 50 is the output from ½ on the grid, 100 will always be the output from 1 on the grid. This same tube may be able to put out 200 from a grid voltage of ½, but not 400 from 1. If the designer asks it to make ½ into 200, it will become "nonlinear." Distortion.

The amplifier must also be linear in its dealings with the various frequencies: ½ volt at 2,000 cycles must produce the same power output as ½ volt at 10,000 cycles. Otherwise certain sounds will be reproduced too loudly, and others too softly. Manufacturers advertise their amplifiers as "flat," entirely linear, within ½ or 1 or 2 decibels (db) in the range of 20 to 20,000 cycles. The decibel is always comparative; it measures an increase or decrease from a given sound quantity. At the ordinary amplifier's ordinary sound quantity of 70 or 80 db a difference of less than 2 db is quite inaudible, and an amplifier flat within ½ db can be considered perfectly linear. The amount of noise added to the signal by the amplifier itself (hum, and so on) should be at least 70 db below the output signal, to make sure that you never hear it.

harmonic and IM

If the electrical impulses that make music were simple on-and-off pulsations, that would end the problem. In music, however, the power at each cycle does not commonly come on and go off instantaneously, but starts up, grows gradually and fades away. The electrical currents in the amplifier must match this wave pattern of musical tones, and an alteration in the shape of the wave may produce serious distortion.

Distortion comes in two familiar varieties, harmonic and intermodulation. The first occurs when electron-flow impulses begin vibrating on their own, reinforcing the strength of certain of the impulses being fed into the amplifier. The second occurs when two separate tones are fed into the amplifier, and interact with each other, canceling and reinforcing in wild illogic, producing new, essentially unmusical sounds—"sum" and "difference" tones.

Harmonic distortion in itself is relatively unimportant, but an amplifier with high harmonic distortion usually will have also a high IM—and intermodulation distortion *is* intrinsically unpleasant. Amplifier designers counteract both forms of distortion in two ways. One is by hooking two tubes together in certain stages of amplification so that they do the work of one while correcting each other's faults ("push-pull" is the term used; almost all good amplifiers are "push-pull" in their final stage, and some are push-pull throughout).

The other way is by a device called "negative feedback." Most modern amplifiers produce more power than is actually needed to run the speaker. So a certain proportion of this power can be siphoned off from the output tubes, turned upside down and backwards (figuratively speaking), and *fed back* into the earlier stages of amplification. Any distortion in wave forms caused in the operation of the tubes will thus be counteracted by a mirror image of the same distortion placed onto the grid. Some amplifiers have as much as 30% of their power sent around the circuit once again by negative feedback. This type of design leaves the amplifier less reserve power to handle sudden peaks in the music—but it gives a very clean sound within its own range of power.

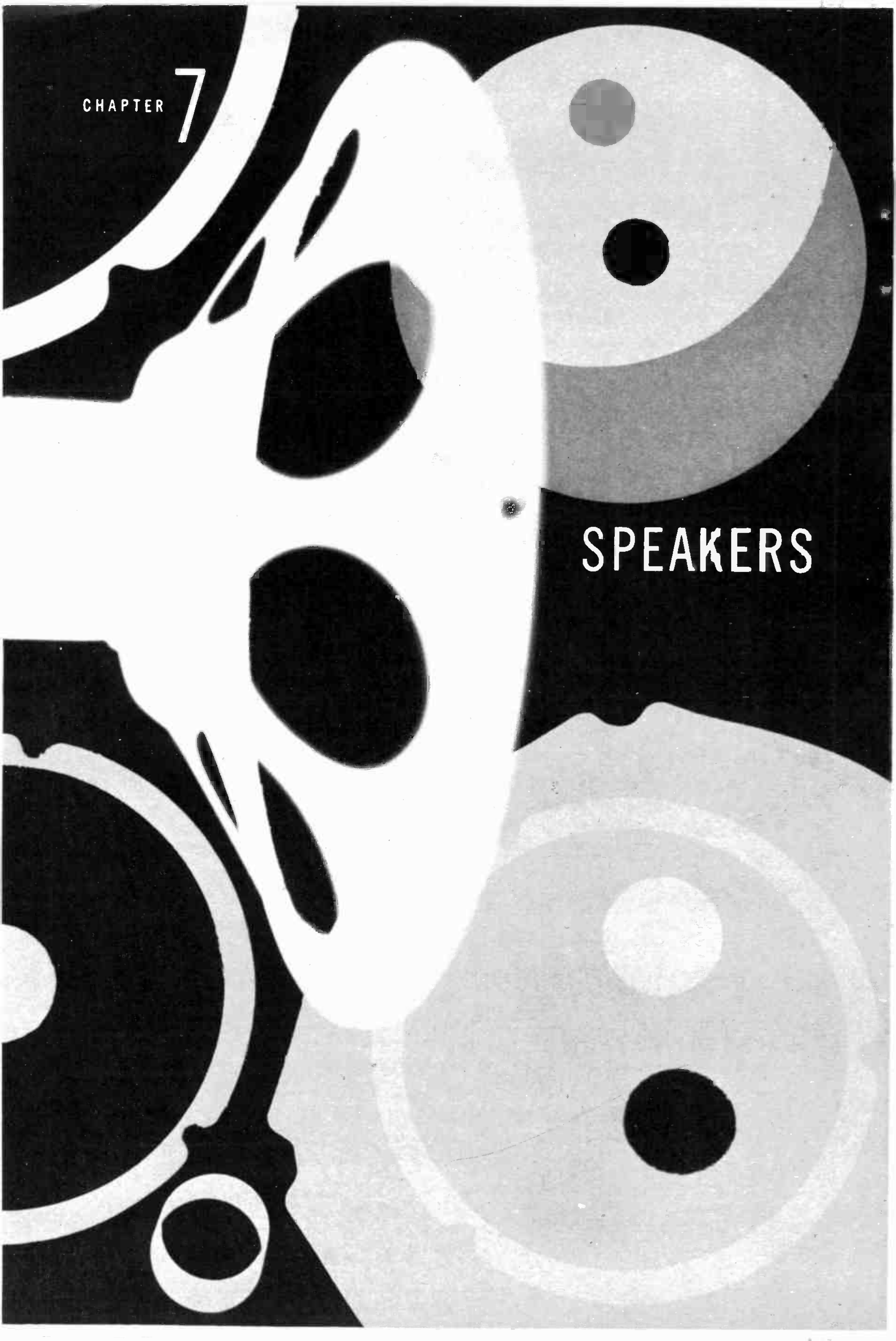
RECOMMENDATIONS: **Amplifier design is practically perfected, and you can buy as good an amplifier as you wish. At the highest power ratings, Scott ($196), McIntosh ($250) and Fisher ($160) are excellent, the easiest to find and to service. In the 25-to-30 watt area, 20 companies, including the three mentioned above, make splendid power amplifiers (most of them priced in the $100 range). Good 15-watt amplifiers start with the Pilot AA410, at $50, and work up. British amplifiers rated at 10 or 15 watts will usually perform to the specifications of American 20- to 25-watt machines.**

Preamplifier control units are almost as good as power amplifiers, and the price you pay depends on the flexibility you demand. At this writing, the Scott 121 ($160) offers the most flexibility and demands the highest price. In the $85 to $110 range there are 15 excellent preamps, including the Fisher and a lesser Scott. Among the least expensive good preamp control units are the Pilot and GE, at $50.

Among complete amplifiers, in which the two parts cannot be purchased separately, the Leak TL-10, on two chassis, gives 10 watts of extremely clean sound for $107. Single-chassis preamp-amplifiers run as low as $50-$60 for the Grommes, the Bogen and the Bell, $70 for the Pilot, all acceptable for minimum high-fidelity.

CHAPTER 7

SPEAKERS



The speaker must transform electrical

signals into musical sound—a tough assignment,

which has been approached from all angles

AND ENCLOSURES

You can buy a violin for $50 or $400,000, but it will not be the same violin. Loudspeakers acceptable for high-fidelity use can be bought for as little as $22 or as much as $800. The cheapest of them will sound less disagreeable than a cheap fiddle, and the best will reproduce the sound of a great violin with almost absolute accuracy. Isaac Stern, the famous violinist, said the other day that by tinkering with the controls on his phonograph he could get "a real violin tone." No greater compliment exists. What makes the phenomenon possible is the superiority of electric current to human fingers as a means of causing and controlling the vibrations that create sound.

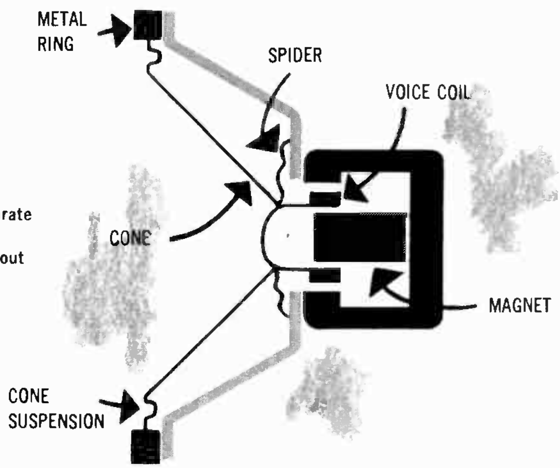
There are several basic loudspeaker designs, but only two are significant today. These are the electrostatic and the magnetic, or moving-coil, systems. The electrostatics are just coming into high-fidelity use and are not yet commercially significant. There's a discussion of these new speakers at the end of this chapter. What you will almost certainly end up with, if you shop now or in the near future, is a magnetic speaker.

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. If you still have such a speaker, don't try to replace it by yourself: that way lies electrocution. Modern speakers, however, use a strong permanent magnet, and they're harmless.

I

MAGNETIC SPEAKERS

The heart of every magnetic speaker is a magnet and a coil of wire, called a "voice coil." A fluctuating electric current is fed through the coil, and sets up an electro-magnetic 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.



Current goes to voice coil, making it vibrate within the field of the magnet. Vibration of the coil makes the cone pulse in and out

the magnet

Almost every modern magnetic loudspeaker uses an Alnico V permanent magnet. Alnico V is an alloy of ALuminum, NIckel and CObalt, 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 eleven pounds. Cheaper, smaller speakers may have magnets as light as four ounces. 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.

If the gap increases with the weight of the magnet, however, the speaker will be more efficient electrically (that is, louder for the same quantity of current in the voice coil, because the coil can vibrate over a wider area) but not necessarily more accurate acoustically. Heavy permanent magnets cost money. Stephens, for instance, makes an "LX" line of low-frequency 15-inch speakers, identical in frame and cone—the 103LX, with a 4½-pound magnet, nets for $66, and the 120LX, with a 1½-pound magnet, for $29.

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 used 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.

When the voice coil drives the speaker at the frequency of its fundamental resonance, the cone will vibrate more vigorously, which means a peak in its response curve. And below its fundamental resonance the cone will become heavy and will respond reluctantly to the motion of the voice coil. The softer the composition of the cone, the lower the fundamental resonance. For this reason, speaker manufacturers make the cones as soft as they can be—and still work.

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 will have much longer walls than an eight-inch speaker. 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. In the British-made Wharfedale speaker the cone is suspended from the ring by a cloth insert, which is one of the reasons that the Wharfedales, size for size, have lower fundamental resonances than almost any other speakers. The American Permoflux Royal speaker has a cone slit at intervals along its edges to make its suspension more flexible. The RCA seven-inch all-purpose speaker achieves remarkably good bass response by bending the paper back over a slight stiffening at the edge of the cone and attaching it to the metal mounting ring by this folded, nonfunctioning edge.

cones at high frequencies

Bass response, of course, is only half (or a third, or a quarter) of the problem. And the big speaker which behaves properly and efficiently at low frequencies will usually respond erratically at high frequencies.

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 twitch by the voice coil does not reach the edge of the cone before the next twitch 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 5,000 cps, because only the center part of the cone is in action at 5,000 cps. Asked to reproduce the entire range, it will sound boomy, accented toward the bass—we say that the treble response falls off.

The smaller the speaker, the smaller the problem it has in reproducing higher frequencies. A five-inch speaker, unless specially treated to respond only to the lower frequencies, will probably go all the way up to the top of the audible range (though not very smoothly near the top). Carefully constructed eight-inch speakers are good, if not perfect, to 13,000 cycles; 12-inchers to 11,000.

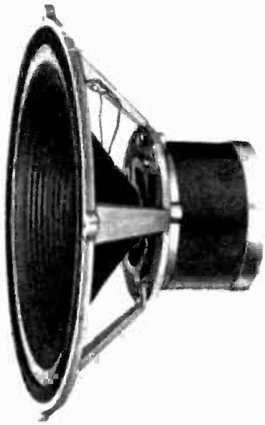
Various devices are used to improve the treble response of a large speaker. The center section of the cone may be stiffened, or backed with a thin plastic coating, to improve efficiency at high frequencies. In some speakers a metal diaphragm is inserted, three inches or so from the voice coil, for relatively separate reproduction at the treble range. This latter device also gives some help with the directional difficulties that afflict single-cone speakers. The lumbering low frequencies, with their 20-foot-long sound waves, meander all over the house. But the flashing high frequencies, with sound waves an inch long or less, beam more or less straight out from the cone and never reach a listener sitting at the side.

SINGLE SPEAKERS

Because large speakers are best at low frequencies and small speakers best at high frequencies, most audio experts recommend that you break up your sound-making among two, three or four speakers of different sizes, each working within its own best range. A "crossover network" divides the electrical signal from the amplifier into separate high-frequency and low-frequency impulses. The high-frequency signals go to a little speaker, the low-frequency signals to a big speaker.

Ideally, though, a phonograph should have only one speaker, which would work perfectly throughout the audible range. It is not the single speaker which is the compromise in design, for the multi-speaker system is artificially and essentially no more than a substitute for the still-unobtainable single speaker. The Wharfedale 12-inch ($75) is the closest we have yet come to the single, untreated paper-cone speaker which will reproduce the entire audible range. The next best is the Hartley 215 ($65). Both are British-made.

In the early days of high fidelity, designers who wanted to perfect a single-speaker system went to work on the larger speakers, stiffening cones and building metal diaphragms. One of the earliest of these designs was the Altec-Lansing Dia-cone, now replaced by the 412 ($45), which uses a single cone broken into two functioning units. A somewhat greater range has been achieved by the metal-diaphragm design of the Jim Lansing D131 (12-inch, $72) and D130



Wharfedale 12/CS/AL holds the paper-composition cone to the metal frame by means of a cloth suspension, lowering the speaker's fundamental resonance

Altec 412 design, replacing Dia-cone divides high and low frequencies between semi-independent parts of a single cone

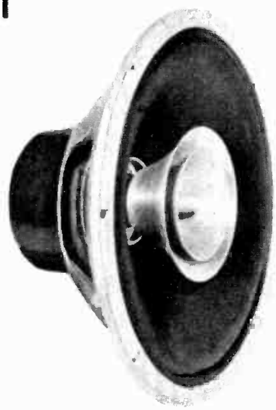
Another English design for a single full-range loudspeaker, the Hartley 215 is only 10 inches in diameter, requires a nine-inch baffle opening

Jim Lansing D130 uses aluminum diaphragm, costs more than the Altec, gives better reproduction at very low frequencies

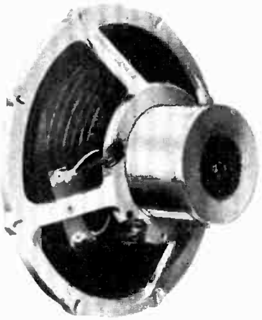
(15-inch, $76). All such speakers begin to roll off in response around 4,000 cps, but the roll is very gradual and very smooth, and there's a decent signal at 14,000 cps.

From the separate high-frequency diaphragm it was only a step to the separate high-frequency cone, driven by the same voice coil as the main speaker cone. Two models are outstanding in this modified single-speaker design, the Stephens 102FR (15-inch, with a 4½-pound magnet) at $70, and the Electro-Voice Radax SP15 (15-inch, 5¼-pound magnet) at $76 and Radax SP12 (12-inch, three-pound magnet) at $56.

For the less elaborate hi-fi rigs, the best bets are the eight-inch and 10-inch single speakers made by Permoflux and a large collection of British manufacturers—Wharfedale, Stentorian, Goodmans. The Wharfedale 8/CS/AL, at $21, is an acceptable speaker by any standards, and it can be purchased in an R-J enclosure specially made for it—$55 for the package, and a fine package it is for



A single voice coil drives both cone and high-frequency diffuser in the Stephens "co-spiral," available with different magnets



Wharfedale 8/CS/AL is designed as full-range speaker for installations of minimum high-fidelity, can also be used as a mid-range speaker

a small apartment. The Permoflux 8-V-81, which costs $8 more, goes down another five cps (which, at this point on the scale, is nearly two whole tones). Wharfedale's 10-inch speaker (W10/CSB) goes down still another 15 cps for astonishingly extended bass response, and the treble response is good. Canby recommends this speaker highly in an R-J *12-inch* enclosure. At $39.20 it is one of the bargains of the high-fidelity business.

All these speakers give extremely good high-frequency response as far as they go (the Wharfedale eight-inch can be used as a "tweeter" in a two-way system), and a cheap way to get a very high-quality speaker system is to buy *two* of these relatively inexpensive units. Two speakers working in phase will substantially reinforce each other's bass response without notably boosting the high frequencies. Keep it in mind.

Coming rather soon to the American market is a brand-new sort of single speaker—the British GEC eight-inch *metal-cone* loudspeaker. The cone is a special duralumin rather than paper, which means that it can be driven more easily below its fundamental resonance and that it will work as a unit at very high frequencies. Only one of the authors of this book has heard the GEC, and he heard it under ideal conditions in the London offices of the British General Electric Company. Two speakers were mounted in a rather small, octagonal enclosure with a port at the bottom between two curtains of fiberglass.

In this enclosure, and with the amplifier designed for it, the little GEC was remarkable—completely smooth, not the least metallic in sound and musical over the entire audible range. The speaker itself sells for only $35; two speakers in the special baffle would cost $130. One of the greatest recording engineers in the world considers this speaker the finest for sale at any price, anywhere. Its American importers, however, profess to find it full of bugs, and too difficult to manage in the home. In any case it should appear on the American market during 1956.

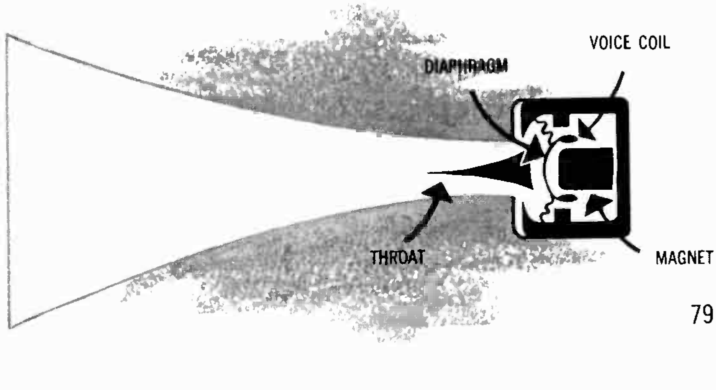
STANDARD COAXIAL SPEAKERS

On the whole, American speaker manufacturers gave up on the all-in-one speaker some years ago and concentrated their attention on the coaxial. This device consists of two speakers—a large "woofer" for the low and low-middle frequencies, and a small "tweeter" for the high-middle and high frequencies. The output signal from the amplifier is divided by a crossover network, so that only the lower-frequency impulses go to the woofer, only the higher-frequency impulses go to the tweeter. The little speaker is mounted concentrically (on the same axis: coaxial) inside the big speaker. Most commonly the little speaker is a horn rather than a cone.

A horn speaker consists of a magnet and voice coil, plus a diaphragm which vibrates with the voice coil and a horn which "couples" the diaphragm to the air, acoustically amplifying the tiny sounds of the diaphragm. The horn and the "driver unit" are often available separately. The diaphragm may be made of very thin metal or parchment. Good horns vie in accuracy with the very best small cones and are far less susceptible to subsidiary resonance problems. But the horn must be at least a quarter as long as the sound wave it will create. A 100-cycle sound wave goes through 1,100 feet of space in one second, so each wave is 11 feet long. To couple a diaphragm to the air at 100 cps, a horn would have to be 2¾ feet long. Worse yet, the opening of the horn would have to be 2¾ feet in diameter. Impractical.

To fit inside a coaxial speaker, a tweeter horn can be no more than five inches or so in length—and even this is a little large for comfort. Very few coaxial speakers "cross over" from the woofer to a horn tweeter below 1,000 cps; 1,500 or 2,000 cps is a more common crossover point. Since the diaphragm-and-horn combination is far more efficient (louder for the same quantity of current) than the associated bass cone speaker, any such two-speaker system, coaxial or otherwise, embodies a "balance control," which cuts down the power going into the tweeter and keeps the highs from overbalancing the lows. Sometimes this control

Operating according to fundamental acoustic principles, horn speaker uses a column of air to give audible volume to the vibrations of a voice coil



is easily accessible to you, so that you are able to do your own balancing.

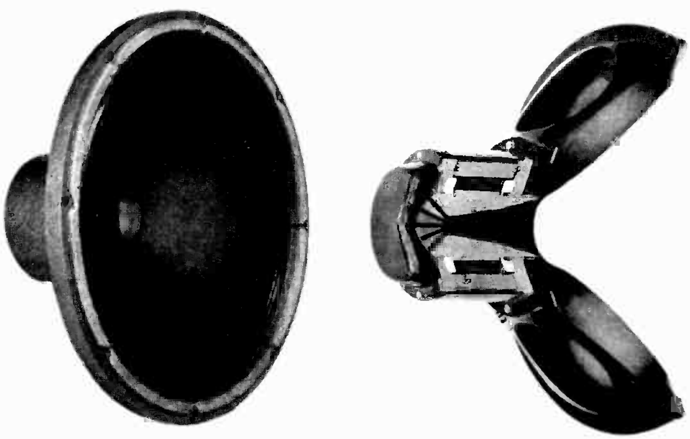
Almost all speaker manufacturers make at least one kind of coaxial speaker. Most experts seem to rate the British Tannoy 15-inch ($159) and the Altec-Lansing 604C ($156) as the best, though other makes have their admirers. Either of these two will give gorgeous reproduction of sound when mounted in a relatively simple bass-reflex enclosure (preferably in a corner) or in a folded-horn enclosure. It should.

Lesser models of the Altec and Tannoy coaxials also are good and are less expensive (about $135 for the Tannoy, $120 and $100 for Altecs).

