

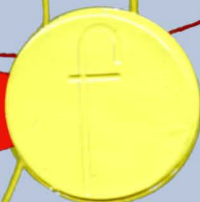
The

STEREO SOUND

Book



Focal **SOUND**book



STEREO SOUND IS EASY if you want it to be—it depends on whether you want to listen to it or talk learnedly about it. This book is for people who want to enjoy listening to it and who only want to know enough about the means to be able to arrive at the end with as little trouble and expense as possible.

YOU CAN UNDERSTAND everything in this book if you know how to mend a fuse or change a torch battery. It tells you the How and Why of the new kind of recorded sound; it tells you what equipment you need to reproduce it; it tells you what you can buy ready made “off the peg” and what you can make to your own measure with “build-it-yourself” units.

DO YOU WANT TO CONVERT your present record player, radiogram or tape recorder? The book gives you the cost of everything and advises you on how to choose the equipment to fit your pocket—and your living room.

ALL THE STEREO TERMS you are likely to read or hear are explained clearly in the Glossary at the back of the book.

EVERY FACT IS CHECKED by a panel of qualified sound recording engineers.

THE AUTHOR is a confirmed do-it-yourself-er who writes only about what he has experienced at first hand.

THE STEREO SOUND BOOK



A FOCAL SOUNDBOOK

*The
Stereo Sound
Book*

FREDERICK PURVES

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All About Stereo Sound

'STEREO', 'SOLID SOUND' OR 3-D, TO GIVE IT only three of the commoner names, is the method of recording sound and playing it back to give you as nearly as possible the sensation of listening to the real thing.

Ordinary sound reproducers—like gramophones and radio—can only reproduce the loudness of the sound waves; stereo adds position and direction. The thing is as simple as that, and in practice the result, compared to ordinary sound reproduction is as different as sculpture from painting. But as to how it all works in terms of the way the sound waves travel to you, and the way your ear deals with them when they arrive . . . the sad fact is that no simple explanation is completely true.

The further you go into the theory, the more complicated it gets, until at last you reach a point where you can go no further. Your path is barred by a lot of serious men with slide rules and instruments, arguing about how your brain sorts out the different messages it gets from your right and left ears so that you can tell where a particular sound is coming from—without your having to think about it.

Fortunately there is no need to get involved in the argument. You can enjoy the real thrill of listening to stereo without being either an acoustics engineer or an ear specialist; just as you can appreciate good cooking even if you don't know how to boil an egg.

How much do you need to know?

Of course, to enjoy stereo you need only go out, buy a

stereo playing unit, bring it back home and fit it up in accordance with the maker's instructions. Then you can sit back and listen to a stereo record right away. Lots of people do, and you may wonder why you should waste time reading any more than the bare instructions.

The answer is first that it helps if you know what type of equipment to choose from dozens of makes and models, some using disc records and some using tape. It helps again to know how to place the various units to get the best stereo effect, how to make your own stereo records (if you decide to buy a stereo tape recorder) and how to save money by using your existing equipment as part of the new stereo set-up. It is also useful to know all the other things you can use your equipment for, apart from simply reproducing stereo records.

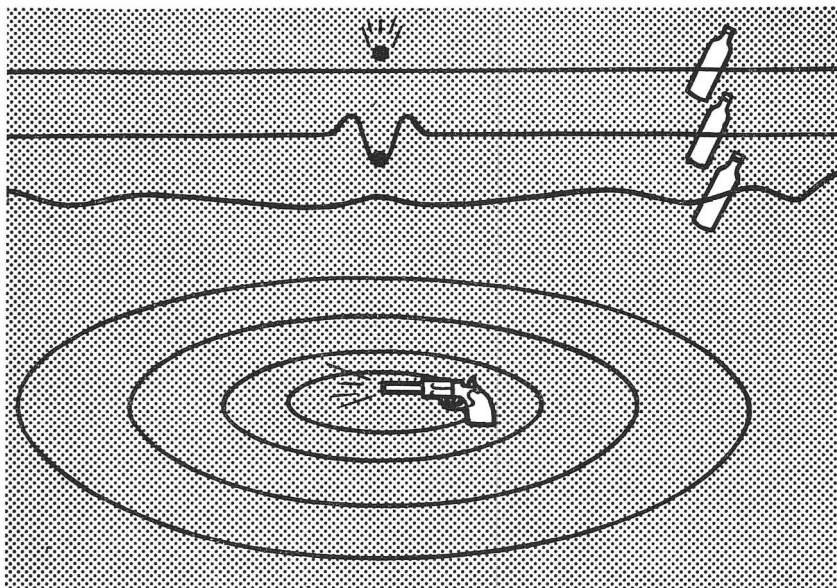
Finally you want to know how to look after your equipment so that you get the greatest possible enjoyment out of it for the longest possible working life. The maker's instruction book can only deal with the bare details as they effect every type of user; it can't make allowances for your personal likes and dislikes or for your particular listening conditions. And, of course, it won't recommend another make of set if the one you think of buying isn't the best for your purpose or your money.

What is sound?

Stereo opens up a new world of recorded sound and like most worlds it has its own particular language. You have to learn it if you want to find your way about. So if you can spare half an hour or so to get familiar with it you will find the time well spent. Let's start right at the beginning with actual sound.

SOUND TRAVELS IN WAVES. You can think of the air around you as something like the calm surface of a pool. If you drop a stone into it you set up a pattern of waves that spread out in circles until they reach the bank. But a cork floating on the water does not move towards the bank;

it simply bobs up and down as the waves pass. This tells you that although the *shape* of the waves moves, the water itself stays still; the level simply rises and falls as each wave goes past.



SOUND TRAVELS IN WAVES. When you drop a stone into a pond (above) you start a wave that moves away in all directions. But a bottle floating on the water just bobs up and down, showing that, while the wave moves, the water stays where it is. When you disturb the air—e.g., by exploding a charge of gunpowder (below), you set up pressure waves that travel outwards in the same way. You can't see these waves, but you can hear them. They are sound waves.

The same sort of thing happens in the air of a room if you strike a note on the piano. The hammer hits the string and starts it vibrating to and fro. When this happens the air around the string is forced to vibrate, and then the air around that, and so on in waves that radiate out in circles like the ripples on a pond.

There is just this difference: the waves on the pond are formed by differences in the *level* of the surface; the waves in the air are the result of differences in *pressure*. And, of course, while the ripples on the pond move across the surface, the pressure waves radiate out in every direction: up, down and to all sides.

WHAT THE WAVES LOOK LIKE. You can *see* a wave on the surface of a pond, but you can't see a sound wave in the air. However, modern scientists can easily show you a picture of a sound wave by using an instrument called an oscilloscope. The business end of this looks like the screen of a small TV set. A point of light on the screen draws a picture of the way the air pressure changes from the beginning to the end of a sound wave.

The picture it draws is exactly like any of the waves on the pond: as the light pencil moves from one side of the screen to the other, the line it traces rises in a hump, falls away to a trough and then returns to the centre of the screen again. This series of pressure changes is called a cycle. Every wave consists of one complete cycle.

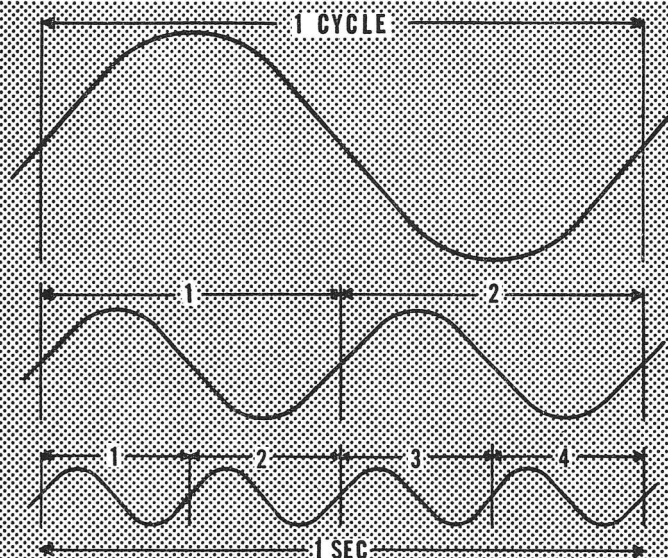
Frequency

If you could see the actual sound waves, you would notice that high notes consisted of short waves, and low notes of longer ones. The higher the note, the shorter the wavelength—a note exactly an octave above another is exactly half the wavelength. In the same way, it takes more complete waves or cycles every second to make a high note than a low one; in fact there are twice as many cycles per second in, say, Middle C on the piano, than in the note C one octave below, and half as many as the note C one octave higher.

Scientists can measure the actual number of cycles per second that go to make any particular note. We know that Middle C on the piano sends out 261.6 cycles—or complete sound waves—per second. This is called the frequency of the note. The note C, an octave higher, has a frequency of

523.2 (exactly twice) and the C an octave below has a frequency of 130.8 (exactly half).

HIGH NOTES—LOW NOTES. We can measure the frequency of all the other notes on the piano in the same way.



FREQUENCY. The air pressure in a sound wave (above) shoots up to a peak, then drops to a trough and finally returns to normal before starting all over again. The number of times this complete cycle is repeated per second is known as the frequency of the sound. The frequency fixes the musical pitch of the note. When you double the frequency (centre) the note rises an octave. Double it again (below) and it rises two octaves.

We can go lower and measure the frequency of such deep-voiced instruments as the double bass fiddle and the lower notes of the organ. We can go higher and measure the shrill notes of the piccolo. Right at the lowest end of the frequency scale—at about 16 cycles per second—the sound stops being a musical note and you just hear a series of

vibrations like the noise you get when you draw a stick along a row of railings. It isn't a note any more, it is just a rattle.

At the top end of the scale, you find that as the vibrations get faster and faster, the note rises higher and higher until something strange happens. Although you can detect the sound with scientific instruments, and measure its frequency, *you don't hear it any more.*

The point where your hearing gives out depends to some extent on your age. When you are young, you may be able to hear sound frequencies as high as 20,000 cycles per second or more, but in later life the highest note you can hear may be no more than 12,000 cycles per second.

However, you can see that if you want to reproduce sounds—in particular, the sounds made by musical instruments—your recording equipment, and the machine you use for playing back the record, has to be able to reproduce sound waves of frequencies from about 30 cycles per second up to at least 15,000. And if it can handle frequencies as high as 25,000 cycles per second, so much the better.

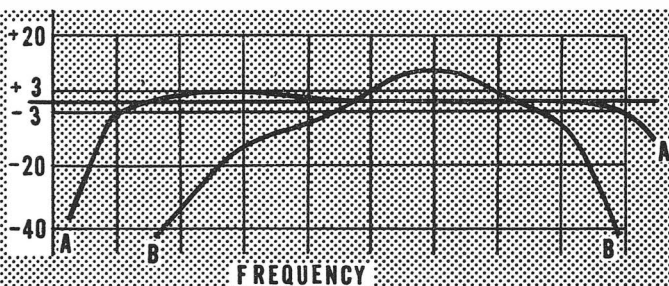
But it isn't enough for your equipment to be able simply to record and reproduce this range of frequencies, it must be able to reproduce them all in the original loudness in relation to each other.

For example, if the record is of the Middle C on the piano, then when you play it on your reproducing equipment you should hear the note of Middle C in the exact pitch of the original. That is the first essential. Then if you take a record made of two notes of the same loudness, one high and the other low, they should sound equally loud when you play them back. But if the high note sounds louder than the low one, then everything you reproduce will suffer in the same way. If you play an orchestral record, the violins will overpower the cellos and double basses; if you play a choral record, the tenors and sopranos will shine at the expense of the altos and basses.

FREQUENCY RESPONSE. You can see that before you can expect a record to sound like the real thing, your playing

equipment must be able to reproduce faithfully all the sound frequencies within the range of your hearing—high and low, loud or quiet.

There are special instruments which will measure how good a record player is at doing this. You can then say that the reproduction is a faithful copy of the original sound from so many cycles per second at the low end of the frequency scale to so many at the high end. This range is called the frequency response. While there is no such thing as an absolutely faithful response, the instruments will tell you how much the performance of the reproducer falls short of the ideal. They measure the error in decibels.



FREQUENCY RESPONSE. You can tell how good your equipment is by drawing a graph of the way it amplifies different frequencies from lowest (left) to highest (right). If it treats them all alike, its response curve stays level from end to end (o—o). A response that never rises or falls more than 3 dB over the normal scale—e.g., A-A—is good. If it varies more than this—e.g., B-B—it does not qualify as high fidelity.

(A decibel—written dB—is the unit used to measure how much stronger or weaker one sound is than another. If there is a difference of 3 dB between two sounds it means that one is half as loud as the other. Your ear can just detect a change in volume of 3 dB. So if the strength of a particular sound never rises or falls more than 3 dB your ear won't notice any change in volume.)

When you read in the description of a record player or tape recorder or sound amplifier that it has a frequency

response of 60 to 10,000 cycles per second \pm (plus or minus) 3 dB it tells you that the set will respond to sounds ranging from 60 cycles per second—about two octaves below Middle C on the piano—up to 10,000 cycles per second—the highest note on a piccolo—and that over the whole range it will not wander far enough above or below the truth for your ear to spot the error. And if the figure is less than ± 3 dB you will know that the performance is something extra good.

What is high fidelity?

The first question most newcomers ask about sound reproduction is what do you mean by Hi-Fi, and has it anything to do with Stereo?

Well, Hi-Fi is simply slang for high fidelity—a standard of reproduction that is faithful to the original sounds to a very high degree. In other words, reproduction that sounds as nearly like the real thing as possible. In terms of frequency response it means a record player that will reproduce all frequencies from at least 60 c/s up to at least 12,000 c/s without varying more than 3 dB above or below the correct value. Most high fidelity systems worthy of the name will do much better than this. But any equipment that does not reach this standard would not be classed as high fidelity.

WHY THE MYSTERY? Since the thing is as simple as that, you may wonder why there is such an aura of mystery and exclusiveness about high fidelity. The answer is that there is no commercial high fidelity sound reproducer; if you want high fidelity you have to get it by building up a system for yourself with separate items, each made by a firm that specialises in that particular article.

You can, of course, go out and buy a complete gramophone or tape recorder or radio in which all the necessary parts are already assembled, but it will not pass the high fidelity test. It will satisfy most people who have not acquired the habit of listening critically, but a trained ear

will notice all kinds of shortcomings such as an over-emphasis of certain frequencies which makes the reproduction sound either shrill or boomy.

Practically all commercial radio sets, gramophones and radiograms suffer in this way because they are designed to sell in production line quantities at a keenly competitive price. The expensive luxury sets are little better in this respect than those in the medium price range, because the extra cost goes on features that show, such as a bigger and more ornate cabinet, built-in cocktail cupboards, luxury styling and all manner of automatic gadgetry.

If you want really tip-top performance, you can't buy it ready made in one self-contained unit. You have to buy each bit separately from a manufacturer who specialises in that particular item and you must connect them together yourself. Before you go to all the trouble, you have to be a special kind of enthusiast—a combination of musical connoisseur and a handyman who has a nodding acquaintance with electronics.

Failing the practical qualifications you have to be prepared to go to a reputable dealer and get him to recommend a set-up to suit your requirements and your budget. He will also sell you a cabinet or fitment to hold the various items and install them and connect them up into a single unit that you can switch on like a radio. This is a more expensive way than assembling everything yourself, but it is the safe way if you don't know anything about the technicalities of this kind of equipment.

How we hear sounds

If you are in a restaurant and a waiter drops a plate, you hear the noise it makes a fraction of a second later. You may not have seen the plate fall, but your ears will tell you quite a lot about it, simply from the sound it makes.

You will have a pretty accurate idea of *where* the plate dropped—in front of you or behind you, to right or to left. You will be able to tell if it fell close by or at the other end

of the room. You might even be able to say if it was a big or a small plate, and if it fell a long or a short distance before hitting the ground. You would know whether it broke or just bounced, and whether it fell on the floor or the carpet.

That is quite a lot of information to get from a sound lasting a short fraction of a second, and it is by no means the limit of what your ear can do in this way. And a system of sound reproduction, to be perfect, should present the recorded sound—say of the dropped plate—in such a way that it will tell you everything you could have learned from listening to the original on the spot—with your two ears.

Stereo sound

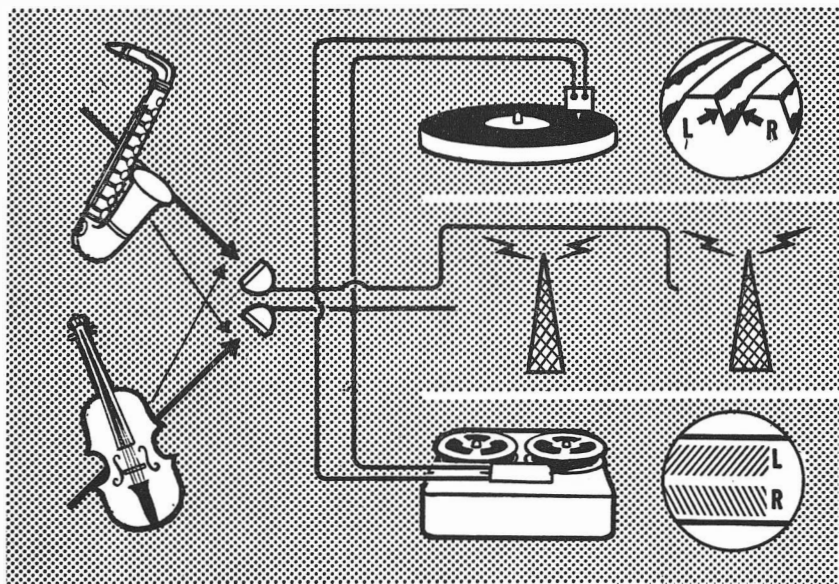
When both your ears are listening to the same sound, there are certain slight differences between what your left and right ears hear. There are several reasons for this:

First, your ears are on opposite sides of your head, so sounds arriving from either side take longer to reach one ear than the other. The difference is only a matter of a 1/500th of a second but your brain will spot it all right. The spacing of your ears is enough to put the ups and downs of the sound waves out of step when your brain comes to add the right and left sound pictures together. (Sound engineers refer to this as a difference in *phase*.)

Next, your ears face in opposite directions, so a noise to the left of your head sounds louder to your left ear—which listens towards it than to your right ear—which listens away from it. And finally, all these differences change in some way as you turn your head from side to side.

In fact your two ears work as a team to build up a feeling of roundness and reality to the sound world about you. They make you feel that you are *in* the picture and not just looking at it. And all this can only happen if your two ears transmit two separate different signals along the nerves to your brain. It is a miracle of adding one and one and getting four instead of two.

STEREO ISN'T THAT NEW. Ever since the first single channel records were made, sound recording engineers have known that they could reproduce something very like the real thing by recording a sound with two microphones and playing the two single channel records back through two speakers. The microphones may be either separated and listening in opposite directions, like your ears, or placed



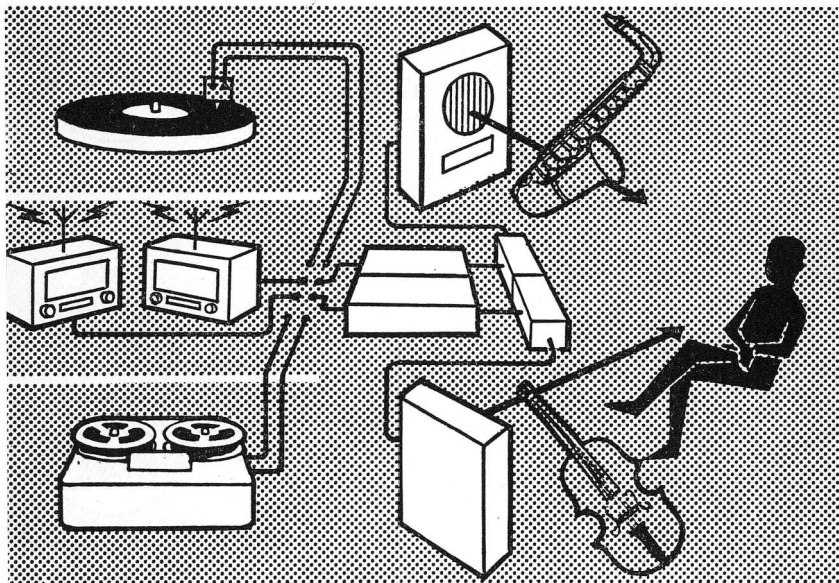
***STEREO SOUND RECORDING.** In the studio two microphones pick up the sounds—corresponding to what your right and left ears would hear—and turn them into two electrical signals. You can record the signals on opposite walls of a gramophone disc groove (top), broadcast them from two radio transmitters (centre) or record them on a magnetic tape (bottom).*

one above the other, listening at 45 degrees to right and left, or in various other special arrangements.

In the same way when you come to play the sound back, there are several possible speaker arrangements, all based on listening to a pair of speakers spaced some distance

apart and in front of you. When you record and play back sounds in this way, you get a close imitation of the sensation of hearing the original sound. With everything correctly balanced, you can imagine that you are standing where the microphones were when you made the record.

STEREO DISCS. For over 50 years this effect could only be demonstrated in the laboratory. Then the gramophone



STEREO SOUND REPRODUCTION. By using the right equipment you can re-create the two electrical signals from the gramophone disc (top), the radio waves (centre) or the magnetic tape (bottom). If you boost the signals with an amplifying system (right centre) and feed them into a pair of speakers, you reproduce the sounds as your ears would have heard them in the first place. This creates the sensation of listening to the original sound.

recording companies developed a way of recording the two 'single channel' signals from the microphones on opposite sides of the same groove and playing the composite recording back through two separate sound reproducing units. It

was launched under various titles such as stereophonic, stereosonic, and 3-D sound. The term 'stereo sound' is used in this book for simplicity.

STEREO TAPES. Stereo sound reproduction had been possible on magnetic tape recorders for some time. In a tape recorder the sound is recorded as a magnetic effect on a tape $\frac{1}{4}$ in. wide, and there is plenty of room to record two signals side by side. Even so, the rest of the set-up was at first too expensive to make the idea worth exploiting on a commercial scale.

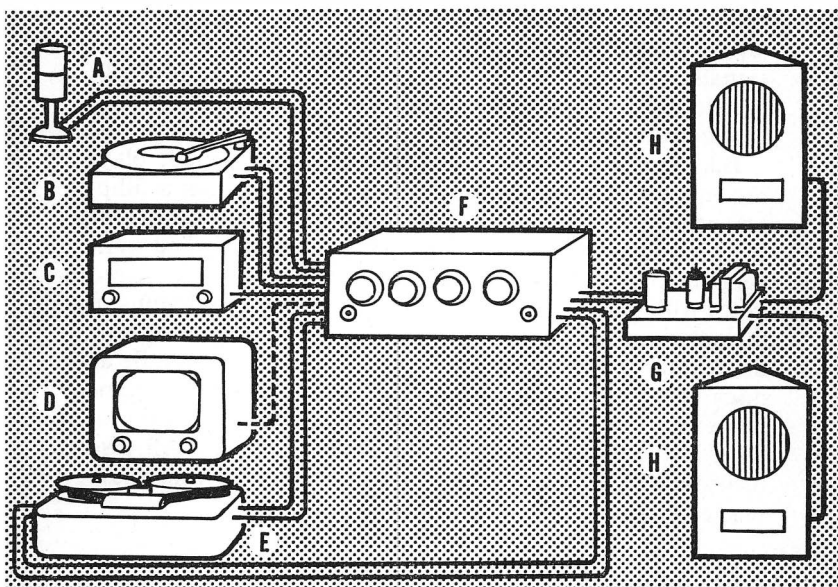
But the cheaper stereo discs and their factory-made playing equipment, have given stereo tape reproduction a fillip, and manufacturers are now turning out stereo versions of their machines together with various adaptors and conversion kits to let you play—or actually record—stereo tapes with existing single channel equipment. And you can buy prerecorded stereo tapes, just as you buy gramophone discs, although they are not yet issued on the same scale as discs. For some time all the commercial recording companies have made their master recordings in the studio on tape, in both stereo and single channel versions. All disc recordings are in fact made in the first place from these master tapes.

STEREO BROADCASTS. Radio, the third source of stereo sound, is still lagging behind the others, but it is only a matter of time before it catches up. At present there are several American transmitters sending out regular local stereo programmes on two wavelengths. In Britain there are only occasional experimental broadcasts—usually on Saturday mornings.

For the present, the BBC broadcasts are being sent out on one radio and one TV channel so that you can combine them by using your ordinary wireless and television sets together. This makeshift arrangement is useful as an introduction to stereo sound, but there is no future for it. It is pretty certain that before long you will be able to enjoy stereo versions of the principal broadcast programmes on

a new type of set, which will receive them on a single radio channel.

THE EQUIPMENT YOU NEED. To reproduce a stereo recording you need the following basic equipment: A gramo-



THE EQUIPMENT YOU NEED to reproduce stereo sound may be either a stereo microphone unit A, or a stereo disc player B, or a combination of radio tuning unit C and television set D, or a tape recorder E. These produce the signals; you need a control unit F, power amplifier G, and two speakers H to turn them into audible sounds. If you want to record the signals you can feed them through the control unit into the tape recorder as shown.

phone turntable and special stereo pickup (for discs) or a tape recorder with a special stereo head (for tapes) and either two separate receiving units or a special type of twin channel receiver (according to the stereo broadcast system) for radio. These units produce the two separate signals required for stereo listening.

Then you need two separate amplifying systems to make the signals strong enough to work the speakers, and finally at least two speakers—one for each channel, to turn the amplified signals into sound.

Single channel sound

The first sound recording was done on a single recording channel—*i.e.*, the signal (the train of electric impulses coming from the microphone) was recorded on one groove in a gramophone disc or a single track on a magnetic tape.

Even when more than one microphone was used—as in making a record of a full orchestra—all their separate signals combined to make a single impression on the groove.

This system of recording gives you only half of the story. When you play it back, no matter how many speakers you play it through, you cannot alter the single channel character of the sound.

A single channel recording can reproduce the various frequencies of the sounds—high or low, shrill or gruff, mellow or harsh—and it can reproduce the intensity of the sound—*i.e.*, the loudness of one recorded sound in relation to another. But it cannot tell you anything about its direction. And it cannot tell you whether you are listening to a loud noise far away or a not-so-loud noise not so far away.

However, in spite of its shortcomings single channel recording can create a reasonably faithful impression of the original sound, and that is just as well, because millions of records of sound, music and events have been made that way, and we shall have to accept them as they are, no matter how many improvements are made in our methods of making new records and reproducing them in the future.

Signpost

You are now coming to the chapters that tell you about all the different kinds of equipment you can buy to reproduce stereo sound, how to choose and install the various

units, how to adapt your existing equipment and how to connect everything up. This is a lot of territory to cover, and you need a signpost to keep you from getting lost.

Remember that a sound set-up is in three main sections:

- 1. The signal source (gramophone, pickup, tape recorder, or radio receiver).*
- 2. The amplifying system, and*
- 3. The speakers.*

Of these, the signal sources are the only things that are different; all the other sections are the same throughout the three types of set-up.

The following chapters take you first of all right through the complete stereo gramophone set-up from pickup to speakers, because at present the gramophone is the cheapest and simplest way of enjoying stereo.

Next come the chapters about the two other signal sources, radio and tape. If you are only interested in radio or tape, and not at all concerned about discs, then skip the Stereo on Discs chapter and read the Stereo on Radio or Stereo on Tape chapter instead. The other chapters on The Stereo Amplifying System and Speakers apply to all three systems and there is no point in printing the same information three times over.

The contents of the later chapters on adapting, buying, installing and connecting up are clear from their titles.

CHAPTER 2

Stereo on Discs

AT THE PRESENT TIME THE SIMPLEST AND cheapest way of getting stereo sound is to buy a disc record player. You can buy the complete equipment 'off the peg' in the form of a gramophone (or radiogram) or a portable record player, or you can buy it as an assembly of separate units forming a high fidelity system.

All three work on the same principle and employ the same basic parts: a stereo disc, a motor and turntable (to turn the disc), a stereo pickup (to convert the record on the disc into electrical signals), an amplifying system (to boost the weak pickup signals and make them powerful enough to use) and the speakers (to convert the amplified signals into stereo sound).

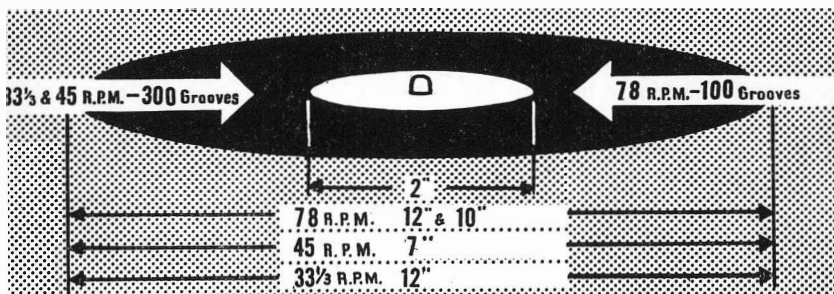
The following chapters will help you to choose your own 'made-to-measure' equipment and put it together. But even if you prefer to buy an off-the-peg set it will still be useful to know about the individual units and how they work.

The disc

The disc that holds the record is a flat circular sheet of flexible plastic called Vinylite. On its surface it carries a fine spiral groove which starts at the outside and ends an inch or two from the centre. The two stereo signals are recorded as humps and hollows on the opposite walls of this groove.

Discs are moulded from a master record cut in the gramophone studios. The cutting head rests on a blank disc which turns as the point of the cutter tracks across it from

the outside to the centre. The two stereo signals from the recording microphones are fed into the cutting head where they give rise to movements of the cutter. These movements take place in two directions corresponding to the right and left stereo channels. A signal from the left channel microphone drives the cutter downwards at an angle of 45 degrees into the left wall of the groove. It doesn't affect the right wall of the groove because it moves parallel to it. In the same way, signals from the right hand channel microphone cut into the right hand wall of the groove but don't affect the left wall. Signals coming from both channels at the same time add up to a composite movement of the cutting head



DISC RECORD. A gramophone disc carries a record of the sound in a spiral groove running from the outside to within about 2 ins. of the centre. The table shows how the number of grooves and the playing speed vary with the different types.

which has the same effect as if you had recorded each signal separately. So you make a single groove in the disc carry two separate signals, one on each wall, corresponding to the right and left stereo channels.