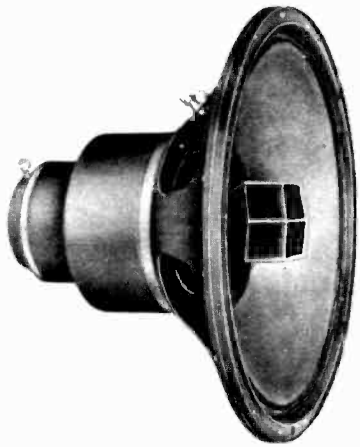
In this price class there are numerous coaxials, of varying merit (and we do mean varying—the quality changes from year to year, and it is best to shop by ear). Notable in the competition for top rating are models by Jensen, Electro-Voice and Stephens. Check for low resonance point (in the woofer), low crossover point (preferably below 2,000 cps) and absence of tweeter screech.

Any 15-inch coaxial speaker will have a greater range than any single speaker presently on the market. But range is not the primary requirement for reproducing music—smoothness comes first. A coax is *two* speakers. Both the woofer and tweeter units can be made a little more cheaply than a single speaker of equivalent sound quality, which must cover a much wider range. But a mechanical crossover network makes for rough sound in the mid-range (where most of the music is), and an electrical network is expensive—especially if it must be made with a power-handling capacity of 30 watts. To equal the sound quality of a single speaker, a coax should cost about twice as much. Really inexpensive coaxials ($25-$35) should be avoided entirely.

Of the coaxials around $100, the most satisfying is the British-made Sten-



British-made Tannoy coaxial mounts the high-frequency horn behind the apex of the low-frequency cone, uses the curvature of the cone to assure adequate dispersion of high-frequency sounds



More usual is the Altec 604C coax design: a multicellular high-frequency horn pokes out almost level with the edge of the cone

Jensen triaxial is three speakers in one: cone; mid-range horn behind the apex of the cone; very-high-frequency driver up front

torian Duplex 12 ($99). Of those considerably under $100, only the British-made Goodmans Axioms ($73, $68, $53) and the GE A1-400 (cone tweeter with ingenious slotted baffle built onto the front of the woofer, 1,800-cps crossover, 12-inch, $41) can be recommended with much enthusiasm. The GE does not pretend to cover the entire audible range, but it is extremely smooth within the 60-10,000-cps area and is usable for some distance on either side. The little Goodmans Mark 80 (10-inch, $68) is a bargain. A pair of them, for $130, will be practically indistinguishable from the most expensive speaker system on the market. But they won't take much power.

Among speakers built on this principle is a triaxial, the Jensen G-160, having three concentrically mounted speakers with crossovers at 600 and 4,000 cps. This is a magnificent speaker, smooth and musical all over the audible range—$253.

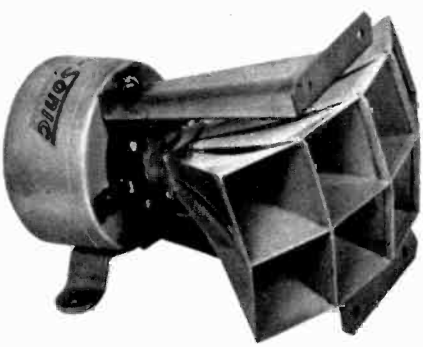
SPEAKER SYSTEMS

There is an advantage to mounting woofers and tweeters on a single axis—all the sound seems to come from a single source. If the cabinet which holds your speakers is far enough away from your listening post, however, the cabinet itself will seem to be the source of the music. You can mount several speakers in the single cabinet. If your musical taste runs to solo instruments and chamber music, there is not likely to be much advantage in a many-speaker system. But it will perform amazingly in the big orchestral and choral numbers that inevitably fuzz a little even in the coaxials. Some of the already packaged systems run up to $800, but others (less convincing, of course) cost only a tenth of that figure.

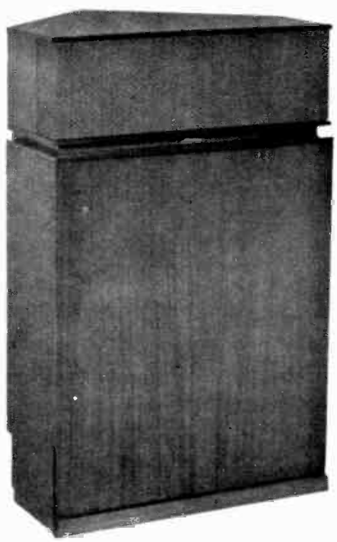
You can buy separate woofers and tweeters on your own, and mount them yourself in cabinets of your choice. Most of the folded-horn enclosures have space above the woofer area for the installation of a horn tweeter. Or, if you prefer, you can buy a larger-than-usual (eight-cubic-foot) bass-reflex cabinet and cut a hole up top for your tweeter. The more speakers, the bigger the cabinet you need—but niceties of enclosure design are necessary only for the woofer, since you can put a tweeter in anything. Among the separate low-frequency speakers the Wharfedale 15-inch woofer ($75) is usually considered the finest, though the University C-15W ($74), the Stephens 103LX ($66), the Electro-Voice 15W ($76) and the Altec 803A ($60) all have their admirers. All are admirable woofers, and when properly mounted will give you too much bass for a small apartment. If you intend to extend the bass response of your speaker by using a "loaded horn" cabinet, you will probably do well enough with a 12-inch woofer, perhaps the Electro-Voice 12W ($56) or Wharfedale W/12/CS ($42). You will also find these more accurate in the mid-range if you plan a two-speaker system with a single tweeter.

Apparently anyone can make a good tweeter, at a price. The cheapest that can be recommended at a low crossover (1,500 cps) is the Bozak B-200X double-cone ($28). The most elaborate tweeters commonly sold to home listeners are unquestionably the Stephens, which come with horns and driver units separate. The Stephens 436 horn, with the appropriate drivers, costs $409, weighs 200 pounds and is nearly four feet long. It will handle all frequencies above 400 cps, and is ideal if you own a theater. Stephens driver-and-horn combinations are available as low as $82, for an 800-cps crossover. To these prices must be added the cost of a Stephens crossover network—$30 at 800 cps, $62 at 400 cps. It is wisest to use the crossover made by the manufacturer of your tweeter. Electro-Voice makes tweeters and crossover networks almost as elaborate as the Stephens. Tweeters that take over at 3,000 cps can be purchased more cheaply—as little as

Below: Stephens 214 ultra-high-frequency driver tweets only above 5,000 cycles, uses eight cells for optimum sound dispersion



Below: Bozak system features paired cone tweeters which are also available separately for use with any low-frequency speaker



Patented Klipsch enclosure loads the front of the woofer for maximum low frequencies. Note the separate tweeter box at top

$22 for the Wharfedale five-inch cone—and will give good over-all response with a 12-inch woofer. Three-thousand-cycle crossover networks are cheaper, too—Wharfedale makes one for $14. The ideal crossover network is the Scott 214X-8 ($30), which gives any crossover between 175 and 3,000 cycles. It sits between the preamplifier and *two* amplifiers, and operates on the very low signal voltage from the preamp. Because each speaker is connected to a separate amplifier you get better speaker damping and more accurate crossover. But you have to buy two amplifiers.

The American engineer's ideal, of course, is the three-speaker or four-speaker system. The new element in the three-speaker set is the "mid-range" unit, which picks up from the woofer at around 400 cycles, and turns over the work to the tweeter between 2,500 and 3,500 cycles. Three speakers are not necessarily more expensive than two, because you can get away with a less expensive tweeter. The three Wharfedales—12-inch, eight-inch and five-inch—cost only $84 for the lot. In addition to the Wharfedale eight-inch, the Bozak B-209 ($45) and the Jensen RP201 (horn, $43) are the most commonly used mid-range speakers. Some engineers recommend Altec 412 or Jim Lansing 130 for mid-range purposes. They are especially good with a Klipsch-enclosed woofer, which should not work above 100 cps. As 12-inch speakers, they can take over at 100 cps and then carry on to the tweeter range. Otherwise, Klipsch-enclosed systems will require a woofer for the folded wooden bass horn, another woofer for the 100-400 cycle range, a mid-range diaphragm horn and a tweeter—four altogether. Three cross-over networks. Much money.

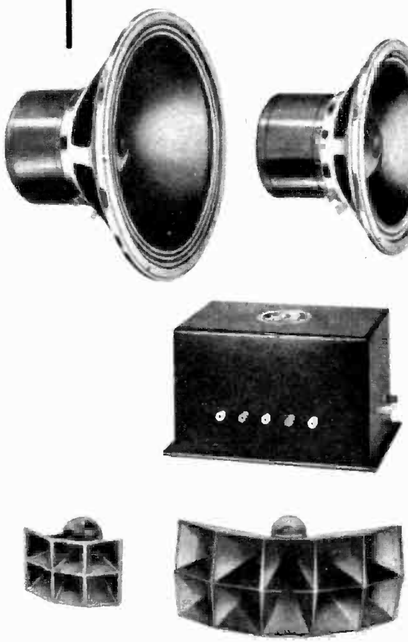
A few people put together multiple speaker systems with four woofers, two mid-range speakers and two tweeters. They wind up with marvelous speaker systems and empty pockets—especially since cabinets for such monsters must be custom-built. For some reason, probably a good one, almost all such systems seem to use Wharfedale or Bozak units throughout.

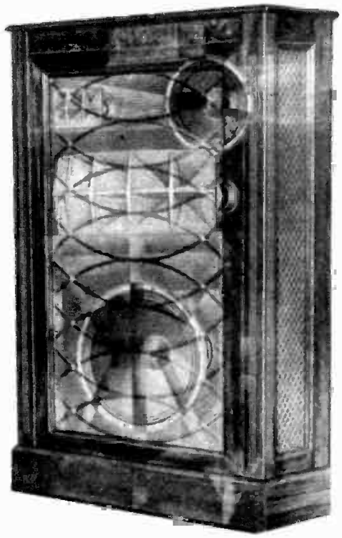
PACKAGED SPEAKER SYSTEMS

Any multi-speaker system must be carefully housed to make sure that the "baffle" arrangement for each speaker is separately and properly designed. To help the customer over this hurdle, and take a little more of his money, many manufacturers market completely housed systems. At the top prices—in the $500 to $800 class—you can scarcely go wrong. For the record, the top recommendations are the Brociner "Transcendent" ("The only speaker I ever heard," said a music critic recently, "that can really sound like a piano"), the Altec 820-C, the Jensen Imperial, the Bozak 310-M, the Electro-Voice Patrician and the Jim Lansing Hartfield.

In the next step down, between $300 and $500, the recommendations are the Jim Lansing 34, the University Dean and the Jensen Triplex. Again, you can scarcely go wrong.

Other speaker systems, running up to $400 in price, have been specially designed to bring the best sound reproduction to the man in a small apartment,





Electro-Voice Patrician system is fanciest commercially available—four speakers (including an 18-inch woofer in Klipsch enclosure), two level controls, four-way crossover: $713

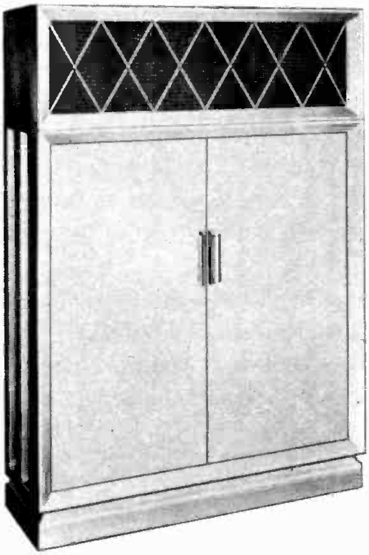
since the big systems are no good in here. You can build these yourself, too, with the Bozak 12-inch, which is made to respond beautifully in a quite small, tightly sealed box. Check with the Bozak people before building your box. All such systems attach the speaker cone very loosely to its outer rim, taking up the slack by special cabinets which exert air pressure against the front or the back of the cone.

Edgar Vilchur's Acoustic Research AR-1 system employs two small cones in a little strongbox whose enclosed air furnishes almost all their springback ($160, complete). The Brociner Model 4, a corner system, uses the tiny but powerful British Lowther coaxial. The edge of the cone is not anchored at all—the strong bass audibility is achieved by feeding the output through a long folded horn. The Model 4 costs about $350 (depending on the wood), and it sounds as though it costs that much—but it won't knock you out of your seat in a small room.

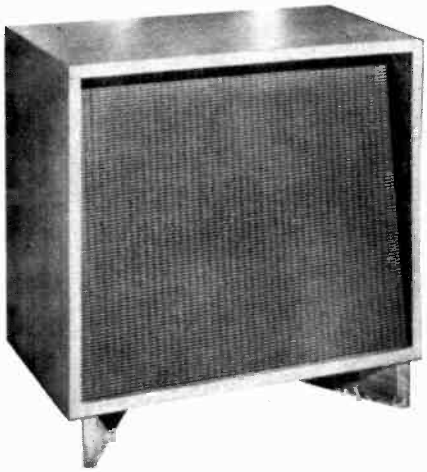
In addition, there has recently been a rash of inexpensive fully housed speaker systems, all under $65. None of them is very exciting. They reproduce most of the range, all right, but very roughly, and they scream at high frequencies. The $40 Heathkit, which you assemble yourself, cuts the tweeter at 13,000 and sounds much better. An entirely different kettle of fish is the Permoflux Largo. It has two cone speakers mounted in a modified horn enclosure that is very handsome and tasteful. It is two feet high by two feet wide by 14 inches deep and, at $98, is a decidedly good buy.

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. The directional



Brociner Transcendent system uses British-made speaker with a loose cone, very intricate baffling for superb results

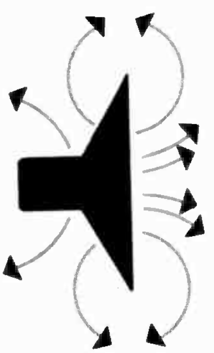


Below: At a price under $100, Permoflux Largo speaker system uses eight-inch woofer, gives rich sound in all but largest rooms

problem, the tendency of high-frequency waves to shoot out on a straight line, makes audio engineers design tweeters with multi-chamber horns, so that they distribute their sounds over a wide hemisphere. The lack of a directional bias—the tendency of low-frequency waves to spread out lazily in all directions—forces 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

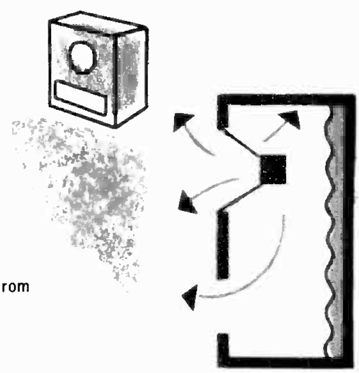


Why a speaker needs a baffle: Low-frequency sound waves, which take up a good deal of space, simply meander after they are created. If the speaker hangs in open air, waves from the rear of the cone will come around to cancel the waves from the front the result of air's resistance to compression in a confined space, it is less acute when 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. Speakers, in general, are inefficient 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 to look around for speaker enclosures that would actually improve the bass response of a speaker.

bass-reflex baffle

The earliest and still the most common solution was the "bass reflex" baffle, a totally enclosed box with a second hole cut in it. The back and at least one side of the box are padded with ozite, fiberglass or some other absorbent material in order to deaden all back-pulsing high-frequency sound waves. The second hole,



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

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. In home construction it is simplest to cut the port too big and then "tune" the cabinet with a sliding panel over the port (see Chapter 9). The lower resonant frequency of the baffle extends the effective response of the speaker. Moreover, low-frequency sound waves from the rear of the speaker, since they are pressure-generated, and thus nondirectional, will emerge from the port practically in phase with the front pulsations. In the infinite baffle the back waves are lost forever, but in the bass-reflex cabinet they come out and help swell the speaker's response at low frequencies. The high-frequency "bounce" from the rear of the speaker is absorbed by the deadening material which lines the back of the cabinet.

Both the tuning of the port and the padding of the walls must be carefully done. An incorrectly tuned port may boost the peak at the speaker's fundamental resonance instead of setting up a separate, useful peak below. And insufficient padding of the enclosure may send reflected mid-range sounds out through the port with the low-frequency sounds. Since sound waves vary in length, the mid-range frequencies will tend to emerge from the port out of phase with the frontal vibrations of the speaker. Rough mid-range response is the result.

To get a properly low resonant frequency from the air inside a bass-reflex speaker, the box must be large: at least six cubic feet for a 12-inch speaker, eight cubic feet for a 15-inch speaker. These are minimum figures.

acoustic labyrinth

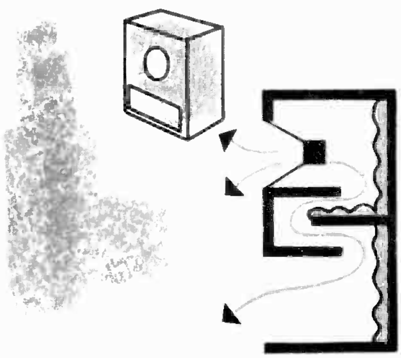
And results that are better still, in the lowest frequencies, can be achieved by an "acoustic labyrinth," a bass-reflex enclosure in which the back pulsations are bounced through a maze of small internal boxes—back wall to front to back again and then out. This device sends the back wave on a much longer path. Since the resonant frequency becomes lower as a column of air increases in length, the acoustic labyrinth extends a speaker's bass response still lower.

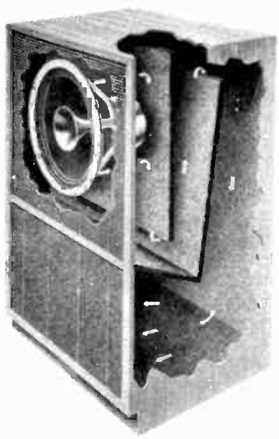
A specialized form of acoustic labyrinth couples the back of the speaker to an "exponential" horn, similar in its workings (though not in its appearance) to the horn on a tweeter. The horn is folded back on itself four or five times (like the coils of a tuba) to achieve the requisite length. Such a horn (called "rear-loaded") multiplies the efficiency of a speaker at the lowest frequencies—but its mouth, and thus the enclosure itself, must be quite large.

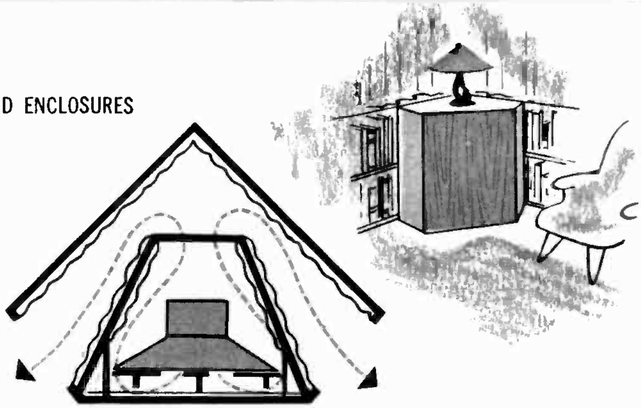
Klipschorn enclosure

Perhaps the most ingenious of all speaker enclosures is the Klipschorn, a patented design which loads the *front* of the speaker. Instead of facing out through a hole into the room, the speaker in a Klipsch faces a closed board. Sound waves from the front of the speaker are pushed around to join those at the rear, and the two travel in consort through a folded exponential horn. They emerge from the enclosure at its sides, into the corner of your room—and the corner itself forms the necessary enormous mouth. Since it does not have to provide the last and largest stage of the horn, the enclosure can be relatively small. Moreover,

Acoustic-labyrinth enclosure lengthens column of air inside the box, brings forward reinforced sounds at still lower frequencies. At left is basic design; right, the special version designed and built by Stromberg-Carlson







Klipsch design blocks the front of the speaker, brings front waves around to reinforce rear waves. Sound emerges from sides; corners of room form mouth of the horn

the design sets up greater air pressure against both front and back of the speaker cone, lowering the fundamental resonance of the speaker. There is no question that the Klipsch adds at least a full octave of clean bass response to any woofer that you care to put in it.

The disadvantages of the Klipsch are two: it can hold only a woofer, and it is too efficient. High-frequency waves cannot (and should not) follow the path of the folded horn, so that a Klipschorn cannot be used with a coaxial or triaxial speaker. And its amplification of the bass response is so great that it cannot be used beyond a speaker's most inefficient low-frequency range. Since the Klipschorn should not be used for frequencies over 100 cps, you need a three-speaker system to use it.

Though the Klipschorn is a space saver, it still requires considerable room—plus room for the other speakers in the system. Neither the acoustic labyrinth nor the rear-loaded horn can be made in a small size. And the bass-reflex cabinet cannot profitably be cut below six cubic feet if a 12-inch speaker is to be used. Since any speaker's performance in the lower range is intimately involved with the kind of cabinet in which it sits, people with small apartments and insufficient cash for a fancy system would seem to be out of luck.

R-J enclosure

A couple of years ago, however, two acoustics engineers designed a neat, tiny speaker cabinet which, when properly adjusted, will rival the sound qualities of a much larger bass reflex. This is the R-J, which uses the principle of the Helmholtz resonator. I will not try to explain the principle of the Helmholtz resonator, but it is worth noting that one of the early uses of this principle was in warfare. The French set up a Helmholtz device to find out where the Germans were keeping Big Bertha. The resonator was so sensitive to sounds that it told French intelligence how far away the cannon was.

The R-J is a totally enclosed box with one opening, slightly smaller than the size of the speaker. The speaker itself is mounted on a board inside the box, facing the opening. The board runs almost, but not quite, the length of the box. The rear waves from the speaker come around the edges of the board and go out through the opening in phase with the front waves. The back of the box is very heavily padded to eliminate all high-frequency bounces. What determines the resonant frequency of the box is the ratio of the space in front of the mounting board to the space behind it. Since the resonator has a sharp resonant peak, the placing of the mounting board must be very carefully calculated—not just for good results, but to avoid horrible results. The R-J is thus best used with a speaker fitted into it by the manufacturer—in practice, the eight-inch Wharfedale.

Unless the speaker manufacturer tells you how to mount his speaker into an R-J, buy another speaker or another enclosure. And remember that the R-J is always a compromise—if you can afford the space for a bigger box, buy one. The real triumph of space-saving, of course, is the Vilchur AR system mentioned earlier. However, you cannot possibly build a Vilchur enclosure without a shop full of measuring instruments and considerable acoustical lore not found in how-to-do-it books.

BUILDING YOUR OWN ENCLOSURE

Other speaker enclosures can be built in the home from specifications which the speaker manufacturer will supply (write to him, addressing the sales engineer). He may urge you to buy his own enclosure, but tell him it's too expensive—it always is—and he'll send you the proper dimensions for your own carpentry. The wood should be at least ¾-inch plywood. If you are not a proficient carpenter, you can buy a kit. And if you are no carpenter at all, you can buy an enclosure, in finished or unfinished wood.

Every speaker enclosure should be airtight and put together with screws and glue (no nails). Every large wall of the enclosure should be braced against another wall: add a collection of 2 x 4 braces to any speaker kit you buy. You may even want to insert some 2 x 4's into a ready-made enclosure. Buy some ozite or fiberglass and some glue, while you're at it, to reinforce the padding supplied with the kit or enclosure. Most horn enclosures do not have padding at the mouth of the horn, though all of them should. You'll vastly improve the operation of the horn if you glue on some extra padding yourself.

Kits for bass-reflex speakers can be bought for as little as $18 for a 12-inch speaker (Cabinart), but the wood supplied is barely minimum—⅝-inch. A better bet is the River Edge Model 710 for a dollar more. Either comes assembled, but unfinished, for $6 extra. Modified bass-reflex cabinets (with a little acoustic labyrinth thrown in) can run as high as $140, finished, with a fancy speaker grille. The GEA1-406, at $50 unfinished or $59 in mahogany or blonde, is a good buy. The Briggs sand-filled corner enclosure ($94) is perfect for a system.

Horn-loaded enclosures are fancier and cost more (and remember to buy extra padding). The Cabinart Rebel-V, which is a modified Klipsch, can be bought unfinished for as little as $33. The same firm makes kits for the larger Rebel-IV at $36 (12-inch) or $42 (15-inch). The Rebel-IV assembled costs $69 (12-inch) or $87 (15-inch). The Klipsch-licensed Electro-Voice enclosures run $65 for the 12-inch, $120 for the 15-inch, and include space for mid-range speaker and tweeter. Among the rear-loaded horns are excellent enclosures by Altec ($122) and Fisher ($130). Stephens enclosures run from $76 to $158 and are excellent for coaxials.

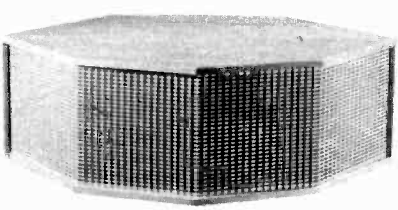
The R-J line starts with an eight-inch shelf model at $25, unfinished, and works up to a 12-inch floor model at $55 with veneer. The floor model is available without legs for installation in a shelf, unfinished, at $30.

Enclosures for mid-range speakers and horn tweeters are no problem, because the horn has no back wave and the mid-range speaker can successfully be enclosed in a small, entirely closed, well-padded box. The Wharfedale three-inch and five-inch cone tweeters are designed to be usd without any enclosure at all. Just set them on their backs, facing the ceiling, and they sound great. How they sound to your neighbors, who knows?

NEW DEVELOPMENTS: ELECTROSTATIC SPEAKERS

There has been, in late months, sudden and continuing development in the field of electrostatic speakers. One of these consists of a membrane or diaphragm suspended between two grilles, which are charged electrostatically according to the impulses put out by the amplifier—one grille being "plus" while the other is "minus," so the effect is push-pull. The membrane is vibrated back and forth between the grilles by the same force that makes an amber rod attract cat hairs, or repel them. Without doubt, this solves one of the great tweeter problems—a large area of membrane can be vibrated very quickly, so that no horn is needed for acoustical amplification. Even at this early stage an electrostatic tweeter in good working order can deliver cleaner treble sound than anything else (except perhaps the free-edge cone-and-horn assembly of the Lowther-Brociner system).

However, push-pull electrostatics still are experimental and delicate. Furthermore, they need a very high voltage, which means that you shouldn't fool around with them while they are in operation and that they require very powerful amplifiers to push them properly. It is tentatively suggested here that the only sensible way to utilize an electrostatic tweeter at home, at the present stage of development, is to incorporate it in a two-amplifier system, with a dividing network fed by the preamp. Two fairly good power amplifiers, one driving the electrostatic tweeter and the other a conventional woofer system, can deliver wonderful results when their respective outputs are well balanced. Otherwise, stay away from electrostatics. They are not, as yet, for novices. (Warning: The electrostatic tweeters made for table-top $100 phonographs are *not* push-pull, and distort dreadfully when producing a complicated tone that's at all loud.)



Janszen electrostatic speaker, first to be commercially made, represents new idea in creation of recorded sound. At this point, electrostatics can be used as tweeters only

RECOMMENDATIONS: Loudspeakers are very much a matter of taste. Among the experts, at this writing, the No. 1 taste is probably the $736 Brociner Transcendent speaker system. A dozen other speaker systems, ranging upward from $300, are excellent for use in a large room. Among the mammoth systems, only the Brociner Model 4 ($350) should be considered for a fairly small room. Among the smaller, inexpensive systems the prize is the Permoflux Largo ($98).

The Jensen triaxial ($253) and (at two-thirds the money) the Altec 604-C ($156) and the Tannoy 15-inch ($159) are most widely loved among triaxial or coaxial speakers. Among less expensive speakers of this type, the Stentorian ($99) and the various Goodmans ($53-$73) are highly regarded. The GE ($41) is pleasing within a limited range.

Most authorities regard the Wharfedale 12/CS/AL ($75) as the outstanding all-range speaker, with the Hartley next ($65). Among single speakers with a metal diaphragm for high frequencies, or a stiffened cone, the top rating goes usually to the Jim Lansing (12-inch, $72; 15-inch, $76), with the Altec (12-inch, $45; 15-inch, $60) and the Stephens (15-inch, $70) not too far behind. Minimum high fidelity is represented by the Wharfedale 8/CS/AL ($21).

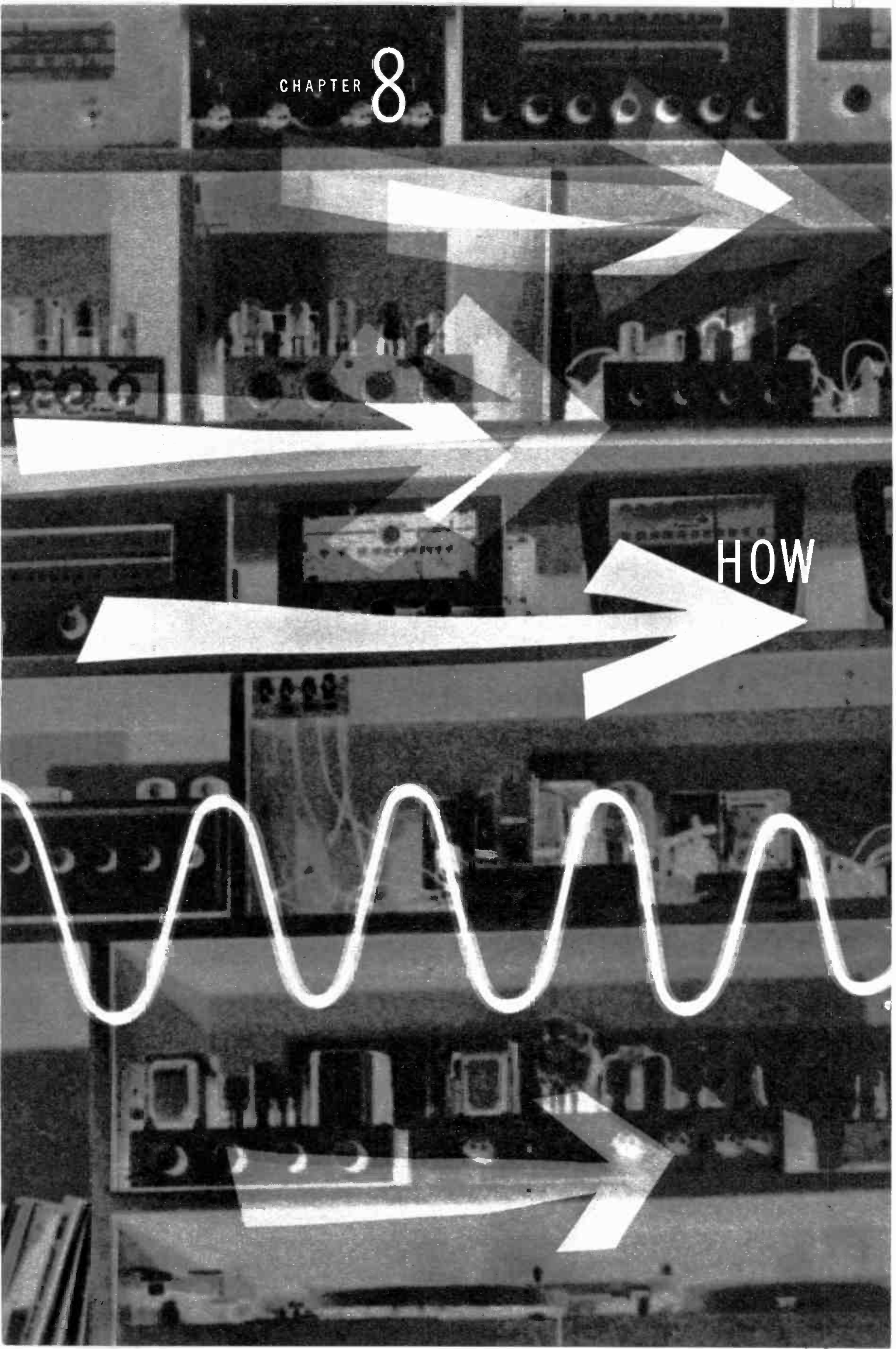
Those building their own speakers will find a choice of a dozen excellent woofers. Most experts choose the Wharfedale ($75) for a large enclosure, the Bozak ($60) for a smaller enclosure (or for a system of several woofers). Jensen ($57), University ($74), Electro-Voice ($76) and others make fine woofers. The most expensive and probably the best tweeters are the Stephens ($82-$409). Electro-Voice ($50 and up), Jensen and University (in their higher price ranges) also make high-quality horn tweeters. The dual Bozak tweeter cones ($28) and the Wharfedale three-inch ($21) are excellent high-range speakers for not too much money. Jensen ($43), Stephens ($80 and up) and Electro-Voice ($47) make mid-range horn speakers; the Wharfedale ($21) and Bozak ($45) eight-inch speakers are also excellent for this purpose. When a very-low-frequency woofer is used in a Klipsch enclosure, the Altec 412A ($45) can be the mid-range speaker.

Speaker enclosures are also a matter of taste. The Klipsch design is unquestionably the most efficient at extending bass range; it can be used only in a system of separate speakers. At present, the rear-loaded acoustic labyrinth or folded-over horn cabinets are most in favor. They can be used with coaxials. The ordinary and relatively inexpensive bass-reflex is still a highly satisfactory speaker enclosure if large enough. Best of the space-saving enclosures is the R-J ($25 and up), which should be used only with a speaker premounted into it by somebody who knows his business. In practice, this usually means the Wharfedale eight-inch for minimum high fidelity.

Speaker enclosures can be bought finished or in kit form.

CHAPTER 8

HOW



The experts pick matched components

in every price range. And they give you rules to follow

whether you do your shopping in person or by mail

AND WHAT TO BUY

The high-fidelity business started off in the wholesale parts stores that service radio repairmen. On the whole, it has stayed there. A section of the store, or a new wing, has been fitted up as a listening room, and a new crew of salesmen have arrived to deal with nonprofessional customers. In a few of the big cities, independent "hi-fi" shops have sprung up. Some of these offer both package sets (in various cabinets) and parts. Most such enterprises have gone broke, however, because the economics of cabinetry and the retail business dictate that the price of a package must be nearly double the price of the parts when purchased independently. Though high fidelity is a big business ($150,000,000 a year), the profit margin on net prices does not justify the kind of retail-store front and display which the package-and-part shops require.

For the customer in a city the purchase of high-fidelity components usually means a few trips into a warehouse area of town which he wouldn't ordinarily visit. If the shop is not upstairs in a loft, the window display is dull, full of bits of esoteric equipment inartistically arranged. Inside is a room, usually without a place to sit down, where phonograph parts are on visual and aural display. Shelves will contain a dozen different record players and changers, 20 different kinds of amplifier and 10 different radio tuners. Along one wall (or two) will be an array of loudspeakers in rough, simple enclosures (usually bass-reflex). Everything is hooked up and plugged in, and a master control board—looking like the panel that faces the pilot in a big airplane—enables the salesman to switch the sound rapidly from one loudspeaker to another, one amplifier to another, one record player to another.

HOW TO BUY

Neither the salesman's recommendation nor the listening test is utterly to be ignored—but neither of them is to be trusted too far. The acoustical properties of an audio showroom are greatly different from those of a home. Even if there are curtains on the windows (which is rare) there is no stuffed furniture to absorb high-frequency waves. A speaker which sounds shrill in an audio showroom may be fine in your home. More often, however, the customer walks out of the showroom with a speaker which overemphasizes the highs. He has been listening to a dozen speakers, one right after another, each for a very short period of time (usually less than a minute per speaker). One speaker sounds much brighter than another, and the customer is irresistibly drawn to it. When he gets it home he finds that it's too bright—the treble range is overemphasized and the sound as a whole distorted. His ears ache after 10 minutes, and he goes around telling his friends that high fidelity is a fraud, and damages the hearing.

Do not try to buy an entire set on one visit to an audio listening room. Be patient, and canny. Three trips are advisable—one to test record players, one to test amplifiers, one to test speakers. In fact, a fourth trip, to try the speakers again, is recommended.

This is a sample of the equipment ready to be tested at New York's Sun Radio. Note the switchboard which allows the customer to make "A-B" tests between brands

testing record players

While testing record players, make sure that the same amplifier and loudspeaker system (preferably the best in the house) is hooked up to every player you try. Don't let the salesman play a big orchestral number; you can't tell much about the performance of a record player from the way it handles crashing cymbals. You *can* tell a great deal from listening to a piano record, preferably one with some nice slow passages. If the player has a wow, the piano will bring it out. Before starting the motor on the player, turn up the amplifier's volume and bass control; if you get hum, make your test with another amplifier. If the amplifier is properly noiseless, put on a record to test for turntable rumble. (Remember, some records incorporate rumble from the studio turntable, so try several). The less the rumble, the better. You will probably never find a wholly rumble-free record changer, but a single-play precision turntable ought not to rumble when new. If you expect to buy a record changer, don't buy a Klipsch-type speaker enclosure–rumble falls just in the area where the Klipsch-type enclosure works most efficiently.

testing pickups

Try out various pickups, preferably on the player you have chosen. Make sure you listen for at least two or three minutes to each pickup. The piano is a good test here, too, but a good loud orchestral record (especially one with a roll on the drums) will give you a notion of the pickup's transient response. The Columbia recording of Stravinsky's *Histoire du Soldat* is an excellent hi-fi test record, since there are seven different solo instruments, including percussion. They should sound crisply themselves all the time. For full orchestra (with drum roll) the Westminster recording of Haydn's *"Military" Symphony* (No. 100), is still excellent–and every audio showroom will have a copy. We would recommend the Solomon recording of Beethoven's sonatas No. 1 and No. 2 as the piano record, because the microphone was hung very close to the strings in this recording, and the percussive piano sounds will test every element of a phonograph's playback accuracy.

testing amplifiers

After you have picked your record player, go away. Come back later and hook the record player into a number of amplifiers, keeping the same speaker. Insist on hearing a very good amplifier first, even if you intend to buy a cheap one. Remember: Piano salesmen have grown rich by offering customers such bad pianos in the early stages of the sale that later on the customers are delighted with a piano that's merely poor. Compare the amplifiers in your price bracket against the best, until you find one that most closely approximates your ideal. Make sure that the sound output is always the same, so that your judgment is not distorted by relative loudness. The Stravinsky record is probably the best test. It is full of sudden peaks which will blur if the amplifier distorts badly at high output. Make sure the treble and bass controls are set "Flat" on every amplifier the salesman demonstrates for you.

testing speakers

When the amplifier problem is solved, take a rest from high fidelity for a few days: the choice of a loudspeaker demands a fresh ear. On your return to the showroom have the record player and amplifier of your choice hooked up to a speaker which costs just a little more money than you wish to spend. (Don't use the best here—if you do, you probably won't find any speaker in your price range that satisfies you, and you'll be miserable. The differences in speakers are far greater than the differences in amplifiers.) After trying out eight or nine speakers, jot down the names of the ones you like best. Check with your friends to see whether they own any of these brands, and if so, what they have learned, good or bad, about the speakers. Do not take a friend's advice about which speaker to buy unless you know that he has owned a lot of speakers—everyone gets used to the sound of his own speaker rather rapidly, and may dislike better speakers because they don't sound like his. (Little speaker systems will sound about the same in the home and in the showroom. Big speakers will sound better in the home.) Go back to the showroom, listen again to the speakers you chose last time, and if you still like one have the salesman pack you up a set of components.

BUYING BY MAIL

People who live in towns and cities where there is no audio showroom are spared the agony of listening sessions--but they also find it more difficult to pick the machine that is best for them.

Lots of audio stores print catalogues and sell by mail. The following are all reliable outfits that carry on a large mail-order business.

ALLIED RADIO CORP.
100 NORTH WESTERN AVENUE
CHICAGO 80, ILL.

HARVEY RADIO CORP.
103 WEST 43RD STREET
NEW YORK 36, N. Y.

HUDSON RADIO & TELEVISION CORP.
48 WEST 48TH STREET
NEW YORK 36, N. Y.

LAFAYETTE RADIO, INC.
100 SIXTH AVENUE
NEW YORK 13, N. Y.

LEONARD RADIO, INC.
69 CORTLANDT STREET
NEW YORK 7, N. Y.

NEWARK ELECTRIC CO.
223 WEST MADISON STREET
CHICAGO 6, ILL.

RADIO SHACK CORP.
167 WASHINGTON STREET
BOSTON 8, MASS.

SUN RADIO & ELECTRONICS, INC.
650 SIXTH AVENUE
NEW YORK 11, N. Y.

TERMINAL RADIO CORP.
85 CORTLANDT STREET
NEW YORK 7, N. Y.

ZACK RADIO SUPPLY CO.
1424 MARKET STREET
SAN FRANCISCO, CALIF.

Every mail-order house has products which it pushes in its catalogues, and no single catalogue contains all the available components by all the manufacturers. Write to several, and look into several catalogues; you don't have to order all your parts from one place. Avoid the components which carry the name of the mail-order house, unless you are sure you know the real manufacturer.

Read the ad descriptions carefully, but take them with a grain of salt. The intermodulation-distortion figure in an amplifier's specifications usually represents IM when only two different frequencies are fed into the tubes—and those will be the two frequencies at which the amplifier shows the least IM. Harmonic distortion and IM should be specified separately. One amplifier, 20 watts on a single chassis for less than $100, advertises itself as ".3% distortion at 20 watts"; this is nonsense. Generally, the more expensive the amplifier, the more reliable the figures will be—but not always. If graphs are shown, they will almost invariably be smoothed out, although speakers actually have extremely jagged response curves. The advertising graphs show straight lines drawn between the points at which the component in question behaves most accurately. British equipment will usually be advertised with accurate response curves. When the British say plus or minus 2 db they mean that the maximum excursion from accuracy will be just that. When American manufacturers make such claims they are often referring to an "average" excursion from the flat. Since British-made equipment is not necessarily better than American-made, the British ads will usually tend to be less flattering to the equipment.

The fact that the ads overstate the performance does not mean that the equipment is no good. There are a few gyps around in the high-fidelity business—but only a few. The vast majority of the components you can buy are worth what they cost and will perform well. Not quite so well as their makers say they will, but well.

When you buy an amplifier by mail, ask the salesman to "run some curves" on it—an IM test and a "square wave" test—to measure distortion and transient response. This will cost $5 or $10, but it will guarantee that you don't get a lemon. And the documentation on how the amplifier worked when new will be helpful when it gets old and wants repairing.

Though a salesman's advice is not the last word of authority, you always want it, whether you are buying in a showroom or buying by mail. You will get better advice, and save a lot of time for yourself and the mail-order house, if you go over your needs thoroughly in your first letter. Here are the most important points for you to cover.

1. How much money you want to spend over-all.

2. What components you want. Whether you own or wish to buy 78-rpm records. Whether you want to buy a tuner, or a TV chassis or a tape recorder (see Chapter 10). How many inputs you will need on the preamplifier.

3. The size and shape of your listening room. (If possible, send along a sketch, indicating where you expect to put the speaker or speakers—see Chapter 9.)

4. If you want a tuner and, if so, whether you live in a steel-frame building. Such buildings call for an antenna (are you sure the landlord will let you put up an outside antenna?). How far away from your favorite FM station you live.

Here's more of Sun Radio's showroom: tuners on the top shelf, amplifiers one shelf down, record players in drawers, speakers in enclosures at the bottom

5. Whether this is to be your hi-fi rig, once and for all. (Do you plan to improve it over the years? If you do, you'll be best advised to put more than the usual percentage of the money into your preamplifier-control unit. Remember that some speakers can be used full-range now, mid-range in a system later.)

Be sure to make the over-all expense figure an accurate one, and don't let yourself get bullied into buying more expensive stuff than you want. The difference between relatively cheap machines and very expensive machines is a difference of degree, not of kind.

PRICES

All prices given in this book are "audiophile net." This had a real meaning some years ago, when you could buy a record changer in your local store for $45 and at the radio-parts store for $27. The list price was for the public, the net price for the radio dealer and the man in the know.

Hi-fi components are not often sold in the local store, however, and the list price quoted in the ads is a kind of fiction, a figure 167% of the price that the audio shop will charge. As the radio-parts stores have expanded into the audio business, their activities have become more and more like those of a normal retail store. And the net price no longer represents a genuine wholesale figure, since it gives a healthy markup to the seller.

If you are ordering by mail you will have to pay the published "net" price: no chance to haggle. Mail-order houses charge you the postage or freight costs, but they don't add anything for handling or for their own costs in correspondence. If you go into the audio showroom to buy, however, you would be wise to explore the "net" price. Usually you can get 10% to 20% off.

The Audio Exchange, at 159-19 Hillside Avenue, Jamaica 32, N. Y., buys and sells used high-fidelity components. The store issues a periodic catalogue of its stock and will put you on a mailing list at your request. A guarantee that the item is in good condition (backed by an excellent repair service) accompanies every sale, and sometimes you will find a considerable bargain. Record changers and turntables are usually a bad buy second hand, because the moving parts wear. But phono pickups last practically forever in a good climate, reconditioned amplifiers are almost as good as new and cone speakers actually improve with age (the fundamental resonance of the speaker goes down as the cone relaxes).

The Audio Exchange also sells new equipment, and will give you a trade-in allowance for your old components—not a big allowance, but often a useful one. For a long time this store had a virtual monopoly of the second-hand business, but some of the new-equipment mail-order houses are beginning to compete.

Avoid used equipment that is not backed by a seller's guarantee. Do not buy used high-fidelity equipment from your friends, unless you know them very well indeed and know that they can and will repair it if it goes sour.

KITS

There are only two known ways of saving considerable money for guaranteed top-quality components. One is to buy from manufacturers who sell only by direct mail, like Radio Craftsmen or Collins (tuners). The other is to buy kits containing all the parts and instructions needed to assemble a given component. Two firms are dominant in the kit business: The Heath Company (Benton Harbor, Michigan) and Tech-Master (sold through audio-supply stores). Both offer power amplifiers equal to those which net for 2½ times the price of the kit, and preamplifiers which net at three and four times the price of the kit.