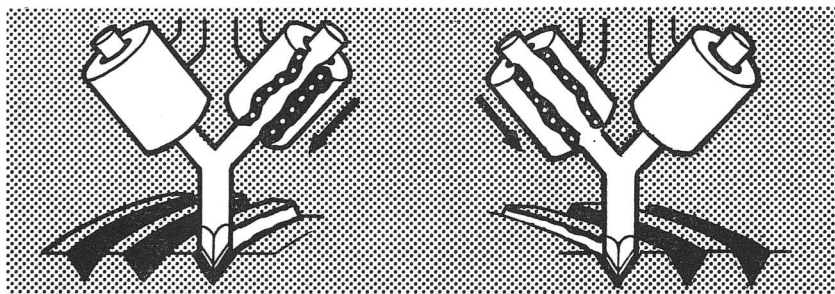
(The groove in a single channel disc is cut by a stylus which moves from side to side and records the signal as a wavy line, using both sides of the groove.)

There are two kinds of disc: (1) coarse groove and (2) microgroove.

COARSE GROOVE. The early single channel discs were recorded and played at 78 revolutions per minute (rpm for

short). They were pressed in a hard black composition and had about 90 grooves to the inch. Their disadvantages were that they were breakable, sounded scratchy, soon wore out and only played for a short time—4-5 minutes for the 12 inch and 3 minutes for the 10 inch. Also, they could not record frequencies very well outside a range of about 100 to 8,000 cycles per second. 78 rpm discs are rapidly going out of production.

MICROGROOVE. Improved materials have made it possible to produce microgroove discs—discs with grooves that are finer and closer together. You can also record them at



CUTTING A STEREO DISC. This is the cutter that carves out the stereo record; it is normally poised in the centre of the groove in the disc. Left: When a stereo signal comes down the wires to the right-hand electro-magnet, it gives the cutter a push downwards into the opposite wall of the groove. Right: When a signal comes down the left-hand wires the left arm gets a push and drives the cutter into the other wall.

slower speeds. Both these steps mean that you can get more grooves and a longer playing time per disc.

You can buy 7 in. 'extended play' (ep) microgroove discs which play for approximately 5 minutes at 45 rpm, and 12 in. lp (long play) discs with up to 300 grooves per inch which play for approximately 30 minutes at $33\frac{1}{3}$ rpm.

All stereo discs are recorded at $33\frac{1}{3}$ and 45 rpm—there are no 78 rpm stereo recordings.

Modern microgroove discs will record frequencies up to

20,000 cycles/sec.; they are practically free from surface scratch and are almost unbreakable. When you play them with a modern lightweight pickup (p. 34), wear is almost negligible.

The disc has a narrow edge of plain plastic before the groove starts. When you play the record you lower the pickup stylus on to this blank edge and push it in towards the centre to make it enter the groove. The first few turns of the groove are also left blank to allow for errors in starting and so that you don't damage the opening of the record if you are careless in pushing the stylus into the groove.

The recorded section of the groove ends in a few blank turns followed by a quick spiral towards the centre. This end groove is introduced to push the pickup arm over suddenly to make it work an automatic brake and motor cut-out switch if your player incorporates either of these end-of-the-record devices.

The recorded part of the groove never goes right to the centre of the disc because the quality of the reproduction falls off in the last few inches. This is because you get about 36 inches of groove for one turn of the disc at the outside of a 12 in. disc but only about 12 inches two inches out from the centre. So you have to squeeze the same number of zig-zags into one-third the amount of groove. (This is a point to remember when you are buying records and are offered a choice between one that gets the whole of a piece on to one side of the record by running the groove close to the centre and one where the record is split and continued on the other side. You may get an extra item for the same price on the first record, but you will get a superior record of the main item on the second.)

The blank in the centre of the record carries the label giving you the title of the work, performers, catalogue number and other particulars.

STATIC. One ever-present problem of this modern type of disc is that the surface easily becomes charged with static electricity and attracts dust particles. As the stylus passes over these particles they produce an unpleasant crackling

noise in the speaker. There is no complete cure, but there are various ways of reducing the trouble.

You can buy a tiny brush on the end of a pivoted arm for dealing with this trouble. The arm is mounted on the deck in the same way as the pickup arm and the brush rests lightly on the record just ahead of the pickup. This removes most of the dust from the grooves before they reach the stylus.

You can also buy anti-static liquids to wipe on to the surface of the record.

Moisture conducts the static away, so wiping the disc with a damp plastic foam sponge stops it from attracting dust particles. And finally, by keeping your records in their protective sleeves when not in use, and handling them by the edges (greasy fingermarks are extremely efficient dust collectors) you can go a long way towards keeping them dust-free throughout their playing life.

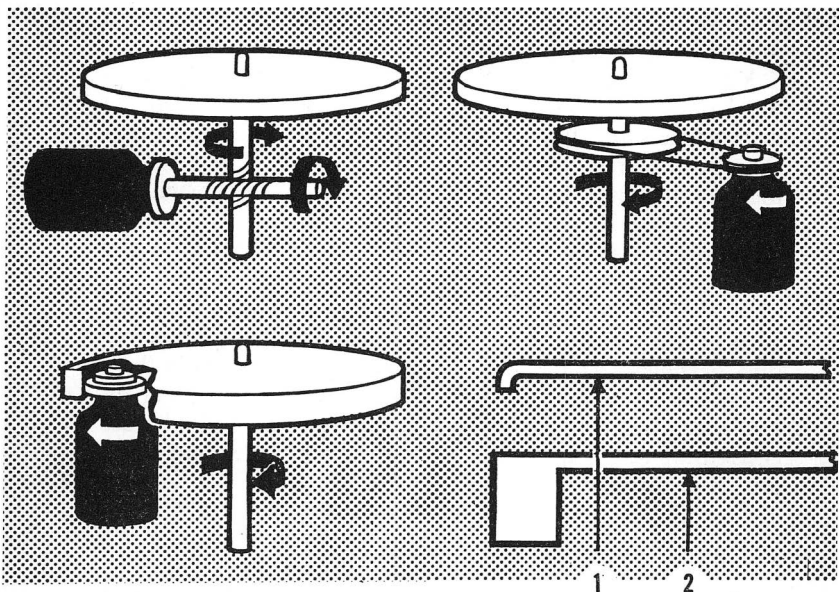
The motor and turntable

The turntable is the round platform that holds the disc you want to play:—A heavy metal plate with a projection in the centre that sticks through the hole in the disc. It is turned at an even speed by an electric motor. The motor is fixed to a flat table called the motor board, on a cushioned mounting—*e.g.*, screws set in rubber.

Sometimes the motor drives the turntable spindle and sometimes it turns a rubber-faced pulley that bears against the rim of the turntable. (This is the way it is done on 'transcription' turntables—*i.e.*, turntables that are so carefully made that they can be used for duplicating a master recording without loss of quality.)

SPEEDS. All modern motor and turntable assemblies are designed to run at all three standard playing speeds—78, 45 and $33\frac{1}{3}$ rpm—at the turn of a control.

In addition to the main speed selector there should be some form of control knob or lever for making fine adjustments to the speed. If the motor runs even slightly too fast



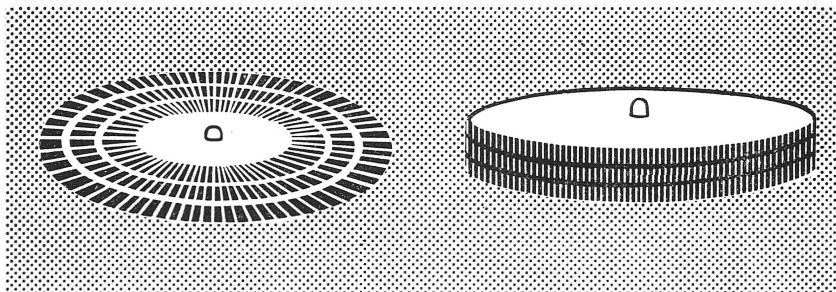
MOTOR AND TURNTABLE. The gramophone motor drives the turntable in one of three ways: direct (top left), by a plastic belt and pulley (top right) or by a rubber friction wheel (bottom left) which bears on the rim. The ordinary turntable 1, pressed from sheet metal, is not suitable for high fidelity reproduction. The transcription turntable 2 is much thicker and heavier, so that it acts as a flywheel and maintains a more constant speed.

or too slow, the pitch of the sound will be higher or lower than it should be. This doesn't matter so much with speech—where you just want to be able to understand what it is about—but it can ruin music. So you must have a fine adjustment—and be able to keep an accurate check on the speed.

CHECKING THE SPEED. There are two ways of checking the speed of the turntable. You can listen to the pitch of a note of music played on a disc against the same note given by a piano or tuning fork and raise or lower the speed until the pitch of both notes is the same. The turntable will then

be running at the correct speed for that disc. This is fine as long as you have a record with a sustained note and a piano or tuning fork you can trust. But there are easier ways.

Nowadays most people use a stroboscopic indicator. This sounds terribly scientific but in fact it is just a disc of white card marked with a circle of alternate black and white bars. When you lay the disc on a record turning at the correct speed and look at it by the light of an electric lamp, the flickering of the light fits exactly with the time it takes for



CHECKING THE SPEED. You place the stroboscopic disc (left) on the moving turntable and look at it by alternating current electric lighting. When the turntable is doing the correct number of revolutions per minute, the set of bars for your particular disc speed appears to be standing still. The stroboscopic pattern may also be printed around the edge of a transcription turntable (right).

the bars to advance one step. When this happens the disc appears to stand still.

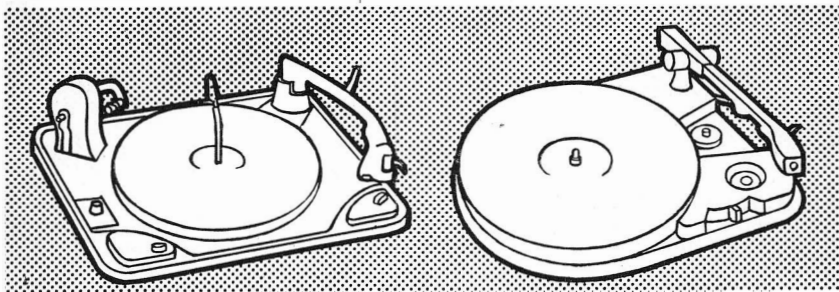
If the speed is lower than it should be, then the bars won't quite move a whole step between one flicker of light and the next so the disc will look as though it is turning slowly backwards. In the same way, if the disc is turning too fast the bars will appear to be turning slowly forwards. All you have to do is to move the fine speed adjustment until the bars look as though they were standing still. You should do this while you are actually playing a disc to allow for the drag of the stylus.

You can get these discs printed with sets of tracks for

all three standard speeds, and many transcription turntables have the stroboscopic pattern marked around the edge.

This type of speed indicator only works with alternating current which gives a flickering light.

FACTORY-MADE SETS. In any radiogram or record player 'off the shelf', the turntable and motor are part and parcel of the complete equipment and you have to accept them as they are. Generally speaking the quality is good enough for the job and up to the standard of the rest of the equipment, but some makers fit a better unit than others in the same price range. If the motor and turntable bear the name of a well-known maker, you will be safe; if the name is not stated, you may be in for trouble.



TRANSCRIPTION UNITS. You can buy the complete assembly of motor/turntable/pick-up arm and head ready to build into your own equipment. The type on the left incorporates an automatic record changer which lowers and plays one record at a time from a stack piled on the centre spindle. The type on the right has to be started, stopped and changed by hand.

TRANSCRIPTION UNITS. If you want something better than the ready made set and you have decided on individual units, you will have to get the motor and turntable and mount them in a playing deck yourself. You needn't be afraid to tackle the job, because the maker always gives you a template or a working diagram to show you where to cut and drill the deck of the cabinet you are going to build or get to take it.

Of course you will have to pay more for a separate turntable and motor but you will have a much better job. You will get a more powerful motor, closer speed control, smoother running, precision engineered bearings, and a heavier and more accurately machined turntable.

These refinements will give you a steadier, quieter running turntable.

Wow. The speed of the turntable must not alter more than 3 parts in 1,000 or you will notice an unpleasant 'wobble' in the pitch of sustained notes. This effect is called 'wow' and it is one of the biggest bugbears of gramophone record and magnetic tape players. You can only avoid it by careful precision engineering of all the parts and accurate fitting and assembly. These things all add to the price you have to pay for a first rate performance.

RUMBLE. Rumble is another headache with record players, and it isn't always the cheaper equipment that gives the trouble. It is caused when mechanical vibrations in the motor or gearing find their way along the pickup arm or up the turntable spindle to the turntable. The vibrations act on the stylus just like the signal recorded in the groove. Stereo pickups are extra sensitive to vibrations of this kind.

The result is an unpleasant rumble from the speakers, which can be next to impossible to get rid of altogether. Rumble has a frequency of about 60 cycles or lower, and while a lot of cheap pickups may be deaf to anything as low as that, a good pickup is sure to reproduce it. So the better your equipment the worse off you are likely to be!

Equipment manufacturers do their best to get rid of rumble altogether, but often the only way out is to pass the signals through a 'rumble filter'. A rumble filter is simply a special type of electrical circuit that absorbs the very low rumble frequencies before they get to the speakers. But don't forget that the filter also gets rid of the very low notes recorded on the disc so you may have to accept a compromise—a certain amount of rumble that you *don't* want for the sake of the low notes that you *do*.

Some motor and turntable assemblies tend to be worse than others; it's a point to listen for when you are choosing your equipment.

Automatic record changers

Most factory made radiograms and record players are fitted with automatic record changers. You stack the records you want to play on top of an extension of the turntable spindle and the machine releases them one at a time so that they fall into the playing position on the table.

The changing mechanism is operated by the pickup arm. While the pickup is tracking in the normal groove, nothing happens. But at the end of the record the groove swings the arm quickly inwards and the sudden movement triggers off the changer. The pickup arm lifts the stylus clear of the groove and moves to the side while the next record drops into position. The arm then moves in, lowers the pickup on to the edge of the disc and starts playing the next record.

An automatic changer is useful for 78 and 45 rpm discs which play for only a few minutes but not really necessary for 12 in. lp discs playing up to half an hour per side. And for high fidelity reproduction you are better off without an auto changer.

Remember, the changer works off the pickup, so the pick-up has to be heavy enough to push the mechanism without jumping out of the groove. But if you add weight to the pick-up your stylus and records wear out sooner. And you need a more powerful motor if you want it to work the changing mechanism *and* spin the turntable as well.

So by all means go in for a record changer if you are more interested in convenience than quality and if you are prepared to replace styli and records oftener.

The pickup

The stereo pickup converts the right and left channel records on the walls of the groove into two independent

electrical signals. (With a single channel record you get only one electrical signal from the pickup.)

There are all sorts of stereo pickups at all sorts of prices, but they all have a pointed stylus connected to a pair of sensitive elements and free to move in two directions independently, just like the cutting stylus used for making the master record (p. 27).

The sensitive elements in the pickup translate the movement of the stylus into electrical signals. There is a pair of these elements in a stereo pickup and only one in a single channel pickup.

The two principal types of stereo pickup, crystal and magnetic, take their names from their sensitive elements.

CRYSTAL. Certain crystals generate an electrical voltage when you bend them out of shape. Slices of two such crystals arranged at right angles and connected to the stylus form the sensitive element in a crystal pickup. Think of a capital Y with the stylus forming the stem and you have a pretty good picture of the arrangement.

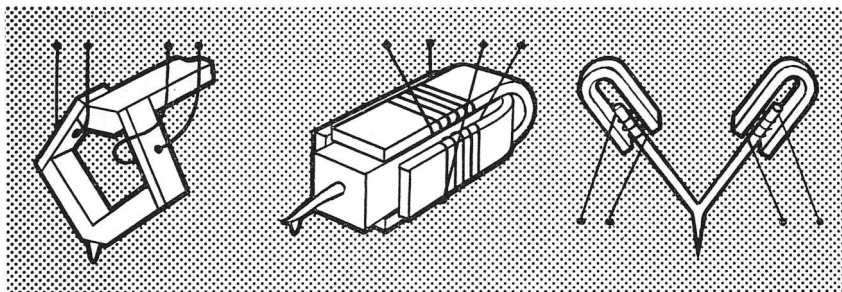
When the stylus gets a push from the left hand wall of the groove, it moves parallel to the right arm of the Y. So it doesn't affect the crystal on that side but it bends the left arm and generates a signal voltage across it. Similarly when the stylus gets a push from the right wall of the groove it generates a signal in the right arm of the Y. So you get two separate signal voltages generated—one across each crystal element—by the right and left sides of the groove.

The cheapest—and also some of the most expensive pickups—use crystals. Generally speaking the cheap ones have a high output—*i.e.*, they generate a strong signal—but low quality and they are affected by heat and damp.

There is a different type of crystal pickup which uses a ceramic element. These crystals give a really good performance and damp or heat have no effect on them. **But they** cost more than the ordinary sort and have a much lower output so you have to buy more powerful—and expensive—equipment to boost the signals to usable strength.

MAGNETIC. There are several types of pickup based on the principle that if you place a coil of wire in a magnetic field and then change the direction or strength of the magnetism you get a current of electricity in the coil.

In the moving coil type of magnetic pickup the stylus is connected to two tiny coils of wire in the same Y-shaped arrangement that you have in the crystal element above. Each coil lies in the concentrated field of a powerful magnet. The movement of the stylus is passed on to the coils in such a way that a record on the left wall of the groove generates signal voltage in the left hand coil and a record on the right wall generates a signal in the right hand coil.



PICKUPS. In the crystal unit (left) the movements of the stylus bend two slices of crystal and generate the stereo signals. In the magnetic types the stylus moves a magnet in relation to two coils (centre) or coils in relation to two magnets (right). In each case the movement generates the stereo signals in the coil wires.

Moving coil pickups are generally in the high fidelity—and high price—class.

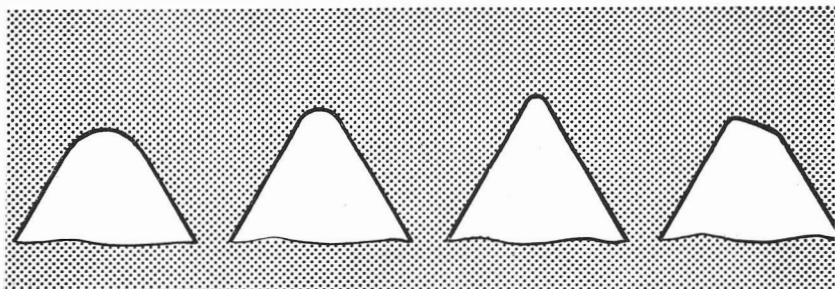
In the variable reluctance type of magnetic pickup the coils are stationary but the pickup stylus is connected to a 'floating' part of the magnetic system so that a slight movement of the stylus causes a big shift in the path of the magnetic field. (Technical people say that it varies the 'reluctance' of the path—hence the name). This is the most popular type of magnetic pickup although it is a bit over-sensitive to electrical interference—e.g., hum from the

alternating current supply. Variable reluctance pickups are generally in the medium price range.

There are various other ways of making magnetic pickups. In one type, for instance the coil is stationary and the magnet is connected to the moving stylus. And so on.

The stylus

The stylus is a pointed needle fastened to the sensitive element of the pickup. It rides in the groove of the record and is shaped to fit it exactly. The humps and hollows of the recorded signals on the walls of the groove force the point of the stylus to vibrate and it transmits the movements



STYLUS. The point that follows the groove in the disc is actually a rounded end with a radius of $\cdot003$ in. for coarse groove single-channel discs (left) and either $\cdot00075$ in. (left centre) or $\cdot0005$ in. (right centre) for microgroove stereo discs. When the smooth radius wears to a sharp chisel edge (right) the stylus has reached the end of its useful life.

to the sensitive elements of the pickup where they get sorted out into the right and left stereo signals.

The stylus has to be as hard and as smooth as possible so that it will not wear out quickly and so that it will not damage the groove. So styli are made from either sapphire, ruby or diamond. A diamond costs most but it lasts longer than the others. A sapphire stylus will play about 100 lp records—say 50 hours—before it wears to the state where it can no longer give good quality reproduction, and where

it has developed an edge that could damage the groove. A diamond stylus would be good up to 2,000 hours.

The point of the stylus has to be very carefully ground and polished to suit the type of record it is to play. A stylus for playing microgroove records (33 $\frac{1}{3}$ and 45 rpm) must have a point with radius of one thousandth of an inch or less. A coarse groove stylus (78 rpm) has a radius of three thousandths of an inch or less. You can't change the two types about. A coarse groove stylus would ruin a microgroove record and a microgroove stylus would rattle about in a coarse groove.

CHANGING OVER. The stylus usually has to be fitted in the pickup by the makers or the dealer. If you want to play both types of disc you have three alternatives. You can buy a pickup arm fitted with a socket which will take plug-in heads fitted with 1p and 78 rpm styli—or a pickup with a 'turnover' cartridge head. This has a microgroove stylus on top of the head and a coarse groove stylus below. To change from one to the other you simply turn the head in its socket. Or you can have a head with a turnover stem which has one stylus cemented on each side of the stem.

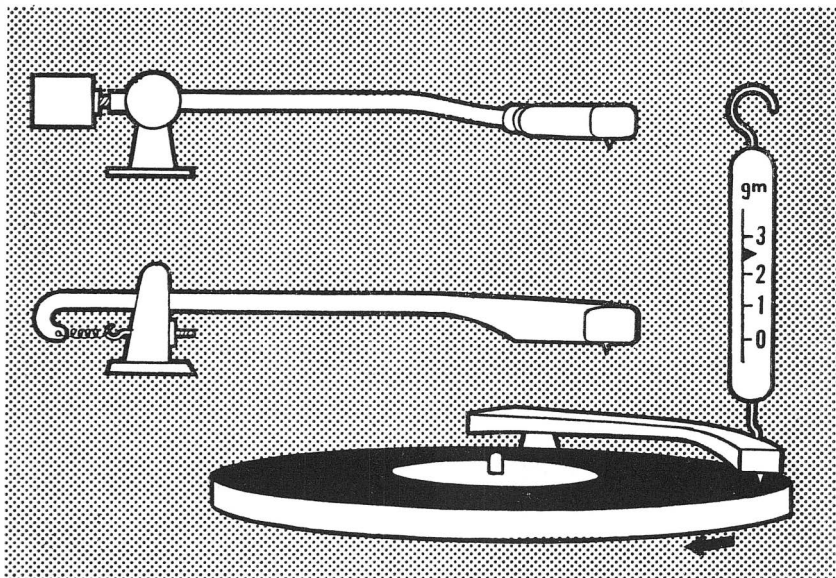
Most pickup heads are designed to plug in to the arm so that you can pull them out to have the stylus changed.

It isn't easy to tell by looking at a stylus if it needs renewing. You can keep count of the number of playings or if you are really particular attach a press-button counter to your playing table. Every time you play a record you press the button. When the counter registers the maximum number of playings recommended by the maker of the stylus you have a new one fitted. This makes certain that you will throw away the stylus before it can damage your records. Dealers have a special microscope for checking your styli to see if they need renewing.

STYLUS PRESSURE. The area of the tip of the stylus is microscopic, so the least weight resting on it creates an extremely high pressure when you work it out in terms of pounds per square inch. It may easily amount to 20 tons

per square inch, and any excess weight on the pickup or stiffness in the arm can account for a lot of expensive wear and tear on stylus and disc.

As you can't make the tip any bigger, you have to keep down the weight resting on the stylus. You can do this in two ways; you can cut down the weight of the pickup and arm, and you can counterbalance the arm with a weight or



STYLUS PRESSURE. Most of the weight of the pickup and arm are taken off the point of the stylus either by a counterbalance weight (above) or a compensating spring (centre). You can measure the stylus pressure by just raising the pickup with a delicate spring balance (below).

spring to take part of the load of the pickup off the record.

In practice both methods are adopted—often at the same time—depending on the type of pickup. It usually works out that the lighter the pickup the better the quality and the higher the cost. The cheaper types of single channel pickup may operate with a pressure of as much as 10 grams, but

weights as big as this are out of the question with stereo pickups where the radius of the stylus tip is smaller and the effect of pickup weight is so much greater.

If your stereo pickup has a 'three quarter thou.' stylus the weight on the disc should not be more than about 4 grams. For a high quality type of pickup with a 'half-thou.' stylus the weight should be 2 grams or even less. (Some stereo pickups work with a pressure of less than 1 gram). You can buy several sorts of gadget for measuring the weight resting on the stylus.

CARE! When you are playing with such tiny weights on the stylus the slightest shock can make it jump out of the groove with the risk of damage to the disc or the stylus.

The surface of the disc must be kept dead level. If the table slopes at all, the stylus will tend to skate off the record or get jarred out of the groove. In a house with a springy floor this will sometimes happen if you walk across the room.

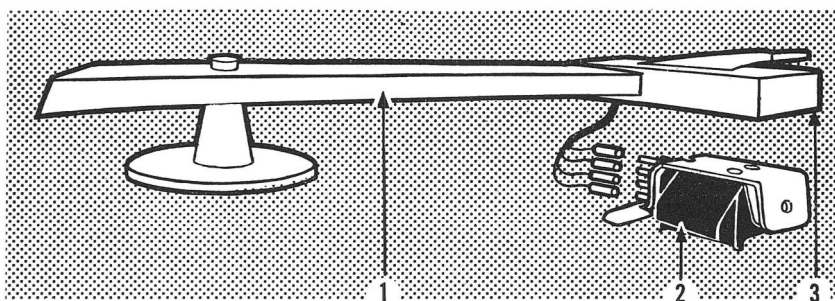
When you lower the stylus on to the record you have to be extremely gentle or you can easily damage it. If you want to be on the safe side you can have a simple attachment to fit at the side of the turntable to do the lowering for you. Compared with the cost of a damaged stylus or pickup movement, the gadget is well worth the expense. (Some pickup arms have a raising and lowering mechanism already built in, and if your turntable has an auto-changer you can set it to do the job even if you are just playing one record and not using the changer).

Pickup assembly

The complete pickup assembly consists of the pickup arm and the head, complete with stylus. The arm may be made by one manufacturer and the pickup head by another—each specialising in his own part of the job. So you can choose the arm and the pickup head separately if you like, or you can buy the complete assembly in one.

ARM. The arm supports the head of the pickup as it

moves across the disc. It is usually a metal plate or plastic rod or moulding and is pivoted on a pillar next to the turntable. It carries the screened leads which connect the amplifying system to the pickup head. As the arm swings across the record, the pickup head moves on the arc of a circle and so it meets the groove at an angle which is constantly changing. To do the job properly the arm ought to guide the head straight along the radius, so that the stylus would always be at the same angle to the groove. You can get arms which will do this, but they are apt to be complicated, delicate and costly.



PICKUP ASSEMBLY. The pickup assembly consists of a pivoted arm 1 which holds the head moulding 3 into which you fit the cartridge 2. The cartridge incorporates the stylus and either crystal or magnetic elements for converting the movements of the stylus in the disc groove into the stereo signals.

Most arms have to work on a compromise arrangement. The support pillar is mounted at a point which makes the angle of the head correct at two places on its journey across the record, and only throws it slightly out one way or the other the rest of the time. This position is critical, and when you buy a pickup arm the manufacturer always gives you a template so that you can mount the pillar at the correct distance from the centre of the turntable. You have to do this job accurately; even a small error will increase the wear on the stylus and spoil the reproduction quality.

HEAD. The head holds the 'works' of the pickup—*i.e.*, the

stylus and the crystal or magnetic sensitive element. Sometimes the head is supplied as a complete item consisting of the 'works' already mounted in a plastic moulding which plugs in to the arm. Some manufacturers supply an arm with a choice of interchangeable plug-in heads of this type.

The alternative is an arm with an empty plug-in head moulding or shell. You then have a choice of 'works' which you can fit into the shell to make the complete pickup. When the 'works' are supplied as a separate insert for this type of pickup assembly the unit is called a cartridge.

There is no standard arrangement for the plug and socket connexion between the head assembly and the pickup arm. Some makers use a three-pin and some a four-pin connexion for stereo. For single channel reproduction, some use two and some three pins. The pins make the electrical connexion from the pickup head to the lead which connects it to the amplifying system. They also hold the head securely on the end of the arm.

CARTRIDGE. The separate cartridge that you insert into a head shell is popular for high fidelity setups since it gives you a bigger choice of head units. Cartridges made by one manufacturer do not always fit automatically into shells made by another, but they can usually be adapted without much trouble.

There is a fairly general agreement among manufacturers to fix the cartridge to the head by two screws, spaced $\frac{1}{2}$ in. between centres. The cartridge is fitted with a flange drilled with two holes to take the screws, and the head moulding carries the threaded holes. The holes in the cartridge flange are elongated to allow for differences in the pitch of the screws in different heads and to give you a bit of latitude for adjusting the stylus position in relation to the head.

Unfortunately manufacturers do not all use the same type of screw thread in the head shell, and the heads themselves vary in shape and dimensions. When you buy a cartridge you usually get an assortment of fittings—*e.g.*, spacing washers and screws—to adapt them to different head shells;

but to be on the safe side you should always check with your dealer that the cartridge will fit your pickup head moulding.

TURNOVER CARTRIDGES. Many 'popular' quality stereo pickup assemblies are designed to play both coarse and microgroove (single channel and stereo) discs. They have a 'turnover' type head with a stylus for 78 rpm on one side and a stylus for $33\frac{1}{3}$ and 45 rpm discs on the other. The microgroove stylus will play both stereo and single channel records. You simply turn the head of the pickup over to suit the disc you want to play. This is a handy arrangement but it isn't suitable for high fidelity equipment.