Assembling an amplifier kit requires great patience, the ability to follow directions meticulously, skill at connecting and soldering wires and a little imagination (if it doesn't work after you plug it in). No specific technical training is required. Everything is identified by color, exact description or a picture in the instruction book. This is not to say that you can't go wrong, because you can. But if you're a genuinely careful person, you shouldn't.

Unless you are a practiced hand at this sort of thing, you should figure approximately 40 hours of work for assembling a Williamson-type amplifier kit. It would take a practiced hand between 15 and 20 hours; that's why you save the money.

Preamplifier kits are trickier to assemble. Before you try this job you ought to be able to read a wiring diagram. Sixty hours would not be an unusual length of time for the average home assembler to require in order to put together a preamp kit.. And the usual warnings apply: Anything that goes wrong in the preamplifier will be magnified immensely by the power amplifier.

Both Tech-Master and Heath offer a wide range of choice in their kits (Heath makes a splendid minimum hi-fi speaker kit at $40). Write for a catalogue.

RECOMMENDED COMPONENTS

The following sets of components (photographs on pages 102-105) are recommended by the authors of this book as starting points for your shopping. Tastes in sound, like tastes in music, are individual. For some reason, none of the objective tests—the waves on the oscilloscope, the tracings on the graph paper—ever seem to prove the superiority of one product to another. The differences between two brands at the same price are usually infinitesimal. By listing one

I

piece of equipment rather than another, the authors of this book do not mean to imply that it is necessarily "better." It is tempting to list half a dozen of each of the components in each price range, but such a list would be less useful. So the authors have chosen the following sets of components, confident that you would enjoy the music they can produce.

THE BEST

REK-O-KUT B-12H TURNTABLE	$120
ELECTRO-SONIC TONE ARM	56
TWO DANISH ELECTRO-SONIC PICKUPS, WITH DIAMOND STYLI	90
H. H. SCOTT 121-A PREAMPLIFIER AND 265-A AMPLIFIER	363
BROCINER TRANSCENDENT SPEAKER SYSTEM	732
	$1,361

AS GOOD AS YOU COULD WISH

GARRARD TURNTABLE	$87
FAIRCHILD 202 TONE ARM	65
TWO FAIRCHILD PICKUPS WITH DIAMOND STYLI	75
FISHER 80-C PREAMPLIFIER, 50-A AMPLIFIER	259
JIM LANSING 34 SPEAKER SYSTEM	364
	$850

PERHAPS EVEN BETTER, BUT TRICKIER

COMPONENTS CORPORATION TURNTABLE	$85
WEATHERS M-122 SYSTEM, WITH ARM, CARTRIDGE, OSCILLATOR, EQUALIZER; DIAMOND LP STYLUS	94
BROCINER MARK 30A AMPLIFIER	98
JANSZEN ELECTROSTATIC TWEETER WITH DUAL BOZAK 12-INCH WOOFER	360
	$637

TOP QUALITY AT BARGAIN PRICES

WEATHERS K-700 RECORD SYSTEM,* WITH TURNOVER CARTRIDGE AND SAPPHIRE STYLI	$132
SCOTT 232-A AMPLIFIER	100
TANNOY 15-INCH COAXIAL SPEAKER	159
TANNOY WINDSOR CORNER ENCLOSURE	75
	$466

*Weathers is extremely fragile. If more than one person is to handle the system, substitute:

COMPONENTS CORP. TURNTABLE	$85
LIVINGSTONE TONE ARM	13
TWO GE PICKUPS WITH DIAMOND STYLI	40
SCOTT 120 PREAMPLIFIER (DRAWS POWER FROM 232-A AMPLIFIER)	69

EXCELLENT AND MODERATELY PRICED

THORENS E-53 TURNTABLE	$60
LIVINGSTON TONE ARM	13
GE RPX-052 "TRIPLE PLAY" WITH LP DIAMOND	23
LEAK TL/10 REMOTE CONTROL AMPLIFIER	107
PERMOFLUX LARGO SPEAKER SYSTEM	97
	$300

MORE SPEAKER, LESS PLAYER

MIRAPHON XM 110 RECORD PLAYER	$35
GE RPX-052 "TRIPLE PLAY" WITH LP DIAMOND	23
GE A1-200 PREAMPLIFIER	57
GROMMES 220 BA AMPLIFIER	58
WHARFEDALE SUPER 12/CS/AL SPEAKER	75
RIVER-EDGE MODEL 800 CORNER ENCLOSURE (ASSEMBLED, UNFINISHED)	32
	$280

MINIMUM HIGH FIDELITY

MIRAPHON XM 110 RECORD PLAYER	$35
GE RPX-052 "TRIPLE PLAY," LP DIAMOND	23
GROMMES 56PG AMPLIFIER-PREAMPLIFIER	58
WHARFEDALE SUPER 8/CS/AL IN R-J ENCLOSURE (UNFINISHED)	46
	$162

PACKAGE MACHINES

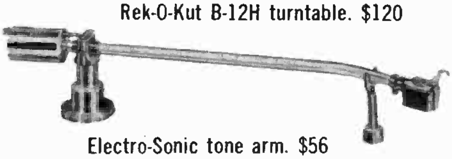
If, despite all you've read, you insist on buying a ready-made phonograph or radio-phonograph package, you'll find several makes satisfactory (see page 105 for photographs). Of the table phonographs, two—the Mitchell and the Columbia 360K—are the most adequate. The Mitchell with magnetic pickup and record equalization costs $200. The Columbia model features diamond stylus and fixed equalization, and runs about $160.

The most inexpensive respectable console is the V-M, which has a bass-reflex speaker box. It costs $200, and nothing else at this price should be considered. The Admiral, at about $800, offers $350 worth of high-fidelity parts, and sounds fine. In the same price range the Stromberg-Carlson offers you separate parts and speaker cabinets, and an acoustic-labyrinth speaker enclosure. Here you're getting about $500 worth of parts for your $800. The Kingsway "Apollo" contains four British-made speakers and the only British FM tuner on this side of the Atlantic. Custom-built, it's housed in an unusually handsome cabinet. Perhaps $400 worth of parts for $970. Lastly, Bell & Howell has a new line of phonographs encased in very handsome Paul McCobb cabinets. They run from $500 to $1,800—the former for phonograph alone, the latter with AM-FM radio and tape recorder. The line features wonderful preamplifiers, very good amplifiers and decent but by no means top-quality speakers. Once again, however, the components are worth only about half the total price.

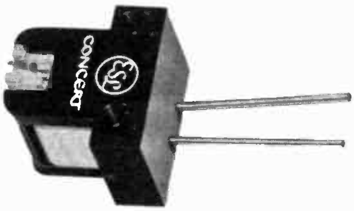
THE BEST

1 $1,361

Rek-O-Kut B-12H turntable. $120



Electro-Sonic tone arm. $56



Two Electro-Sonic pickups, diamond styli. $90

H. H. Scott 121-A preamplifier
and 265-A amplifier. $363

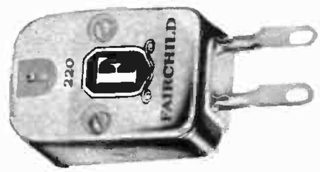
Brociner Transcendent speaker system. $732

AS GOOD AS YOU COULD WISH

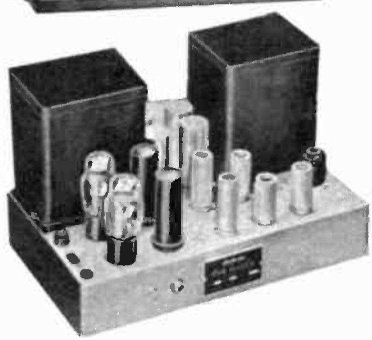
2 $850

Garrard turntable. $87

Fairchild 202 tone arm. $65

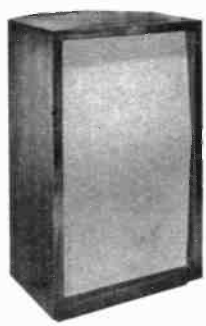


Two Fairchild pickups, diamond styli. $75



Fisher 80-C preamplifier, 50-A amplifier. $259

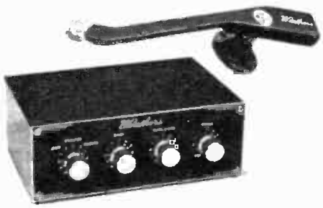
Jim Lansing 34
speaker system. $364



PERHAPS EVEN BETTER, BUT TRICKIER

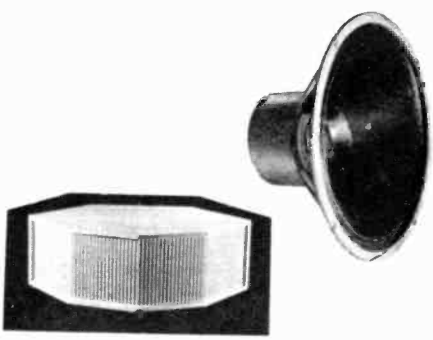
3 $637

Components Corporation turntable. $85



Weathers M-122 system with arm, cartridge, oscillator, equalizer, diamond LP stylus. $94

Brociner Mark 30A amplifier. $98



Janszen electrostatic tweeter with dual Bozak 12-inch woofer. $360

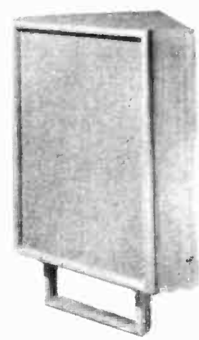
TOP QUALITY AT BARGAIN PRICES

4 $466

Weathers K-700 record system,* with turnover cartridge and sapphire styli. $132

Scott 232-A amplifier. $100

Tannoy 15-inch coaxial speaker. $159

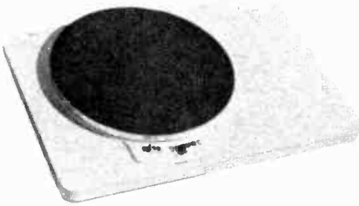


Tannoy Windsor Corner enclosure. $75

*Weathers is extremely fragile. If more than one person is to handle the system, substitute:
Components Corporation turntable. $85
Livingston tone arm. $13
Two GE pickups with diamond styli. $40
Scott 120 preamplifier (draws power from 232-A amplifier). $69

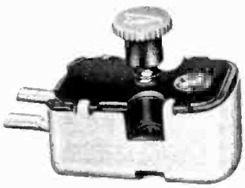
EXCELLENT AND MODERATELY PRICED

5 $300

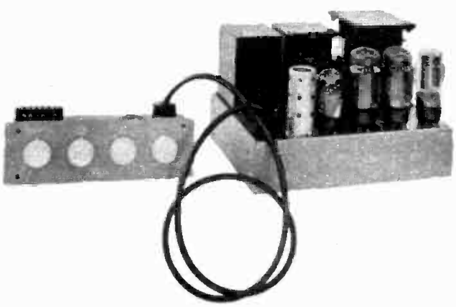


Thorens E-53 turntable. $60

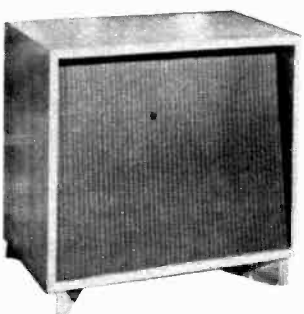
Livingston tone arm. $13



GE RPX-052 "triple play" with LP diamond. $23



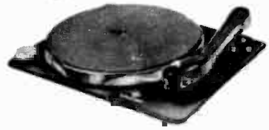
Leak TL/10 remote control amplifier. $107



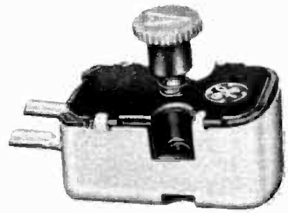
Permoflux Largo speaker system. $97

MORE SPEAKER, LESS PLAYER

6 $280



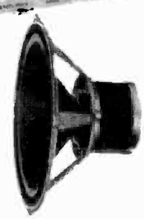
Miraphon XM 110 record player. $35



GE RPX-052 "triple play" with LP diamond. $23

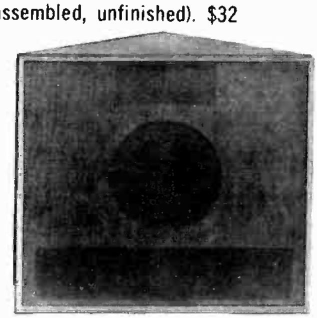
GE A1-200 Preamplifier. $57

Grommes 220 BA amplifier $58



Wharfedale Super 12/CS/AL speaker. $75

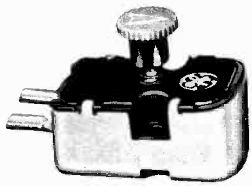
River Edge Model 800 corner enclosure (assembled, unfinished). $32



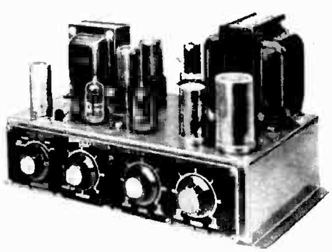
MINIMUM HIGH FIDELITY

7 $162

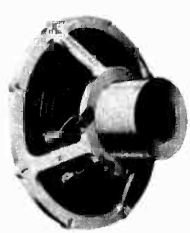
Miraphon XM 110 record player. $35

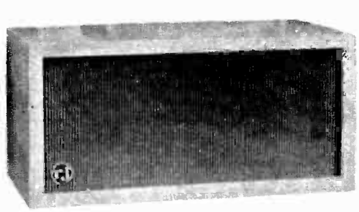


GE RPX-052 "triple play" with LP diamond. $23



Grommes 56PG amplifier-preamplifier. $58



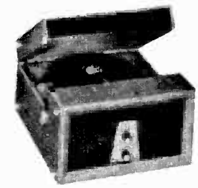


Wharfedale Super 8/CS/AL in R-J enclosure, unfinished, $46

PACKAGE MACHINES

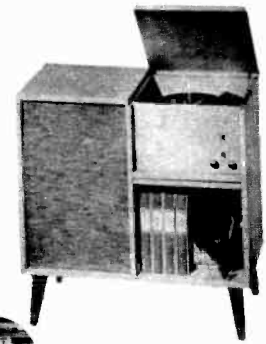
If you insist on buying a ready-made package, these are the most satisfactory. But remember you are paying heavily for a fancy cabinet.

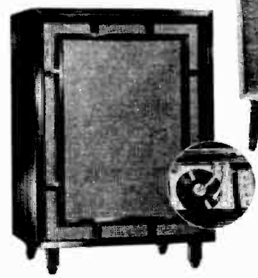
Columbia 360K table phonograph. $160



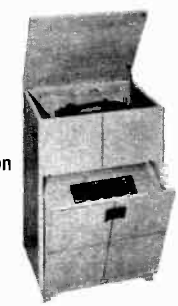
Mitchell table phonograph. $200

V-M console. $200



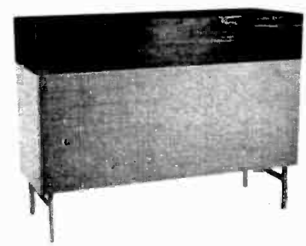


Admiral console. $800

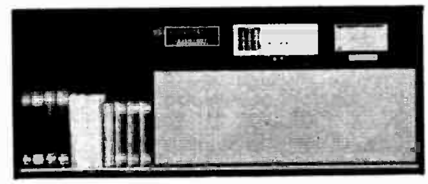


Stromberg-Carlson console. $800

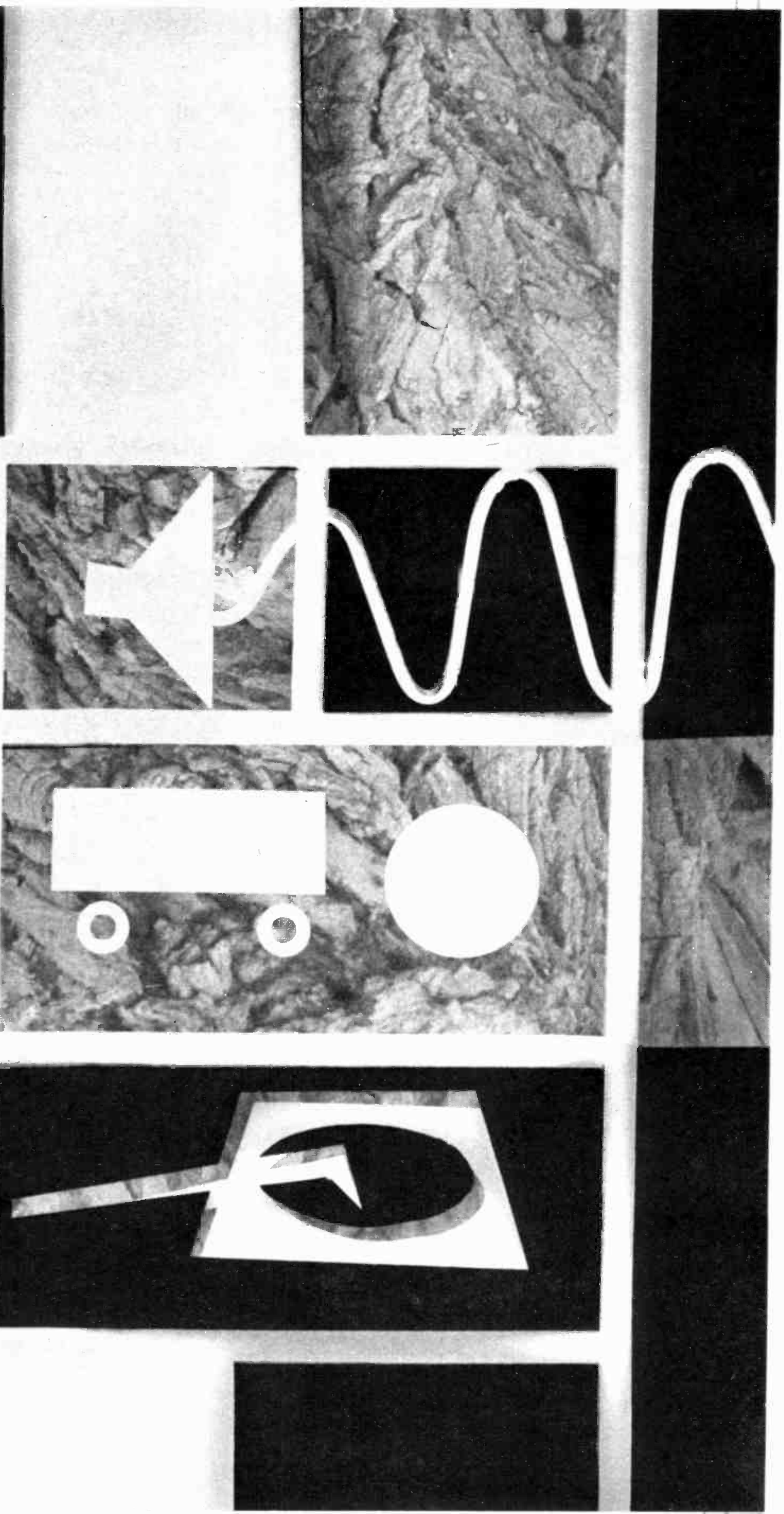
Kingsway Apollo console. $970



Bell & Howell console. $1,800



CHAPTER 9



Putting a hi-fi set together is easy. Just remember: where you install it can be as important to the sound as the quality of the components themselves

INSTALLATION

Unless you pay for an installation job, your equipment will arrive at your house in the manufacturer's original cartons. If the component has been out of the carton for testing, the store may have removed the manufacturer's instruction sheet. If it's possible, ask the store to leave the instructions in the boxes. If your equipment comes without instructions, write the man who sold it to you.

Each part will arrive separately packed: enclosure, speaker, amplifier, preamplifier, pickup, record player. In addition to the parts themselves, you will need enough FM (or TV) 300-ohm antenna wire to connect the loudspeaker to the power amplifier. Using 300-ohm "twin lead" instead of close-coupled lamp cord may keep a high-feedback amp from oscillating at supersonic frequencies.

You will also need low-capacitance shielded cable (no more than four feet of it) to connect the pickup leads with the preamplifier. To avoid nuisance, ask the man to furnish the cable with a plug-and-collar "pin tip" connector already attached. If you are using a separate preamplifier and amplifier, and you wish to mount them some distance apart, you will want an additional quantity of low-capacitance shielded cable (up to 50 feet). Don't worry about the meaning of terms such as "low capacitance". Whether you understand them or not, the man from whom you buy your equipment will know them, and that is what's important. For tools, you will need a screw driver, a soldering iron and a tin-and-lead solder with a rosin base.

ASSEMBLING THE COMPONENTS

The job of assembling components is neither complicated nor particularly time-consuming. Even allowing plenty of time for reading of instructions, three hours would be a lot to put into the audio connections. If you're buying your stuff from an audio showroom, you can probably get a man from the store to do the connecting for you, at roughly $4 an hour.

mounting speaker in cabinet

The speaker cabinet will come with one wall off, so that you can get into it. It will be cut for your size speaker. The speaker itself will come with all necessary mounting hardware. If the audio shop will drill the screw holes for your speaker at no extra charge, have them do it; if not, take an auger and make the necessary holes. Screw the speaker on tightly, and try not to touch the speaker cone.

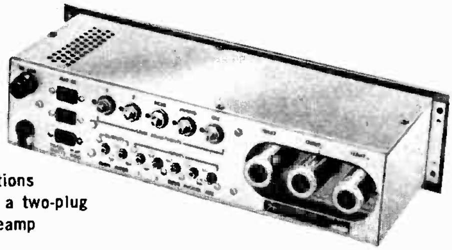
tuning the enclosure

If you are using a bass-reflex enclosure, this is the time to "tune the port." Tunable enclosures come equipped with a slide which enables you to diminish or enlarge the rectangular opening in the box. Set the slide so that the opening is about two-thirds its maximum size, and hook a dry-cell flashlight battery onto the two electrical-connection screws of the speaker. (If the speaker is coaxial, hook the battery to the woofer screws.) The speaker will make a popping sound: *ping-ng-ng*. Move the slide and try again, and again, and again—until the speaker goes *punk*. When the speaker makes a punk instead of a ping-ng-ng, the port is tuned. Make sure you close up the enclosure—put the missing wall in place—before each test with the battery.

connecting speaker to amplifier

If your speaker is a single-cone unit, you simply attach the twin wires from the amplifier to the electrical-connection screws on the metal frame of the speaker. If your speaker is a coaxial, or you have bought a woofer-and-tweeter combination, attach the FM-antenna wire to the "input" terminals of the crossover network, and attach the crossover network to the appropriate speaker connections. Everything will be plainly marked.