You can buy a stereo pickup cartridge which will also play single channel lp records because both discs will play at a stylus pressure of about 2 grams with the same stylus (preferably a ' $\frac{3}{4}$ thou.'). But you cannot expect a pickup adjusted to a stylus pressure of 2 to 3 grams or less for stereo discs to turn over and play 78 rpm discs which need a stylus pressure of 7 to 10 grams to keep them in the groove.

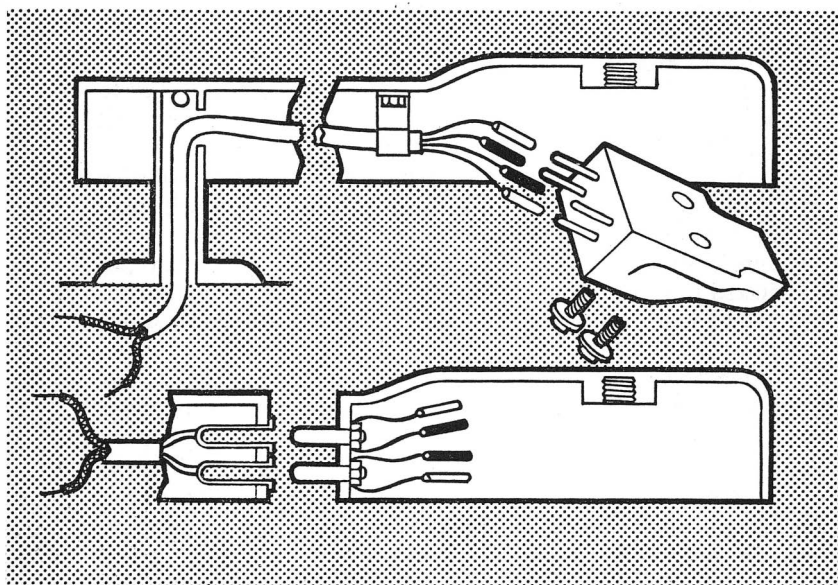
On commercial players the manufacturers usually compromise with a nominal pressure of 3-4 grams or even more for turnover cartridges of this type. If you must play a mixture of coarse and microgroove records, then you have to accept a compromise of this kind, but you will have to put up with more rapid wear on both stereo stylus and disc, and you will get a lower standard of quality.

The only really satisfactory arrangement is to have one arm and pickup mounted for stereo and single channel lp discs and a separate assembly for 78 rpm. You can then operate each one at its correct stylus pressure.

ELECTRICAL CONNEXIONS. Mounting the cartridge in the head is only half the job; you have to make the electrical connexions.

The plug pins in the headshell have short lengths of thin flexible wire attached to them and the cartridge connexions are brought out on to pins. When the cartridge comes from the maker the pins are fitted with slide-on metal sleeves ending

in soldering tags. To connect up the cartridge to the shell you have to take off these sleeves and solder them to the wires from the shell. You then push the sleeves back on to their pins and mount the cartridge in the shell with the two fixing screws. (This arrangement saves the cartridge from being overheated and ruined by the heat from the soldering iron.)



ELECTRICAL CONNEXIONS. The cartridge pins are connected to the pickup leads through sleeves soldered on to the leads (above). When the arm is designed to take interchangeable plug-in heads, the sleeves are soldered to the pins on the head moulding that plug into the sockets on the end of the arm.

On a stereo cartridge you have two pairs of pins and sleeves and the arm should have two separate screened leads. One tag in each pair carries the right or left channel signal and the remaining tags are the 'common' connexions. You should join the 'common' tags together. Next find the pins which plug in to the sockets joined to the metal braid

'screens' of the leads. Solder the common wire to both pins. You connect the signal tags to the pins which plug in to the sockets joined to the insulated leads. Each channel now has its own screened lead with the screens made common at the pickup head.

Some pickup assemblies are designed with three pin connexions from the cartridge through to a twin screened lead—*i.e.*, two insulated wires in a single metal braid screen. This is not a good arrangement; if there is room you should always connect the screens together at the pickup head.

With a single channel pickup there is only one lead with a single insulated signal wire in the centre. In this type the plug-in head may be equipped with two or three pins. If you want to fit a stereo cartridge to the head you will probably have to drill a hole through the shell and pass a second screened lead through to connect up the second channel. You will have to run this lead along the side of the arm and fasten it in place with adhesive tape.

When you make connexions of this sort to the pickup head, be sure that they don't interfere with the free movement of the arm—*e.g.*, don't force a thick flexible wire through the channel or pull the wire tight around the bend where it runs from the arm into the pillar.

CROSSTALK. If you run the two stereo signal wires in a common screened lead, you may get interference—cross-talk—between the two channels. In practice, for a number of reasons, a trace of the signal from one channel always gets across to the other.

Crosstalk can be measured in decibels (p. 15) giving you the ratio of strength of the signal on one channel to the strength of the trace that leaks over from the other. The greatest amount of crosstalk your ear will allow for good stereo reproduction is 15 dB.

FREQUENCY RESPONSE. All pickups have an upper and lower limit to their performance and in practice it is usually the upper limit that matters. Even the cheaper pickups will respond fairly well to the lower frequencies on the record,

but towards the top end of the scale the differences between a cheap and an expensive pickup soon begin to show up.

The cheapest pickups of all—those fitted in the ‘popular’ type of record player, may not be able to reproduce sounds much above 5,000 cycles per second, while the expensive ones will easily reproduce the highest frequencies you are likely to get on a record—20,000 cycles or even higher.

When you remember that most musical sounds owe their character to the extremely high frequencies, you will see that if you want quality you will be well advised to avoid cheap pickups. (As in most things there is a happy medium and only a dyed-in-the-wool-fanatic will find it necessary to buy one of the most expensive pickups).

The Stereo Amplifying System

IF YOU TRY TO PLAY A RECORD BY CONNECTING your pickup leads direct to the speakers, you won't hear anything. The signals generated by the pickup are too weak; they need to be at least 1,000 times more powerful to give you a reasonable amount of volume from the speakers. So you have to boost them up.

The equipment you use for boosting the signals is called the amplifying system. It is sometimes all in one piece but more often it is in two separate units, one, the preamplifier (or control unit), coming first, and the other, the power amplifier, coming after, between the preamplifier and the speakers.

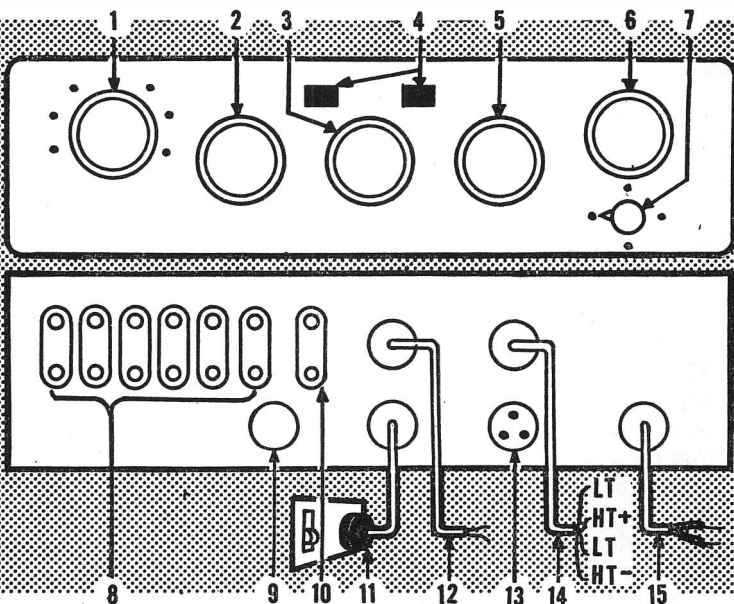
In each stereo amplifier there are two identical preamplifiers and power amplifiers, one for each channel, but you don't have to fiddle with two sets of controls. The units are designed so that one set of controls on the preamplifier and one on the amplifier looks after both channels.

And there is a separate balance control that you can set to even up any initial unbalance between the two channels—caused by slight differences in the components, or the speakers, or even in the acoustics of the room (p. 127).

Preamplifier

Most people are a bit puzzled by the need for both a preamplifier and a power amplifier. Why not a single unit?

The answer is that you *can* have a single unit so long as you only want to do one job, but you usually want your amplifying system to do more. You want to be able to deal



PREAMPLIFIER (CONTROL UNIT). Above: The preamplifier gets the various signals ready for boosting by the power amplifier. It has a selector switch 1 for picking out the signals you want to reproduce, tone controls for bass 2 and treble 3, sometimes switches for cutting out high frequency whistles and low frequency rumbles 4, a stereo balance control for levelling up the two channels 5, a volume control for boosting weak signals or cutting them down if they are too strong 6, and a selector switch 7 for connecting one channel to both speakers or reversing right and left channels. Below: At the back of the control unit you have inputs for Radio, Gram, Tape, Auxiliary 8, output to tape recorder 10, mains supply to power amplifier 12, power leads from power amplifier 14, signal outputs to power amplifier 15, power take-off for auxiliary equipment 13, connexion to mains plug 11 and a pre-set control for adjusting the auxiliary inputs 9 so that you can connect signal sources not provided for by the regular positions of the selector 1.

with signals from both crystal and magnetic pickups of all types, or from stereo tapes, or from radio channels. And all these signals vary widely in their strengths and in other electronic particulars. The table below makes this clear. It shows you the average signal strength you get from a

number of sources, measured in millivolts (thousandths of a volt).

THE SIGNALS THEY GIVE

<i>Signal Source</i>	<i>Typical Output Measured in Millivolts</i>
Moving Coil Pickup	20 or less
Variable Reluctance Pickup	100 or more
Crystal Pickup	100 up to 3,000
Tape Head	1 to 5
FM Aerial	10 or more, depending on siting of aerial and distance from station

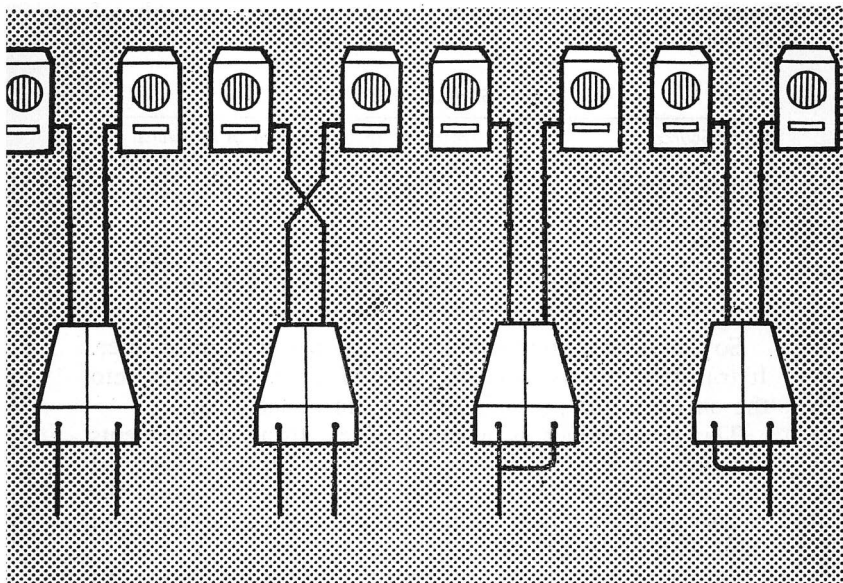
So you need a preamplifier to act as a sort of interpreter. It translates all the various types of signal language into the only one the power amplifier can understand.

The preamplifier is a mass of electronic components mounted on a metal chassis in a box with a panel carrying the control knobs and switches. You can either build the chassis into your own cabinet or stand it in its case on a shelf with the rest of the units.

On the back of the preamplifier case there are the sockets for the various inputs—from pickups of one or more kinds, tape recorder, radio, and perhaps a spare pair of sockets for special equipment.

Tape recorders call for an extra connexion because you want to record *from* the signals through the preamplifier as well as to play back a recorded tape *into* it. So you have a pair of input sockets on the preamplifier for playing back a tape and amplifying it, and another a pair of output sockets to connect to the input of the tape recorder when you want to make a record—*e.g.*, from a gramophone disc or from a radio programme. These two pairs of sockets make it possible for you to play one tape recorder through the preamplifier and record the signals on a second recorder—a useful way of editing tapes to save cutting and splicing (p. 110).

CONTROLS. On the preamplifier control panel you have a switch, giving you a choice of inputs from the various signal sources, controls for boosting or cutting both bass



SPEAKER SWITCHING ARRANGEMENTS. The speaker control switch on the preamplifier lets you listen to stereo normally (left) or with Left and Right channels reversed (left centre). You can also listen to the left-hand channel through both speakers (right centre) or the right-hand channel through both speakers (right). The last two are also suitable for listening to a single channel record on both speakers.

and treble frequencies independently, a volume control, a balance control and a rumble filter (p. 33).

There may also be switching arrangements to let you select any of the following:

- Normal Stereo—Both channels through to both speakers.
- Stereo Reverse—Above, with channel-speaker connexions reversed.
- Single Channel—Right- or left-hand stereo channel through to one speaker.
- Single Channel—Right or left stereo channel through to both speakers.

The preamplifier is also known as the control unit because through it you control the volume and tone of the reproduc-

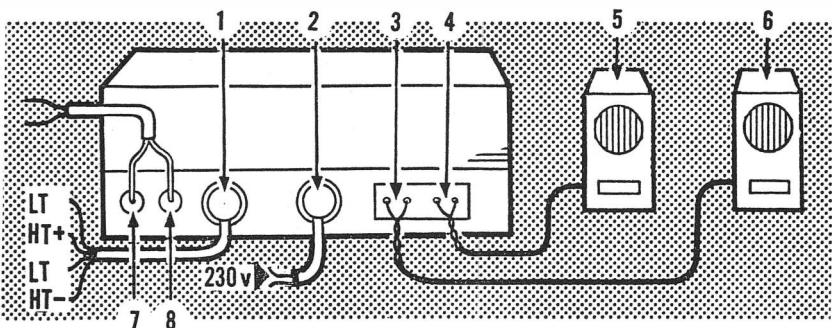
tion, switch the set-up on and off, and select the inputs, outputs and channel connexions.

As with everything else in the sound set-up, quality ranges from those that are too cheap to be good to those that are so good that you can only appreciate their performance with a bench full of measuring instruments. Between these extremes you should be able to find something that will give you what you want without paying for more than you can appreciate.

Power amplifier

The power amplifier takes the weak signals fed into it by the preamplifier and boosts them until they are powerful enough to drive the speakers.

All stereo power amplifiers look pretty much alike these days because the basic components are similar and the differences are mainly concerned with circuit refinements, maximum power, control facilities and exterior styling. The components are mounted on a chassis which has a panel for control knobs, switches, sockets for the input and output connexions and generally a power supply socket for the preamplifier (p. 59).



STEREO POWER AMPLIFIER. The power amplifier takes the weak signals 7 and 8 coming from the control unit, boosts them and provides powerful signals at the outputs 3 and 4 to drive the speakers 5 and 6. It also provides high and low tension current 1 for the control unit. The mains connexion 2 is made via the on/off switch on the control unit.

When the amplifier is intended for use as a self-contained unit, the components behind the panel are completely boxed in and the whole thing is finished to make it look neat and attractive. The case is always well ventilated because the valves inside develop a fair amount of heat. You have to remember to leave plenty of holes for the heat to escape through if you build a power amplifier into a cabinet.

DISTORTION—ENEMY OF QUALITY. A good amplifier, designed and built to high fidelity standards, should amplify the signal faithfully, but there are at least a dozen ways in which it may fall short of the ideal and when it does, you get poor reproduction quality.

The enemies of good quality are called distortions. No amplifier is completely free from them.

One common type of distortion is produced when the amplifier has an uneven response to different frequencies. This is called 'frequency distortion'.

When two frequencies add together in the amplifier to create a third that was not present in the original signal you get 'intermodulation distortion'.

'Harmonic distortion' creeps in when the amplifier doesn't respond exactly to sudden changes in the strength of the input signal. These are by no means the only offenders.

'Mains hum' is another enemy of good quality. It comes from the alternating current supply and produces a steady, low-pitched note that you notice in the quiet passages.

Finally there is always a certain amount of unwanted noise produced along with the signals from all sorts of inside and outside sources. All this gets amplified and comes out of the speakers as a rushing, hissing background to the actual programme. This ever-present 'mush' is called the 'noise level'.

HOW MUCH IS TOO MUCH? You can get all these distortions in the best amplifiers, but they shouldn't be bad enough for you to notice. But of course, the less you want to hear of them, the more you have to pay for your equipment.

The maker's specification lists most of the worst dis-

tortions. The following table is a rough guide to how much of any particular distortion your ear will accept without worrying about it.

DISTORTION—HOW MUCH IS TOO MUCH

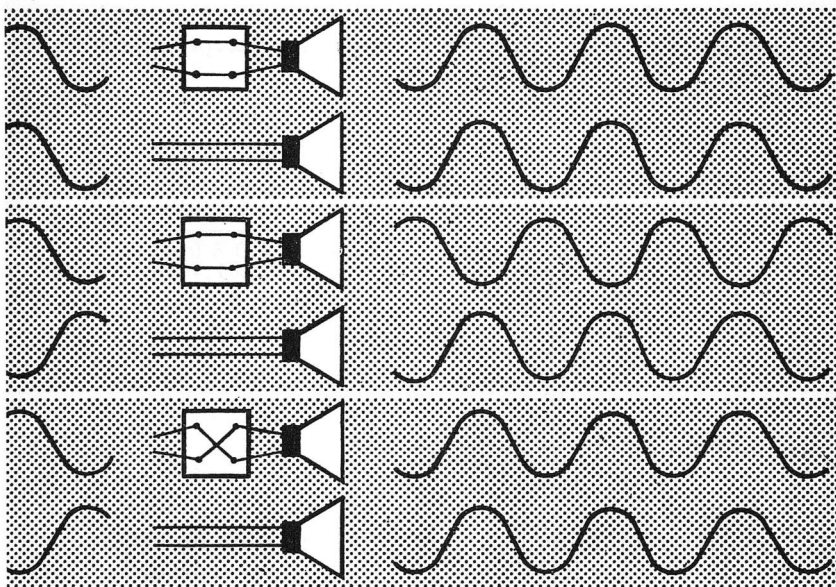
<i>Type of Distortion</i>	<i>How it is Measured</i>	<i>Greatest Amount of Distortion your ear will accept</i>
Frequency	In dB above or below the ideal response over the stated frequency range (p. 14).	\pm 3dB from 60 to 12,000 cycles
Harmonic	Percentage of intensity of the unwanted frequencies to that of the true signal.	0.5%
Hum Noise	No. of dB below the level of the true signal. (Sometimes stated separately, sometimes together as 'H & N' and sometimes together as NL or Noise Level.)	35dB

The various distortions are usually worst when the amplifier is delivering its full power—*i.e.*, with the volume turned up on a loud signal. So when the manufacturer states the amount of any particular distortion the value should be measured at the full working output of the amplifier. The output for which the distortions are no worse than the figures quoted by the manufacturer of the amplifier is referred to as its 'undistorted output'.

CONTROLS. When the power amplifier is designed to work in conjunction with a stereo preamplifier by the same maker, it has no controls. The multiple lead connecting the two units incorporates all the connexions for controlling both units from the preamplifier. The on-off switch on the preamplifier controls both units. The power of the signals delivered by the amplifier to the speakers is controlled by the volume control on the preamplifier.

When the amplifier is sold as a completely separate unit it has its own volume control and on-off switch.

In either type of unit you may find a refinement in the shape of a speaker phasing switch. This lets you change



PHASE SWITCH. For the true stereo effect both signals should emerge from the speakers with their ups and downs 'in step' (top). If the original signals are out of step (centre) the output from the speakers will be out of step and there will be no stereo effect. The phase switch reverses the ups and downs of one signal and brings the out-of-step signals back into step again when they come out of the speakers, thus restoring the stereo effect (below).

over the pair of output connexions to one speaker to bring its in and out movement into step with its opposite number—known as bringing the two speakers into phase. In a factory built assembly this point is taken care of automatically and you can't connect the speakers incorrectly, but when you assemble your own units there are several points where you can get the two channels out of phase. It makes things very much easier if you can use a switch to check that both speakers are pushing and pulling together as they should.

Your ear will quickly tell you which way to set the switch for true stereo reproduction (p. 130). (Remember that the channel phasing switch is a refinement that you can do

without if you are prepared to experiment with the connexions of the actual leads until the reproduction sounds right.)

Choosing your amplifier

The first step in choosing the power amplifier is to decide the power you want it to deliver to the speakers, remembering that 5 + 5 watts—*i.e.*, 5 watts from each speaker—is all you want in a normal 12 × 15 ft. room and 3 + 3 will do if your room is smaller than that. This figure gives you the undistorted power you want to take from the outputs of your amplifier.

You won't need to worry about the input if you are connecting it to a preamplifier because by and large all preamplifier outputs are suitable for all power amplifier inputs.

Next you will have to consider the power supply. You can buy an amplifier with its own built-in supply and a socket for supplying power to the preamplifier and other equipment, or you can have a separate power pack to feed all your units. The information given on the following pages will help you here.

ONE OR TWO UNITS? If you are planning a stereo set-up using an existing single channel record player or tape recorder with its own built-in amplifier, you may only need to buy one more single channel amplifier for the extra channel (p. 122). But if you are building or assembling a stereo system from scratch, then you will need either two matched amplifiers or (preferably) a complete 2-channel stereo amplifier. This is usually cheaper than two separate items since all the parts are mounted on one chassis and use a common power supply.

You will also have to decide whether you want an independent unit in a case or just a chassis mounted unit to build in to a cabinet with the rest of the set-up.

COST AND QUALITY. The number of amplifiers available will probably bewilder you for a start, but in fact they will not all be suitable for your purpose.

When you have weeded out the ones that are of the wrong power or have too many or too few control facilities, your choice will lie between the highest possible quality at one end of the scale, and the cheap and nasty 'bargain' equipment at the bottom end. You will be safe in choosing a medium priced amplifier—the cheapest are not worth buying, and the most expensive are wasted unless all the rest of your equipment is up to the same standard. (You can compare qualities by referring to the frequency response, p. 140.)

In the medium price range you can expect a frequency response of about 20 to 20,000 cycles \pm 3 dB, while in the top bracket you have amplifiers with a frequency response as good as 5 to 30,000 cycles \pm 0 dB—in other words, with a flat response over the whole range of audible frequencies.

You have to remember that whatever the manufacturer may do, *you* listen to music with your ears—not an assortment of scientific instruments, and it takes a very good ear to tell the difference between an amplifier with a frequency range from 30 to 12,000 cycles and one costing two or three times as much with a faultless response from 5 to 30,000 cycles. So when you come to make the final decision, there is no need to unbalance your budget to buy the last word in technical perfection.

Power supply

Preamplifiers and power amplifiers both need a supply of low and high tension current. The low tension supply (in Britain) is generally alternating current at 6·3 volts, while the high tension supply is always direct current at 250 volts. These power supplies come from a transformer with suitable high and low voltage tappings connected to the alternating current mains.

The high voltage is rectified (converted into direct current) by a special type of valve or a metal rectifier. But even after rectifying, the current still carries a trace of unevenness which would produce a hum in the speakers, so before being fed to the supply circuits it is passed through a smoothing circuit.

The low voltage is used only for heating the valves; it is not usually necessary to rectify it, but in some circuits, where the hum from the mains must be kept as low as possible, a specially smoothed and rectified low voltage supply may be used for heating the valves that are most likely to pick up hum.

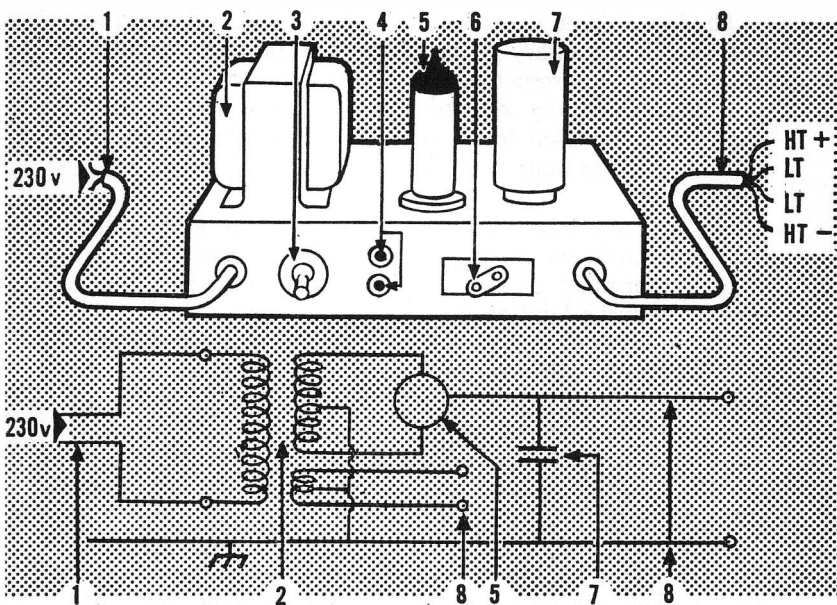
POWER PACK. The assembly of mains transformer, rectifier or rectifiers, smoothing chokes and condensers is known as the power pack. Its job is simply to supply the electronic circuits with the kind of electricity they need.

The power pack is usually built in to the amplifier (which is then called a 'self-powered' unit) but you can also have a completely separate power pack to supply all the various units, in which case you buy them all 'unpowered'. The pre-amplifier may have its own built-in power supply, but more often it is supplied from a socket on the power amplifier through a multiple lead and plug.

Most power amplifiers and some tape recorders have a socket for supplying power to other electronic equipment. Such sockets are only intended to provide high and low tension current to a preamplifier or radio tuner, which only require a small current. They are not for connecting to power amplifiers because power amplifiers require much heavier supplies of high tension current—120 milliamps or more as against 30 or so for a preamplifier or tuning unit.

When you buy a self-contained unit, the power supply will be able to cope with all the circuits connected to it, but if you buy a unit that needs a separate power pack or an auxiliary supply from another piece of equipment, make sure that your supply source will deliver the current you want *at the correct voltage*. The voltage of an ordinary power pack falls as you take more current from it, so the power pack will only operate at the correct voltage if the circuit draws the right number of milliamps from it. If your equipment draws less than this, the voltage of the supply may shoot up and spoil the quality of the reproduction. It may even shorten the life of your valves.

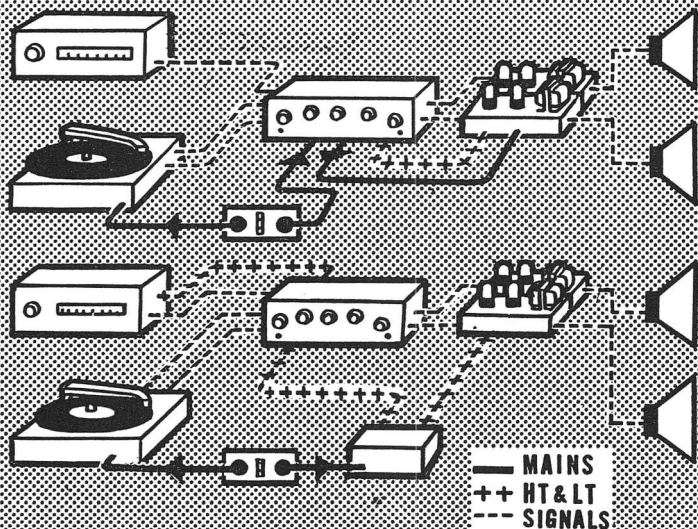
The maker always states the power requirements of equip-



POWER PACK. This is an independent unit for supplying high and low tension current for amplifiers, tuning units, etc., which do not include their own built-in power. Alternating current from the mains 1 has its voltage changed by transformer 2, is turned into direct current by the rectifier valve 5, smoothed by condenser 7 and delivered by multiple lead 8 to the amplifier or other circuit. The mains supply is controlled by on/off switch 3 and adjusted to the correct input voltage by mains adjuster plug 6. Fuses 4 protect the A.C. and D.C. circuits against overload.

ment (when it is not self-powered) and the power output of power packs or auxiliary power supply sockets. This lets you choose the right size of power pack for your equipment.

POWER FOR EXTRA UNITS. Choosing a power pack is a straightforward arrangement when you are only connecting one piece of equipment to the supply, but if you want to run, say a radio tuner, a preamplifier and a power amplifier off the same power pack, you have to watch that one unit



POWER FOR THE STEREO UNITS. With self-powered equipment (above) the radio tuner and amplifying system have separate connexions to the A.C. mains. The supply for the amplifying system goes to the power amplifier via the on/off switch in the control unit. With unpowered units (below) you need an external power pack to supply high and low tension current to the various electronic units.

does not interfere with another. If you are not familiar with electronic circuits, you had better leave this type of circuit to your radio dealer or an expert friend if you are lucky enough to have one.

This question of power supplies is extra important when you are converting single channel equipment to stereo. Don't economise on power supplies if it means overloading your existing equipment. Remember, a small amount of overloading may not be serious enough to blow a fuse, but it can set up mains hum and distortion and give you poor quality reproduction.

The Speakers

THE FINAL JOB OF TRANSLATING THE TWO amplified stereo signals into sound is carried out by a pair of loudspeakers.

A loudspeaker—speaker for short—is another of those pieces of equipment based on the two-way connexion between magnetism and electricity. In the speaker you turn the electrical ups and downs of the amplified signal into a similar magnetic push and pull acting on a diaphragm. The to and fro trembling of the diaphragm sets up sound waves and you get your original sound once more—or a more or less true copy of it depending on the quality of your equipment.