Every speaker is made to operate at its best at an input of a certain impedance. This will be given on the speaker itself, as well as in the literature that accompanies it. Your amplifier probably will supply at least three different impedances at the output. These, too, will be plainly marked. Attach the other end of the FM-antenna wire so that one wire is in the "common" or "ground" screw of the amplifier and the other wire in the screw marked for the appropriate impedance. If you buy a Wharfedale speaker you will find a 15-ohm impedance marking on it. Attach it to the 16-ohm impedance output on the amplifier. The distortion caused by a mismatch of one ohm will be absolutely inaudible.



Simple sockets for simple plugs make electrical connections easy. Cable from pickup goes into the MAG socket, and a two-plug cable runs from output socket to amp on this Fisher preamp

connecting preamplifier to amplifier

The preamplifier will come with an output cable and a plug which fits into a plainly marked socket on the amplifier. If you want to extend the cable, just splice in additional low-capacitance cable, both wire and shield.

connecting pickup to amplifier

Your tone arm or record changer will come with an appropriate lead wire, usually ending in a terminus at the bottom of the pickup mounting. One of the prongs of the terminus will be a ground, so marked; attach and solder to that the shielding wire of the low-capacitance cable. To the other terminus solder the center wire of the cable. At its other end the cable plugs into an input socket plainly marked on the preamplifier.

connecting other inputs

If you are using other audio inputs (tuner, tape player, TV), plug them into the appropriate sockets on the preamplifier. All such components will come equipped with an output cable which ends in a plug.

the power supply

Audio systems run on electricity, 60-cycle AC, 110 volts or thereabouts. If you have DC, skip high fidelity; if you have 220 volts, call in an expert. Otherwise there is no problem.

The simplest way to get electricity to all components is through a self-powered preamplifier that has a power supply for auxiliaries. The power supply will be a simple socket like the one in your wall. Into it plug an extension cord with an adapter for three ordinary plugs. And into the extension, plug the power amplifier, the turntable and the tuner (or tape recorder or what have you). Then the on-off switch of the preamplifier will automatically supply or deny power to all the parts.

If the preamplifier does not have an auxiliary power supply, the amplifier usually will. The same process is followed. Since the preamplifier turns the amplifier on or off, the results are the same.

There is no reason why you can't plug each item separately into the wall socket; it's just that much more of a nuisance. Power amplifiers, however, must be controlled by the on-off switch of the preamplifier.

Plug-and-collar inputs will ground all the audio parts to the amplifier. You might also run a wire from the casing of the turntable motor to the "ground" prong on the terminus below the tone arm. If it's convenient, ground the whole system by a wire from the amplifier chassis to the nearest radiator or water pipe.

I

PLACING THE COMPONENTS

The speaker mounts in its enclosure, and it can be placed anywhere in the room, preferably where it will sound best (see the last half of this chapter). The power amplifier can sit at a distance from the speaker and from the preamplifier. It does give off heat, however, and it will wear out quickly unless it has sufficient ventilation. Place it in a closet, or in an open-backed box with at least two inches between the rear of the box and the wall of the room. And don't handle it while it's on. It can give you a nasty shock.

The preamplifier (or the entire amplifier, if you buy a one-chassis unit) must stand near the record player. The cable from the tone arm to the preamplifier should never be more than four feet long. High-frequency signals will leak out if the wire is longer, and extraneous noises (mostly hum) will leak in. Most preamplifiers today come in reasonably good-looking cases, and can stand on the chairside table. The back of the unit is always open (or covered only with a metal mesh), so that heat can escape. Preamplifiers produce much less heat than power amplifiers, but don't place them in an unventilated box.

If you put the preamplifier on the chairside table, you have to find a place less than four feet away for the record player. You can have a record player that sits exposed to view, and then you have no problem. You can buy a base for any record changer at about $5 or for any turntable-and-tone-arm combination at $10 to $15. The record player comes with all necessary mounting hardware, including springs, and the base will be precut to the player you have bought.

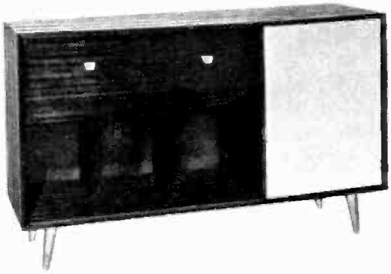
Those who want something a little neater will find small table cabinets with lift tops precut for the various record changers at $15 a cabinet (Argos). The same company makes a matching table cabinet, for a dollar less, to hold a single-chassis amplifier or a tuner. Neat, but not elegant.

However you mount a record player, by the way, it would be sensible to line the bottom of the base (or the supports of the mounting board, in a more elaborate cabinet) with ¼-inch foam rubber. A speaker sets up considerable vibrations throughout a room, and any shaking of the record player will get into the sound system as distortion—"acoustical feedback." You can cushion the amplifier and preamplifier with foam rubber, too, if the amplifier is to sit in the same cabinet as the speaker (which is not recommended). Place your cushions only under the corners of the amplifier chassis, since the bottom of the amplifier develops heat too.

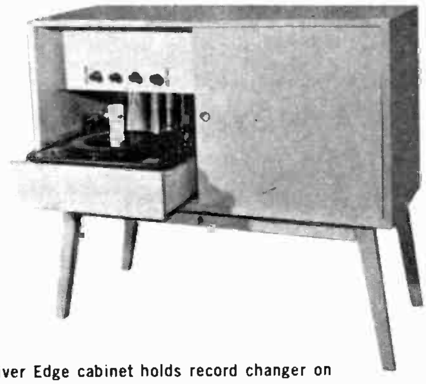
HOUSING THE SYSTEM

Most people who are buying high fidelity will probably want something less obtrusive than table-top cabinets. If you're good at carpentry you can always build your own. There is nothing particularly complicated about designing an equipment cabinet. The Douglas Fir Plywood Association, Tacoma, Wash., will be glad to supply you with ideas; so, probably, will your audio salesman.

Every record player comes with a "template," a piece of paper with a draw-



Among the relatively inexpensive equipment cabinets available in the audio stores is this Cabinart 800. Unfinished, it's $96



River Edge cabinet holds record changer on low sliding drawer, preamp-control unit above, power amplifier behind the closed door

ing exactly to size of the hole that must be cut in the mounting board. You can cut it yourself with a keyhole saw, since it isn't a precision job, anyway.

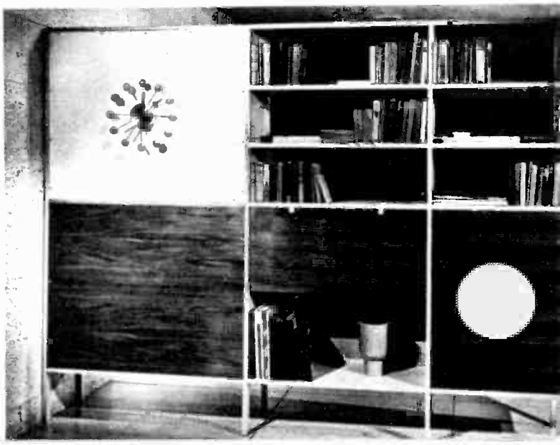
The audio showrooms and mail-order houses sell slide drawers, for use if you want to pull the record player out of the cabinet. Generally, however, you'll be better off with a lift top and a stationary record player—your player and records won't be jolted in and out. Preamplifiers and tuners can be bought with mounting escutcheons, either at the same price or for a few extra dollars.

The plainest, simplest and cheapest equipment cabinet is the Cabinart 70, slightly less than three feet high and two feet wide; you can get it in kit form for $27, or fully assembled, unfinished, for $36. It's also not elegant, but it has a lift top. Others are available, in various wood finishes and designs, from Angle Genesee, Argos, Customode, Master-Tone, Ram, River Edge, Uni-mode and many others. Prices run up to $200, down to about $60.

If you want quality furniture, you are best off at Jens Risom and Herman Miller. Risom makes a matching corner speaker enclosure that is acoustically excellent. Miller speaker enclosures tend to be somewhat too small. Most of this cabinetry is modern design. If your home is traditional, look around for a usable antique item which can house hi-fi components. Those with early American homes can convert commodes, Dutch ovens, big butter churns, washstands. And almost every big city has a shop that specializes in custom installation of high-fidelity equipment—for a price.

Jens Risom cabinet holds the guts of radio, television set, phonograph, tape recorder. Matching enclosure stands in a corner

Room-divider from Herman Miller solves the entire housing problem for the hi-fi installer, saves space, looks good, avoids standing wave



I

WHERE TO PUT YOUR SPEAKER

Setting up a phonograph in your living room does not require a 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 best equipment can sound unbelievably bad in the wrong room.

The first problem, obviously, is size. Except perhaps for the Brociner Model 4 and Transcendent (both of which employ curved horns to guide their tweeter treble to you), none of the big speaker systems will sound musical in a small room. A small speaker, likewise, will sound flat and insipid in a big room.

Furnishings will make a difference. Heavy drapes, upholstered furniture, rugs on the floor and tapestries on the walls—all absorb high-frequency sound waves. There are several effective ways of dealing with this. One of them is to aim the speaker directly into a bare corner to achieve maximum breakup of the high-frequency beam. (The disadvantage here, of course, is that the *back* of your speaker will then face into the room.) Another is to place a speaker, if it's a small one, under a grand piano, aiming up. Still another is to aim the speaker at any hard, rough object (a radiator or a bookcase full of books or records).

If none of these devices is practical, turn up the treble, either on the balance control of a two-speaker system or on the tone-control panel of your preamplifier. This distorts the sound coming out of the speaker, but it creates the proper balance in the room. Turning down the bass-control knob will often be as effective as turning up the treble—it's the balance, not the frequency range, that counts.

If turning the tone control solves your problem, be sure not to sit right in front of the speaker.

People with bare floors and windows, and molded-plywood furniture, will sometimes find too much treble in a distortion-free sound system. The classic way of improving bass response (to balance exaggeration in the treble) is to place the enclosure in a corner, facing out. Then the low-frequency waves cannot simply spread out along the sides of the room, but will curve off the corner walls toward the listening area. If there is still too much treble, turn down the knob. Too little treble is simply dull; too much is physically painful.

A room is an enclosed air space which may have a resonant frequency of its own. Ordinarily the sound waves from a loudspeaker are sufficiently broken up by objects in their path so that the room does not begin to boom. Sometimes, however, a loudspeaker placed against a wall and facing a blank wall on the other side will create a "standing wave." The sound waves bounce off the far wall and return in such a way that their crests and troughs coincide with the crests and troughs emerging from the speaker. You will get a big bass boom in some parts of the room and no bass response at all in others.

When a "standing wave" occurs, you can't just turn controls. You can put a chair in the path of the loudspeaker, or a hanging on the opposite wall. Or you can move the speaker itself—sometimes as little as 18 inches. If your speaker is against a wall, make sure it isn't in the middle of the wall. If it's in a corner, point
 it in some direction *off* the direct diagonal. You'll always get a poorer dispersal

of the sound if the path of the speaker cuts the room into neatly identical rectangles or triangles.

speakers in walls

Speakers in the floor or ceiling give you an unnaturally placed sound source. When you hear music in a concert hall, it comes from a point level with your eyes, or downward at a relatively slight angle. Music under your feet somehow never sounds real. And the ceiling is almost always a flat surface parallel with the floor: danger of standing waves. Music from the ceiling is also unnatural. A very low-frequency woofer that doesn't go above 125 cps spreads sound waves out in all directions and may sometimes be mounted successfully in the floor.

Speakers in the walls are in theory all right. But *you can't move them,* which means that your room decor becomes dependent on the hi-fi set. And sometimes you can't get the air in the room to behave properly against the motion of a wall-emplaced speaker. Again, the very low-frequency woofer is safe, and nothing else really is.

speakers in pairs

Single-instrument sounds ought to come out of a single speaker box, but an orchestra will usually sound best from two. Two speakers can be hooked up to a single amplifier without crossover network or other such gadgetry, but don't try two 15-inch coaxials unless you have a pretty big room. Generally, a pair of speakers in separate enclosures must stand against a wall rather than in a corner, and they should be fairly close together. Sometimes two speakers standing near each other will produce "phase distortion"—that is, one of them will be compressing the air in its neighborhood while the other one is in the rarefaction part of its cycle. You can tell when this happens, because the sound is rough. Reverse the two wires feeding one of the speakers. If this doesn't work, move the speakers apart or closer together, and you may get them properly "in phase."

One advantage of having two separate speakers in separate boxes is that you will be ready for binaural, when and if it sweeps the world (see Chapter 11). Two moderately priced speakers are usually as good as one expensive speaker, so it won't cost you much extra money.

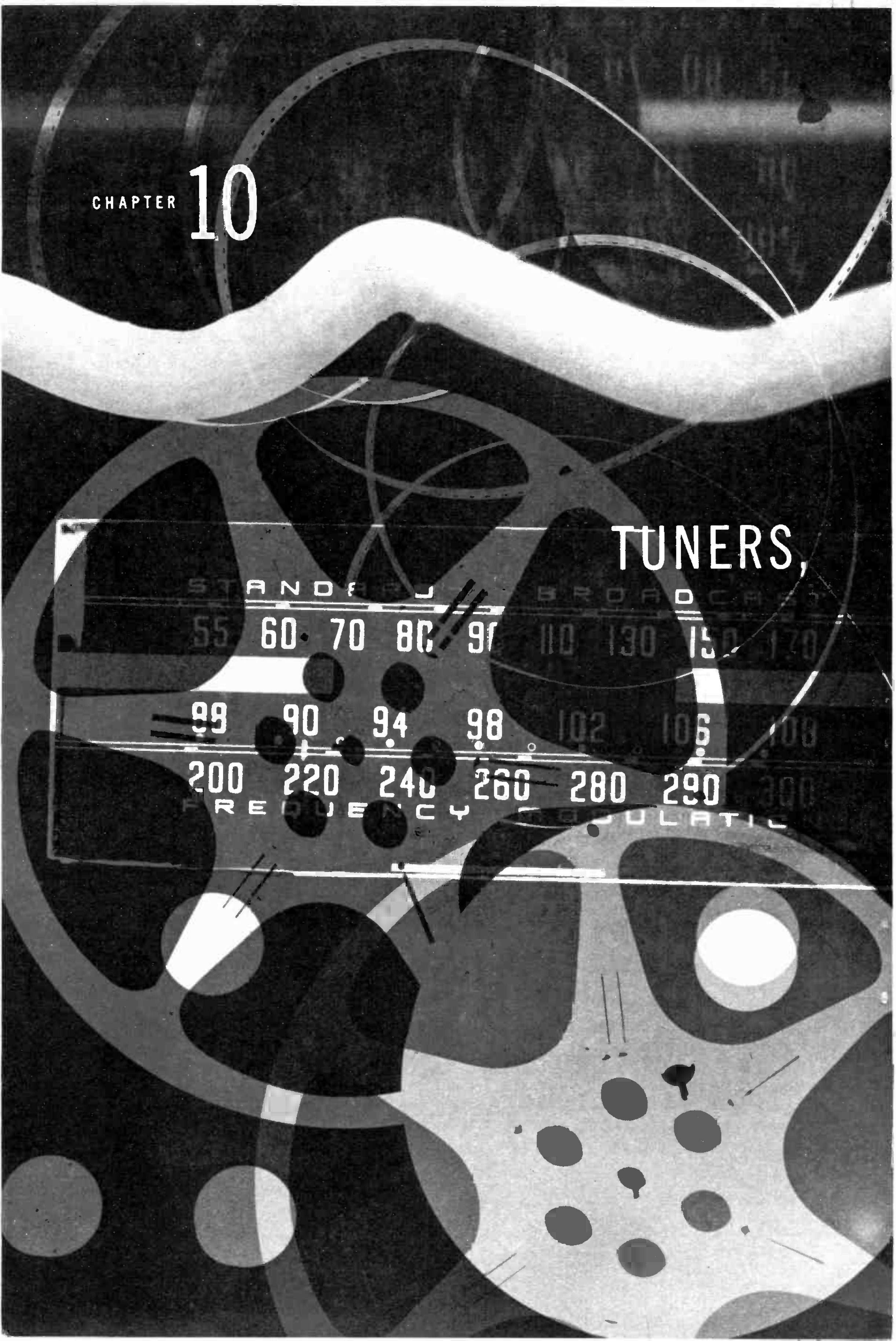
auxiliary speakers

There's no reason why you can't have one speaker in the living room and another in the bedroom and another in the dining room. Make sure you have separate cut-offs for them, so they don't all play all the time. If they're speakers of different sizes and qualities, put a separate level control on each.

You can also hook up a speaker in the garden, but don't expect top results. University makes a hi-fi outdoors speaker which is basically a modification of a public-address loudspeaker; Stephens makes a speaker and a hanging shed like a bird cage to baffle it. Important: bring your outdoors speaker indoors and store it during the winter.

CHAPTER 10

TUNERS,



With high fidelity you're not limited to sound on records. You can have fine FM reception, enjoy your own tape recordings, even plug in TV

TAPE AND TV

Sound is a physical phenomenon, and in its attempts to move around, it runs into the inertia of air and objects. A very high-frequency electrical signal, however, does not meet physical resistance, and a really strong signal (such as 50,000 watts from an AM transmitter) may be detectable hundreds or even thousands of miles away. Radio.

Each radio station sends out its own signal, at an assigned frequency. This is the so-called "carrier frequency." It identifies the station, enables the home radio to tune in, and "carries" the sound. In AM ("amplitude modulation") radio this carrying is done by varying the strength (or "amplitude") of the signal according to the frequency of the sounds to be broadcast. The result is an enormously powerful signal with a wiggling variation in strength toward the top of its output. You will recall that an amplification tube puts out a considerable DC voltage with an audio-frequency wiggle up top. A condenser eliminates the DC current and passes on the audio frequencies. In receiving the broadcast the tuner performs a similar operation. It eliminates the signal frequency and keeps the audio-frequency wiggle.

The process is by no means so simple, of course. The radio-frequency voltage generated in the tuner's antenna may be as little as .00001 volt—and the audio-frequency signal is only a wiggle on that. Before anything can be done with an impulse this small, the whole thing must be amplified. Then the tuner must discriminate, that is, get rid of as much as possible of the extraneous electrical energy that is crawling around the signal, reject other signals broadcast by distant stations on or near the same frequency.

TUNERS: AM VS. FM

"Near" the same frequency is good enough to cause trouble, because amplitude modulation employs side bands around the carrier frequency. AM radio frequencies run from 530,000 cycles to 1,660,000 cycles per second. When the carrier frequency is modulated by the audio frequency, the transmitter broadcasts a sum frequency (carrier plus audio) and a difference frequency (carrier minus audio) as well as the central channel. If an AM station at 600,000 cps were to broadcast tones ranging as high as 15,000 cps, it would be active over the range 585,000 cps to 615,000 cps. Now AM signals wander thousands of miles over the face of the earth, bouncing up and down between the ground and the ionized layers of atmosphere, 60 to 100 miles up. The complete AM-frequency range covers only 1,100 kilocycles. If each station used up, with its side bands, 30 kilocycles, there would be vast interference between the many stations. Matters are bad enough right now, when most AM stations limit themselves to 5,000 or 6,000 cps as a maximum audio frequency, and few if any go higher than 8,000 cps. AM radio, therefore, is not at present a wide-range affair, and plugging an AM tuner into a high-fidelity rig will accomplish only a moderate increase in the presence of the sound.

FM ("frequency modulation") radio is another story. In this process the carrier frequency is *directly* modulated by the sounds to be broadcast. FM carrier frequencies are much higher than AM—they run from 86 to 110 *million* cycles per second. A given station with a carrier frequency of 90,000,000 cps will broadcast a 15,000-cps tone at 90,015,000 cps, and the radio tuner will detect a divergence from the carrier frequency rather than a change in the power of the signal.

An FM system has several advantages. Any number of factors (including the nearby operation of certain TV receivers) can influence the amplitude of a radio-frequency signal, and thus AM reception is constantly plagued by static and assorted noises. However, only the transmitter can vary the frequency of a signal, so FM reception (with a good set) is as quiet as a vinylite record. Frequency modulation does not create the side bands of amplitude modulation, so it does not have to worry about its neighbors. From the very beginning, in 1934, when Major Armstrong set up his first experimental FM station, FM broadcasting has been on a wide-range, high-fidelity basis.

The disadvantages of FM are two. The signal will not travel so great a distance and can sometimes be blocked off, while AM permeates the very air. And the equipment for detecting minute differences in frequency is more expensive than the equipment necessary for detecting minute differences in power. AM radios can be sold through retail outlets for as little as $10, and they work. The cheapest FM radio will cost at least $35, and it won't be much good.

Left: Fisher 80-T tuner and preamp gives choice of inputs and equalization curves, AM or FM reception

Right: H. H. Scott FM tuner costs $150, provides separate level control. AFC is replaced by wide-channel circuits

You have to live fairly near an FM station to receive FM broadcasts, because the carrier frequency travels on a straight line, instead of bouncing up and down off the clouds, and eventually it heads out into space. If you do live within grabbing distance of an FM transmitter, however, an FM tuner will vastly enlarge the variety of music and high-fidelity sounds available through your hi-fi rig.

buying a tuner

A radio tuner is a radio with the amplifier and speaker left out. It is the easiest part of a hi-fi rig to install. You simply plug it into a wall socket with one plug and into your control unit with another plug. It's then ready to work. An AM tuner will come equipped with a small loop aerial, which is quite enough unless you live in a mountain valley. An FM tuner will probably need something a little more elaborate. In a wood-frame house near a station the antenna built into most sets will be sufficient. In similar houses further away a "dipole" antenna will be useful. Since the FM band is right in the middle of the frequencies allotted to TV, any TV aerial will work fine as an FM aerial. The same aerial can be used for both. If you live a long distance away from the nearest station, you will want a high aerial. And if you live in a steel-frame building—even one quite close to an FM transmitter—you may need an outside aerial.

Almost every tuner that costs $60 or more will give high-fidelity results when plugged into a good amplifier and speaker. The farther away you are from an FM transmitter, the more expensive the tuner you will need. Probably the best present FM tuner is the REL Precedent. It may not outperform any of several other tuners the first year, but five years later it will not have flagged, and they will. For this you pay more than $300—a good buy if you own a relay radio station. Otherwise there is small reason for you to buy such precise, heavy-duty, professional-quality equipment.

Among tuners designed for the home the H. H. Scott 310 (FM only) probably is the top-rated aristocrat (or was at the time of this writing). It costs $150 and is so good that when "assisted" by a signal-booster its signal gets *worse*. By

I

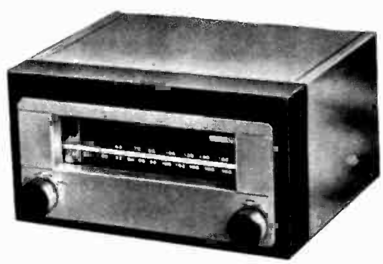
the time this book is in print the same probably will apply to many, if not most, of the top-quality home tuners—Browning, Fisher, Bogen, Radio Craftsmen, Collins, to give some examples. Prices in this group are fairly indicated by the Scott. AM-FM models run from $150 up, FM-only models from $150 down.