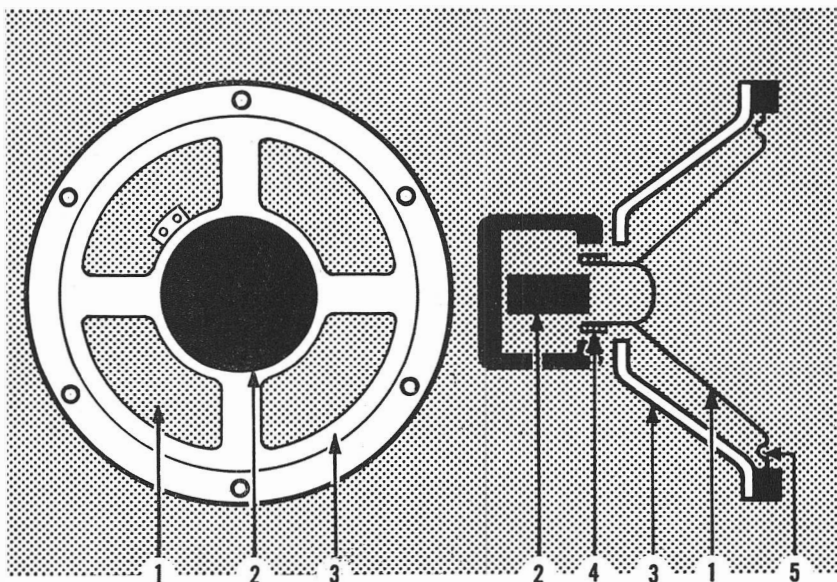
There are several different types of speaker and doubtless new types will be coming along in the future, but at present the moving coil speaker is the most popular. (If you are curious about the other types you will find a brief description of them at the end of this chapter.)

Moving coil speakers

In a moving coil speaker, the driving force comes from a coil of wire, called the speech (or voice) coil, wound in the form of a hollow cylinder. It is supported in a narrow circular gap formed between the poles of a specially shaped and very powerful permanent magnet. The full power of the magnet is concentrated across the gap and passes through the turns of the coil. The output from the power amplifier is connected to the coil and the amplified signal flows around the turns of the coil

thus creating a magnetic field. This field alternately pushes and pulls against the field of the permanent magnet, making the coil move to and fro in the gap.

The coil itself is fixed to the apex of a shallow cone of stiff fabric or similar material supported in a ring of felt or plastic foam mounted in a circular frame. The frame has



MOVING COIL SPEAKERS. Left: A moving coil speaker consists of a fabric cone 1 with a coil 4 attached to it. The cone is mounted in a chassis 3 on a flexible surround 5 and holds the coil in the field of a powerful permanent magnet 2. The signal current flows around the coil and sets up its own magnetic field which pushes and pulls against the field of the permanent magnet, making the cone vibrate and send out sound waves.

struts to support the permanent magnet (which is quite a heavy chunk of metal) and the speech coil is held in the centre of the gap and prevented from rubbing against the sides by a thin metal 'spider'. As the coil vibrates to and fro in the field of the magnet it pushes the fabric cone in and out, creating sound waves.

THE LOW NOTE PROBLEM. A speaker of this type can be made to respond to currents vibrating at frequencies from around 20 per second up to 20,000 and even higher. But it is not enough for the speaker just to 'respond'; its movement must be great or small, fast or slow, in exact proportion to the strength and frequency of the signal.

In this respect, however, the speaker by itself does not do a very good job of work. It will reproduce high frequencies efficiently, but as the frequency of the signal falls lower and lower, the amount of sound given out gets less and less in proportion.

The trouble is that when the coil pushes the cone forward it builds up air pressure in front and 'suction' behind. If the cone is moving slowly enough—*i.e.*, when the frequency of the vibrations is low—the air at the front has time to slip around to the back; the pressure cancels out the suction and you are back where you started. (Just as you can pull an oar slowly through the water and watch the water flowing from the front to the back of the blade without moving the boat forward.)

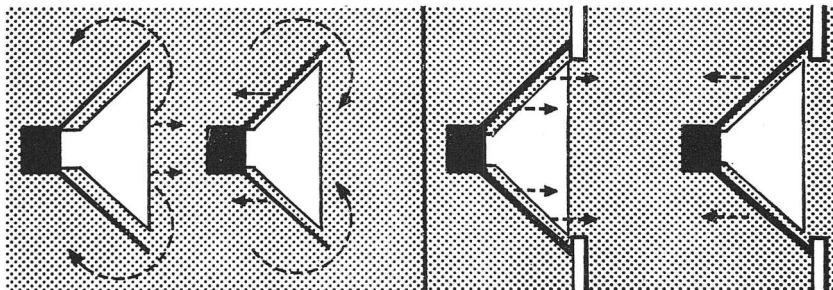
As the frequency of the current through the coil rises, the cone moves faster and faster and the air gets less time to move out of the way. So more and more of the pressure in the front of the cone goes out in the form of sound waves and you begin to hear something for the power you are supplying to the speech coil. (When you try to make the oar move quickly, the water no longer flows around it; the oar begins to bite and the boat starts moving forward.)

This is the big problem of the moving coil speaker: how to get the cone to push out sound waves at the lower frequencies instead of simply flapping backwards and forwards like an oar stirring up the water without moving the boat.

BAFFLES. One way of solving the problem is to mount the speaker in the middle of a large thick panel of solid material called a baffle. The baffle may be made of wood, concrete, or even metal, and it needs to be at least 4 ft. square if the speaker is to get down to frequencies of 50 cycles a second or less. The baffle cuts off all communica-

tion between the pressure waves at the front and back of the cone. So when the cone moves forward it has to push all the air in front of it, setting up a sound wave. On the return journey it pushes out a similar wave at the back. The sound from the back simply bounces off the wall of the room and mixes with the sound from the front.

You can mount the speaker in the wall of the room and use that as a baffle, but you will only get half the sound in the room; the other half will be wasted on the other side of the wall. But while a baffle does a better job for you, it is—alas—a big and cumbersome piece of furniture.

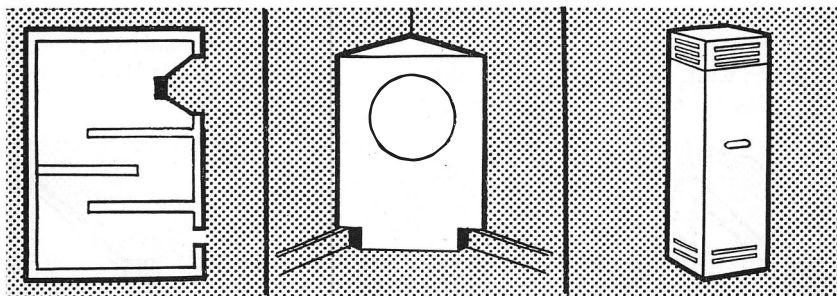


BAFFLES. An unmounted speaker (left) is not very good at turning low frequencies into sound because the cone moves slowly and gives the air time to move out of the way. When you cut off the escape of the air with a baffle (right) the sound waves radiate from the front and back of the cone instead of cancelling each other out.

REFLEX ENCLOSURES. The most popular way of loading the speaker is to mount it in a closed box called a reflex enclosure. This is a cabinet anything up to 3 ft. high, 2 ft. wide and 18 in. deep, with a hole for the speaker high in the front panel and an open port cut close to the floor. The sides of the enclosure are made thick to prevent the air pressure from escaping through to the back by making the material vibrate.

What happens is this. The cone moves forward, pushes the air in front and sends out a sound wave. Next it moves back, and pushes the air behind it into the cabinet in the

form of another similar wave. This one travels down through the air enclosed in the cabinet and out of the port. The height of the cabinet and the path taken by the sound wave are worked out so that at the exact instant when the wave comes out of the port at the bottom, the next sound wave is being sent out by the front of the speaker cone. So



REFLEX ENCLOSURES. By mounting the speaker in a reflex cabinet (left) you make the sound waves from the back of the cone emerge from the port in the bottom 'in step' with the waves from the front. So you get more sound for your money. The corner unit (centre) is an economical way of building a reflex cabinet from two pieces of wood. The column type of speaker (right) is simply a reflex cabinet in another—and for some purposes more convenient—shape.

the two waves join up as one and you get the maximum sound output for the power being fed into the speech coil.

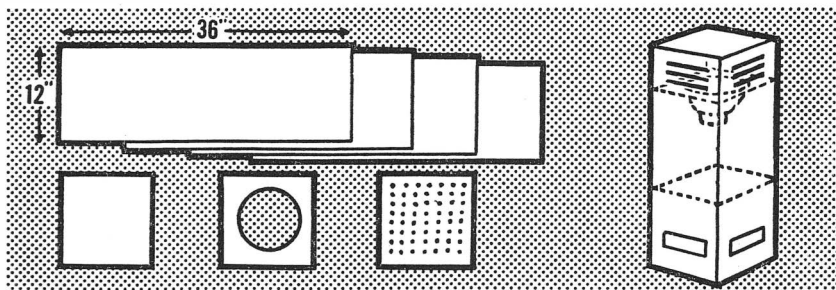
For stereo listening, where you must have at least two speakers, large reflex cabinets are out of the question unless you have a really large room (or can afford to have one built specially for music). Most people have only a limited amount of spare space and must have something that fits into the living room layout.

Corner speakers

One popular solution is a reflex cabinet made by fixing a panel across the corner of a room and closing off the space with a triangular lid. The walls and the floor help to project

the sound into the room and make it appear to come from a more spread out source.

This is quite the cheapest form of speaker enclosure and one you can make yourself. (One refinement is to 'bevel' the front panel by building it as a centre section flanked by two narrow panels set to meet the wall at right angles.)



GLUE-IT-YOURSELF COLUMN SPEAKER. Column speakers are easy to make yourself if you are anything of a handyman. The one illustrated is made from $\frac{1}{2}$ in. plywood. You can buy it in kit form or get a blueprint and cut it out of your own timber. It will give excellent results with a 6 or 8 in. speaker.

Column speakers

Another solution, the column speaker, is a good type to use if you have to listen to stereo in small rooms. It is actually a kind of reflex cabinet in the form of a hollow square column made from four long panels of wood joined along their edges to make a tall, open-ended box with the speaker mounted on a panel about $\frac{1}{4}$ way down. The cone faces upwards and sends sound waves up the column and out into the room through louvres around the top end. The bottom of the column is open and at some point below the speaker there is a perforated partition of sound absorbing material. This arrangement acts in the same way as a reflex cabinet: it slows down the pressure wave from the back of the cone so that it comes out in step with the next pressure wave from the front.

You can get a column speaker only 9×9 in. base and 3 ft.

high and housing a 6 in. moving coil unit with a frequency response from 11,000 down to 100 cycles. Even a small living room can stand a pair of speakers this size without looking over-furnished. If you want to make your own column enclosures you can get working drawings from the dealer where you buy the speakers. Or you can buy the wood already cut to size in a 'Glue-it-Yourself' kit. Or you buy them complete and ready to connect to your stereo amplifier.

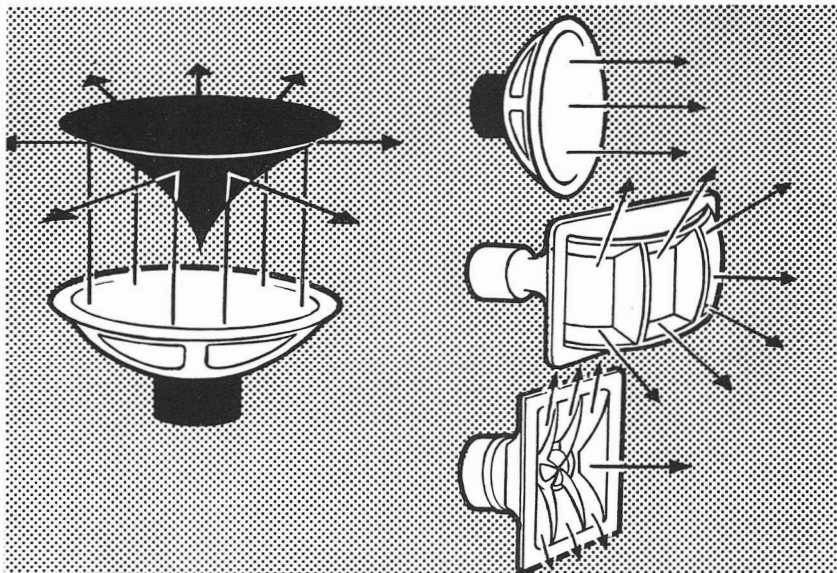
Treble units

You can't play very high notes on a bass fiddle or 'cello and if you slack off the strings of a fiddle to make it play lower notes than usual, it won't sound pleasant. This is because there is a connexion between the size of the instrument and the range of the notes that sound well on it. If you want to cover the widest possible range you use a double bass for the lowest notes, followed by the 'cello and viola for the medium range and finally the violin for the high notes—each instrument having a smaller sound box and shorter strings than the one before.

It's the same thing with speakers. While you *can* squeeze high notes of a sort out of 12 in. speakers mounted in reflex cabinets or corner enclosures you don't get the best possible reproduction. If you want to do justice to the highest notes of all—the frequencies that give brilliance to the ping of the triangle and the clash of the cymbals—you need speakers with cones as small as 3 in. diameter.

Eight or ten inch speakers mounted in cabinets to get a good low frequency response can't be expected to do both jobs but will be able to cope with frequencies up to the point where the 3 in. speakers take over. So by combining the two, you can get a full-bodied response to the low and medium tones with the extra brilliance in the top that makes all the difference between good and really first class reproduction. Fortunately the tiny speakers—called 'tweeters'—don't cost a lot, and they don't need to be mounted in a baffle or cabinet.

SPREADING THE HIGH NOTES. 'Tweeters' have an awkward trick of shooting the sound straight out in beams like motor car headlights, so you only hear them both if you are sitting right in front and you only get the full stereo effect if you sit dead on the intersection of the two beams. Manufacturers overcome this by fitting shaped reflectors with



TREBLE UNITS. High notes tend to shoot straight out of the speaker in a narrow beam like a spotlight (top right). One way of making them spread out into the room is to point the speaker up at a curved reflector of hard, polished wood (left). Another way is to divert the sound waves by a horn arrangement (right, centre and below).

a hard, polished surface in front of the cones. The high frequency sound waves bounce off the reflectors and spread over the room instead of staying in beams.

You can get almost the same effect by mounting the tweeters on top of the speaker cabinets and pointing them into the corners of the room so that the sound is reflected in all directions off the corner walls.

Three-speaker assemblies

Eight or ten inch speakers in reflex enclosures with 3 in. tweeters form a satisfactory combination, but with a 12 or 15 in. speaker and large reflex cabinet you get the best results by adding an intermediate speaker of 6 or 8 in. There is no need to mount this one in a cabinet since the low frequencies can safely be left to the big speaker (woofer).

This is, of course, the usual kind of speaker set-up for high fidelity reproduction of single channel sound, and no doubt such a pair would give you really wonderful stereo. But two of this kind are rather more than the average room can accommodate and most people are happy to do without the lowest frequencies and make do with a couple of smaller (and cheaper) speaker units.

At the same time, if you already own a high fidelity single channel set-up, there is no need to scrap your big speaker when you turn over to stereo. There is no hard and fast rule about having two identical speakers. You can use your high fidelity speaker assembly for one channel and, say, an 8 in. column speaker plus tweeter for the other. This would give you better stereo than you would get from two identical 8 in.-plus-tweeter speakers. The extremely low notes from the 'woofer' add very little to the stereo impression but they round off the reproduction on both channels and help to get rid of the 'hole-in-the-middle' effect (p. 133).

CONNECTING THE EXTRA SPEAKER. If your speakers are complete with tweeters when you buy them, they will be already correctly connected inside the units and you will only have the usual pair of terminals to connect to each amplifier channel. But if you want to add a pair of tweeters to your existing speakers to improve the high notes you must do it the right way. The usual method is to connect a small condenser in series with the tweeter (to block the low frequencies) and then connect the circuit in parallel with the main speaker.

You have to make sure your tweeter is 'in phase' with the

main speaker in each case—*i.e.*, that they both push and pull together (p. 130). To check this you connect an ordinary $1\frac{1}{2}$ volt dry cell across the terminals of each speaker in turn and notice whether the speaker cone moves in or out. Change the connexion of the tweeter around until both cones move the same way when the current is on.

If you want to add a middle frequency speaker and tweeter to an existing 12 or 15 in. speaker you will have to obtain a specially designed 'crossover filter'. This is an electrical unit that divides up the signal into frequency bands, passing on to each speaker the band of frequencies it is designed to handle—*e.g.*, it would direct all frequencies below 1,000 cycles to the woofer, everything from 1,000 to 10,000 to the middle range speaker, and everything above 10,000 to the tweeter.

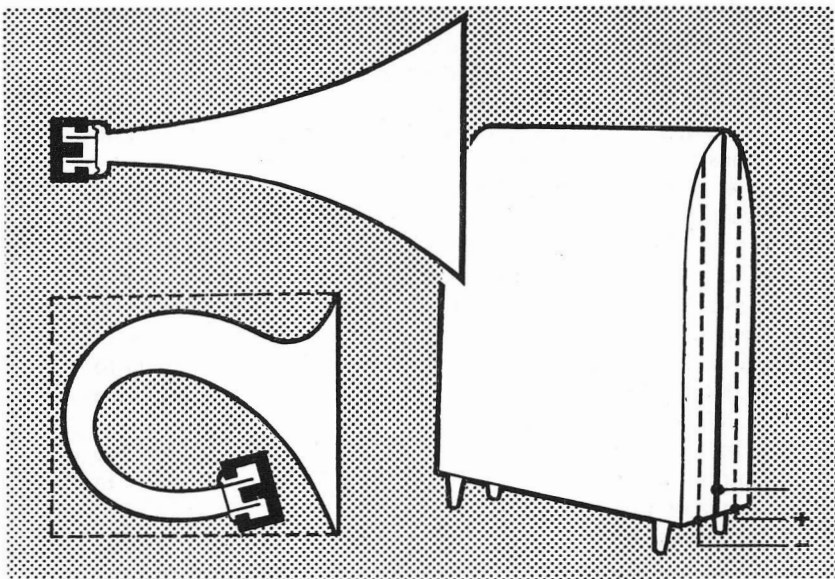
In practice the various frequency bands overlap; the figures quoted are the points where the bias of the filter in favour of the lower band of frequencies 'crosses over' and becomes a bias in favour of the next band higher up the scale. (See also p. 134.)

Other speakers

The moving coil speaker is not the only type used for stereo sound reproduction but it is the most popular. There are two other alternatives, horn and electrostatic.

HORN are a version of the moving coil type because the driving unit is a small moving coil speaker. The difference lies in the method of loading the coil unit—*i.e.*, converting the to-and-fro movement into sound waves. This type of speaker is loaded by mounting the coil in the narrow end of a long horn made of metal, wood or even papier mache. The longer the horn the deeper the note it will reproduce but the more awkward the whole thing becomes. To get down to 30 cycles per second you need a horn 30 feet long ending up in a flare 20 feet wide.

Manufacturers can tuck quite a large horn into a small space by various ingenious methods of construction but



OTHER SPEAKERS. In some moving coil speakers the coil unit is mounted at the narrow end of a long horn (top left) which may be folded to save space (bottom left). In the electrostatic speaker (right) the signal is applied to a diaphragm between two grids connected across a high voltage. The diaphragm vibrates as a whole, so it needs no baffle or enclosure.

these tend to make the unit more expensive than a normal speaker for the same performance.

Horn speakers are used in cinemas and for public address systems because they are capable of handling large volumes of sound. Also, in cinemas and out of doors the extra size doesn't matter. However you can get folded horn console speakers for domestic stereo, and there are midget horns designed for use as tweeters.

ELECTROSTATIC work on quite a different principle. The drive is spread over a large area—anything up to 3 or 4 square feet. The moving element is a flat diaphragm about 2 ft. 6 in. wide by 1 ft. 6 in. high stretched between two

pieces of metal mesh—arranged like a sandwich. A polarising voltage is applied between the outer layers of the sandwich, creating an electrostatic field between them. The output from the power amplifier is connected between the diaphragm and the layers of mesh.

As the signal voltage fluctuates the diaphragm is pulled to and fro by the charged outer grids. The vibrations of the diaphragm set up sound waves which radiate from its whole area so there is no need for any baffle, cabinet or horn.

Electrostatic speakers are directional, and make the greatest volume of sound inside a flat cone-shaped field with a horizontal angle of about 70° and a vertical angle of about 15° . They are manufactured in the form of a shallow oblong cabinet standing on edge—something like a fire screen. They work best when they are two feet away from the wall and parallel to it, so they tend to take up a lot of space in the room.

The quality of the sound from an electrostatic speaker appears thin to some people while others look on it as the last word in faithful reproduction. Some types seem to lack good bass response but the upper frequencies are always particularly fine. This is why small electrostatic speakers make such good tweeters. These are comparatively cheap, but the full scale speakers are apt to be more expensive than the moving coil designs with the same performance.

Stereo on Radio

A RADIO RECEIVER CONSISTS BROADLY OF four departments: the receiving aerial, the signal filter, the signal amplifier, and the signal reproducer.

The aerial sticks up into the hurly-burly of radio waves being sent out by all sorts of transmitters on all sorts of wavelengths here, there and everywhere. Some signals are picked up by aerial and get through to the receiver. A lot don't get as far as that, either because their wavelength is too short or too long, or because they are too weak or they are travelling in the wrong direction. The aerial in fact acts as a kind of crude filter to get rid of a lot of the signals that are no use to you.

The signal filtering department (called the radio frequency or RF end of the receiver circuit) sorts out the signal you want from the mixed bag that comes through from the aerial, and it translates it into the kind of electronic language that makes sense to the next department. It does this finally with a valve called a diode.

When the signal leaves the diode it is strong enough to hear in a pair of headphones, but not nearly powerful enough to drive a speaker. That is where the amplifier takes over. Its job is to boost the signal and pass it on to the speaker where it comes out as loud a sound as—or even louder than—the original speech or music heard by the microphone in the broadcasting studio.

The equipment

In a commercial radio set you get everything (and sometimes the aerial too) in a single complete unit. But if you

already have a set-up for reproducing stereo or single channel records you need only buy the signal filtering section of the radio. When you buy it separately it is called a tuning unit. You connect the aerial to the input end and the other end to the input of your preamplifier (p. 116); and you have a first class radio receiver.

For receiving stereo transmissions you need two independent receiving circuits. It would simplify things if the two signals could be handled by the same type of receiver but at the moment, in Britain at least, you can't do this and you have to accept an untidy mixture in which you receive one channel by the straightforward method described above and the other on the sound section of your TV set.

F.M. radio

A normal radio set is designed to receive A.M. signals, that is, broadcasts in which the signal is transmitted by Amplitude Modulation—*i.e.*, changes in the *size* of the radio wave. This type of broadcast will carry for long distances and it enables a transmitter to serve a very large area. But it is plagued by interference from other broadcasting stations over just as wide an area and it suffers from atmospheric—interference from thunderstorms, atmospheric electricity and all sorts of electrical equipment.

Nowadays this type of broadcast is being rapidly superseded by the F.M. system. This transmits the signal by Frequency Modulation—*i.e.*, by changes in the *frequency* of the radio wave. F.M. radio is practically free from interference of any sort—natural or man-made. F.M. transmitters have a shorter range so more of them are required to serve a given area. By this time, however, most people in Great Britain are within the area of good reception of at least one F.M. radio transmitter.

F.M. radio receivers cost more than A.M. receivers in the same class, but if you can afford it, you will find it worth your while to pay the extra pounds. If you live in one of the really bad reception areas you may have no choice in the matter; it will be F.M. or nothing.

ADDING AN F.M. TUNER. If you already have a high fidelity single channel disc or tape reproducer or a stereo set-up, you need not buy a complete radio set; you need only buy the signal tuning unit and plug the output in to your preamplifier radio input socket. You can buy either an F.M. or A.M. unit, or one that will receive both.

Don't forget when you are adding up what it is all going to cost that you will almost certainly need a special aerial for an F.M. receiver unless you are quite close to the transmitter. If you are on the outer fringe of the reception area you will need a fairly ambitious one. These aerials are highly directional and you have to site them carefully and well above roof level to give the strongest possible signal.

Stereo from your radio

For some years experimental stereo broadcasts have been put out by a number of American radio stations and more recently by the B.B.C. In Britain, part of the trouble is that there are no wavelengths to spare for the extra channel. In addition, the programmes have to be received on two separate radio sets and it isn't everybody who can switch on two sets in the same room.

At the present time the problem is being solved by transmitting one channel on radio and the other on TV sound, since there are many millions of homes with TV sets and most of those also have a radio, even if it is only a small portable type. Even so the programmes can only be sent out on wavelengths borrowed for the occasion at times when they can be spared without upsetting normal broadcasting.

So far there are no definite plans for broadcasting the two channels on two separate sound radio programmes and it will probably be some time before agreement is reached between set manufacturers and broadcasting authorities on a suitable system. This, when it comes, must not call for prohibitively expensive alterations to existing sets and it must reproduce as well through the ordinary single channel radio sets where the owners are not interested in—or can-

not afford—stereo. Regular stereo programmes will therefore have to wait until the technical and economic snags have been ironed out.

USING EXISTING RECEIVERS. The average listener receives the two channels on his normal TV and F.M. receivers with their own built-in amplifiers and speakers. There is not much point in trying to reproduce them through a stereo set-up. Your TV set will usually be the fixed member of the team and this will decide where you place the radio set—or the extension speaker running off the radio set. The two sound sources should be about 6 feet apart and facing slightly inward. As the TV sound is always used for the right hand channel, the radio or speaker will have to be on the left.

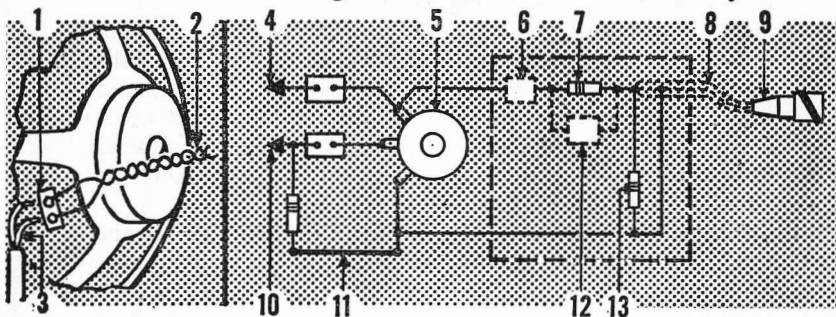
There is usually an announcement at the beginning of the broadcast to let you check the right and left of your set-up. (If you get the channels the wrong way round, it won't spoil the stereo effect, but it will change things around so that actors will make their entrances from the wrong side and the brass will sound from where the strings ought to be.

Ideally you should have the two speakers looking towards a point about 9-12 feet away and you should station yourself at that point to get the maximum stereo effect. In practice you will find you have quite a bit of latitude and you can always experiment with different positions, angles and distances until you get the best arrangement. (You will find more on this subject under *Listening to Stereo*, p. 127.)

USING EXISTING STEREO EQUIPMENT. Of course, such a set-up is only makeshift. The characteristics of the sets, amplifiers and speakers are anything but equal, and balancing them up is a hit-and-miss business. If you already have stereo equipment for reproducing stereo discs or tapes, you can connect the two signals to the normal inputs on your stereo preamplifier and get them under proper control. If you are already using your amplifier and speakers in conjunction with an F.M. radio tuning unit, the left hand chan-

nel is already provided for and all you have to worry about is the TV channel.

CAUTION! With an ordinary radio set, you can take an output either from the extension speaker sockets (low impedance) or the pickup sockets, or connect to the volume control (both of these are high impedance connexions). You are safe in doing this with most radio sets, but if you



IF THERE IS NO EXTENSION SPEAKER CONNEXION. Left: Solder the lead in parallel with the speaker terminals. Right: For the best quality connect the leads to the radio diode as shown in circuit, where 4 is diode connexion to volume control; 5, 10 to audio stages; 11, chassis; 3, .025 μ F condenser; 7, 1-2 megohm resistance; 12, 35 PF condenser (if lead is over 10 ft.); 13, 50-100,000 ohm resistor; 8, screened lead; 9, plug into tape recorder.

do it with the TV sound circuit you may run into serious trouble because on most TV sets the chassis is live. The connexion *can* be made, but it calls for an extra piece of equipment, known as an isolating transformer, and you need a cut-out switch in the TV speaker circuit to keep it from joining in and spoiling the stereo balance. This is not a job for the uninitiated; you will be well advised to go to your radio dealer, tell him what you want to do, and leave him to modify the circuit for you.

Balancing the signals

Once you have arranged the two outputs you simply plug them into your stereo preamplifier input and repro-

duce them through the speakers just as you would reproduce from the stereo pickup. The output from the radio and TV sets will usually be much greater than from the pickup, and you may have to balance a high impedance signal from your F.M. tuning unit against a low impedance signal from the TV set isolating transformer. Your preamplifier will almost certainly provide suitable circuits for both types of input. You can start balancing by switching off each channel in turn and comparing the volume from each speaker, adjusting the level and the tone either at the set or with the preamplifier balance control until they both sound the same. Once you have achieved a satisfactory balance between radio and TV inputs in this way you can adjust the volume of the combined stereo output from both speakers with the ganged volume control.

Stereo on Tape

PRERECORDED MAGNETIC TAPE IS THE MOST popular source of stereo sound after the gramophone disc. In many ways it is a better proposition because it is practically everlasting, it offers more room for the recorded signals and the playback head isn't as likely to get damaged as a pickup and stylus.