If you live within, say, 50 miles of the transmitter you want to hear, you really do not *need* such an expensive tuner. Several of the manufacturers that make ultra-precise models also make less ambitious ones. At the next level down, FM-only tuners run in the neighborhood of $80 and are quite adequate to serve in the outer suburbs. If you live really in the city (meaning close to the transmitters) you can save still more money. Try, for instance, the Harman-Kardon A-200 AM-FM at $70, or the FM-only Realist made by the Radio Shack (167 Washington St., Boston) for $40. As usual, a kit will save money—the $24 Heathkit FM tuner is worth three times the price.

Older FM tuners had a tendency to "drift," to lose the station as they heated up. Automatic Frequency Control (AFC) has licked this problem thoroughly. It grabs the signal and snaps it into full focus as soon as you tune anywhere near it. Your tuner should also contain some means of "AFC defeat," however. When the AFC is switched on, your tuner may glide past weaker stations without noting their existence, clinging to the stronger signal just before it. With the AFC off, the tuner will detect the weaker station.

Those who are seriously interested in binaural sound (see next chapter) will want to consider the Browning RJ-49 ($230) or the Scott 330 ($170) binaural tuner, with separate AM and FM outputs, usable simultaneously. However, a Bogen AM tuner ($70) and any FM tuner, plugged into a two-channel amplifier, will produce practically the same results—and the cost is likely to be less. Or perhaps you would like short-wave with your AM, in which case you would do well to investigate Browning's L-500 ($88).

Many of the new tuners come completely equipped with full controls, a preamplifier for magnetic cartridges and, in some cases, even a power amplifier—all on the same chassis. On the whole, this mingling together of components represents a step backward to the days of console radios—you lose flexibility,



Harman-Kardon A-200 gives excellent AM and FM reception inside a city, plugs into any control unit, costs only $70

Rival to Fisher 80-T is Pilot 860, with both radio channels, preamp with five equalization positions, variable load for magnetic pickups and sometimes quality. The Fisher 80-T ($185), Pilot AF-860 ($180) and Scott 331 ($190), however, give you excellent tuners, and fine preamplifiers.

TAPE RECORDING

On a record, sounds are preserved by means of physical wiggles. Getting the wiggles off the record and into the shape of electrical impulses involves, as we have seen, considerable risk of distortion. Moreover, it involves pressure on the record, and friction. On even the best machine any record will wear down, and there always will be a certain amount of surface noise.

Tape recording, on the other hand, preserves electrical signals. Instead of cutting into a disc, the audio frequencies magnetize an iron-oxide coating on a plastic tape. In the playback process the magnetized tape moves past an electromagnet, a ferrous ring with a gap, wound around with a coil of wire. This sets up a tiny voltage similar to that created inside a magnetic pickup. But the sound generation is all electrical, and the physical rub of the tape against the playback head does not get into the signal. Further, the rub does not (in any reasonable time) damage the tape's content, so there is very little deterioration.

Tape is also far more flexible than discs. You can cut it and splice it together again, eliminating sections you don't want. You can erase the magnetic impressions and use the tape again for some other piece of music. Moreover, you can make your own tape recordings, whereas a phonograph pickup cannot be made to cut a disc. All sorts of advantages.

But all sorts of disadvantages, too. Variations in the speed of a turntable will create an unpleasant wow in a phonograph, but a very slight variation is practically inaudible. Almost any variation is unpleasant in a tape machine, however, and tape reels are not heavy enough to give the flywheel effect which keeps turntables steady. (A heavy capstan, which holds the reel, is used instead, but not quite so successfully.) Records warp, which is a nuisance but not a catastrophe; tape stretches (except on the very best machines), and this *is* the end. Though records may wear out if played very often, they stay as good as new if you play them only occasionally. But tape dries out within three or four years, no matter how carefully you handle and store it. Also, the magnetic impulses "printed" onto the tape are not always stable. At speeds of less than 15 inches per second (the four standard speeds are 3¾, 7½ and 15 inches at home, 30 inches in recording studios) high-frequency impulses come so close together that they tend to blur. Finally, since the tape is wound on itself in reels there is some danger that strong impulses will print through onto the tapes above and below.

All these factors have combined to keep the tape recorder from overwhelming the phonograph, as was freely predicted five years ago. We now know that you have to spend at least $150 for a tape mechanism and special preamplifier to get fidelity equal to that of *AM radio*—and that nothing under $300 will buy you tape equipment equal in its fidelity to a good but not great record player. In short, a high-fidelity tape recorder will cost as much as all the other parts of a hi-fi rig put together.

Moreover, tape itself is expensive: up to $7 an hour just for the raw material. Prerecorded tapes (there are five important brands—A-V, RCA, Omega, Webcor and Phonotapes) run close to double the cost of records that play an equivalent length of time, at equivalent fidelity. You can make the cost of tape cheaper by recording at 3¾ inches per second, but your maximum high-frequency reproduction is likely to be in the neighborhood of 5,000 cycles. A better way of cutting costs is to use the tape as a "double track." The tape is ¼ inch wide, and by recording the top eighth and the bottom eighth separately, you can double the amount of music or sound on the tape without appreciable loss of sound quality. If you expect to edit a tape, to snip off this part or that and then splice together, double-track recording will not be possible.

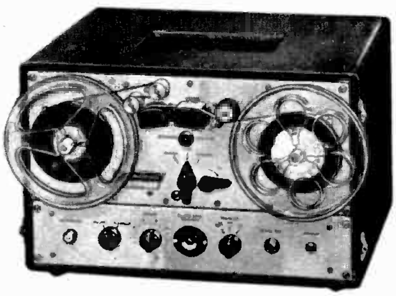
All this is, on today's market, unavoidable. But to these difficulties the tape-recorder manufacturers have added still another of their own making. Like the record manufacturers, each has his own pet equalization curve which boosts the treble and cuts the bass. Equalization is not variable on a tape recorder. It is fixed by the manufacturer. Thus a tape made on one machine will not always sound right on another, which means possible trouble with prerecorded tapes.

Despite these sour words, the rich audiophile, with at least 300 loose dollars to spend, will probably get more fun from a tape recorder than from any other part of his set. He can record an FM broadcast direct from his tuner (which may have a tape-output plug) or his preamplifier control unit (which *should* have such a plug). The broadcast will be his to play, at almost its original quality, whenever he feels like it. He can save wear on his records by taping them when new (the time when anybody plays a record most often) and playing the tape instead of the record during the early months. When he's become a little tired of this record, he can erase the tape and use it again to lessen wear and tear on a later favorite. And if he has musical skills himself, or friends who play and sing, he can make private recordings of nearly professional quality. These are instructive as well as entertaining.

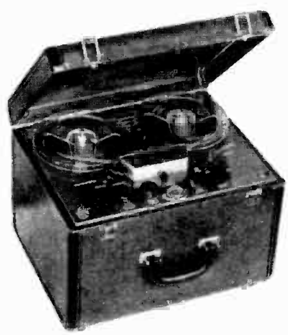
buying a tape recorder

Table-model, complete-in-themselves tape recorders, which sell at anywhere from $100 to $225, are strictly for practical jokes and baby's first burp. They will not give anything resembling the sound quality of, say, the Columbia 360K

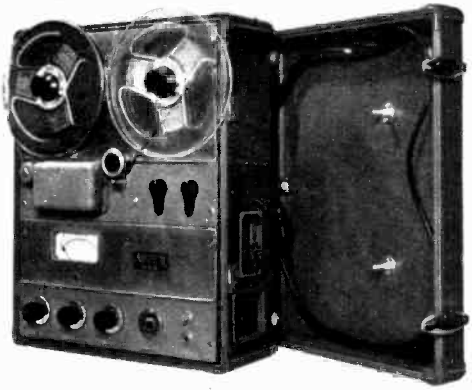
Magnecord M-30, at $300, is a sturdy piece of goods, will go to 10,000 cycles per second at a speed of 7½ inches



Crestwood 404 requires careful handling and regular reconditioning, has fine wide-range response for $230



Concertone 20-20 records or plays at
15 inches, gives full-frequency reproduction,
but needs constant servicing



Almost all professional musicians
choose Ampex 600. It offers full fidelity at
7½ inches, costs almost $550

table-model phonograph. Even if you short-circuit their inferior audio systems and plug them into your own amplifier, most will give you results no better than a prewar record. And they don't last—the moving parts wear out with astonishing speed, the tape stretches, the motor flutters. Avoid them.

The least expensive tape machine that can be recommended for medium-fidelity use is the Pentron MP-2, at $135, which plugs into your own amplifier and will go up to 9,500 or even 10,000 cps at 7½ inches per second—when new. It has two "heads"—one for recording or playback (depending on how you set the switch), the other to erase a tape. A recording meter tells you how to set the level controls to avoid overloading. But you can't monitor (listen as you record, which helps you make good recordings and also allows you to hear the program you want to tape).

If you want to do a little better, try the Crestwood 404 ($230), which has everything a professional recorder has except the durability that comes with $400 worth of precision motors. This really is an excellent little machine, worth equipping with a good microphone, worth the care you will have to expend to keep it working properly.

The next step up is the $300 Magnecord M-30, which has approximately the same frequency range as the Pentron (and the same lack of a monitor head), but is far more sturdily constructed and distortion-free. A new model—the 536BX—gives a hysteresis motor, 15-inch speed and full range for $370.

Up from that is the $445 Concertone 2020, a modification of the entirely professional Berlant Broadcast recorder. It provides separate recording and playback heads, so that you can listen as you work, and gives a 15-inch speed as well as the 7½-inch which is the top on the cheaper recorders. At 15 inches per second the Concertone will handle the entire audio-frequency range, and when new it will give professional quality. A year later its performance will be considerably (though not necessarily vitally) impaired. The same machine can be bought with a hysteresis-synchronous motor, to eliminate waver, for an extra $100.

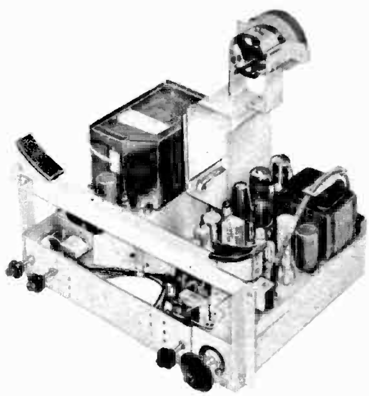
Better still is the Ampex 600, which costs $550 and is unquestionably the professional musician's choice. It runs at only one speed—7½ inches per second—but goes to 15,000 cycles and is remarkably accurate and distortion-free throughout its range. It has separate recording and playback heads, for monitoring. Sturdily built, as tape recorders go, and likely to last longer.

The competition at or about this price includes improved versions of the

Magnecord, the Berlant itself and the Pentron "Dynacord." Ampex and Magnecord have other, wholly professional models that go up to $1,300.

Playback tape machines, which will produce music with prerecorded tapes but will not record by themselves, are already on the market. The Pentron, at about $95 (to plug into the rest of your audio system), is the best seller: medium fidelity. Magnecord plans a similar machine at about the same price. Ampex has put on the market a beautiful playback unit, which will also handle binaural tapes—at $400 for the tape deck and preamp alone.

The maintenance of a tape recorder requires a bottle of carbon tetrachloride and a small brush, to clean the moving parts, plus a "demagnetizer" to run over the recording and playback heads after every half-dozen hours of use. (The heads will become magnetized in use, introducing noise.) Every tape machine will need regular reconditioning by an expert, preferably the manufacturer and preferably once a year. In buying a tape recorder, therefore, you should keep an eye on the manufacturer's address. Choosing among the top brands, you might be best off buying the one made nearest your home.



This is Tech-Master TV kit assembled, no easy feat. Kits run $150 and up, include all parts except picture tube

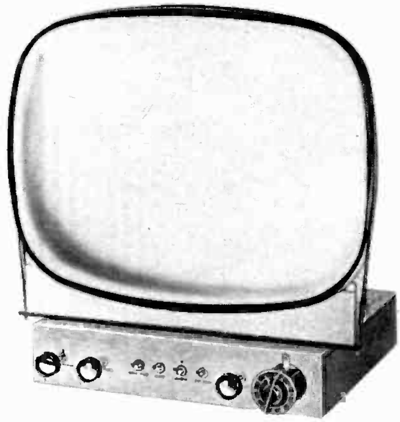
TELEVISION

Whatever the deficiencies of the video part of television, the audio can be fine. It is broadcast by FM, and when the TV station cares about these matters TV sound can be every bit as good as an FM broadcast.

No commercial television set is equipped to give you sound of this quality, however. Television is expensive: a 21-inch picture tube alone will net for something like $40, and both the detection equipment and the amplification must be elaborate in order to run the tube. Audio amplifiers, bad ones, can be made quite cheaply, and so can the six- and eight-inch speakers used in most television sets. So the tendency is to save money on the audio. A $400 television set will most likely sound inferior to a $150 table-model phonograph.

A skilled TV repairman, or the shop in which you buy your set, can detach the audio section of the unit from the amplifier and plug it into your hi-fi rig. The job is easy, and it ought to be cheap. Before having it done, however, you might consider whether you *want* first-rate sound to go with the third-rate pic-

Fleetwood TV chassis come assembled, without picture tube, from $200 up. At right, the minimum, with a 21-inch rectangular tube installed



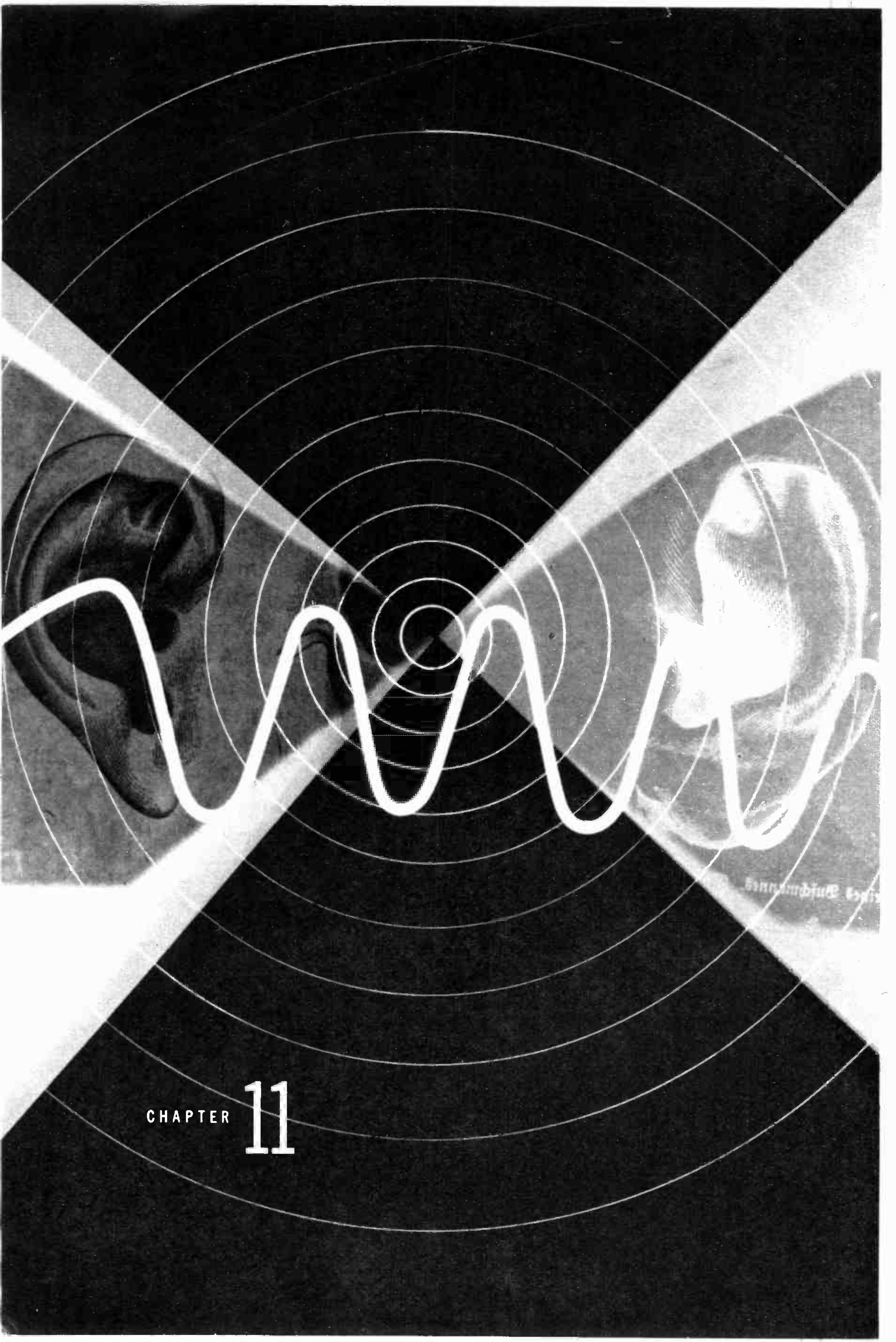
ture which is the best TV can offer. Some people do, some don't—it's your choice.

TV chassis, to be built into custom cabinets, are available from several manufacturers—most notably Tech-Master and Fleetwood. These are complete sets without cabinet, including the usual weak audio amplifier and inexpensive speaker, but they provide a ready-made cutout for your own amplifier. Some Fleetwood chassis are available without speaker. These units are not cheap—$175, complete with 21-inch tube, is about the lowest, and $300, with 27-inch tube, about the highest. But they are considerably better built than the cabinet units you can buy in the stores for about the same price.

Tech-Master also offers TV kits, for about two-thirds the price of the assembled chassis. There's money to be saved here if you know what you're about—but don't try it without a solid background of success in assembling amplifier kits.

RECOMMENDATIONS: **The REL Precedent is an FM tuner of professional quality, at a professional price—$300. For distant reception of FM, a number of excellent tuners are available at or near $150; the first on the market was the Scott, but Browning, Fisher, Bogen, Radio Craftsmen, Collins and others have similar tuners on the way or already in the stores. At $80 or so the same manufacturers, plus Harman-Kardon and others, make FM tuners which will be entirely serviceable within roughly 50 miles of the transmitter. Inside the city, or in the suburbs, even less is demanded from a tuner. Here the Harman-Kardon A-200, AM-FM at $70, or the Radio Shack Realist, FM only at $40, will probably be satisfactory. Bogen makes an excellent AM-only tuner at $70; Browning an AM-short-wave tuner ($90) and a "binaural" tuner, AM-FM ($230). Scott also has a binaural tuner ($170). The Heathkit, FM only, is again the best buy—$24, in parts.**

Ampex retains its place as the No. 1 tape recorder, at a minimum price of $550. Concertone and Magnecord make home recorders of lesser quality, at prices between $300 and $450. The Crestwood, at $230, gives, when new, something approaching high fidelity. All these prices are for tape deck and preamplifier alone—no amplifier, no speaker. No package, table-model tape recorder qualifies as a musical instrument. Tape machines for playback only range from $395 for Ampex high fidelity to $95 for Pentron medium fidelity.



CHAPTER 11

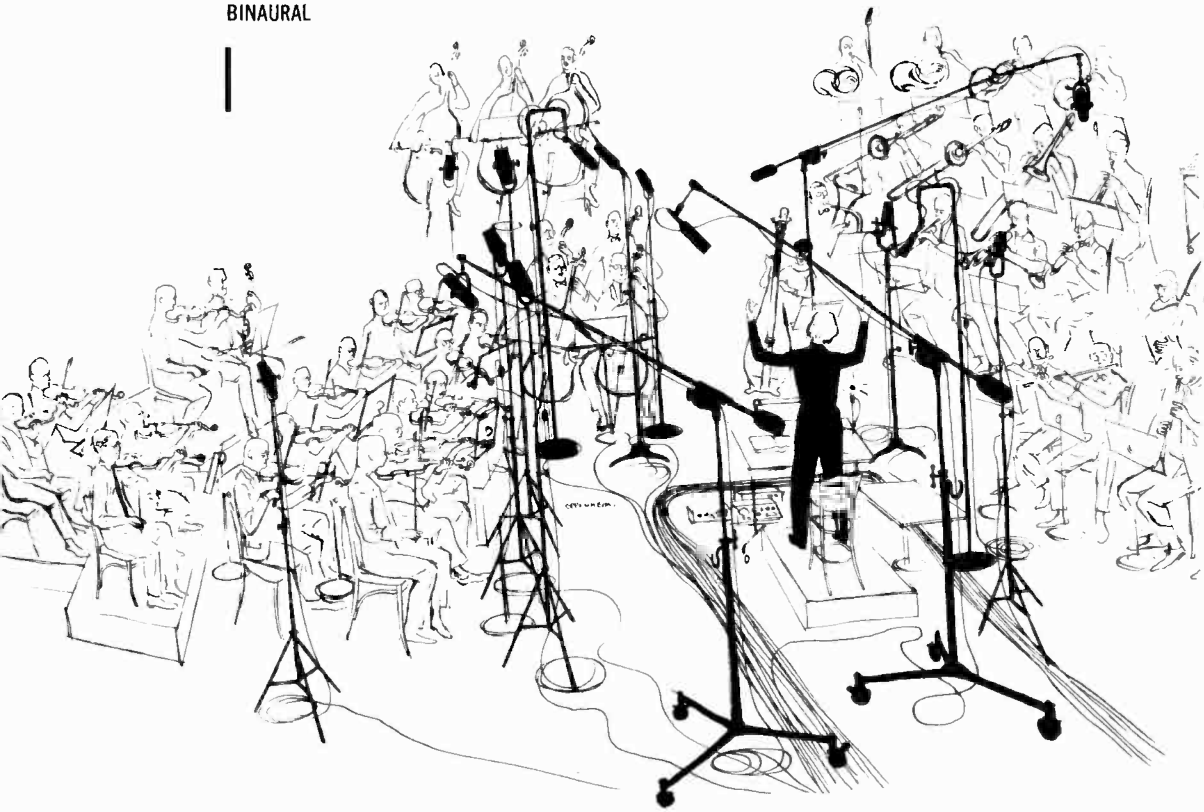
Three-dimensional sound: newest thing in the audio world. Praise has been lavish, criticism severe. These are the facts in the matter

BINAURAL

For the past four years any time anyone has asked what's new in high fidelity he's been told about binaural sound—and rightly so. However, chances are he's received a different story every time. A few critics have pronounced it "the living thing." Some call it a dead horse. We prefer a middle road.