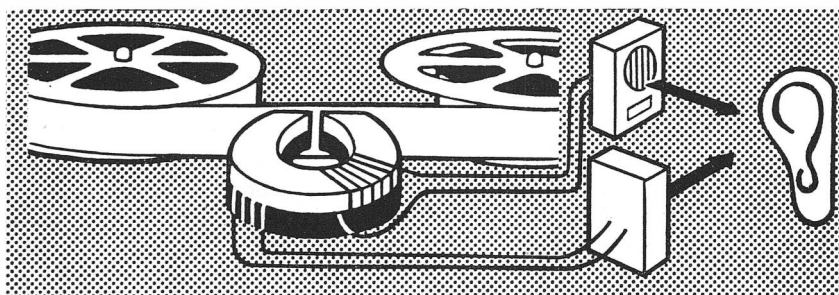
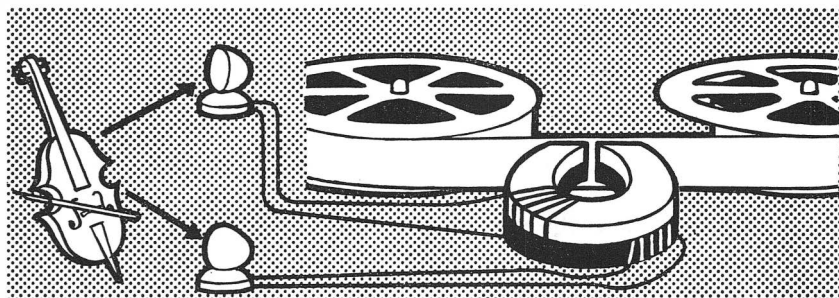
But tape needs more complicated machinery to handle it; it is trickier to load, and recordings take longer to duplicate, so they tend to cost more. However, the recording companies are quickly getting over these disadvantages. They are making tapes as easy to fit and change as discs and they are extending the playing time in various ways.

The biggest advantage of tape is that you can make your own records on it and you don't need to be a millionaire to afford the equipment. Better still, you can wipe the recording off the tape and start again—thousands of times. Up to now no manufacturer has been able to make a disc recorder to compete with the ease and cheapness of tape, so while discs can never be more than a means of passive enjoyment, tape adds all the thrill of a creative hobby.

This chapter will tell you how a tape recorder works if you don't know. But if you already own a single channel tape recorder and want to find out how you can change to stereo—either to play prerecorded tapes or to record your own stereo tapes as well—you'll find all the information in Chapter 9. And if you are starting without any equipment and want to know what sort of machine to buy, Chapter 8 will help you.

How a stereo tape recorder works

In a stereo tape recorder the two signals record on to a flexible plastic ribbon, coated with a layer of finely powdered iron oxide. This coating can store a magnetic pattern indefinitely; the stereo record is made of two patterns stored side by side on the same length of tape.



HOW A STEREO TAPE RECORDER WORKS. When you make a stereo tape record (above) the sound is picked up by two microphones (taking the place of your two ears), which turn it into two electrical currents. These currents are connected to coils wound around a pair of electro-magnets 'focused' on the top and bottom halves of a moving recording tape. The microphone currents create two streams of magnetism which record on the tape as it passes.

On playback (above) the magnetism on the tape sets up currents in the coils corresponding to the original microphone currents. These are boosted by the amplifier and turned back into sound by the stereo speakers.

RECORDING. When you make a record on magnetic tape you pull the tape over a recording head which turns the electrical ups and downs of the two stereo signals into magnetic ups and downs. The head is built in two sections, one above the other. Each section is connected to one stereo channel and concentrates its magnetism on a narrow track of the tape, one on the top half and the other on the bottom half. So you get two permanent records side by side on the tape as it moves over the head. These records do the same job as the groove in a stereo disc; they store the stereo signals until you want to use them.

PLAYING BACK. When you play back the record you pull the same length of tape over the head once again, in the same direction. This time the head works in reverse and turns the magnetic ups and downs back into electrical ups and downs which you can amplify and turn into sound in the speakers. Most tape recorders take advantage of the two-way action of the head to make the same one do for recording and playing back, but some have separate heads.

The tape

The tape is to the tape recorder what the disc is to the gramophone. Ordinary magnetic recording tape is made of plastic coated with an even layer of magnetic iron oxide—a pure form of common rust. It is $\frac{1}{4}$ in. wide and 1 to 2 thousandths of an inch thick, depending on the type.

WHAT SORTS ARE THERE? You can buy several sorts of tape, the difference being mainly in the thickness of the base material and the coating. You get more of the thinner tape on a spool, but it costs more per foot.

Tape is sold on plastic spools varying in diameter from 3 to 7 in. for ordinary domestic recorders and up to $10\frac{1}{2}$ in. for professional and commercial machines.

The playing time of a spool of tape depends on the size of the spool and the speed of the tape. Stereo tape records are mostly made at the standard speeds of $7\frac{1}{2}$ or $3\frac{3}{4}$ inches

per second (usually written ips). Single channel tape recorder speeds vary from 15/16ths to 15 ips with the majority using $7\frac{1}{2}$ or $3\frac{3}{4}$ or both.

Reproduction quality depends on tape speed; the faster speeds yield better quality.

The table below shows how many feet of tape you get per spool of Standard tape (which is the thickest and cheapest), Long Play (which costs more but plays half as long again) or Extra Thin (thinnest and most expensive, playing twice the time of a spool of Standard tape).

PLAYING TIMES OF STEREO TAPES (hr. min. sec.)

Tape Speed (i.p.s.)	3-in. Spool			5-in. Spool			5 $\frac{1}{4}$ -in. Spool			7-in. Spool		
	175 ft.	250 ft.	300 ft.	600 ft.	850 ft.	1200 ft.	850 ft.	1200 ft.	1800 ft.	1200 ft.	1800 ft.	2400 ft.
$7\frac{1}{2}$	- 4 40	- 6 40	- 8 0	- 16 0	- 22 40	- 32 0	- 22 40	- 32 0	- 48 0	- 32 0	- 48 0	1 4 0
$3\frac{3}{4}$	- 9 20	- 13 20	- 16 0	- 32 0	- 45 20	1 4 0	- 45 20	1 4 0	1 36 0	1 4 0	1 36 0	2 8 0

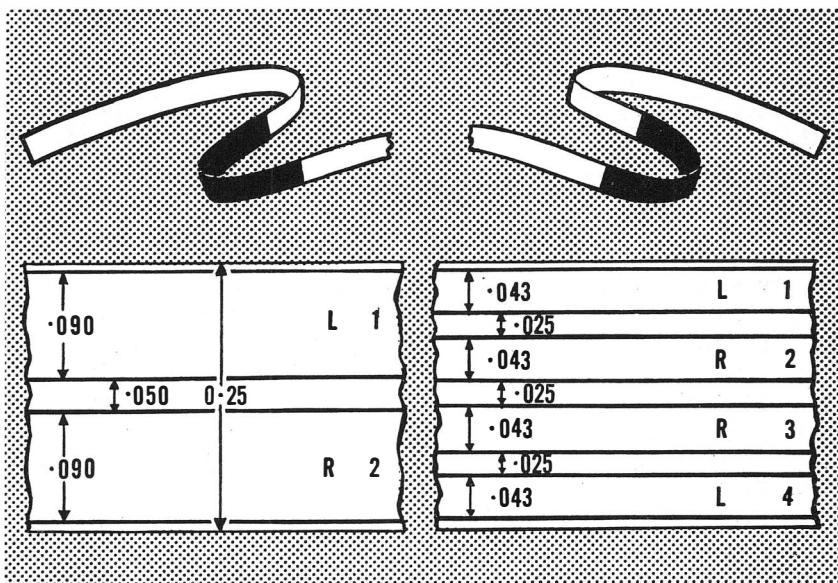
The above table gives the playing time for 2-track recording. For 4-track recording, multiply these playing times by 2. The lengths per spool vary with the different manufacturers; the figures given above are usual, but not universal.

Most tape recorders—and recording companies—use the whole width of the tape to carry two recordings side by side. You only need one recording track for a single channel record, but you need two for a stereo record. So you only get half the playing time from a length of stereo tape. This has led the tape recorder manufacturers and the recording companies to look for ways of increasing the playing time. One way of doing this is to record at a slower speed— $3\frac{3}{4}$ ips instead of $7\frac{1}{2}$. Another way is to use only a quarter of the width of the tape for each track and get two stereo records on to the tape instead of one. This sounds like getting something for nothing, but in fact you pay for it by sacrificing some quality.

2-TRACK TAPES have the stereo signals recorded side by side across the whole tape with a gap of 0.03 in. between each track and a margin of 0.01 in. along each edge of the tape. The left hand channel is recorded on the top half of the tape and the right hand channel on the bottom half.

4-TRACK TAPES carry two complete stereo records. If you divide the tape into 4 parallel tracks, numbered 1 to 4 from top to bottom, then the first stereo record is made on tracks 1 and 3 and the second on tracks 2 and 4. When you record or play back a tape of this kind you run it from the full spool on the left hand side of the deck, over the tape heads and on to the empty spool on the right hand side of the deck.

When all the tape runs off the left hand spool, you change the spools about, right to left, and turn the full spool over (like turning the page of a book). This brings the second



THE TAPE. The magnetic tape you buy on spools (above) has a length of coloured leader tape on each end and usually a length of metal foil which operates an automatic, electrically operated, end-of-tape stopping mechanism. In 2-Track Recording (bottom left) you record the left-hand channel on Track 1 along the top of the tape and the right-hand along Track 2 along the bottom. In 4-Track Recording the tape is divided into four tracks, so that you make two distinct stereo records, one using Tracks 1 and 3 and the other on Tracks 2 and 4.

set of tracks into the recording position with the tape once again at the ready on the left hand spool. So you record (and play back) the two stereo records with only one set of heads.

Some tape recorders are made with 2-way decks which will record and play back the tape in either direction. There are two sets of heads: one set which acts on the top track when the tape is moving from left to right, and the other which acts on the bottom track when the tape is winding back from right to left. With decks of this type there is no need to turn the spool over when you want to change from one track to the other; you simply press a control key which reverses the tape and at the same time switches to the second set of heads. So far no manufacturer has turned out a stereo tape recorder with a 2-way deck for playing or recording 4-track stereo tapes in this way.

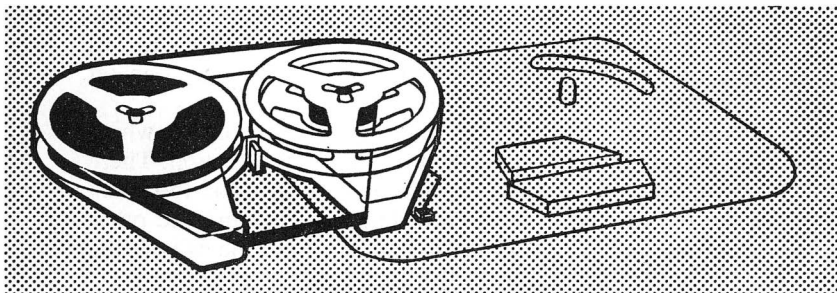
Loading the tape

To load the tape you fit the full spool on to the left hand holder, thread it through the sound channel with the dull side towards the heads and secure it to the centre of the empty spool on the right.

There are various ways of fastening the end. The simplest way is to pull the end through the side of the spool and turn the spool anti-clockwise until the tape laps over itself around the hub. Some spools have a slit running down one of the flanges, others have a slit across the hub. Both ideas make it easier to fasten the end of the tape quickly, but the job is still apt to be troublesome.

Tape magazines

Some manufacturers supply the tape in plastic magazines holding one full and one empty spool already threaded. You simply fit the magazine to the deck and press the start key. When the tape comes to the end, the drive slips and the tape stays fastened to the hub of the supply spool. To play the second track you simply turn the magazine over and press the start key again.



TAPE MAGAZINES. Some tape spools are supplied in an easy-loading magazine already threaded to an empty take-up spool. An automatic clutch action prevents the tape from winding off when it reaches the end. The magazine can only be used on a deck specially designed to take it.

There is an automatic brake built in to secure the spools and prevent slack tape from forming when the magazine is off the machine.

You can now buy single channel prerecorded tapes in magazines in this country and in America you can get 2- and 4-track stereo tapes packed in this way. But, of course, you can only use magazines on machines specially designed to take them.

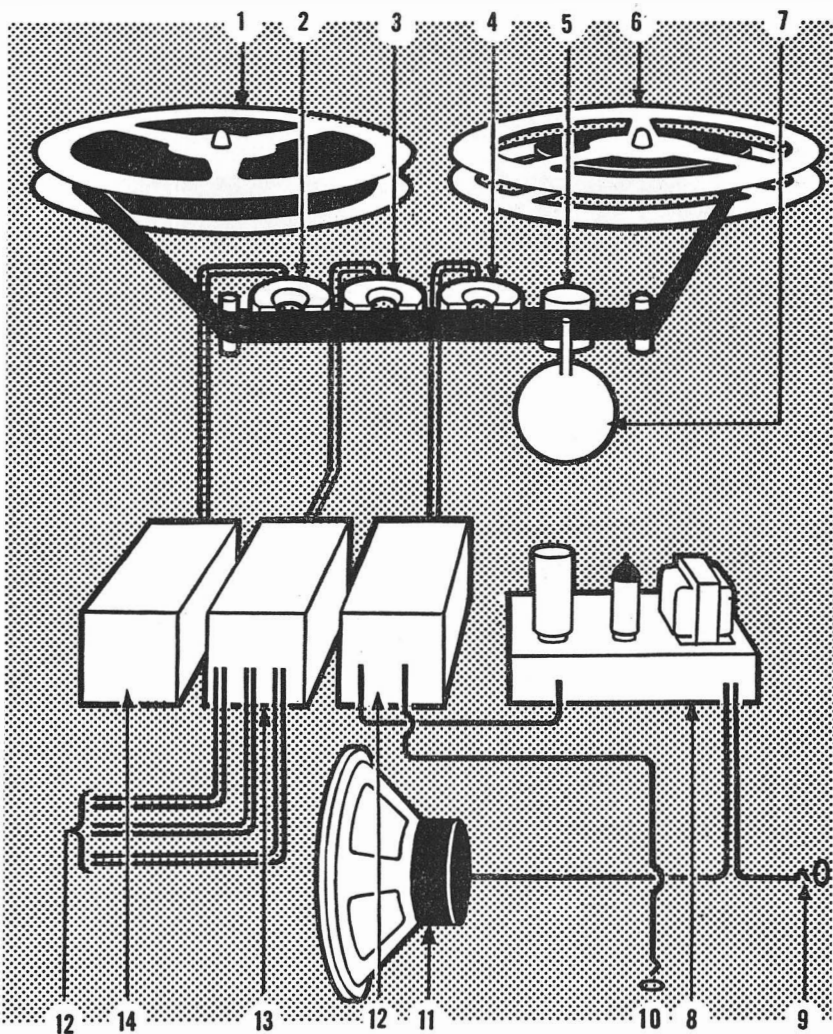
The make-up of the tape recorder

In a stereo tape recorder you have four parts: 1, the tape transport mechanism for pulling the tape through; 2, the sound channel, which holds the recording and playback heads; 3, an amplifier to boost the signals you want to record and also the ones that come from the tape when you play it back and 4, speakers to turn the electrical ups and downs of the signals into sound waves that you can hear.

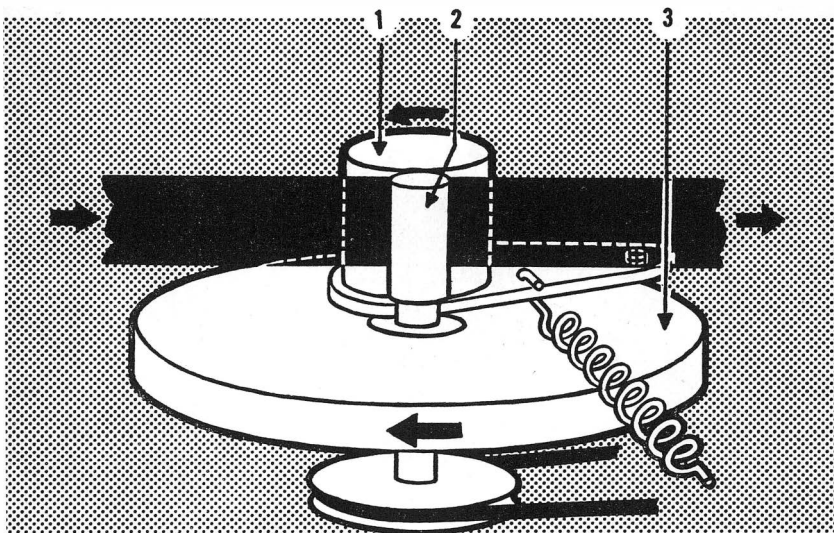
You also have a number of controls for making the machine do what you want.

Tape transport

The tape transport mechanism winds the tape off the supply spool, pulls it over the heads for recording or playing back, and winds it on to the take-up spool.



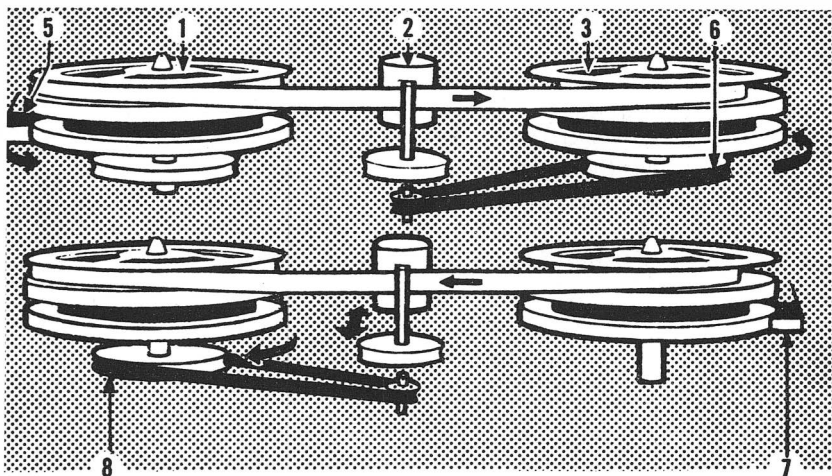
MAKE-UP OF A TAPE RECORDER. Supply spool 1, erase head 2, record head 3, playback head 4, capstan 5, take-up spool 6, recording amp. 13, oscillator 14, tape amp. 12, power amp. 8, speaker 11, output for ext. speaker 9, output for ext. amplifier 10.



TAPE TRANSPORT. The tape is pulled through the sound channel by being squeezed between a rubber-faced spring-loaded pressure roller 1 and a motor-driven capstan roller 2. The flywheel 3 keeps the capstan turning at a steady speed.

DURING RECORDING AND PLAYBACK two rollers grip the tape and draw it over the heads at a constant speed. One roller (the capstan) is turned by an electric motor with a heavy flywheel to keep the speed even. The other (the pressure roller or idler) is free to turn. It squeezes the tape against the revolving capstan so that the tape gets pulled through the two rollers like washing through a wringer.

A light brake checks the supply spool to keep the tape taut as it runs over the heads and through the capstan. The take-up spool is turned by a drive which incorporates a slipping clutch. The drive is always trying to turn the spool faster than the tape will let it, but when the pull in the tape is just enough to make it wind on firmly, the clutch slips and allows the drive to overrun.



SPOOLING THE TAPE. During recording and playing (above) the tape comes from the capstan 2 and is wound on to the take-up spool 3, which is driven by an electric motor through a constantly slipping clutch 6. The clutch keeps the tape taut but slips as soon as it reaches a reasonable tension. A light check brake 5 stops the left-hand spool 1 from over-running the tape.

During Fastwinding (below) the left-hand spool is turned at a high speed in the reverse direction by an electric motor, while the right-hand spool is checked by a light brake 7. The capstan and pressure rollers are opened to let the tape run through quickly.

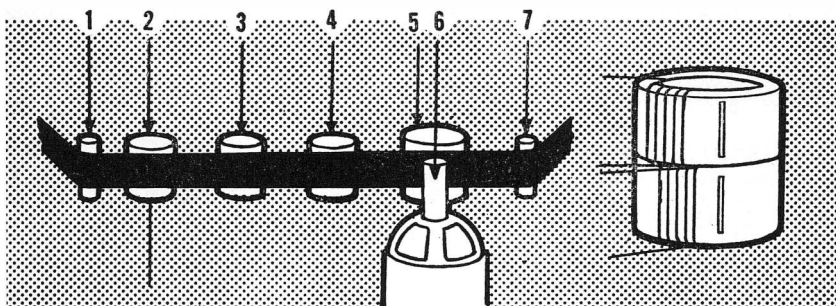
FAST WINDING. All tape recorders have two 'fastwind' positions of the main tape control: one for fastwinding left to right and the other for fastwinding from right to left. When you put the control into either of these positions you automatically release the capstan drive and leave the tape free to run through the rollers at high speed. Most tape recorders will fastwind a whole 7 in. spool of tape in 2 to 3 minutes.

Sound channel

Tape heads and capstan are mounted between the supply and take-up spools under a cover with a slit in it. You drop

the tape into this slit when you are threading it from one spool to the other. This assembly is called the sound channel.

The twin stereo heads are stacked one above the other. Each one consists of a ring-shaped core of special metal (which has the property of concentrating magnetism) wound with a coil of insulated wire. When you make a record the signal currents flow around the head coils and set up magnetic pulses in the cores. Each core has a narrow gap which 'focuses' the magnetic pulses on the tape, leaving the stereo record in the form of two parallel tracks.



SOUND CHANNEL. As the tape travels along the sound channel it meets a guide post 1, the erase head 2, recording head 3, playback head 4, and gets drawn between the pressure roller and revolving capstan 5 and 6 before being led on to the take-up spool by the final guide post 7. The heads (enlarged, right) are made up of two electro-magnets stacked one above the other.

The sound channel also includes an extra unit—called the erase head which comes into action automatically when you make a record. It floods the tape with a powerful magnetic field which fluctuates up to 70 thousand times a second. This completely removes any previous recorded sound so that the new recording goes on to a clean tape.

A guide pillar at each end of the sound channel keeps the tape running smoothly over the heads and pressure pads hold it in close contact with the head gaps.

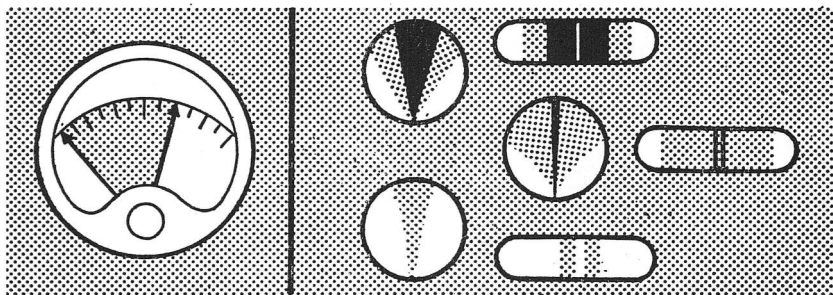
Amplifying system

The amplifying system does two jobs.

First it boosts the signals you want to record so that they will be strong enough to magnetise the tape. (There are separate inputs for each kind of signal—*e.g.*, for radio, microphones or pickups—so that the recording amplifier can give each one the right amount of boost.)

Next it takes the weak signals formed in the playback head and boosts them to make them powerful enough to drive the speakers—when you play back the tape.

The speakers may be built in to the tape recorder—as



RECORDING LEVEL INDICATORS. These are guides to good recording that tell you when you have got the signal strength just right. The meter (left) is marked to show you the highest reading you can have before you start overloading the tape. The various types of magic eye (right) wink to indicate: under-recording (never closing fully, top), over-recording (closed most of the time, bottom) and just right (only closing fully on occasional strong signals, centre).

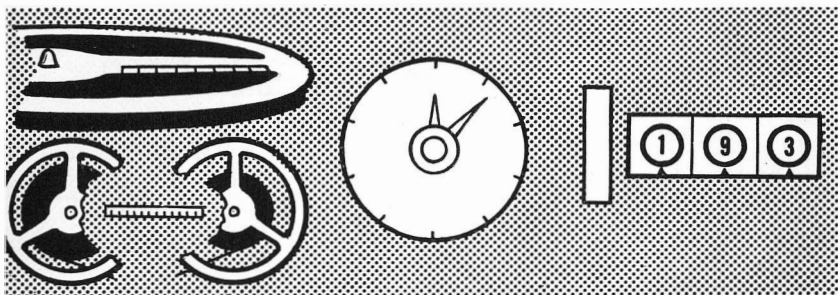
in most single channel machines—or they may be supplied as separate units that you couple up to the amplifier with extension leads (p. 152).

Controls

Every tape deck has a control to select the standard operations of record, playback and fastwind (forward and

reverse). It may also have a pause control which brings the tape to a sudden stop or starts it again just as suddenly when you release it. On machines with more than one tape speed there is also a speed selector.

On the amplifier there may be one combined, or two separate, recording level controls to adjust the strength of the signals you are recording. You use this in conjunction with magic eye indicators—or meters—which show you the strength of the signals in each channel. (Or you may have a single indicator with a 2-way switch.)



FINDING YOUR PLACE ON THE TAPE. Most spools and some tape decks are marked to indicate how much tape you have used (left). The clock-type meter (centre) and digital counter (right) driven by the capstan motor enable you to pin-point your place on the tape within an inch or two and give an accurate measure of the recording or playing time used up or still to come.

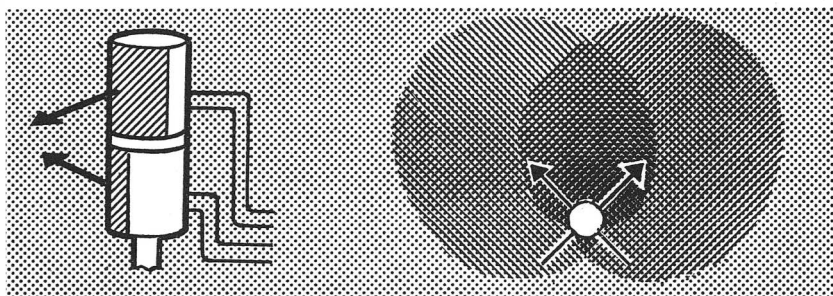
There is always a volume control to adjust the output to the speakers and also treble and/or bass controls to vary the tone. Among the refinements there may be a straight through switch which allows you to amplify from any of the inputs without recording them and without having the motor running or the set speakers switched on, and a super-impose button which allows you to record one signal on top of the record already on the tape.

The controls of the latest tape recorders are engraved with symbols instead of words. These symbols have been

agreed internationally. Here are the ones you are most likely to meet:

- Record
- ▽ Playback
- ← Fast Rewind
- Fast Wind Forward
- ✕ Internal Loudspeaker switched OFF
- ⊙ Pickup

FINDING YOUR PLACE ON THE TAPE. Nowadays practically every machine has some sort of counter or clock



MICROPHONE UNIT. The stereo microphone consists of two individual microphones of the same kind stacked one on top of the other (left). The centre lines of the microphones cross at right angles, so that one takes in more of the sounds from the left and the other more of the sounds from the right.

dial so that you can note the position of any item on the tape and go straight back to it whenever you like. (You have to remember to set the counter or dial back to zero before you start playing back or making a record.)

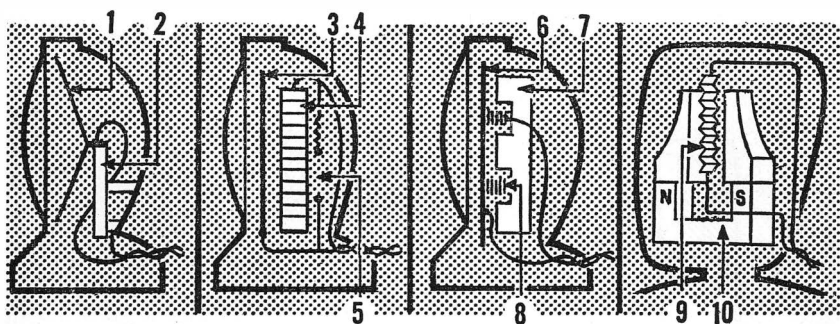
Alternatively there is usually a scale marked along one of the spokes of the spool. This serves as a rough guide to the position of the record on the spool. Some tape recorders have a scale of this sort marked on the top of the deck.

Microphone unit

The microphone unit used for recording live stereo con-

sists of two identical microphones or electronic ears. They collect the sounds made by the subject you want to record and convert them into electrical signals which you can amplify and feed into the recording heads. You must have at least two microphones—one for the right and one for the left channel—to make a stereo tape record.

While the microphones are not actually part of the tape recorder, they are essential if you want to do any live



MICROPHONE TYPES. Crystal (left): The vibrations of the diaphragm 1 bend a piece of special crystal and generate the signal voltage. Condenser (left centre): The diaphragm 3 has a polarising voltage applied to it, and when it vibrates in relation to the perforated plate 4 it changes its potential and creates the signal. Moving Coil or Dynamic (right centre): The coil 8 attached to the diaphragm 6 vibrates in the field of a permanent magnet 7, cutting the magnetic lines of force and generating the electric signal. Ribbon (right): A thin slip of corrugated metal foil 9 between the poles of a powerful magnet 10 vibrates in response to the velocity of the sound waves and generates a signal current.

recording yourself. Sometimes the microphones are supplied with the machine, and sometimes you have to pay extra for them. As they can be fairly expensive you should always check this point when you are comparing tape recorder prices.

‘VELOCITY’ OR ‘PRESSURE’. All microphones can be classified as ‘velocity’ or ‘pressure’ types. Velocity microphones depend on the *movement* of the sound wave over the sensitive element. Pressure microphones are worked by

the rise and fall in pressure *created* by the sound wave. In these two classes there are several different kinds of microphone, using various types of sensitive element. The types can vary in their working principle, in the strength of the signal they generate for a given amount of sound, and in the direction of the sounds they hear best.

Broadly speaking the velocity types are directional (since the movement of the air over the element depends on whether the microphone is in line with the direction of the sound waves or across their path) and the pressure types are omni-directional since the air pressure at any particular point acts equally in all directions. And again, broadly speaking, velocity microphones are more suitable for stereo recording than pressure types, which have no directional 'sense'.

There are 4 kinds of microphone commonly used with tape recorders: crystal and condenser, which are pressure types; dynamic and ribbon (which are velocity types).