The theory of binaural (or stereophony, of which binaural is the simplest form) is this: 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. Your left ear and your right ear hear slightly different sounds—but you hear the music with both ears. Monaural, by definition, is strictly "one ear" recording. Since it mixes sounds on a single tape for playback by a single pickup, it's not designed to reproduce full-dimensional sound. To recapture completely the feeling of a concert hall, the home should be equipped with two loudspeakers, each playing slightly different sounds.

Hence, binaural. It starts right in the recording studio where two microphones (or two sets of microphones), one for each ear, are used to pick up the sound. The record is cut with two slightly different sets of grooves. For playback you then need a double pickup, and two different channels in preamplifier and amplifier (or two different preamps and amps). And finally, of course, you must have two full-range speakers or speaker systems.

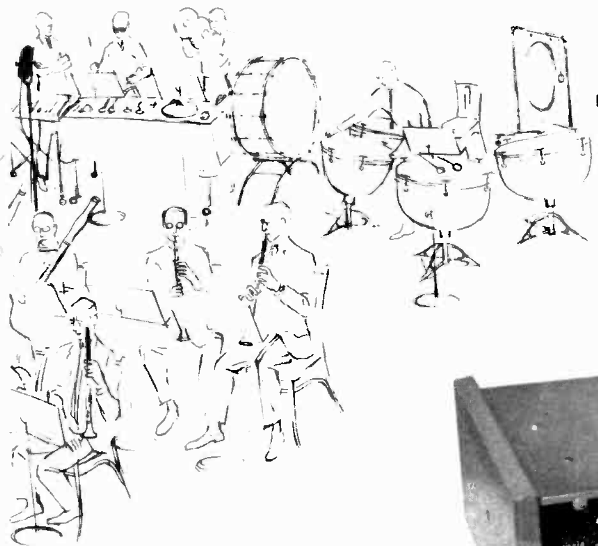


BINAURAL: PRO AND CON

The advantages of binaural are a greater feeling of presence and an illusion of "depth." There is also, oddly enough, some advantage in price. A binaural system does not require the very best of components. The ear rejects distortion (except, of course, a booming bass or screaming treble) and seems to hear a fuller frequency range. A binaural system at $400 will probably sound as good as a monaural system at $400, though it requires many more parts.

Engineers, musicians and record people argue fairly often about the extent to which binaural recording and reproduction improves the quality of recorded sound. One record–*New Orleans Jazz,* made by Emory Cook, one of the top recording wizards and chief binaural pioneers–is an astonishing success on a binaural system. It is literally something different from ordinary recording, more lifelike than anything else you've heard in your living room. No other binaural recording is quite so convincing.

Binaural on records has one serious disadvantage: only half as much music per disc, because the two ear's worths must be recorded separately. So far, all binaural discs have given one ear on the outside half of the record, and the other ear on the inside half. A double-headed tone arm, with two pickups, plays the record. London Records is authoritatively reported to have somewhere in its gigantic works a new kind of binaural record, less extravagant of disc space–but it will be some time before this appears on the market. RCA Victor, too,



An artist's impression of an RCA Victor binaural recording session at New York's Manhattan Center. The conductor is Leopold Stokowski, the orchestra a free-lance aggregation of his own choosing. Results will be issued on tape

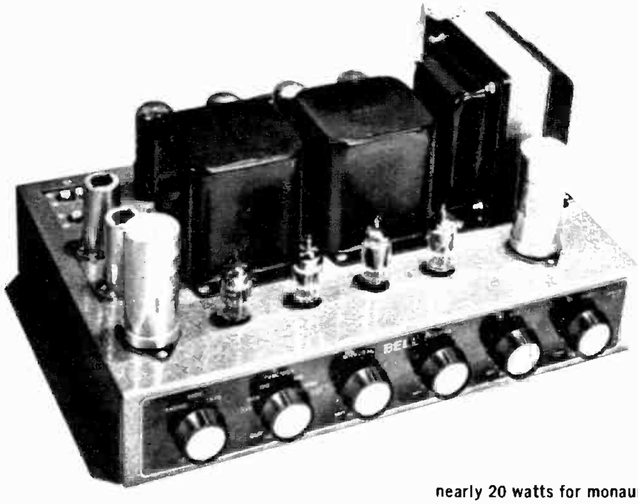
Cook binaural preamplifier requires two separate power amplifiers. It will also work—though very inflexibly—on ordinary monaural recordings

feels that binaural has a great future, but only on tape. And double-track tape, each track for one ear, does seem more practical than the half-length disc.

Audiosphere has made a series of binaural prerecorded tapes, and the Livingston binaural catalog is also available on tape. Very expensive, this: $10 for the equivalent of a 10-inch LP. Warning: Very little of high musical quality has yet been made available in a binaural form, despite four years of propaganda from binaural enthusiasts.

The best way to find out what you yourself think of binaural sound is to sample some via radio. (Demonstrations at audio shows are not much use, because they present enormous sounds in tiny rooms.) The American Broadcasting Company and a number of local stations broadcast binaural programs, one ear on AM, the other on FM. You can play the FM section through your tuner and hi-fi system, and the AM system on any portable radio. Differences of sound quality between the two channels are surprisingly unimportant in the total effect of binaural sound. You will probably get the best results if both speakers are on the same wall, six or seven feet apart, and you sit facing them about 10 feet from the wall. Move the portable radio around until you get what you consider the most striking effect. For fun, you might also try binaural through a headset of earphones. (Permoflux makes a fine binaural headset for $49). It doesn't sound like a concert hall at all, but it's an incredible experience.

Livingston Arm has two heads to track twin bands
on binaural record; inside head can be locked up and out of the way
if you wish to play ordinary monaural discs



Ten watts for each channel, or
nearly 20 watts for monaural, is available by a flick of the
"function switch" on this Bell 3-D amplifier

WHAT TO BUY

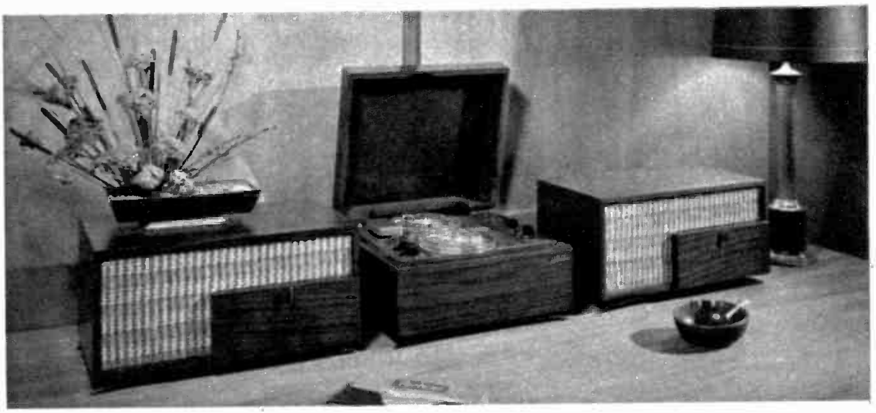
If you agree with Emory Cook, RCA and London Records that binaural is the coming thing, and you haven't yet bought a hi-fi rig, you might want to set yourself up binaurally from the beginning. You use the same turntable as for monaural (record changers are definitely not recommended here). The tone arm will be the Livingston 3-D, at $35. This arm also comes equipped with two Fairchild pickups, a diamond stylus in each, for $90—a considerable bargain, since the Fairchilds alone run $75. The two heads of the arm are on separate swivels, so that you can lock one of them up and off the record when you want to use the arm for an ordinary, monaural LP.

Two companies make single-chassis binaural amplifiers: Bell (10 watts on each channel for $147) and Newcomb (12 watts on each channel for $180). Both can be used as single-channel amplifiers, with nearly double the rated binaural output, for conventional recordings. The Cook BN/mn preamplifier, at $70, requires two separate power amplifiers for binaural use, and will work monaurally. It is, incidentally, relatively inflexible: a pair of inputs for radio *or* tape and a pair of inputs for records is all you get. But, for quality goods, it is also quite inexpensive.

Any two full-range speakers or speaker systems will work on binaural. If you want the ultimate, Cook has organized a *16-speaker* Bozak system, eight speakers per ear, which sounds—naturally—magnificent. Pairs of lesser speakers do quite

Browning AM-FM binaural tuner
($230) lets you listen
on one channel, record on the other

New Ampex tape phonograph
plays prerecorded tapes, monaural and binaural,
with professional quality. It costs $400



well enough, however. Two Goodmans coaxials in modest bass-reflex cabinets, for instance, do not cost more than many a high-grade monaural speaker system, and they can quite easily be equipped with switches to make them function in unison for monaural purposes.

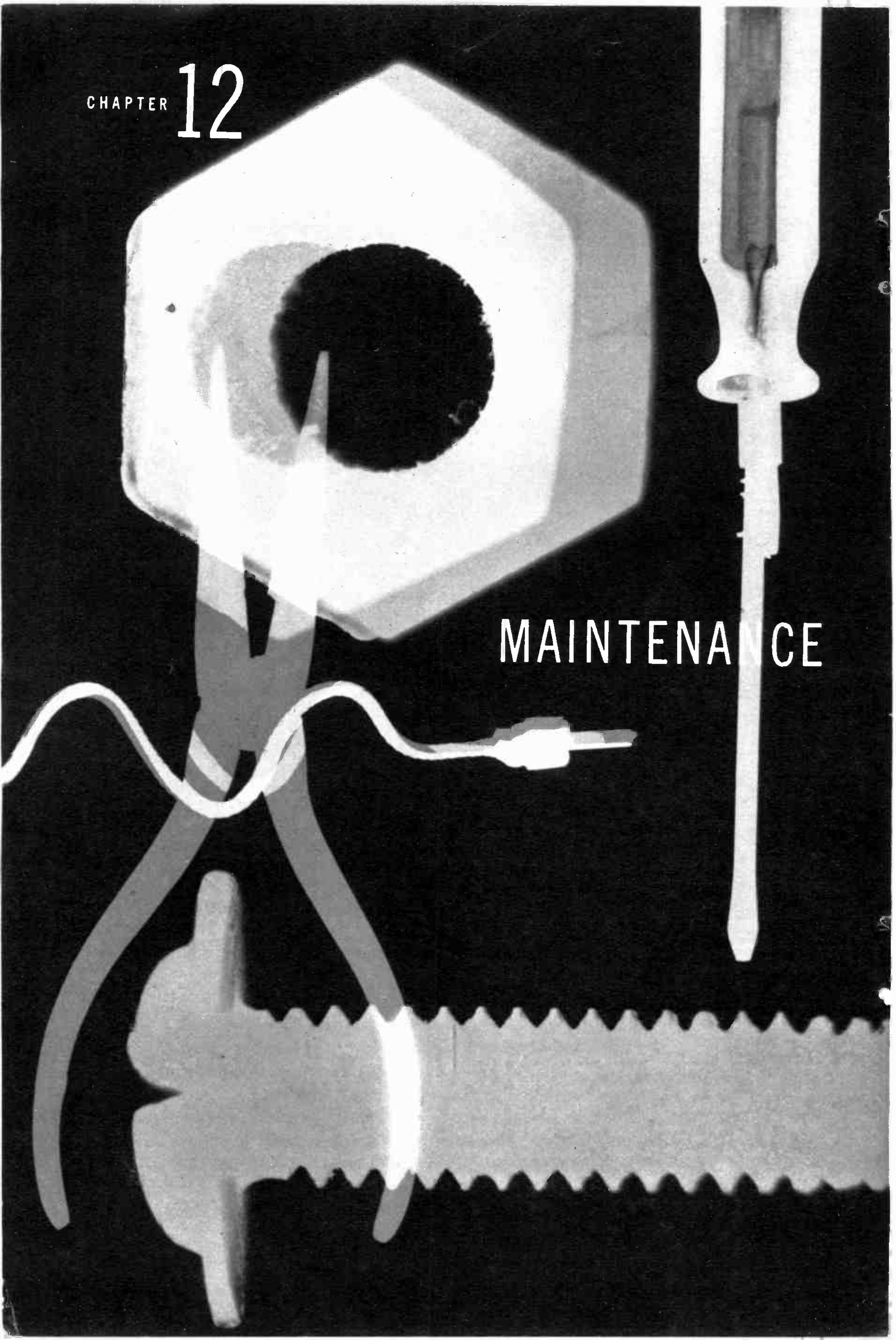
Switching your present monaural system to binaural will require the Livingston arm, a second preamplifier-amplifier and a second speaker. If you use a record player (instead of a separate turntable and tone arm), you can convert by means of a Cook clip-on conversion bracket (only $6), which holds a second cartridge at the proper distance from the first. This arrangement is not ideal, because of the weight and balance problem, but it works if you are willing to spend some time adjusting it. The Cook clip-on is supposed to work with changers, too, but we don't recommend trying it. Changer operation is just too brutal.

The rest of the conversion need not be particularly expensive, because you can safely buy a $60 preamp-amplifier single-chassis unit and a small speaker for your second ear. The sound quality on the two channels need not be identical.

If you are interested in both tape and binaural, Concertone makes the "1600" binaural tape recorder (also usable monaurally) for $495-$595 with a hysteresis motor. They suggest that with this machine you can make your own binaural recordings, but take the suggestion lightly. If the engineers have trouble making successful binaural recordings, you're likely to yourself.

CHAPTER 12

MAINTENANCE



Properly installed, a hi-fi set is no more fragile than your old phonograph. But some day it will need repair. Here's how to save yourself money and trouble

AND REPAIR

The repair situation is no better with high fidelity than with anything else, but with proper precautions you shouldn't have many repair problems. When you do have, there are steps you can take to minimize trouble and expense.

A good proportion of all the trouble that comes up in hi-fi sets traces back to faulty installation. Watch out for heat. Make sure your amplifier and your radio tuner have lots of ventilation. Don't mount a tuner right above an amplifier in a cabinet, because the heat from the amplifier is likely to break down the performance of the tuner. Make sure all your wiring connections are solid and well soldered from the start; use good shielded cable for the pickup-to-preamplifier connection, and FM 300-ohm twin-lead for the connection to the speaker. Brace the walls of the speaker enclosure and make certain they're airtight.

When trouble does arise you'll find that the audio stores do keep something in the line of a repairman around the premises, and the mail-order houses usually have a small repair department. If your machine was set up by a custom-installation expert, he may take care of servicing it. However, the corner radio repairman cannot ordinarily be relied on.

No matter how you get a malfunctioning part repaired, however, you'll save yourself time, money and worry if you can convey some idea of what's wrong. You then can send the repair department straight to the source of the trouble — or perhaps you can even repair it yourself.

HOW TO LOCATE THE TROUBLE

The most important thing to realize about diagnosis is that the trouble probably isn't what you think it is. There are ways to isolate the source, though.

If, when you're playing a record, the machine begins to sound horrible, try another record. The trouble may not be in your machine at all. If you're playing the radio, try another station. When one record or station works and another doesn't, don't worry about your machine.

If all records sound bad, and you have a radio-tuner plugged into the system, switch your input knob to "radio." When the radio works well and the records don't, the trouble must be in the record player – turntable, pickup, arm, wiring or preamplification. If both sound bad, it's almost certainly in your control panel, your amplifier or your loudspeaker.

The most common troubles in a phonograph are the following:

HUM: Almost always in the pickup, the preamplifier or the wiring between them. Make sure all connections are firm, and everything is grounded. Then make sure all connections are made from and to the right points. Check record against radio to see if you get hum from both; if you do, it's almost certainly in the control unit or the connection to the amplifier. Wiggle the plugs into the preamplifier and amplifier inputs, since the plug itself may have been jarred loose. If in this process you get a huge, jarring noise, don't let it bother you unduly. This is the common symptom of broken ground connection. Usually it means that a pin-tip connector has come part-way detached. In these connectors (poorly designed but universally used) the central or "hot" wire prong extends beyond the ground-connecting "collar." With the hot wire feeding a signal, and no ground to complete the circuit, the amplifier goes promptly into overload action. Shut it off (before it damages your speaker) and locate the incomplete ground connection.

RUMBLES AND THUMPS: Turntable trouble, almost always from a record changer. Inexpensive amplifiers and speakers work well with record changers, because they don't reproduce very low frequencies. If you plug a changer into an excellent amplifier and speaker system, it may make a sound like a distant artillery barrage. Get a better turntable, or a sharp low-frequency cutoff filter. The condition will be exaggerated if the changer is mounted too tightly. Loosen the screws (keeping changer level) and see if the "give" of the mounting springs helps.

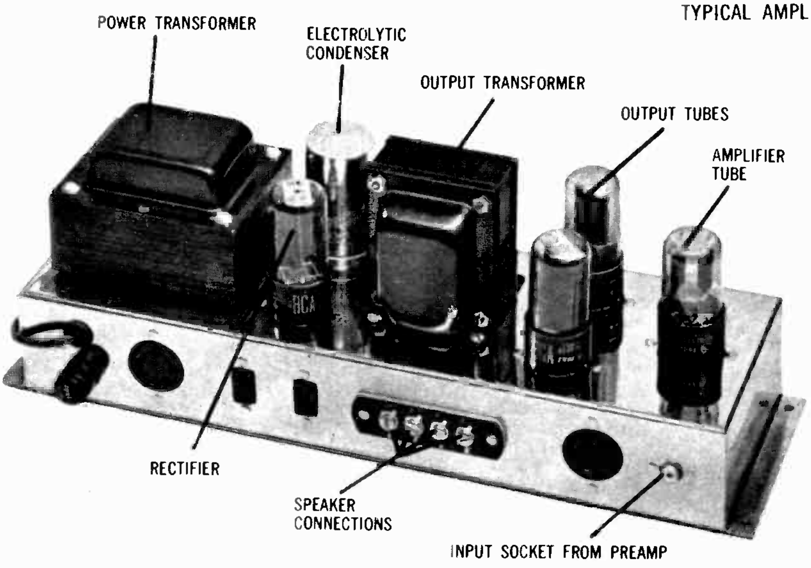
SQUEAKS AND WHISTLES: Probably a defective tube. Tap your tubes with the eraser end of an ordinary pencil and see if the whistle goes away (or the speaker pings loudly) when any one tube is jolted. Take that tube out and see if all the prongs at the bottom are straight; if not, bend them straight. Try again. No soap? Take the tube out again and hold the shank of your soldering iron about half an inch away, and then move the iron slowly away from the tube. If the tube is magnetized, this may demagnitize it. If it still doesn't work, buy a new tube. In fact, it's a good idea to buy a few spare tubes when you buy your amplifier: 12AX or 12AU for the early amplification stages, plus a pair of matched output tubes. Quality control is pretty weak in tube manufacture, and tubes are always going wrong.

CHATTER: Probably the same as SQUEAKS AND WHISTLES. If it's real "talking," however, it's probably in the output tubes. Try a new *pair* (output tubes have to be matched). Don't discard the old tubes. Test them in a radio-parts store and buy a new one to match the good tube.

WOW AND FLUTTER: Turntable. If your changer or turntable is driven by neoprene wheels (all but direct-drive and belt-drive turntables are), get some spare wheels. They tend to wear irregularly, and you can check a wow problem by changing wheels. Another occasional source of wow is a motor made to be used here or in Europe, at 117 or 220 volts, with a switch or a screw that can be turned to set the unit for your voltage. Should the voltage indicator be wrongly set, the turntable will revolve erratically. Sometimes a bent turntable or shaft will cause the trouble, and then you have to get a new turntable. If it's fairly new, you'll probably get one free.

FUZZINESS: Could be anything. If it's just on phono it's probably in the pickup. Makesure you're using the right stylus: microgroove for 33's and 45's, standard groove for 78's. Clean out the dirt around the stylus (use a soft brush and clean away the dust every time you play a record). Check to see if the stylus itself is bad. Fuzziness that's noticeable only at loud sounds is probably an overload on the amplifier, but it may also be a worn and tired tube somewhere. Try another 12AX

TYPICAL AMPLIFIER



or 12AU. Dust in the pickup may also discriminate, fuzzing reproduction only at high volume. You may also have the 1,500th pressing from the same stamper, so try another record. If the sound is just a little "rough," it may be one of the output tubes. Since they work in push-pull, one of them can disappear from the operation without greatly lowering the volume of sound.

SPEAKER TROUBLES are rare. Once you know what your machine sounds like, you'll probably be able to spot anything in the speaker by the sound. If there are queer sounds in the bass, they may be caused by a looseness in the speaker enclosure. The voice coil can come a little loose and rub against the magnets, giving you a clatter on peaks. In a coaxial speaker dirt may get in the voice-coil area of the tweeter. And a moist climate may create condensation—even rust—inside the magnet-and-coil sealed unit. Most of these defects can be remedied—but by an expert.

TOOLS

If you have any handiness at all, you'll want to try your own minor repairs after you've done the diagnosis. You'll need a spirit level for your turntable when you have to tinker with the springs, and a "stroboscope disc," a paper circle with a collection of dots, to show you whether the turntable is revolving at the right speed. In a fluorescent bulb (and to a lesser extent in an incandescent bulb) 60-cycle AC current sends the light out in 60 quick flashes per second. The strobe disc (which should cost you no more than a quarter) is so printed that the dots will seem to stand still when the disc is revolving at the desired speed under a bulb lit by alternating current.

You'll want to oil your turntable once every three months, six months or year (whichever the manufacturer recommends). Ordinary motor oil is a little thin for this purpose; No. 10 SAE or an equivalent (such as Lubriplate) will do better. Don't put in too much oil, but don't get disturbed if your turntable starts more slowly after an oiling (especially in winter). Make absolutely sure that oil never gets onto the drive wheels or idler wheels of the turntable. For cleaning the moving parts of a turntable, tone arm or pickup use carbon tetrachloride.

So far as operating tools are concerned, you'll need a soldering iron, rosin-core solder, a screw driver with an insulated handle, and snake-nose pliers. Buy a couple of rolls of Du Pont electrician's tape. You may find two sizes of screw driver convenient. "DB" wire connectors, which hook two ends of lamp card together without solder or tape, will be time-savers. Anything you can't do with these tools you probably won't want to try yourself.

PICKING A REPAIRMAN

Every one of the audio salesrooms and mail-order houses does a certain amount of repair work, but it isn't profitable and not one of them likes to do it.

A few dealers will sell you a service contract when you buy your equipment, and in the long run such contracts are usually worth having.

The dealer who helps you look at half a dozen different pieces of equipment, and doesn't put the screws on you to buy and get out, will be helpful when you have repair problems, too. Some dealers—not all—will answer repair questions over the telephone. Don't appear unannounced at your dealer's with your non-functioning amplifier—call him first. Even if he doesn't like to answer questions over the phone, he'll at least be prepared to receive you when you show up.

If you've moved since you bought your equipment, write the manufacturer of the item that isn't working and ask him if there's a dealer in your new town who carries his equipment. The dealer will either be equipped to repair it himself or will know who is. When there isn't any dealer, call the engineer of the local radio station and ask him who repairs the station's phonographic stuff.