CRYSTAL. These have a sensitive element made of the same kind of crystal as that used in a crystal pickup, and it works in the same way—*i.e.*, the crystal is mounted so that one end is fixed and the other rests on the middle of a diaphragm. When sound waves press on the diaphragm they make it vibrate like the skin on a drum. The vibrations bend the crystal to and fro and generate an electrical signal between the opposite faces (just as the movement of the gramophone stylus generates a signal in the crystal pickup).

The signal is picked off by a pair of wires and led to the input of the tape recorder. Crystal microphones can be manufactured for a few pounds and they give a proportionately strong signal. They tend to reproduce high frequencies better than low; they give excellent reproduction of speech and they belong to the high impedance type of electronic equipment. Ordinary crystal microphones are omnidirectional.

CONDENSER. Two metal diaphragms with air separating

them—like the ends of a drum—form a condenser. When sound waves beat against the diaphragms they make them vibrate, alternatively squeezing them together and sucking them apart. As they do this they change the electrical state of the condenser. By connecting the condenser to a delicately balanced electrical circuit you can make it convert the sound waves into an electrical signal and record it in the usual way.

You have to supply a separate voltage—called the polarising voltage—to this type of microphone, so it is not as easy to deal with as the other types. Condenser microphones give extremely good quality and are used for broadcasting and commercial record making. They tend to be costly and (with the exception of one famous make) are not used on tape recorders in the 'popular' bracket. Condenser microphones are classed as high impedance types, they give a comparatively weak signal that has to be greatly amplified before recording. They are generally of the omnidirectional type.

DYNAMIC. The sensitive element in this type of microphone is a tiny coil of wire fixed in the centre of a thin diaphragm or at the apex of a cone of stiff material. The coil is free to move between the poles of a powerful magnet. When sound waves make the diaphragm vibrate, the coil trembles in the magnetic field between the magnet poles.

This movement creates a signal voltage in the coil corresponding to the vibrations of the sound waves you started with. You can feed this signal into the recorder input, and record it in the usual way.

Dynamic microphones sell for as little as £2, but you can pay ten times that figure for one with a really good performance. These microphones reproduce speech extremely well and give a good strong signal for a small input of sound. They are directional, and hear things better from directly in front and behind than from the sides or above and below. They are normally of low impedance and if you want to plug one in to a high impedance input you have to do it through a transformer made specially for the job.

RIBBON. In a ribbon microphone there is a strip of extremely thin metal foil (the 'ribbon') held in the narrow gap between the poles of a high powered magnet. Sound waves strike the ribbon and set it vibrating and as it moves to and fro in the magnetic field it sets up a fluctuating voltage between its ends. This voltage forms a weak signal which you can amplify and feed in to the recording head.

Ribbon microphones tend to be more delicate than the other types (you can damage one by blowing at it to 'see if it is working'). On the other hand they give excellent quality and will record speech and music up to broadcast standard. They are normally low impedance and directional and they hear best over a figure 8-shaped field with the lobes in front and behind. Ribbon microphones usually cost more than the crystal or dynamic, but less than condenser types.

Directional properties

For a lot of single channel recording an omni-directional microphone is all you want and most popular tape recorders are supplied with a fairly cheap, but reasonably good crystal microphone. This will do for most domestic recording, for amateur music and dramatic group work, conferences etc. But when you want to narrow down the field to cut out all but your subject, you need a more or less directional type.

For directional work you have a choice of microphones with a figure-8-shaped field—mostly the ribbon type—and those with a cardioid (heart-shaped) and pear-shaped fields. These are mostly dynamic. You can get cardioid microphones which can be adjusted to include a wide or narrow angle, and there are various types intermediate between the pear-shaped and the figure 8—*i.e.*, with more or less of the back lobe of the 8 cut out.

Choosing your stereo microphones

The microphones used for making stereo tapes vary in type according to the recording system. Most commercial

recording studios use directional microphones mounted either back to back or one above the other and facing away from each other at anything from 90 to 180 degrees. It is not absolutely necessary to have two identical microphones, but if you are converting single channel equipment and already have a single directional microphone (ribbon or dynamic) it will be safest to buy another microphone of exactly the same type. If you are starting from scratch you can buy a specially designed stereo microphone with both heads in one fitting although it is probably wiser—and cheaper—for amateurs to buy two identical microphones since they can use them separately for single channel work.

Sometimes the manufacturer includes a complete stereo microphone unit in the cost of the machine. Other manufacturers sell the machine without microphones and then offer you a choice of several different kinds, ranging from cheap to very expensive. It is all right for you to buy the expensive unit if you are going in exclusively for high quality music, but there is no point in having a costly—and delicate—instrument if you want to record all sorts of subjects, in and out of doors.

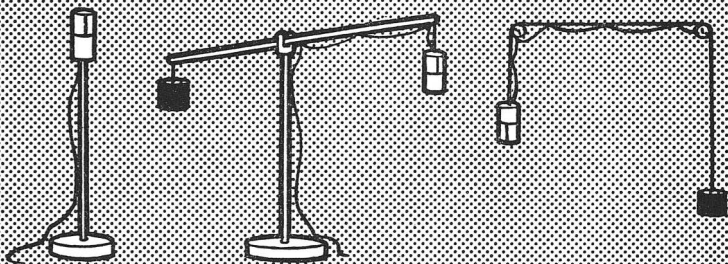
For most purposes a pair of low priced crystal microphones on a floor stand will do all you want and you won't have to handle them with kid gloves. They should be assembled as a single unit with their axes crossed at 90 degrees. This microphone set-up won't give you such a sharply focused stereo effect as a pair of directional dynamic microphones, but it won't call for a lot of fussy trial and error to find the best position and on an average you will get better results.

Microphone stands

When you are doing single channel recording you can hold the microphone in your hand or stand it on the table and walk about. But for stereo recording the microphones must not move while recording is going on or the results will sound extremely odd: the sound will appear to change direction and anyone listening won't know where he is sup-

posed to be in relation to it. And while you can talk into the microphone from a distance of 18 inches when you are making a single channel record, you can't get away with the same thing on stereo. Remember, the stereo record puts you where the microphone was in relation to the original sound, and you don't want to feel when you listen to the record that you are a midget sitting on the speaker's desk or being held up and waved about in front of his face.

So the stereo microphones have always to be mounted on a stand. You must be able to extend it up to at least 8 ft. and its base should be heavy and broad to stop the weight

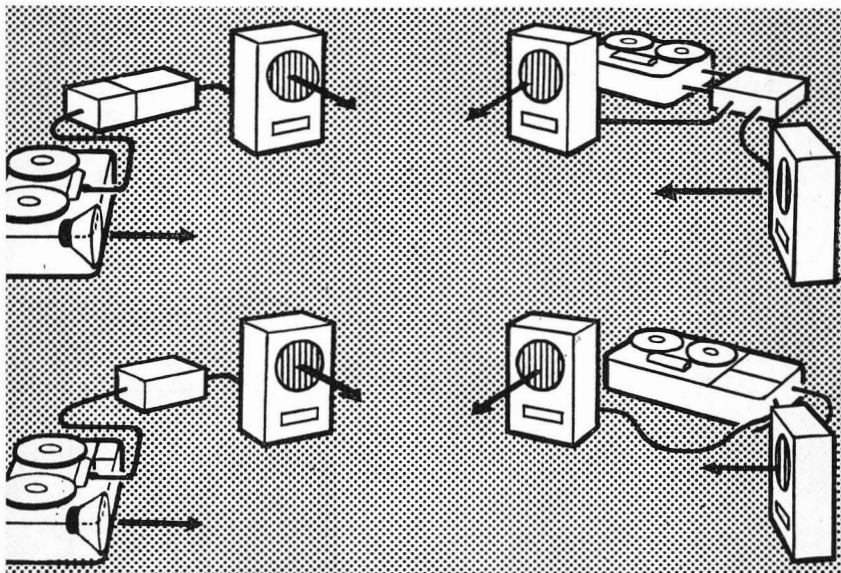


MICROPHONE STANDS. You can't have a roving stereo microphone; it must stay put on a stand and let the sounds do the roving. If the floor stand (left) gets in the way (or interferes with the cine shot) you can suspend the microphone unit from a boom (centre) or pulley (right).

of the cables from pulling it over. The microphones are sometimes hung from a boom or a pulley so that they can be raised or lowered. This way you can keep the floor clear of cables.

Tape recorder types

You will find many more different types of stereo tape recorder than of disc playing machines. There are three principal reasons for this. A tape machine is generally expected to record as well as play back. It has to be completely self-contained and portable. And you may want your stereo machine to make and play single channel records as

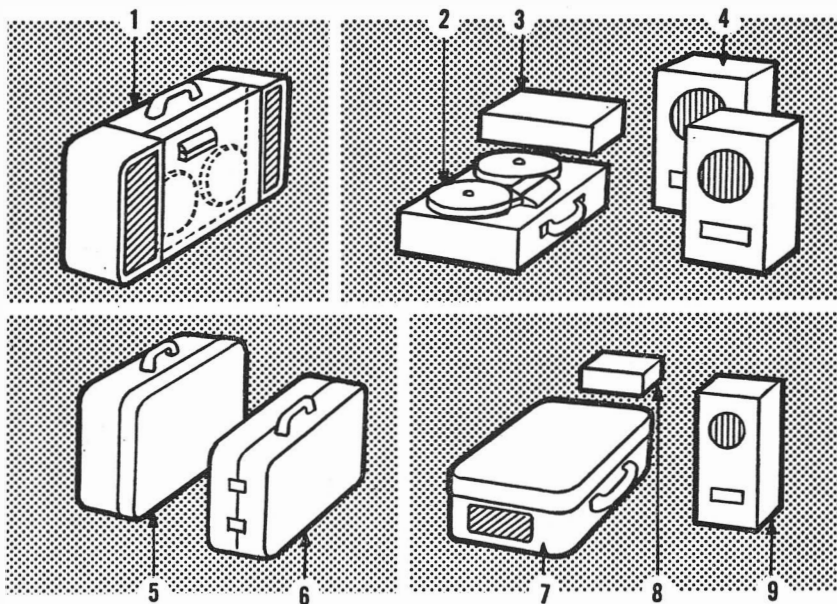


STEREO TAPE RECORDER TYPES. You can have a self-contained single channel machine with a connexion for an external preamplifier, amplifier and speaker (top left), or the same thing with the preamplifier built in (bottom left), or a stereo deck that requires a complete stereo amplifying system and speakers (top right), or one with the amplifying system built in, which only requires a pair of external speakers (bottom right).

well. So you get stereo tape recorders in all shapes and sizes and it will be some time before they settle down to a standard pattern like the gramophone and record player.

HOW MANY UNITS. Single channel tape recorders usually have the amplifying system and speaker built into the same carrying case as the tape deck, but in a stereo machine the extra equipment adds so much to the size and weight that many manufacturers parcel it out into separate units.

Sometimes the deck and amplifying system go into one case with the pair of speakers in a separate carrying case. Sometimes the main case holds the deck and tape ampli-



HOW MANY UNITS? Here are some of the ways of making up the stereo tape recorder package. Top left: Self-contained recorder plus two detachable speakers 1. Top right: Stereo tape deck and head preamplifiers 2, independent power amplifiers 3 and speakers 4. Bottom left: Stereo tape recorder complete 5 except for speakers which combine to form separate carrying case 6. Bottom right: Single-channel recorder with stereo heads 7, independent power amplifier and speaker to reproduce second channel 8 and 9.

fiers only. (With this kind you have to plug in to an external stereo power amplifier and speaker system.)

Generally speaking, if the machine is designed for stereo it is more compact and the controls are easier to operate. If it is simply an adapted single channel design you will have to connect up one or more external units and so have more controls to fiddle with.

If you already own a single channel machine you may be able to buy parts to adapt it for playing and even recording stereo, or the maker of your machine may do a stereo conversion job at a fixed price. (See p. 125.)

Making Stereo Tape Records

THE GREAT VIRTUE OF A TAPE RECORDER IS that you can use it for making your own stereo records on tape. If you only want to listen to commercial records, discs are cheaper and give you a bigger selection of titles; you will be wasting your money by paying the extra for a tape machine. So if you have gone to the expense of buying a stereo tape recorder, do get your money's worth out of it by making *records* with it. Don't be content to play only tapes that someone else has recorded for you.

Amateur tape recording with stereo equipment is a new and exciting game, whether you are interested in music, drama, entertainment—or in sounds for their own sake.

Its scope is almost unlimited because you can make stereo tapes from microphones, gramophone records, radio transmissions and even from another tape recorder. The wonderful part of it all is that it costs you nothing to experiment and find out all about it for yourself—you can always wipe out your mistakes and try again on the same tape.

How to record from a microphone

You make 'live' recordings with a microphone unit (p. 91). This is the basic recording drill:

1. Connect the tape recorder to the mains.
2. Load with tape.
3. Select the tape speed.
4. Place the microphone unit in position.

5. Adjust the recording level.
6. Set the main control to Record.
7. Start the tape.
8. To finish recording, stop the tape.
9. Note the tape position indicator reading.
10. Fastwind the tape back to start.
11. Switch off and return all controls to Off position.

PLACING THE MICROPHONE. If you don't get the microphone unit in the right position in relation to your subject you will finish up with a lop-sided recording and no amount of juggling with the balance control will put it right. Just think of your subject as filling the stage of a theatre and place your microphone unit in the centre gangway of the stalls so that one section points to the right wing and the other to the left. Its distance from the centre of the footlights should be at least equal to the width of the stage. In this position there will always be a big enough difference between the two microphone signals to create the stereo effect. Remember that throughout the recording session the microphone unit must stay in the same position.

ADJUSTING THE RECORDING LEVEL. On some stereo tape recorders you can adjust both inputs independently; each input channel has its own indicator and variable control.

On other machines you have a single control which adjusts both channels at the same time. With this type you have to balance the input signals before they go into the recorder.

Some machines have separate controls for each channel but only one indicator, which you can switch over to the channel you are adjusting.

The indicators may be meters or the familiar magic eye type.

The meter is usually marked with a red line to tell you when you are over recording; the magic eye closes up completely under the same conditions. You have to adjust the

recording level control so that the indicator only runs into the over-recording region on the very loudest signals. So long as you don't persistently over-record, the higher you keep the recording level the better.

What to record

Some sounds make better stereo subjects than others. Generally speaking, spread out sounds—*e.g.* groups of people talking—or moving sounds, give the most striking stereo effects.

Sounds recorded indoors tend to produce a stronger sensation of depth and spaciousness than sounds out of doors, because the reverberation tells you at once that you are in a room.

On the other hand, the impression of movement is easier to capture out of doors because there is no reverberation and the directional effect gets a chance to show up.

VOICES. A straight stereo record of a single person talking at the microphone will be disappointing. You can make a big improvement by getting your subject to walk about as he talks. His movement (and the sound of his footsteps) will build up a stereo impression of the room and give position to his voice.

If the spoken words are by way of a commentary on some incident that you are recording, have the speaker about 2 feet away from the microphone unit and to one side. Turn down the recording level so that the noises from the actual scene form a background to the commentary. If you have got the microphone placing right, the background noises will preserve the stereo impression without drowning the commentary.

When you record a number of people—*e.g.*, on the stage or during a social gathering—the closer you place the microphone unit to the group, the bigger the difference will be between the near and far voices. If you get the microphone unit too close, the near voices will over-record and the far ones will be too faint to understand. So choose a micro-

phone position at least as far away as the distance between the nearest and farthest points of the group.

Children running about and playing make a splendid subject for stereo recording either in or out of doors. A school playground where there are echoes from surrounding walls is particularly good. You simply fix up the microphone unit, set the recording level and leave everything alone while the tape is running. Don't twiddle the controls or shift the microphone and you will be rewarded with a record that you will never want to wipe. Incidental sounds of bouncing balls, skipping ropes, all help to make the record really live.

When you record random groups of people in this way you notice one of the most striking benefits of stereophonic recording. A single channel record is a complete jumble of sounds; you have to strain your attention to pick out a word here or there and the noise is irritating to listen to for any length of time. With a stereo record, the voices spread out in breadth and depth. You can follow isolated discussions without any trouble and even if you are not listening actively, you don't find the sound distracting.

MUSIC. While solo instruments always sound better when you record them on two channels, you don't get the full benefit of stereo until you tackle a group. One of the greatest joys of stereo is the way it separates out the various instruments and presents you with a clear pattern of musical sounds instead of a confused jumble. So start recording musicians in groups as soon as you can. Get around your local music clubs, dance orchestra, your church organist and even your local Salvation Army brass band. Most of them will be only too happy to co-operate.

A small chamber music group—say two violins, viola and 'cello or a three or four-piece dance band are just about the right size for an amateur set-up. Anything approaching a full orchestra is outside the scope of the simple 2-microphone unit.

Place the microphone unit as for recording group voices and once you have established the right recording level,

leave the controls alone from beginning to end of the item you are recording.

Most wind and string instruments record well, but when you make your own single channel records of percussion instruments—piano, guitar, harp, etc.—you are apt to find them disappointing. In fact, even the commercial recording studios find these instruments a bit of a headache and have to call on lots of expensive equipment and a great deal of top-secret know-how to record them even reasonably well. And there is something about these instruments that brings out the worst in amateur equipment, making you notice such things as wow, flutter and distortion that you never dreamed were there.

Stereo changes all that. The wow and flutter and the rest may be there, but the extra sound dimension seems to push them into the background. The effect is most striking with piano music—usually the worst subject for amateur recording. You should set up the microphone unit facing the centre of the keyboard and about 6 ft. away and turn the recording level control to about two-thirds the level you would normally use. When you play the tape back the result should sound almost indistinguishable from the real thing.

(With all percussion instruments it is a good idea to keep the recording level on the low side—*i.e.*, the magic eye should never appear to be more than three-quarters closed on the loudest notes.)

SOUND EFFECTS. There is no limit to the fantastic sound effects you can create with a little imagination and a stereo tape recorder. Make a collection of odd ironmongery—pots, pans, bells, tins, boxes, children's toys, old musical instruments—anything that makes a distinctive noise when you drop, hit, rattle, squeeze, smash or tear it. Then throw away the book of rules and enjoy yourself.

Practically everything you record will be worth listening to so long as it includes the satisfying sound of breaking rules and the horrified yells of protest from the Medes and Persians. Do all the things you've been told not to: record at one speed and play back at another; wave the micro-

phone unit around as you record; rest it on top of an alarm clock; stand it inside the piano or under the bonnet of your car with the engine ticking over.

You can have a lot of fun by plugging separate microphones into each stereo channel. This lets you reproduce a different sound through each speaker and mix them in different proportions by playing around with the balance control. With a little experimenting you can create all kinds of startling distortions of the stereo effect.

For this kind of frolic you can buy a pair of crystal microphone inserts for a shilling or two from any Government surplus store. Connect the inserts to lengths of screened lead with suitable plugs (p. 147), substitute them for the regular stereo microphone unit, and let yourself go.

Ordinary everyday sounds are worth recording too. Even if you take the microphone unit no further than the window of your room, you can record a whole range of outdoor effects that will take on a livelier interest when you play them back indoors—e.g., a motor or hand mower at work on the lawn outside, birds in the garden, the footsteps of the postman, traffic in the streets, children playing, and so on. But choose a calm day or wind noises will spoil everything.

How to play back

When you have recorded the tape and wound it back to the start, you can play it back at once. It doesn't have to be processed or treated in any way. If your machine includes power amplifiers and speakers, here is how you play back the tape:

1. Set up the speakers (p. 136).
2. Switch on the recorder.
3. Set the main control to playback.
4. Start the tape.
5. Adjust tone, volume and balance controls to your liking.
6. Stop the tape at the end of the record.
7. Fastwind back to the beginning.

If your recorder has no built-in power amplifier and separate speakers, you have to play back through the normal stereo reproducer set-up. You connect the tape recorder output sockets to the stereo preamplifier input sockets with a pair of screened leads and plugs (p. 152), set the preamplifier input control selector to the appropriate position, and play back the tape as above.

Some stereo tape recorders have two sets of outputs—one low and the other high impedance (p. 144). The low impedance sockets are connected to the built-in power amplifiers. They will deliver enough power to drive extension speakers without any further boosting. The high impedance sockets tap off the playback signals before they get to the power amplifiers. These are the sockets you use when you want to play back your tapes through a stereo reproducing set-up. (In this case you want to cut out the power amplifiers in the tape recorders because your independent amplifier/speaker set-up will give you better quality and more power.)

You may find when you play back the tape that there is a certain amount of high frequency mushiness. This is 'tape hiss'; it varies according to the tape and the type of head and the electronic arrangements in the tape recorder. It may be exaggerated with some kinds of speaker assembly. However, you can always get rid of the worst of it by turning down the treble control on the tape recorder or the stereo preamplifier.

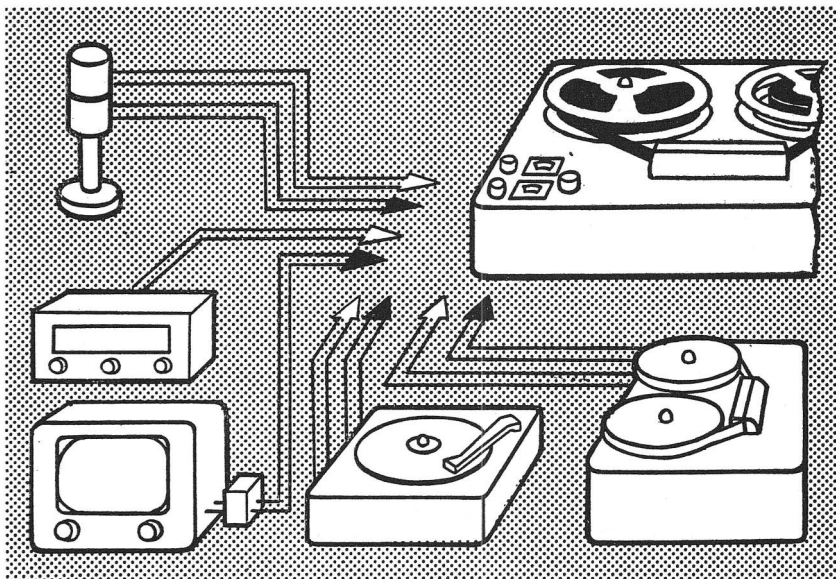
Generally speaking you should always play your tapes back through high quality external equipment when you have it available and only use the built-in amplifier/speaker system when you want to use the tape recorder away from your stereo set-up.

How to record stereo broadcasts

The stereo broadcasts put out by the B.B.C. from time to time (p. 21) are always worth recording because the material is specially selected to make the most of the two channels. These broadcasts give you a chance to build up a

library of stereo sound that would be impossible to collect in any other way.

To receive the stereo broadcasts you need two receivers; one, the right hand channel, must be tuned to the TV sound transmission and the other, the left hand channel, to the normal F.M. or A.M. radio transmission (p. 73). Most people use their TV set for the right hand channel and listen to the sound through the normal set speaker.



FOUR WAYS TO RECORD STEREO. You can make your own stereo tape records from a stereo microphone unit (top left), a radio tuner for Channel 1, and a TV set (with isolating transformer!) for Channel 2 (lower left), or a stereo pickup (lower centre), or even another stereo tape recorder (lower right).

When you want to record the broadcast, you have to connect the TV circuit to the Radio input of your tape recorder. This is not an easy job because the TV set chassis is usually live, whereas the tape recorder chassis is earthed. It is disastrous to connect the two unless you make special

arrangements to isolate the connecting lead from the high tension voltage on the TV set.

However, you can buy (for under £10) a special tuning unit, designed to receive only the sound part of the TV transmission. This only needs a simple—generally indoor—aerial. If you intend to go in for broadcast recording seriously, it will be well worth your while to invest in one of these units. It will give you better quality reception, and it will be completely safe.

If you are receiving the left hand channel on a self-contained F.M. or A.M. radio set, you will have to connect your tape recorder either to the extension speaker terminals of the set or—preferably—to the diode output (p. 76).

With an F.M. tuning unit (p. 73) you simply connect the output direct to the radio input socket for the left hand channel on the tape recorder.

You will generally want to listen to the programme as you record it. (This is called 'monitoring'.) How you do this will depend on your equipment. With some tape recorders you can listen on the actual tape recorder speakers. Where the tape recorder has no built-in power amplifier and speaker section, you have to monitor the signal on *external* equipment—*i.e.*, you plug the output of the tape recorder into the preamplifier of the normal stereo reproducer set up.

Here is the recording drill:

1. Connect the radio receivers to the appropriate inputs on the tape recorder (TV sound to right channel, F.M. or A.M. to left channel).
2. Tune both receivers to the programme.
3. Adjust the recording levels.
4. Record as for 'live' input, above (p. 100).

Remember that when you record from a stereo microphone unit, both the microphones are balanced, but with individual radio receivers (or individual microphones, for that matter) the signal levels are bound to be different. You have to balance them before you can record them.

You can balance the signals by ear if you first centre all

the amplifier controls and then adjust the radio receivers until the sound from the speakers is equal on each channel. Or if your tape recorder has separate recording level meters or magic eye indicators you can adjust the levels at the input of the tape recorder.

The last method is more reliable because it is difficult to judge balance accurately by listening, and you need to start with perfectly balanced listening conditions — something that few people can hope to find in an ordinary home.

How to record from gramophone discs

Generally speaking, if you already have a stereo set-up for playing stereo discs you won't gain anything by taping them to play on your tape recorder. However, if you do want to transfer your records on to tape there is nothing to prevent you (except, perhaps, the Copyright Act, p. 153). You have to make sure that you have the right sort of pickup for the gramophone inputs of your tape recorder. (See *Connecting Everything Up*, p. 144.)

If you are lucky you will be able to feed the two stereo signals from your pickup or record player straight in to the gram input sockets on your tape recorder. You can then go ahead and record the disc on to tape just as if you were recording from your stereo microphones. But if the impedances do not match or the output of your pickup is too low, you will have to use a suitable pair of input transformers (p. 145). You can get the same effect by feeding the signals through a stereo preamplifier.

When you tape a disc you can make as many preliminary experiments as you like before you go ahead and make the finished record. You can try different settings of the record player or preamplifier controls in conjunction with a number of different positions of the recording level control and different readings of the input meter or magic eye. Once you have found the settings of the various controls that give you the best reproduction quality when you play back an actual sample, you know that the final recording will be what you want.

How to record from another tape recorder

There is no difference in principle between taping a disc and taping a tape played back on another tape recorder. If you have a choice of high or low impedance outputs from the playback machine, it is generally best to record from the high impedance sockets. There is no need for both machines to run at the same speed. You can transfer a tape played at $7\frac{1}{2}$ ips on to a tape recorded at $3\frac{3}{4}$ ips. You are unlikely to want to transfer from a lower to the higher speed, because that way you use more tape without getting the extra reproduction quality of the higher speed. However, there is nothing to stop you doing it if you want to.

Here again you can experiment as much as you like and check the result by actually playing back the recorded tape.

Editing

Up to a point you can use a second recorder in this way for editing tapes when you want to cut out some of the original recording or add items from other tapes.

This type of editing is a comparatively straightforward matter with single channel records, but not so simple with stereo. For instance, if you want to mix parts of two tapes recorded under different conditions, you can easily introduce unpleasant jumps in the position of the sound source. The commentary or bit of musical continuity that you want to insert might join up happily in terms of volume but stick out like a sore thumb in terms of position.

These finer points belong to the higher art of stereo recording and are only mentioned here to remind you that there is more to a stereo record than two single channel signals. When you buy a stereo disc or pre-recorded tape, all the finer technicalities of recording have already been taken care of, and the process of copying is just a matter of normal 'dubbing', but when you start recording your own tapes direct from your own microphones, or want to start cutting and rearranging commercial recordings, you go beyond the scope of the ordinary user—and of this particular book.

The Complete Set-up

BY THIS TIME YOU KNOW THE BASIC principles of stereo sound reproduction and the names of the various pieces of equipment, how they work, and what they do. This chapter tells you how to install your equipment to give the best results, and how to provide the best listening conditions.

Up to this point all the types of stereo signal have been dealt with separately, but when you come to fit up the various units, the same principles apply whether you are taking your stereo from discs, tape or radio.

In theory, the best stereo arrangement is to have your speakers at two angles of an equilateral triangle and to station yourself at the third angle with the speakers looking towards you. Fortunately this theory leaves room for a lot of variation or only one person in the room would enjoy the full stereo effect. (You can enjoy a symphony concert without having to sit in the centre of the stalls.)

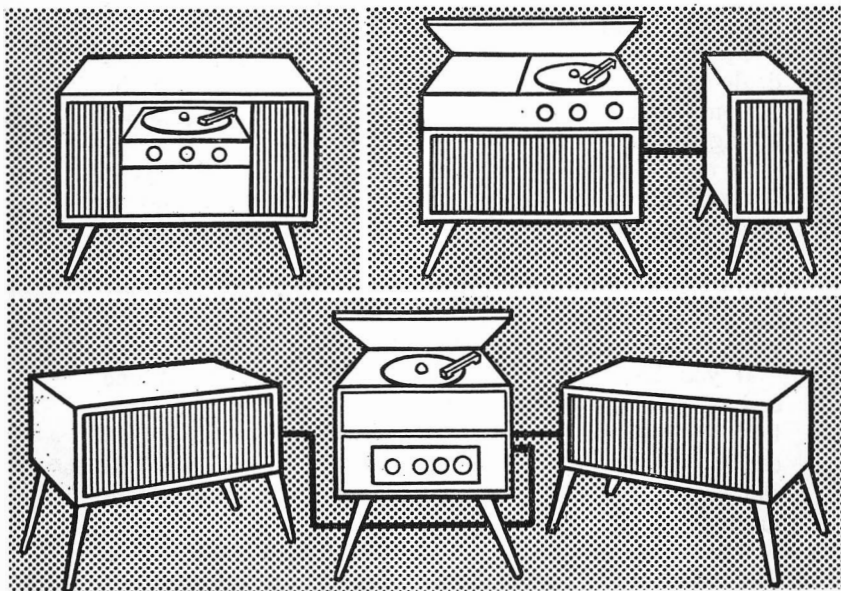
If you have two speakers about 8 feet apart at one end of your room, then in practice you will get satisfactory stereo from a point 8 or 10 feet from the speakers and up to 4 feet on each side of the centre line. You can get an average domestic-sized audience inside these limits.

If you go too far to one side, the speaker on that side will sound louder than the other and a lot of the stereo effect will disappear. But the impression will be no worse than if you are listening to an orchestral performance or an opera from a box at one side of the stage. (You can read more about this under *Listening To Stereo* (p. 127).

Off the peg

The simplest stereo reproducer is the ready made disc reproducer (p. 140) which may be a gramophone pure and simple or a radiogram which will play single channel radio and discs or stereo discs. With this, and every other type of stereo set-up, it is the position of the speakers that matters most. You can put the rest of the equipment to suit the shape of the room, or the position of the rest of the furniture without upsetting the stereo effect. But the speakers must be in the right places.

There are three ways of fitting speakers in ready-made sets: one unit; two unit and three unit assemblies. Each one calls for a slightly different layout of the units.



OFF THE PEG. You can buy factory-made stereo disc players in various forms—e.g., self-contained set (top left), self-contained single channel reproducer with external speaker, and sometimes power amplifier for the second channel (top right), or with both speakers separate from main console (below).

ONE UNIT. In this type of set the units are built in to a wide cabinet—up to 6 ft.—with a speaker mounted at each end facing forwards. While this is the most compact arrangement, it does not make the most of the stereo effect because the speakers are too close. However, if you only have room for an all-in-one set, stand it with its back to the wall as close as possible to the centre of the shortest side of the room. This is the best position if you can sit facing it, about 8 ft. away. If you can afford to waste the space, you can experiment with it across the corner. This way it may spread the stereo effect over a more useful area of the room.

TWO UNITS. Here you have a single channel radiogram with an external speaker for the second stereo channel. This allows you to increase the separation between the speakers handling the two channels. You can usually switch the channels over to make the set speaker handle either the right or the left hand channel. This lets you put the set at the most convenient side for you to reach when you want to change a record or adjust the controls.

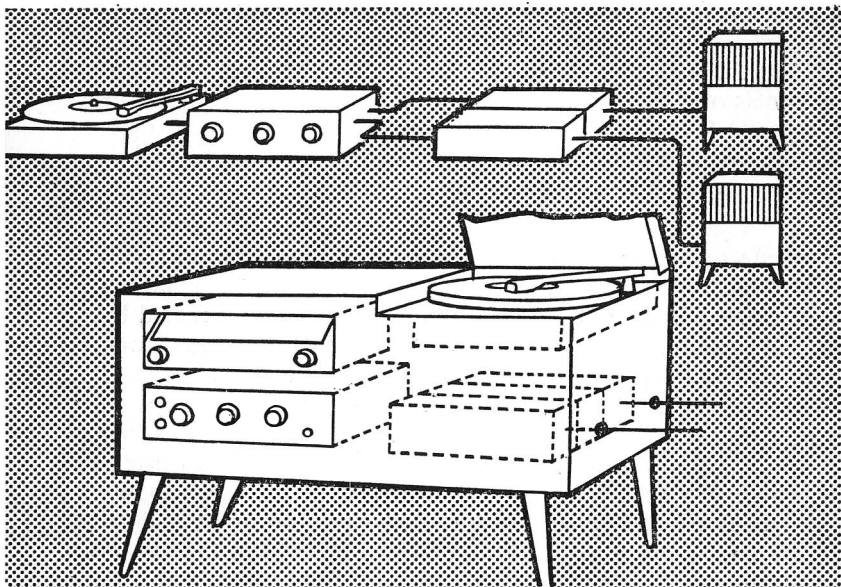
THREE UNITS. This set-up is the most convenient and effective arrangement of the three so long as you can afford the space. You have the above two units plus a second extension speaker. Now both stereo channels are handled by the external speakers, the set speaker being switched off and reserved for single channel records. The big advantage of this arrangement is that you can have the set near you in the best position for record changing and knob twiddling and the speakers at a distance in the best position for listening. Although it means that you will be too close to the speaker in the set when you want to use it for single channel records, you can always cut out the set speaker and switch the output over to the two stereo speakers. This is, in any case, the best way of listening to single channel records on disc or tape—or to a single channel broadcast.

If you are going in for a ready made set-up you can pay (in Britain) anything from £35 (for a portable record player

with two small detachable speaker units) to over £150 (for a console stereo radiogram with two full size speakers in reflex enclosures). It all depends on what you want—and how much you are prepared to pay.

Made to measure

If you decide to buy the separate units and put your own stereo set-up together there is no limit to the possible arrangements and you can spend a fortune if it takes you that way. However, remember that you can live happily with less-than-high-fidelity quality in stereo equipment where you couldn't tolerate it for five minutes in a single a particularly critical ear and can afford to pamper it. channel set-up. So don't buy top price units unless you have



MADE TO MEASURE. For reproducing gramophone discs you will need a motor and turntable, a control unit, a power amplifier and a pair of speakers. You can connect these up as individual units (above) or assemble them all together with or (preferably) without the speakers in one self-contained cabinet (below).

Starting from scratch, you will need the following items :

1. Three- or four-speed motor and turntable (p. 29).
2. Pickup arm with optional stereo and single channel heads (p. 40).
3. Either separate stereo preamplifier and stereo power amplifier (or a combined stereo pre-and-power amplifier) or stereo pre-amplifier and two separate single channel power amplifiers (p. 51).
4. Two speakers mounted in suitable enclosures (p. 63).
5. Cabinet for the gramophone turntable and pickup. This cabinet may also house the amplifying system (in which case get the units in chassis form), or you may prefer to keep the other units separate and stand them on a shelf or fit them into a book unit near the turntable (in which case buy them complete in cabinets).

The following specimen specification will give you a basis to help you plan your own outfit in terms of British price standards.

	£	s.	d.
1×3-speed motor and turntable	20	0	0
1×pickup arm with stereo crystal head and diamond stylus	10	0	0
1×optional single channel crystal head			
1×stereo preamplifier	15	0	0
1×6+6-watt stereo power amplifier	15	0	0
2×column speakers complete with 8-in. and 3-in. speaker units	40	0	0
Coffee table cabinet for turntable	20	0	0
	£120 0 0		

The output from this set-up would be ample for the average living-room—*i.e.*, anything up to 15 ft. × 12 ft. The prices are for equipment of reasonable quality and are about half the price of the out-and-out high fidelity equivalents. At the same time they are not the cheapest units you can buy. If you are a hobbyist you might save half the cost of the turntable cabinet by making it yourself. You could also make your own speaker enclosures and fit speaker units at half the cost of new assemblies.

You can't hope to build anything from units as cheap as the cheapest mass-produced equipment. But when you get

over the £50 mark you can always get better reproduction for your money by assembling your own set-up from units made by specialists.

LAYOUT. If you have separate units, you tuck them away in odd corners to suit yourself and where-to-put-it ceases to be a headache—as it is apt to be with the all-in-one stereo console gramophone. For instance, you can stand column speakers at the ends of a row of bookshelves, and scarcely notice them. You can build preamplifiers and power amplifiers into book units or simply stand them on top of a bookshelf near your favourite listening chair. The table cabinet for the turntable will take up some of the floor space, but as it will probably do the job of a table that you would have there anyway, you won't be any worse off.

ADDING RADIO. If you want to include an F.M. tuning unit (p. 73) then there will have to be space for it in the cabinet either alongside the turntable or, better still, with the control panel at the front so you don't have to raise the lid every time you want to listen to the radio. The additional cost of a radio tuning unit for one channel only would be from £15 to £25, depending on the make and on whether you buy a self-powered unit or one that takes its power supply from your amplifying system (p. 56).

ADDING TAPE. If you want to add a stereo tape recorder (p. 97) you can choose between connecting up a portable type every time you want to use it, or enlarging your turntable cabinet and building in a stereo tape deck. The only drawback to the built-in tape deck is that you can't carry it around with you to make records or play them back. But a stereo tape recorder is never exactly portable anyway so you may feel you are losing nothing by building it in to your permanent set-up. Don't forget that the all-up weight and bulk of a turntable and stereo tape deck will make the cabinet an extremely heavy piece of furniture so it might be wiser to build the tape deck in to the book units alongside the preamplifier. The cost of adding a stereo tape repro-

ducer would be around £80 and for a stereo recorder up to £120.

If your preamplifier has input sockets for connecting direct to a playback head (as many of them have) you can save quite a bit of money by installing a tape deck instead of a complete self-contained machine. This will let you reproduce pre-recorded stereo tapes and will cost you around £50 including the cost of the stacked stereo head. You won't be able to record your own stereo tapes with this set-up but as it won't be portable anyway you wouldn't gain much by adding the extra recording equipment.

WIRING. One important—and too often neglected—item in the set-up is the wiring. Remember you have to provide a mains connexion to the turntable motor and the pre-amplifier or amplifier, or both; and you have to connect the stereo cables from pickup to preamplifier, preamplifier to amplifier, and amplifier to speakers. If you don't take this into consideration when you are deciding on the positions of the various units, you can end up with a formidable array of 'knitting'. (See *Connecting Everything Up*, p. 144.)

Adapting Existing Equipment

TO A LOT OF SOUND ENTHUSIASTS THIS WILL be the most important chapter for some time to come, because it usually works out that anybody who is really interested in listening to stereo already has a single channel set-up—and probably an out-and-out high fidelity job at that. If you are in this position you won't care for the idea of trading in your existing set for a song and laying out your hard earned cash for a brand new stereo outfit.

First of all you will want to look pretty hard at the alternatives. This chapter tells you most of them, and you can be pretty sure that if you already have a good single channel set-up you will be able to adapt it for quite a bit less than it would cost you to do a deal for a new one.

Adapting gramophone set-ups

If you have an ordinary radiogram you can adapt it for stereo very simply. The extra parts you will have to buy are: 1, a stereo pickup complete; 2, arm, head moulding and stereo cartridge; 3, a small combined pickup preamplifier and amplifier with an output of 3 to 6 watts; and 4, an extra speaker in a cabinet of about the same size and type as the one in your set.

Don't make the mistake of buying super high fidelity units, because it is pretty certain that your present gramophone will not measure up to their standard.

As long as your extra units have a reasonably good performance on single channel by themselves, you will be more than pleased with the results when you pair them up with

your gramophone for stereo. If you are a handy type you will be able to make the necessary changes yourself, but if you have any doubts about your ability, your local radio dealer should do the job for about £1. So the cost of the conversion will work out something like this:

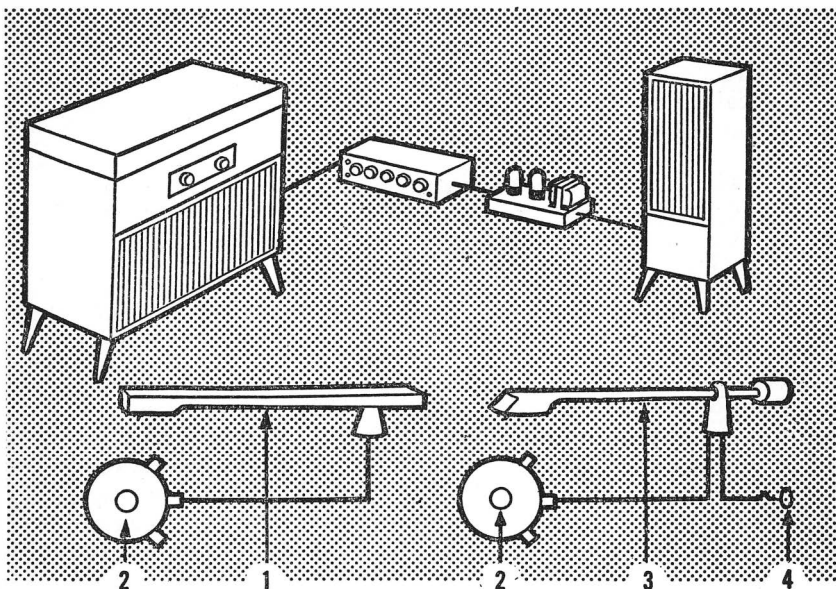
	£	s.	d.
Pickup arm with head moulding ...	4	7	0
Crystal stereo cartridge ...	2	15	0
Combined single channel preamplifier and 3-watt power amplifier ...	8	10	0
Speaker enclosure ...	6	0	0
8-in. speaker ...	2	10	0
	<hr/>		
	£24	2	0

Remove the existing pickup arm and fit the new one in a convenient space on the motor board, using the maker's template to fix the exact position for the pillar. Connect one lead from one pair of stereo pickup terminals—*i.e.*, one signal wire and one 'common'—to the gramophone circuit at the point where the existing pickup lead is exposed and the other pair of terminals to a piece of screened cable long enough to reach to the preamplifier.

If you want to be tidy you can make the second connexion through a jack plug and socket (p. 149) mounted in the back panel or on the deck of the gramophone.

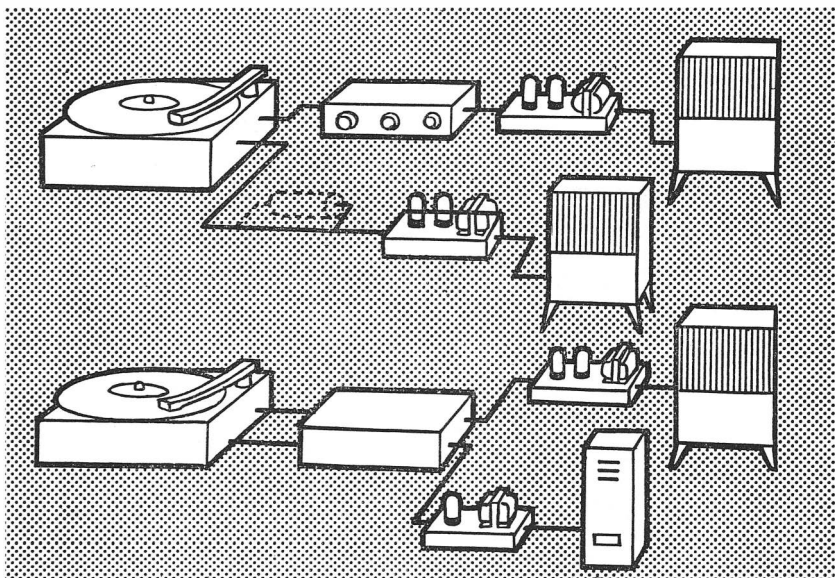
POWER CONNEXIONS. The amplifier unit will have to be connected to the mains by an extra length of flex plugged in to the power socket feeding the gramophone. A neater arrangement is to fit a mains socket in the back or side of the gramophone cabinet and connect it internally to the incoming mains supply after it passes through the on/off switch. You can then plug your amplifier into this point and cut out a long length of trailing flex and a bunch of plugs at the wall socket. The gram on/off switch will control both the gram and the extra amplifier.

RADIOGRAMS. The above method of converting to stereo is the same whether you are dealing with a radiogram or a simple record player. On a radiogram, the radio side of it



ADAPTING A RADIOGRAM. Above: To convert a radiogram to play stereo records you need a stereo pickup with a separate control unit, power amplifier and speaker connected to the second channel. The existing radiogram controls, amplifier and speaker will handle the other channel. Below: You take away the existing single channel pickup 1 and replace it with a new stereo pickup 3. Connect one channel to the pickup tag on the volume control 2 and the other to a jack plug socket fitted into the back of the radiogram. The pickup lead screens (not shown) should be connected to the radiogram chassis and the sleeve of the plug socket.

will not be affected by the change; but when you switch to radio the set will operate normally and you will get nothing on the second channel speaker. You can choose whether you will simply switch off the second channel amplifier when you want to listen to radio or single channel records, or whether you will fit a connexion from the diode of the radio circuit (p. 76) to the second channel preamplifier input so that you can listen to single channel on both speakers (p. 137). If you decide to make the diode connexion you will have to insert a separate switch so that you can break the



ADAPTING A HIGH FIDELITY SET-UP. If you already own a good high fidelity system you can convert to stereo by adding a stereo pickup and a power amplifier and speaker for the second channel (top). (You may need an input transformer (shown dotted) if you want to use a magnetic pick-up.) It will usually be better to scrap your existing control unit and invest in a stereo control unit. You can offset the extra cost by using a smaller power amplifier and speaker for the second channel (below).

connexion when you want to go over to stereo and amplify the two channels independently.

Adapting a high fidelity set-up

If you have a 'made-to-measure' record reproducer there are several alternatives open to you. The obvious one is to change your single channel pickup for a stereo and simply duplicate everything right through from that point—*i.e.*, buy a preamplifier, amplifier and speaker assembly to match those you already have. But even if the cost doesn't worry you there are other things that will.

WHERE YOU CAN ECONOMISE. To start with, your present single channel equipment almost certainly gives you all the volume you want, and if you double the output you will only be able to use half of it.

The next thing is that you don't really need two 'woofers' for stereo because the stereo effect doesn't depend on the low frequencies. In any case most people have a job to find room for one bass reflex cabinet, and two would be out of the question.

If you are looking for the cheapest way out, you can make do with a smaller speaker for the second channel—e.g., an 8-in. speaker in conjunction with the output of the main speaker assembly, so you can save money on the amplifying equipment.

When you come to the extra amplifying units you can simply add a preamplifier and power amplifier (either separate or combined) big enough to load the second speaker. This could be your cheapest way out because it makes use of all your existing equipment. But the big disadvantage of this set-up is the separate volume and tone controls for each channel.

If you can afford it, pension off your present amplifier and buy a stereo preamplifier with a single set of ganged controls.

Here is a specimen to give you some idea of what this type of conversion would cost at present in Britain:

	£	s.	d.
Pickup head moulding with crystal stereo cartridge	3	7	6
Stereo preamplifier	12	0	0
Single channel power amplifier (5 watt)	10	10	0
Reflex enclosure	11	0	0
8-in. speaker and 3-in. tweeter unit	9	0	0
	<hr/>		
	£45	17	6

The extra items in this case will cost you less than it would to double up on all the single channel items; they will take up very much less space, and in an ordinary living-room you would find it difficult to spot any difference between the sound of the luxury and the economy set-ups.

SWITCHING ARRANGEMENTS. Your preamplifier ought to provide for listening to single channel on either one or two speakers—*i.e.*, you should be able to switch one of the preamplifier inputs through one amplifier and speaker or through both at the same time. And it will make things easier if you choose one with a channel change-over switch to reverse the right and left channels (p. 47). A phasing switch to alter the phasing of one speaker in relation to the other (p. 130) is a luxury you can do without if you don't mind experimenting with the connexions of one of the speakers until you get the phasing right.

Adapting a tape recorder

If you already have a single channel tape recorder, how do you adapt it for stereo? Is it cheaper than trading the machine in for a brand new stereo model?

Well, first of all make up your mind whether you just want to play pre-recorded tapes or whether you want to make stereo records as well.

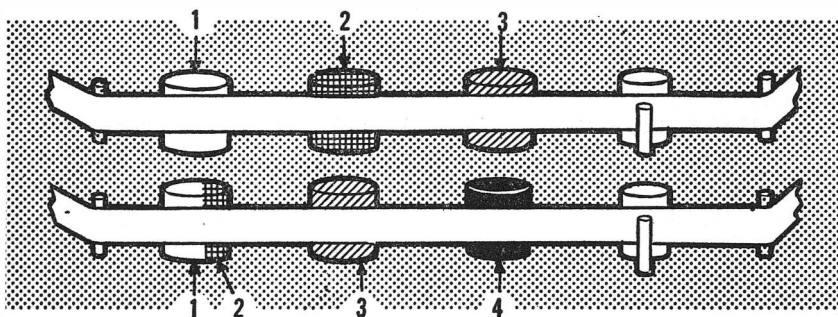
Adapting your present machine to play stereo tapes is not so difficult—some deck manufacturers sell the necessary parts for converting their own decks. First you have to fit a stacked head (p. 88) in the sound channel. If you want to keep your single channel record and playback facilities—as you most certainly will—then you have to make room for the extra head or sacrifice some other facility.

On one widely used deck you take away the automatic end-of-tape stop and fit a combined stop and single channel-erase head in its place. You can then scrap the old erase head, shift the single channel record/playback head into the empty space and fit the new stereo stacked playback head. On 2-way decks you can give up the right to left erase head position and fit the stacked head in its place.

Next you have to connect the four terminals on the stacked head to a pair of screened sockets mounted either on the deck or on the case. And you have to arrange to switch off the single channel electronics because you do not want your single channel head to play the top track of the stereo

tape. You had best give up any idea of using your built-in power amplifier for one of the stereo channels. The job is usually too tricky to be worth it. The simplest and cheapest way out is to keep the stereo and single channel circuits separate.

That is the whole job—as far as your machine goes. If you already have a stereo-from-discs set-up, you have only to arrange to plug the outputs from the stacked head into the input sockets on your preamplifier. If you have to buy your



ADAPTING A TAPE RECORDER. On some single channel machines there is an automatic stop 1 (above) in addition to the erase head 2 and record/play head 3. You can replace the stop by a combined stop/erase head 1+2 (below), shift the record/play head into the original erase head position, and fit a stacked stereo record/play head 4 in the vacant space. (You have to provide external record/play equipment for the stereo head and arrange to switch out the single-channel head when you want stereo.)

stereo amplifying system, remember that you must get one where the stereo preamplifier has correctly equalized inputs for playing direct from the tape heads. And if the stacked heads are the low impedance type (which they mostly are) you will have to insert a pair of low-to-high impedance transformers in the leads between the stereo tape head and the preamplifier.

WHAT IT COSTS. You can convert your existing machine this way with the least amount of mechanical or electrical

interference. Here is the rough cost of doing the job with the parts supplied for the deck mentioned above:

	£	s.	d.
Combined erase/stop head to replace existing separate items	2	0	0
Stacked stereo playback head	7	7	0
Two head transformers at 30s. each	3	0	0
Shorted plug for normal inputs to mute single channel playback head		6	0
Labour (if the job is done by your dealer), say ...	2	10	0
	<hr/>		
	£15	3	0

To this figure you will have to add the cost of preamplifiers and speakers. You probably already have these for reproducing discs. If not, you can see how much this part of the equipment will cost on p. 115. This set-up will let you play pre-recorded tapes using both tracks on a standard magnetic tape. You will also be able to record and play single channel tapes as usual. But you won't be able to make stereo records. For this you will need more equipment.

It is worth while adapting a single channel machine to reproduce stereo tapes without being able to record them but there is no point in adapting it to record if you can't play back the result. But although the cost and difficulty of the first job may be justified, in the second case it is generally out of the question. You will generally find it cheaper to trade in the old machine in part exchange for a properly designed stereo model.

CONVERSION KITS. There are some professional makes where the conversion works out a little cheaper than the complete new outfit, but even then the clutter of extra pieces of equipment, wiring, switching—and controlling it all—make it a doubtful proposition. There are manufacturers who advertise conversion kits, but before you buy one you might like to take a look at what you are letting yourself in for.

THE EXTRA EQUIPMENT. First of all you will need either a stacked head for recording and one for playback, or a com-

bined record-playback head. Then you will need a new erase head which will wipe the full width of the tape. So out goes any hope of making room for the extra head by using a combined erase/stop head to win the space normally taken up by one of the individual units. And you can say goodbye to single channel recording, because your new erase head will automatically wipe out the second track as you record the first.

You will also need a pair of recording amplifiers with some form of visual signal level indicator and control, and the amplifiers will have to include equalisation for different types of input signal. You can't hope to squeeze all these items into your existing case, so they will have to go into a separate cabinet and you will have to connect them to your recorder through a bunch of screened cables—including a power supply cable—with all the added risk of picking up hum. And as most heads of this type have to be of low impedance, you will have to include a pair of input transformers in the system.

IS IT WORTH IT? Now add the extra equipment you will need for reproducing the tapes you have recorded. Think of all the extra switching operations, and you will have a better idea of the size of the job. Even so, you *can* buy a complete kit for converting some makes of single channel tape recorders for making and playing back stereo tapes (cost, about £75). And if you happen to be the type of keen amateur who has the necessary tools, equipment and the ability to work miracles with junk—well, you might be able to do the job yourself at less than the cost of a complete new stereo machine.

If you want to know what would be involved in converting your own machine, you can always write to the manufacturer about it. He may be able to supply a conversion kit or give you an estimate for doing the job for you, or tell you of some firm that is prepared to do it.

Listening to Stereo

IN THE EARLY DAYS OF STEREO, WAGGISH journalists and comic artists were always sure of an easy laugh with their pictures of the stereo fan sitting at the geometrical apex of an equilateral triangle with the speakers at the other corners. However, by this date most people know that you can enjoy stereo without the help of a tape measure or protractor. Even so, there is a best position for everything and an ideal type of room; the nearer you can get to these conditions, the better your stereo will be.

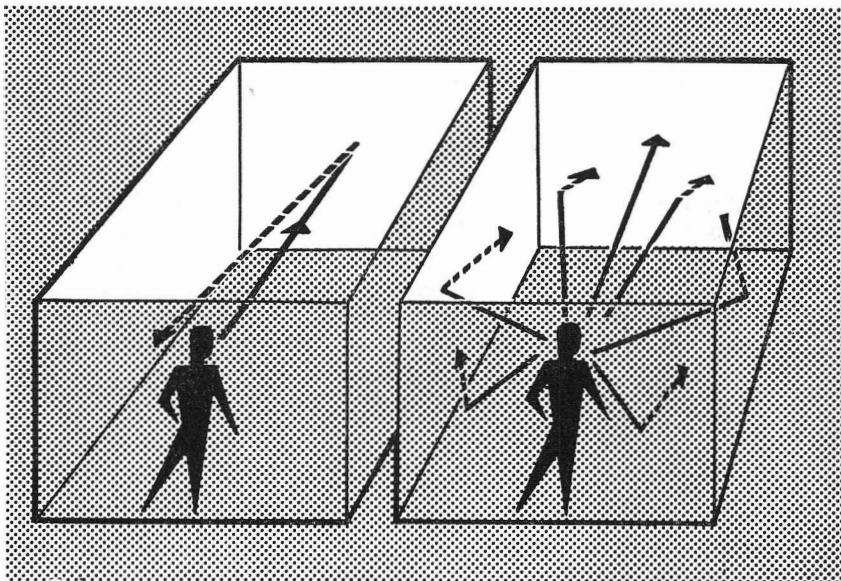
Sound in the room

First of all take a look at the way the sound is affected by the room you hear it in. It is all a matter of how the various surfaces of the wall, ceiling, floor and the furniture treat the sound waves that fall on them and the way vibrations build up and die away in the air enclosed in the room.

You have to remember that sound waves bounce off smooth, hard surfaces like a ping-pong ball off a table top, and they fall dead when they hit a soft, fluffy surface the way the same ping-pong ball falls dead into a bowl of flour.

ECHO. If you stand in front of a high wall and clap your hands, the sound goes out in all directions. Part of it travels straight to your ears and you hear the noise almost as soon as you make it. Part of it goes away from you, hits the wall and bounces back and you hear it a fraction of a second afterwards. The sound waves that bounce back off the wall are called an echo. The loudness of the echo depends on

the surface it strikes—the echo off a glazed brick wall is almost as loud as the original sound; on the other hand, the echo off one of the new sound-absorbent wall surfaces would be too faint for you to hear.



SOUND IN THE ROOM. When your voice bounces off a hard surface and comes back to you so that you hear it a second time, that is an echo (above). In practice the sound in a room goes on bouncing backwards and forwards off walls, floor and ceiling for some time, creating a slowly fading background noise. This is reverberation. The reverberation factor (time for a sound in the room to drop to one millionth of its original volume) is important to recording engineers.

REVERBERATION. When the surfaces that reflect the sound enclose a space to form a room, the echo bounces from wall to wall and you hear the same sound again and again until it dies away. You only hear separate echoes if the room is very large and the walls are good sound reflectors. In any room smaller than the Albert Hall the echoes have a shorter distance to travel, so they come back quicker and get mixed

up with the original sound. You don't recognise them as echoes; they give you the impression of a hangover of the original sound. So every sound seems to be drawn out, how much depending on the reflecting power of the wall, floor and ceiling surfaces and the size of the air space in the room.

The time a sound takes to die away to one millionth of its original loudness is called the 'reverberation constant'. Sound engineers have to take it into account when they design a concert hall or a theatre. They can control it by altering the proportions of the hall and by using sound-absorbent wall surfaces and ceilings. They don't try to get rid of reverberation altogether, because that would make the hall sound dead, but they try to be sure that notes will not be carried on as echoes long enough to interfere with notes coming after. A reasonable amount of reverberation gives a liveliness to the sound in a room, and that is a good thing, whether you are in the audience or on the stage.

Controlling the acoustics

Your stereo room is going to have echoes and reverberation, and they will be different from any other room that ever was. They will vary according to the kind of floor covering—carpet, polished wood, tiles, etc. They will vary according to what sort and how much furniture there is in it. Upholstered furniture absorbs sound and cuts down echo, light wooden furniture tends to increase it.

The size and proportions of the room will affect the reverberation. Curtains will damp it down, windows will step it up. You can't do a great deal about these things, but it is well to keep them in mind when you are arranging your stereo equipment. Don't pay a lot of attention to the 'expert' who tells you that this must go there and that can't possibly go here. It may be the best arrangement in *his* house, but that doesn't say it will be best in *yours*.

If you have a choice, don't choose a room where the width is exactly so many times the height, or you may get sudden jumps in the sound volume at certain frequencies

emphasising particular notes in one part of the room more than in another. If you notice this happening you may be able to get rid of it by angling the speakers differently or by shifting them to a different wall of the room. You can often make a big change in the acoustics (sound response) of your room just by drawing the curtains.