REPAIR BY MAIL

If there's nobody in town who can do the job, you'll have to use the mails. The thought to keep in mind at all times is that you don't want to ship your equipment, unless you absolutely have to. If you ordered originally from a mail-order house, and you kept the original packing, shipping is a little less dangerous. But hi-fi equipment is fragile stuff, and it just will not stand the kicking around that packages are often subject to in the mails.

The purpose of your first letter should be to find out what, if anything, you can do yourself. If you bought from a mail-order house, write to them. And if their answer doesn't produce results, write to the manufacturer. You can also write to one of the magazines in the audio field—*High Fidelity, Audiocraft* or *Audio. High Fidelity*, for instance, answers up to 80 service letters every day. The address is Great Barrington, Mass. Just remember to make your letter as explicit as you can.

If, finally, you have to send your equipment off, make sure you know how to pack it; if you're not entirely certain, make packing the subject of a separate letter. Most manufacturers have a form letter on packing.

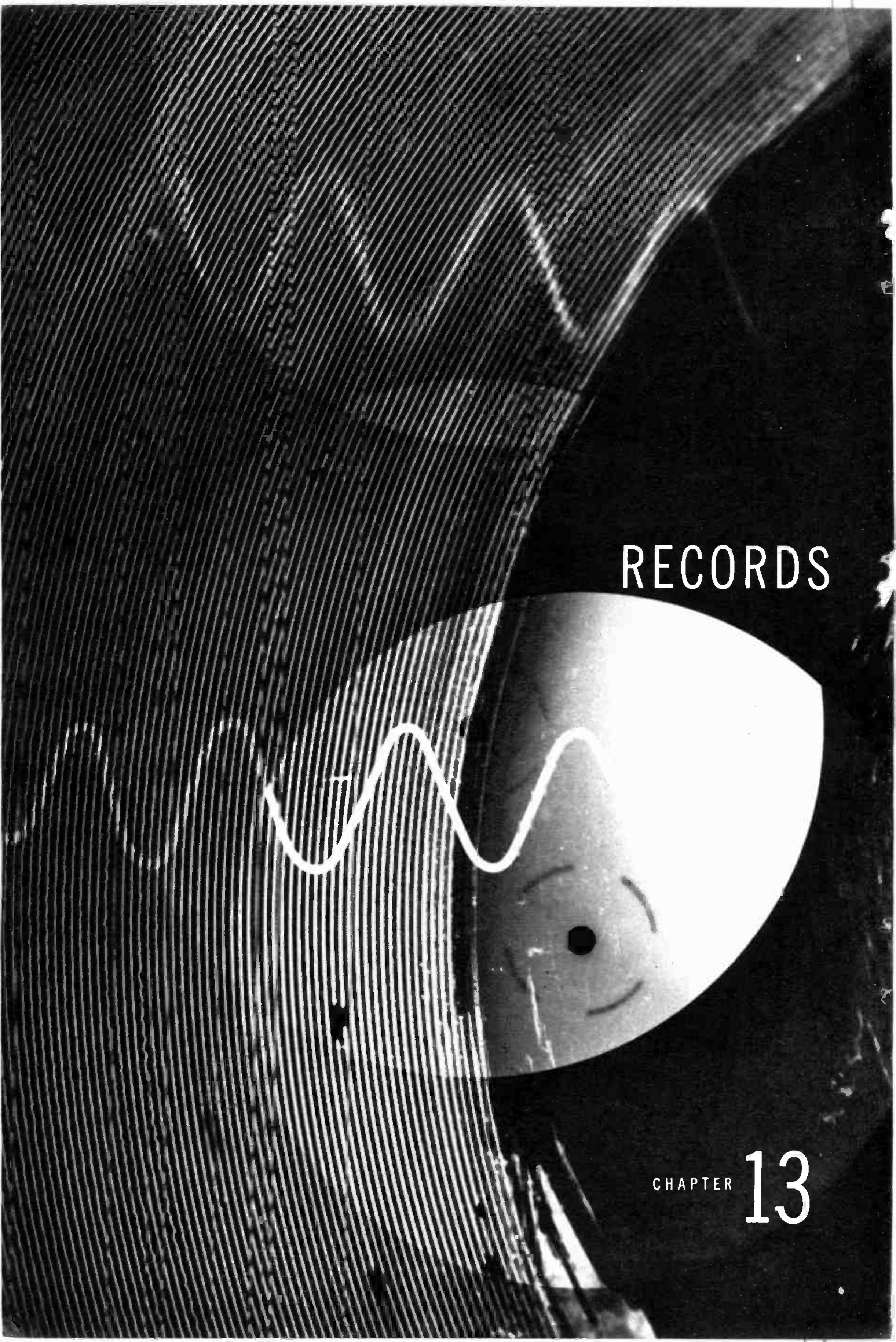
Never send any piece of equipment to the manufacturer or the repair department of a mail-order house until you have written them and they have replied. Once the repair service has replied and given you shipping instructions, you can send it knowing that it will go immediately into the right hands.

Pickup manufacturers are the best organized for repair service, especially those who tell you to send your cartridge back for stylus replacement. Pickering boasts that it gets the stylus changed and the pickup reconditioned (if necessary) within 48 hours of the arrival of the package. Amplifier and speaker manufacturers are much slower.

Incidentally, the repair situation, poor as it is, will not be accepted as an excuse for not buying high-fidelity equipment. Components wear far better than the standard stuff in commercial radio-phonographs.

RECORDS

CHAPTER 13



The authors—and a jazz expert—draw on their experience as record critics to come up with a permanent list of outstanding, well-recorded performances

OF HIGH FIDELITY

Out of every 100 people who buy a hi-fi rig, 98 want to play records on it. You can omit a record player entirely, and simply plug a radio tuner or tape recorder into the amplifier, but you don't. People who want only radio or tape somehow buy the low-fidelity package radios and tape recorders that you find in the department stores. It's only with phonograph records that you can use all the buttons and knobs on the control panel. And since your friends often have the same records, you get a unique chance to compare your property with your neighbor's.

Records can be bought by mail order or in person at any of two thousand stores. As almost everybody knows by now, you should not ordinarily pay list price for records: 20% off for a $3.98 disc, 25% off a $4.98 disc and 30% off a $5.95 disc should be the minimum satisfactory discount. One exception to the rule is the "collector's" dealer, who sells only at list price but will pick, check and guarantee your copy for you. If you love a recording enough, this service may be worth the extra money.

Taking care of a collection is not nearly so difficult as some experts might have you think. Records should be handled by their edges, or by one edge and the center label. You should stack them in an upright position—not flat on their back—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. Most new records come in protective paper or plastic shields, which is sensible preventative medicine; keep the shields, and keep the records in them.

RECOMMENDED RECORDINGS

The following list is a tabulation of the LP recordings that one or both of the authors of this book feel to be of permanent value. It is a "bomb-proof" list. No recordings in the foreseeable future should make anything on it unsatisfactory.

Almost all the records on this list are postwar recordings. The musical artistry of the last decade has been, unfortunately, demonstrably inferior to that of the 30's; but most records made before 1942 are so bad technically that much of the enjoyment to be derived from them has been lost, and we don't feel this fact can be ignored. The situation is worst with orchestral music; such masterful performances as the Schnabel Beethoven and Mozart concertos, Weingartner's Beethoven, Brahms and Wagner, can be recommended only to those who have trained their imaginations to hear what isn't on the record. Piano solo is next bad; chamber music and vocal recordings are usually satisfactory even today. But you can't honestly call them "high fidelity"—they don't even pretend to it. Neither do the record companies who reïssue the discs: most such records are labelled "Treasury," and none is called "high fidelity."

We *have* largely ignored the difference between 1949 and 1955 recording techniques: the job is undeniably done better today, but you lose little of the musical sense with a '49 recording properly equalized. If you care strongly about these things, you'll want to avoid the lowest-number records in the catalogues of the big companies; but it probably isn't worth your trouble. Recording values are transient, and make their greatest impression on the first time around. Musical values are permanent, and grow on you with each hearing.

This is a list, then, of fine performances well recorded. We have not tried to give you a "basic library." These are at least 19 recordings of the Beethoven *Fifth Symphony*, but not one of them qualifies as bomb-proof. None of them is even very good. Thus, no Beethoven *Fifth;* we feel you'd be better off waiting for the right one to come along. The Schubert song cycles are among the great experiences of music, but no LP recording of any of them has what we would consider "permanent value." The same sad fact rules out the operas of Monteverdi and Handel, Mozart's music for woodwinds alone, Beethoven's piano trios, and much else that is eminently worth hearing, knowing and owning.

No piece of music that both of us consider complete trash has been included, however good the performance. Otherwise, it is the performance which distinguishes a record and makes it something to buy and to treasure, and it is this quality which lies behind our recommendation of these 100 classical recordings. Finally, because the jazz cult grows day by day, and because neither of us feels qualified as a critic in that field, Jack Crystal, a noted jazz connoisseur and owner of the famous Commodore Music Shop in New York, has given us his pick of the 21 finest hi-fi jazz recordings.

100 finest HI-FI recordings

* indicates list price of $3.98 or less † indicates list price of $5.95 or more

SYMPHONIES

BEETHOVEN **No. 9 in D Minor, Op. 125 (Choral)* Toscanini, NBC Symphony RCA Victor LM-6009
**No. 3 in E Flat Major, Op. 55 (Eroica)* Leinsdorf, Rochester Orchestra Entre 3069
BERLIOZ *Symphonie Fantastique, Op. 14* Ormandy, Philadelphia Orchestra Columbia 3ML-4467
BRAHMS *No. 4* Krips, London Symphony London LLP-208
DVORAK *No. 5 (New World)* Kubelik, Chicago Symphony Mercury 50002
HAYDN *†No. 100 (Military)* Scherchen, Vienna Symphony Westminster 5045
MAHLER *No. 1 (Titan)* Walter, N. Y. Philharmonic Symphony Columbia 5SL-218
MENDELSSOHN *No. 3 (Scotch)* Kletzki, Israel Philharmonic Angel D35183 or T35183
MOZART *No. 35 (Haffner)* Beecham, London Philharmonic Columbia 3ML-4770
**No. 40* Leinsdorf, Rochester Orchestra Entre 3070
RACHMANINOFF *No. 2* Ormandy, Philadelphia Orchestra Columbia 3ML-4433
SCHUBERT **No. 8 (Unfinished)* Leinsdorf, Rochester Orchestra Entre 3070
TCHAIKOVSKY **No. 6 (Pathetique)* Monteux, Boston Symphony RCA Victor LM-1901
VAUGHAN WILLIAMS **No. 1 (Sea Symphony)* Boult, London Philharmonic London LL-972/3

CONCERTOS

BARTOK *†For Viola* Primrose, Serly, London New Symphony Bartok 309
BEETHOVEN **No. 4 for Piano* Curzon, Knappertsbusch, Vienna Philharmonic Orchestra London LL-1045
BRAHMS **No. 1 for Piano* Backhaus, Böhm, Vienna Philharmonic London LL-911
COPLAND *For Clarinet and Strings* Goodman, Copland, Columbia String Orchestra Columbia 3ML-4421
GRIEG *†In A Minor for Piano* Novaes, Swarowsky, Pro Musica Symphony Orchestra Vox 8520
HAYDN *In E Flat Major for Trumpet* Eskdale, Litschauer, Vienna State Opera Orchestra Vanguard 454
LISZT *†No. 1 for Piano* Farnadi, Scherchen, Vienna State Opera Orchestra Westminster 5168
MENDELSSOHN *For Violin* Francescatti, Mitropoulos, N. Y. Philharmonic Symphony Columbia 4ML-4965
PROKOFIEV *For Violin* Milstein, Steinberg, Pittsburgh Orchestra Capitol P-8303

ORCHESTRAL MISCELLANY

BACH **Brandenburg Concertos 2 and 3* Munchinger, Stuttgart Chamber Orchestra London LLP-144
BOYCE *Little Symphonies 1, 4, 6, 8* Haas, London Baroque Ensemble Westminster 5073
HANDEL *†Concerti Grossi 1-4* Scherchen, English Baroque Orchestra Westminster WAL 403
IBERT *Divertissement* Desormiere, Paris Conservatoire London LL-654
MOUSSORGSKY *Pictures at an Exhibition* Kubelik, Chicago Symphony Mercury 50000
RIMSKY-KORSAKOV *Scheherazade* Ormandy, Philadelphia Orchestra Columbia 5ML-4888
ROSSINI-RESPIGHI **Boutique Fantasque* Irving, Philharmonia Orchestra Bluebird LBC-1080
R. STRAUSS *Don Juan* Furtwängler, Vienna Philharmonic HMV 19
STRAVINSKY *Sacre du Printemps* Steinberg, Pittsburgh Symphony Capitol P-8254

SOLO

BACH *Suites for Cello Nos. 4 and 5* Fuchs (viola) Decca 9660
**Well-Tempered Clavier, Bk. II, 1-8* Landowska (harpsichord) RCA Victor LM-1152
BEETHOVEN **Sonatas Nos. 16 and 18* Backhaus London LL-951
CHOPIN *†Sonatas in B Flat Minor and B Minor* Novaes Vox 7360
**Polonaises Vol. I* Rubinstein RCA Victor LM-1205

KODALY *Cello Sonata* Kurtz Columbia 3ML-4867
MOZART †*Fantasia and Sonata in C Minor* Badura-Skoda Westminster 5317
SCHUBERT *Cello Sonata* Gendron London LL-654
SCHUMANN **Fantasia in C* Curzon London LL-1009
——— *Cathedral Voluntaries and Processionals* Biggs (organ) Columbia 4ML-4603

OPERA

GERSHWIN *Porgy and Bess (complete)* Soloists, Chorus, Orchestra, Engel Columbia 5SL-162
LEHAR *The Merry Widow* Schwarzkopf, Loose, Kunz, Niessner, Philharmonia Orchestra, Ackermann Angel 3501 or T35033/34
MOZART *Marriage of Figaro* della Casa, Siepi, Vienna Opera Company, Kleiber London XLLA-35
OFFENBACH *La Belle Helene* Linda, Paris Philharmonic, Leibowitz Renaissance SX-206
PERGOLESI *La Serva Padrona* Soloists, Chorus, Orchestra, Simonetto Cetra 50036
PUCCINI *La Tosca* Callas, di Stefano, Gobbi, La Scala Orchestra, de Sabata Angel 3508 or T35060/61
ROSSINI *L'Italiana in Algeri* Valletti, Petri, Simionato, La Scala Orchestra, Giulini Angel 3529
SMETANA *The Bartered Bride* Soloists, Chorus, Prague National Theatre Orchestra, Vogel Urania 231
J. STRAUSS *A Night in Venice* Schwarzkopf, Loose, Gedda, Kunz, Philharmonia Orchestra, Ackermann Angel 3530
R. STRAUSS *Der Rosenkavalier* Gueden, Jurinac, Weber, Reining, Vienna Philharmonic Orchestra, Kleiber London LLA-22
STRAVINSKY *The Rake's Progress* Conley, Theobom, Harrell, Metropolitan Opera Orchestra, Stravinsky Columbia 5SL-125
VERDI **Otello* Nelli, Vinay, Merriman, Valdengo, NBC Symphony, Toscanini RCA Victor LM-6107
WAGNER **Tristan und Isolde* Flagstad, Fiescher-Dieskau, Thebom, Philharmonia Orchestra, Furtwängler RCA Victor LM-6700
WOLF-FERRARI *I Quattro Rusteghi* Noni, Corena, Chorus, Orchestra, Simonetto Cetra 1239

CHORAL

BACH †*Cantata No. 140* Laszlo, Poell, Chorus, Vienna State Opera Orchestra, Scherchen Westminster 5122
†*Mass in B Minor* Dermota, Poell, Chorus, Vienna Symphony Orchestra, Scherchen Westminster WAL 301
BALES *The Confederacy* Soloists, Chorus, National Gallery Orchestra, Bales Columbia SL-220
BERLIOZ **Damnation of Faust* Danco, Poleri, Singher, Boatwright, Boston Symphony Orchestra, Munch RCA Victor LM-6114
HAYDN *The Seasons* RIAS Orchestra and Chorus, Fricsay Decca DX 123
HONEGGER †*King David* Micheau, Radiodiffusion Francaise Orchestra, Honegger Westminster WAL 204
ORFF *Carmina Burana* Soloists, Chorus, Bavarian Radio Orchestra, Jochum Decca 9706
ROSSINI *Stabat Mater* Soloists, St. Hedwig's Cathedral Choir, RIAS Symphony Orchestra, Fricsay Decca DX 132
SCHUTZ *Christmas Story* Cantata Singers, Mendel REB 3
——— *French Renaissance Vocal Music* Nadia Boulanger Ensemble Decca DL 9629

SONGS

BERLIOZ *Nuits d'Ete* Steber, Mitropoulos, N. Y. Philharmonic Symphony Columbia 3ML-4940
MAHLER *Das Knaben Wunderhorn* Sydney, Poell, Vienna State Opera Orchestra, Prohaska Vanguard 412/13
PROKOFIEV *Five Songs to Poems by Anna Akhmatova* Kurenko Capitol P-8310
PURCELL *Songs* Oberlin Esoteric 535

SCHUBERT *Lieder* Elisabeth Schwarzkopf Angel D35022 or T35022
R. STRAUSS **Lieder* Suzanne Danco London LS-699
RAVEL **Scheherazade* Danco, Orchestre de la Suisse Romande, Ansermet London LL-1196
——— *Brahms, R. Strauss: Songs* Erna Berger Decca 9666
——— **Schubert, Brahms, R. Strauss* Kirsten Flagstad RCA Victor LM-1870
——— *Wolf, Brahms: Songs* Irmgard Seefried Decca 9743
——— *Songs of the Auvergne* Madeleine Grey Columbia 5ML-4459
——— *The Life of Christ thru Aframerican Folk Song* Roland Hayes Vanguard 462

CHAMBER MUSIC

BACH *Sonatas for Flute and Harpsichord* Baker, Marlowe Decca DX 113
BARTOK *Quartet No. 3* New Music Quartet Bartok 901
BEETHOVEN †*Trios for Strings, Op. 8 and Op. 9, No. 3* Pougnet, Riddle, Pini Westminster WL 5219
Quartet No. 9 Budapest String Quartet Columbia 4ML-4581
Quartet No. 13 Pascal String Quartet Concert Hall CHS 1210
Quintet in E Flat Major Serkin, Philadelphia Woodwind Quintet Columbia 4ML-4834
BRAHMS *Sextet Op. 18* Stern, Schneider, Katims, Thomas, Casals, Foley Columbia 3ML-4421
CHAUSSON *Concerto for Piano, Violin and String Quartet* Casadesus, Francescatti Guilet String Quartet Columbia ML-4998
DEBUSSY *Sonata for Flute, Harp and Viola* Baker, Newell, Fuchs Decca DL 9777
DVORAK †*Quintet for Piano and Strings* Farnadi, Barylli Quartet Westminster 5337
HAYDN †*Quartets Op. 76, No. 3 and 4* Schneider Quartet Haydn Society HSQ 35
†*Trios No. 1, 28 and 30* Fournier, Janigro, Badura-Skoda Westminster 5202
HINDEMITH *Kleine Kammermusik No. 2* Fine Arts Quartet Capitol P-8258
MILHAUD *Suite for Violin, Clarinet and Piano* Parrenin, Delecluse, Haas-Hamburger Period 563
MENDELSSOHN **Octet* Vienna Octet London LL-859
MOZART **Divertimento in E Flat* Heifetz, Primrose, Feuermann RCA Victor LCT-1150
Oboe Quartet Tabuteau, Stern, Primrose, Tortelier Columbia 3ML-4566
SCHUBERT *Quartet No. 14* Amadeus Quartet HMV 1058
†*Quintet in A Major (Trout)* Wuehrer, Barchet Quartet Vox 8970
Trio No. 2 A. Busch, Serkin, H. Busch Columbia ML-4654
STRAVINSKY *L'Histoire du Soldat* Stravinsky conducting Columbia 5ML-4964
——— *Eighteenth Century Lute Trios* Tryssesoone, Podolski, Terby Period 587

SPECIAL JAZZ LIST

LOUIS ARMSTRONG *Louis Armstrong at the Crescendo* Decca DL 8169 and 8170
COUNT BASIE *Dance Session* Clef MGC 626
SIDNEY BECHET *Jazz Festival Concert* Blue Note LP 7024
DAVE BRUBECK'S QUARTET *Jazz Goes to College* Columbia CL 566
EDDIE CONDON *Dixieland* Columbia CL 719
CHRIS CONNOR *This is Chris* Bethlehem BCP 20
ELLA FITZGERALD *Songs in a Mellow Mood* Decca DL 8068
BENNY GOODMAN *B. G. in Hi-Fi* Capitol W-565
JAY JAY JOHNSON & KAI WINDING *East Coast Jazz, Vol. 7* Bethlehem BCP 13
GEORGE LEWIS *George Lewis and his Ragtime Band* Jazzman JM 331
THE MODERN JAZZ QUARTET Prestige PRLP 160
GERRY MULLIGAN QUARTET Pacific Jazz PJLP 1
KID ORY *Kid Ory's Creole Jazz Band—1954* Good Time Jazz L 12006
MEL POWELL SEPTET *It's Been so Long* Vanguard VRS 8004
SHORTY ROGERS *Cool and Crazy* RCA Victor LPM 3138
THE SAUTER-FINIGAN ORCHESTRA RCA Victor LPM 3115
BOB SCOBEY *Bob Scobey's Frisco Band* Good Time Jazz L 12006
FRANK SINATRA *Swing Easy* Capitol W 587
JOHNNY SMITH and STAN GETZ *Jazz at NBC* Roost 410
ART TATUM *The Genius of Art Tatum* Clef No. 1 and No. 2
LEE WILEY *Night in Manhattan* Columbia CL 656

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 sound 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, which prevents the rear waves of the speaker from interfering with the front waves. 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 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 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 (in practice, the Klipsch design); *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; *piezo-electric* and *capacitance* pickups have a *constant-amplitude* response. See Chapter 5.

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.

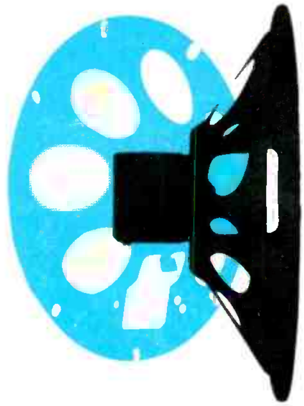
TURNOVER—see *equalization*

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.



HI-FI

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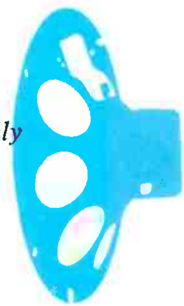

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