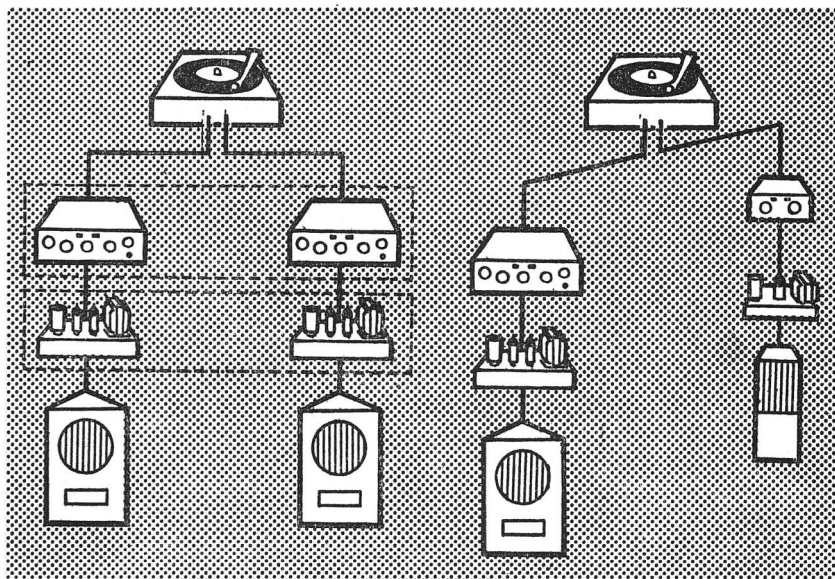
Now you begin to see that the quality and the vividness of stereo depend very much on things out of the control of the set manufacturer. It is all very well to start with your speakers in the theoretically correct position, but you will still have to experiment before you can be sure you have the best layout. You may have had a wonderful demonstration of the equipment in the dealer's showroom, but you can't be sure that by setting up the speakers in the same position in your own living-room you will get the same results. It will always pay you to do some careful experimenting with speaker position, volume levels and stereo balance. Listen to the effect every time from more than one position in the room until you are sure you are getting the best possible results.

Phasing the speakers

You only get the true stereo effect when both speakers are in phase—*i.e.*, when they push and pull together. You can ensure this by making a simple test. Play back an ordinary single channel disc through your stereo pickup and listen to it from a point midway between the speakers. Now get someone to operate the phase switch on the control unit—or change over the connexions to one speaker. When the speakers are in the correct phase you will notice a definite improvement in both the volume and the amount of bass reproduction.

Stereo balance

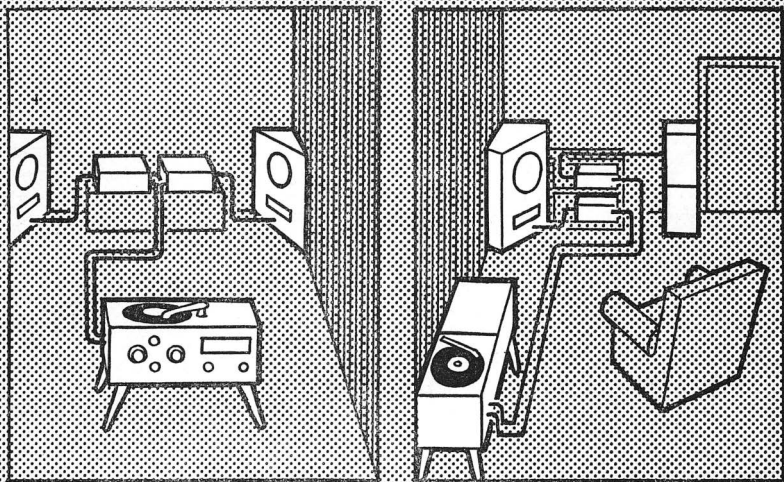
According to the book of words, your stereo set-up should consist of two identical twin channels from the signal source through the amplifiers to the speakers. And



STEREO OFF BALANCE. For most of us a perfectly symmetrical system (left) is too much to hope for. Here the output from the control unit (foreground) feeds two identical power amplifiers and speakers. In practice you are more likely to have a lop-sided room arrangement and odd speakers (right). Fortunately you can still get excellent results by levelling up the outputs of the speakers with the separate volume controls, or the balance control, depending on your equipment.

you should balance the strength of the signals and the gain of the amplifier circuits to give identical outputs. Having done that, you sit on the geometrical axis of the set-up with a leg over each side and enjoy 100 per cent perfect stereo. You even get people who want the manufacturer to fit some kind of meter or visual indicator to show them when both channels are exactly balanced to a milli-whisper.

The people who go all out for perfect balance forget that so many other important items are lop-sided: the room the recording was made in, the room you want to listen to it in, and your own sense of hearing. Most people hear better with one ear than the other, and nobody's ears are mounted



STEREO IN BALANCE. If you are a perfectionist—and have enough room—you can build a perfectly symmetrical stereo arrangement with two identical single-channel high fidelity systems (left). But if you are adapting an existing high fidelity system—or trying to keep the price down—you can economise on the second channel and balance up with the volume controls (right).

in identical positions on each side of his head. The correct stereo balance is the one you arrive at by trial and error with your own set-up in your own home.

First of all, turn up the volume to a comfortable level with the balance control on the preamplifier in the centre.

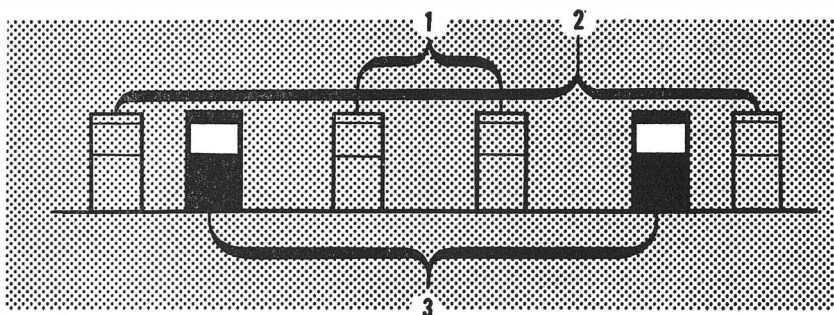
Now try a listening test. Sit first of all in the centre position, 6 to 8 ft. in front of the speakers. Now move 3 ft. to the left of centre and listen to the same record again, leaving all controls as before. Do the same thing 3 ft. to the right, and finally try the centre position again.

Now ask yourself in which position you get the most pleasure out of listening. (Don't get tied up in theoretical considerations about which way the sound source appeared

to move; you are there to enjoy stereo, not to write a technical paper on it.) If the left-hand position sounded best to you, then you want to push that position over to the middle, so you try turning the balance control to make the left-hand speaker sound louder.

Go through the whole drill again until you get the channels adjusted so that the middle position sounds best to you. At this point the balance control may be off centre, but it doesn't matter.

Finally, there is just a chance that the disc or tape you are using for test is not a balanced recording, so use the



THE HOLE IN THE MIDDLE. You get the true stereo effect when the speakers are correctly spaced 3. If they are too close together 1, the sound will not be much different from a single channel system. If they are too far apart 2, you will notice a blank area in the spread of sound. This 'hole-in-the-middle' effect destroys the true stereo illusion.

channel reversing switch to change over right and left signals. When you do this, the stereo effect should stay as before. If you have to alter the balance control again to bring the best listening position back to centre, then you have chosen a bad record and will have to go through the drill all over again with another record. The risk of this happening is slight, but you ought to make the check just the same, because if you start wrong you will be missing something all along the line.

When you set everything up this way it doesn't matter

whether you are using odd speakers—or odd amplifiers—*e.g.*, if you are converting from an existing single channel to stereo.

The 'hole in the middle'

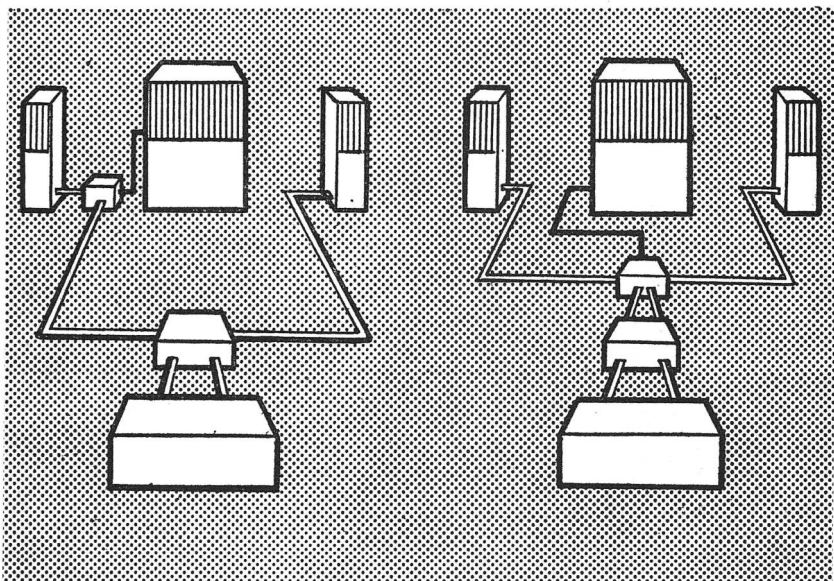
Two speakers should be all you want for good stereo. When everything is properly set up you should get the impression of a spread of sound stretching from one speaker to the other without a break.

For instance, if you are listening to an actor talking or singing as he walks from one side of the stage to the other, you should hear the sound move smoothly over from one speaker, into the centre of the room and on to the other speaker. If he seems to get so far and then jump suddenly across to the other side of the centre, your set-up is suffering from the 'hole-in-the-middle' effect.

It isn't always easy to say what causes the 'hole in the middle'. You will always get it if you have your speakers too far apart, so the first thing to do is to close them in a foot or two. However, if the hole is still there when the speakers are only 6 ft. apart, the trouble is somewhere else.

The next things to suspect are the speakers themselves. Both the speakers—or perhaps even only one of them—may be too directional. Very little of the sound from that speaker will hit the side walls and get reflected towards you. If this is the trouble, then turning the speaker round to face into the corner of the room may be the answer. This will bounce the sound off both walls at a different angle and send it back into the room in a broad fan shape instead of in a narrow beam.

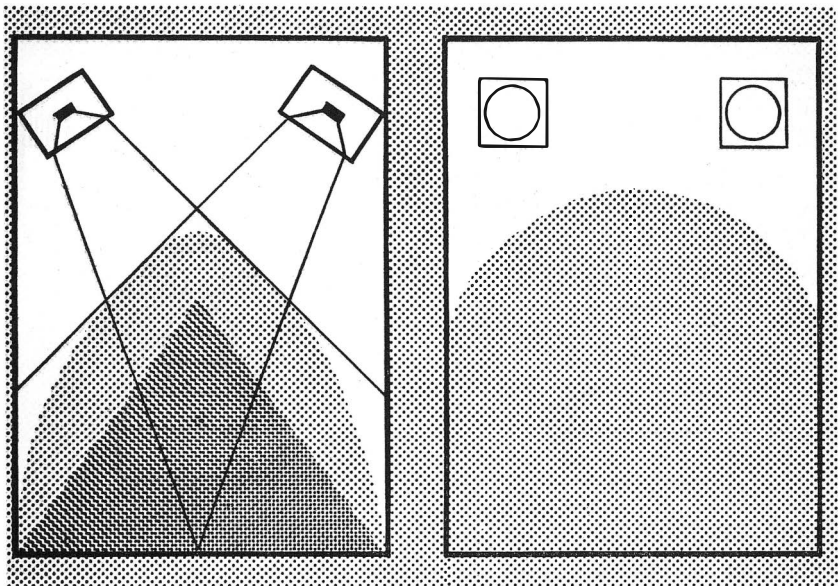
THREE-SPEAKER ARRANGEMENTS. If you are converting from high fidelity single channel and have a large reflex cabinet—or even if you are starting from scratch and the idea appeals to you—you can go in for a three-speaker arrangement with the bass reflex in the centre and a pair of medium-to-high frequency units at either side.



THREE-SPEAKER ARRANGEMENTS. The lower frequencies don't help the stereo effect, so a single 'woofer' will serve both channels. You can use a cross-over filter to tap off the low frequencies from one channel and feed them to the 'woofer' (left), or connect another type of filter to both channels, tap off the low frequencies from both channels, and feed the combined signal to the 'woofer'.

Practically all the sensation of direction comes from frequencies above 300 or so cycles. For these frequencies you only need a modest-sized speaker in an equally modest cabinet. The frequencies below 300 cycles are not as important for the stereo effect, but they add a lot to the pleasure of listening to music. So the object of the three-speaker set-up is to let you use your expensive bass unit to spread the rich 'woofer' tones from the centre of the wall and a pair of cheap speakers to add the stereo effect.

FILTERS AND MIXERS. You feed one of the stereo units direct from one channel and the other through a 'cross-



PLACING THE SPEAKERS. With directional speakers (left) you will generally get the best results over the biggest area with a 'cross-eyed' arrangement. Omni-directional speakers (right) spread the stereo effect over a bigger area, but it is apt to be less striking.

over' filter (p. 69) which filters off the bass frequencies direct into the 'woofer' and by-passes the higher frequencies to the second stereo speaker. This arrangement lets you use a low-priced power amplifier on one channel, since you don't need power for a 'woofer' on both. At the same time you will only be making use of the low frequency output from one channel. The effect may be to give you more treble than you want, but you can get over this by adjusting the tone controls on the preamplifier. If you have only one control, turn it down to cut out some of the top.

As a better arrangement you can use a special mixing unit which will filter off the low frequencies from each channel and feed them into the bass speaker while passing on the higher frequencies to the stereo speakers at each side.

You don't need to have the bass speaker in the centre, but if you can afford the wall space it will sound better in this position and help even more to get rid of the 'hole in the middle'.

Placing the speakers

When you are choosing the best place for the speakers, don't forget that the nearby walls of the room form an important part of the speaker system. All the sound waves from the back of the speakers and a lot of those from the front bounce off the walls before they reach you. Keep the walls clear within two or three feet of the speakers and don't have sound-absorbing surfaces like curtains and shelves full of books and papers around them.

The best angle for the speakers depends on which type you choose. Some speakers are highly directional and send out the sound in a narrow fan-shaped pattern. You get this pattern if your speakers are mounted facing forward in a vertical panel. Column speakers (p. 65), in which the speaker unit looks upwards into the spreader, are designed to diffuse the sound in all directions.

DIRECTIONAL SPEAKERS. If you have directional speakers, you will probably get the best results by angling them inwards so that their lines of fire cross at a point in the centre of the room. How far away from the speakers the lines should cross is something you can find out best by experiment. Try a range of positions starting with both speakers pointing towards the middle of the end wall and finishing with each speaker pointing across the room to the middle of the opposite wall.

With this 'cross-eyed' arrangement you hear the same volume from each channel, even when you move away from the centre. This is because as you move over to the right and get closer to the right-hand speaker you also move into the strongest part of the beam of sound from the one on the left. So the stereo effect is fairly constant from one side of the room to the other.

OMNI-DIRECTIONAL SPEAKERS. If you have omni-directional speakers—*i.e.*, column speakers or any unit where the speaker cones face upwards—simply stand them 6 to 8 ft. apart against the wall. This will create a broad stereo effect over most of the room—particularly if it is long and narrow with the speakers at the corners of one of the short walls. You need all the reflection you can get from the walls of the room, so make sure to keep a clear, unbroken wall surface for 2 or 3 ft. around each speaker. Things like curtains, open bookshelves and upholstered furniture, if they cover most of the wall space near the speaker, tend to soak up the sound and take the edge off the stereo effect.

'Single channel' on two speakers

If you have been collecting single channel discs or tapes over the years, you may jibe at the idea of going over to stereo. The idea of starting from scratch to build up a new library of stereo records—which could easily cost more than the entire stereo set-up—is a bit frightening. But don't forget that your single channel record library will get a new lease of life when you can reproduce it through two speakers. It won't be stereo, but it will be streets ahead of the single channel reproduction you've been accustomed to.

When you share the output of a single channel pick-up, tape recorder or radio tuner equally between the two amplifying channels, you lose the impression of listening 'through a hole' that you always get with a single speaker assembly. The sound seems to come from a broad source between the two speakers, and solo instrumentalists, singers or actors appear to be standing in the centre. However, if your speakers are more than 6 to 8 ft. apart you may notice a 'hole-in-the-middle' effect (p. 134) on single channel that you wouldn't notice on stereo.

The best way out, of course, is to add a third speaker (p. 134), but you may not have the money or the room. However, as your stereo speakers—or at least one of them (p. 132) will be reasonably portable, you can always solve

the problem by placing them closer together when you know you are in for an uninterrupted single channel session.

If you are going over to stereo sound 'by instalments' it is a good idea to start by adding the second speaker and wiring it up for single channel reproduction until you are ready to buy the rest of the set-up.

Stereo on headphones

If you want to listen to stereo without disturbing other people in the house—or if you want to experiment with a stereo novelty for the fun of the thing—you can listen to it on headphones. If you have a pair of headphones you just have to connect the left channel output from your stereo amplifier to the left earpiece and the right channel to the right earpiece.

There are special headphones for the job. They are wired so that you can connect them as an ordinary single channel set or connect the earpieces separately to your stereo outputs. The leads are marked so that you can get them the right way round with both earpieces in phase—*i.e.*, pushing and pulling together. These special headphones are usually the low impedance type which can be plugged straight in to the normal low impedance speaker sockets on your stereo amplifier. When you use them for single channel listening you connect both of the earpieces in series.

Don't forget that the headphones operate on practically no power, so you must add an extra load resistance to take the place of the speakers and absorb the spare power. Unless you do this the voltage of the output circuit may rise dangerously—just as a motor-car engine races if you open the throttle wide with the gear in neutral. The best way to dispose of the unwanted power is to fit a 15-ohm 4-watt power resistor across the terminals of each pair of headphone leads.

How to Buy your Stereo

IF YOU ARE COMPLETELY NON-TECHNICAL and you shy away from anything more complicated than an on/off switch, you will naturally want an 'off the shelf' installation. Even so, you can't afford to go out and buy one like a pound of tea; a reasonably good set-up costs anything from £50 to £150, and you don't want to find too late that you've bought the wrong thing.

Get a technical friend to advise you if you can, and in any event don't settle for anything until you have actually tried it out. A demonstration in the showroom can be very much better—or just that much worse—than it would sound in your own home, but a properly equipped and qualified dealer should be able—and willing—to arrange a showroom demonstration that will reproduce your own listening conditions. If you are undecided, ask to try several sets. Remember *you* will have to live with your mistakes, not the salesman.

Gramophones

You will be quite safe to buy a really good motor and turntable. These items are not likely to go out of date. Remember that the recording companies have put a very great deal of money into the present system, so whatever changes are made in the stereo set-up, the most important part of it for some time to come will be the turntable and motor with the present range of speeds—*i.e.*, 78, 45, 33 $\frac{1}{3}$ and possibly even 16 r.p.m.

So it will be worth your while, if you have anything left over when you have worked out the cost of your stereo equipment, to buy a better turntable and motor. If you invest in a first-class transcription unit, it is fairly certain to be doing its job years after the style of your cabinet has gone out of fashion. The same thing goes for the tone arm if you buy it as a separate item, because anything short of mechanical perfection here will jar on you every time you play a record. So get the best you can afford.

If you must economise, you can start with the pickup cartridge and buy a medium-priced crystal instead of the top-priced magnetic type. You will save anything from £15 to £20 by doing this, and you won't be able to tell the difference in quality until your ear has become highly educated. By that time, if you think the improvement is worth the extra money, you will have had a chance to save it.

The difference between an expensive preamplifier and a cheap one is largely a matter of the extra facilities you get. If you are only going to use it in conjunction with a record player, you won't want the microphone and tape recorder inputs. If you are prepared to change over the right and left channels by reversing the leads, you can do without the channel reversing and phasing switches, and so on. If you are simply converting a high fidelity single channel set-up for stereo records, you can buy a cheap combined amplifier and preamplifier with two inputs—for 78 and lp records at about one-quarter of what it would cost you to put in a stereo amplifying system with the whole range of inputs and switching facilities.

You can economise in the power amplifier/speaker section by keeping the power down. It's a wonderful thrill to be able to turn up the volume with two 12-watt amplifiers and speakers to match, but if you have to wait for the neighbours to go on holiday before you can lift the lid, you are turning stereo into an expensive pastime. If 3 watts per channel is the most you can use for 50 out of the 52 weeks, there is no point in spending twice as much as you need on your amplifiers and speakers.

Tape recorders

If you can do without the stereo recording equipment you can save yourself up to £25 or more. Remember that single channel recording is a straightforward operation but stereo is a job for the expert. So if your main interest lies in listening to stereo at its best, then you had better limit yourself to a single channel recorder that will also reproduce pre-recorded stereo tapes. If you already have a tape recorder you can have it adapted for playing stereo tapes for a fairly modest sum (p. 125). But if you want to convert it for recording stereo as well it will cost you less in the long run to trade it in for a machine specially designed for the job.

When you are buying tape recording equipment, look ahead. Disc players aren't complicated by having to record sounds, and they have been under development for over 50 years, so they have now reached something like finality. But the tape recorder is a much more complicated box of tricks and it is still in an early stage of development. In other words, if you haven't much money to spare, don't rush to buy a lot of expensive stereo tape equipment at present.

Things are very much on the move in the tape recorder world and you may find that your equipment is out of date in twelve months or so. This warning goes for the popular class of machine. It doesn't apply to laboratory and professional equipment. If you are buying a tape recorder, and not converting one, your best plan will be to start with a single channel machine planned so that you can add properly designed units to convert it one step at a time, first to a stereo tape reproducer and then, if you wish, to a stereo recorder.

Radio equipment

At present you can't buy any equipment specially designed for receiving stereo broadcasts. The present transmissions only call for normal F.M. and TV sound receivers.

But if you already have an amplifying system and speaker set-up you may wonder whether it is worth while investing in a single channel radio tuning unit before the broadcasting authorities have made up their minds what they are going to do about stereo in the future.

Is there a possibility that they will introduce a system for stereo broadcasting—*e.g.*, on a single wave length—that will call for a special receiver? Would you be running the risk of having to scrap the equipment you are on the point of buying?

You can be sure of three things: first, there is little hope of a regular stereo service for some years; second, whatever system is adopted, the normal single channel broadcasting will continue for a long time after stereo starts; and thirdly, whatever the system, you will be able to have your present set adapted for less than it would cost you to buy new equipment.

So if you are wondering whether to buy an F.M. tuning unit to complete your set-up, go ahead and do it. The improvement in reception is so great that it will still be a sound investment if it goes out of date within a couple of years of your buying it. And there is no danger of that happening.

Connecting Everything Up

IF YOU BUY A SET OFF THE PEG, YOU ONLY have to plug it in to the mains and connect up the two speakers. If it has a built-in radio, you have to connect the aerial lead, and that will be everything. In any case, the makers' instructions book will tell you how to do it, and in all probability your dealer will send his service engineer along to fix the whole thing for you.

But when you assemble your own outfit you have to connect a number of different electronic units together, and they may not even be made by the same manufacturer. This is where you have to follow the rules if you want to make sure that one unit will work happily with another. Each unit has a number of electronic characteristics that have to match characteristics in its opposite number. The two principal ones are impedance and sensitivity.

Impedance

Impedance tries to prevent alternating current from flowing through a wire or a circuit. It is a mixture of ordinary electrical resistance plus some other electronic factors which apply only to alternating current and which vary with the frequency of the current. Impedance is measured in ohms—like resistance—and when you connect two pieces of equipment together—*e.g.*, a pick-up and a preamplifier—the impedances of both items should be reasonably the same.

The manufacturers' specification usually states the impedance as so many ohms, but for the most practical pur-

poses impedances fall into two broad categories—low, measured in tens of ohms, and high, measured in thousands (Kilohms) or millions (Megohms). The abbreviations commonly used are ohms Ω , thousands $K\Omega$ and millions $M\Omega$. When you connect these two pieces of equipment it is usually sufficient to connect low impedance to low impedance and high to high.

Sensitivity

The sensitivity of a piece of electronic equipment tells you what output it gives for a stated input or, from the opposite angle, the input it requires to make it produce a stated output. You can also use it to mean the maximum output you get from the equipment when you work it at its highest operating level, or the maximum input that you can feed into it without overloading.

Connecting signal source to preamplifier

All you need to know about sensitivity is that the figure given by the maker for the output of a unit should make sense in relation to the figure given for the input you are going to connect it to.

When you want to connect a crystal pickup to your preamplifier you will find that all crystal pickups are classed as high impedance. The one you decide on might have an output of 100 mV (millivolts or thousandths of a volt). This is the output you get when the pickup is playing a really loud passage. You will now have to choose a preamplifier with a suitable input. Most preamplifiers do provide an input for this type of pickup, the sensitivity being somewhere around 200 to 400 mV. On the cheaper models the manufacturer may simply say that it is 'suitable for all crystal pickups'.

If you decide on a magnetic or moving coil type, you will now have to look for a preamplifier capable of dealing with much smaller signals—2 to 20 mV from a low impedance source. You won't find such an input on all preamplifiers and if you are changing to this type of pickup on an exist-

ing stereo player you may have to add a subamplifier unit—a sort of small preamplifier—to transform the signals from low to high impedance and boost them to the level that your preamplifier can handle.

Connecting preamplifier to power amplifier

When you come to the next step in the set-up, you won't have any trouble, because most preamplifier outputs are matched to most power amplifier inputs. You will find that power amplifiers are rated at anything up to 1 volt input to make them develop their maximum output. So long as your preamplifier will deliver at least 1 volt on each channel when it is handling the most powerful signals, you will be safe to connect it to any amplifier. If it delivers more than 1 volt, the volume control will take care of the difference.

Connecting power amplifier to speakers

Next you have to connect the outputs of your stereo power amplifier to the speakers. Once again, most amplifiers are designed to work with most speakers. You may find that your amplifier has a number of alternative low impedance outputs—*e.g.*, 3, 5 and 15 ohms. These figures correspond to the impedances of the majority of speakers. However, if your amplifier outputs are stated as being 15 ohms without any alternative sockets, you should be sure to buy 15-ohm speakers. Impedances at this point are not really critical—*i.e.*, a 3-ohm speaker will work off a 5-ohm output or a 7-ohm speaker off a 10-ohm output.

You must, however, make sure that your speakers are capable of handling all the power you are likely to get from the amplifier. If you connect a pair of speakers that can only handle 3 watts to a pair of 10 watt amplifiers you will not be getting your money's worth out of the amplifiers and be running the risk of damaging the speakers.

Leads

So much for *what* you can connect up to *what*. Now for

how you do the connecting. For this you use connecting leads which may end in tags for fixing under a screw terminal (mostly for permanent connexions) or in various types of plug for pushing in to suitable sockets (mostly for connexions that you want to break from time to time).

The type of connecting lead you use depends on the job it has to do. For connecting your equipment to the mains you use a 3-core flexible cable. You can buy this in a range of colours so there is no reason why it should be an unsightly addition to your set-up. Don't use a longer piece than you need to stretch comfortably from the unit to the mains socket because the slack will tend to get into knots and give trouble. The insulation on the three cables is coloured red (for the live wire), blue or black (for the neutral wire), and brown or green (for the earth wire) so that you can connect each lead to its proper terminal in the equipment (see Plugs and Sockets, below).

For all electronic connexions to signal sources, amplifying units etc. you use screened leads consisting of one or a pair of insulated and colour-coded wires sheathed in metallic braid and covered with an outer layer of insulating material such as PVC. The inner wires are stranded flexible conductors which carry the signal or signals while the metallic braid is always connected to the earthed part of the plug or socket fitting. The metal braid does two jobs: 1, it screens the signal wire against interference from stray electrical fields which might produce noise and hum; and 2, it prevents the signal from radiating interference to other parts of the circuit.

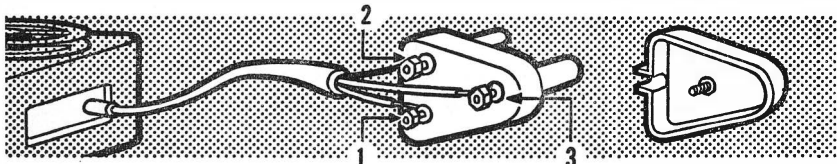
Plugs and sockets

You will have to deal with quite a number of different kinds of plug and socket connexions.

MAINS PLUGS. First come the plugs and sockets for connecting your equipment to the mains. The electricity points in your house may have two-pin sockets rated at 2, 5 or 15 amps (ancient), 3-pin sockets of the same values (recent),

both types using round pins, or 3-pin sockets rated at 13 amps with flat pins (modern). The figures tell you the heaviest current that you can safely take from the socket before the fuse blows.

If you connect, say, a two-bar electric fire, which takes 10 amps to run, to a 5 amp plug, and plug it into the 5 amp socket, you will simply blow the fuse. You can't do any harm that way. But if you connect a cheap and flimsy reading lamp to a 15 amp socket and the lamp or the flex develops a fault, then the faulty part will be able to carry up to 15 amps and get white hot or melt and cause a fire



CONNECTING UP THE POWER. *If your recorder has a two-wire mains lead, it doesn't matter which way you connect the wires to the two-pin plug. If it is a three-wire lead, connect it to a three-pin plug like this: red (live) to 1, black (neutral) to 2, and green (earth) to 3.*

without blowing the fuse. (The same lamp connected to its correct 2 amp socket would blow the fuse as soon as the fault developed and you wouldn't have to call the fire brigade).

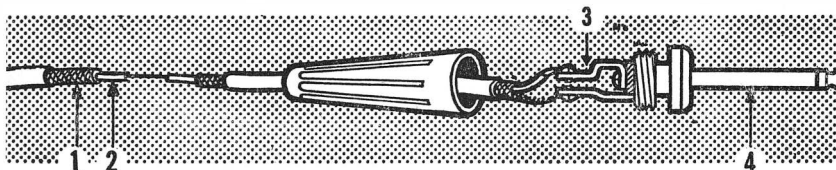
With the 13 amp, flat pin system you can't get into that sort of trouble because the correct fuse is fitted in the plug itself. So the reading lamp would have a 2 amp cartridge fuse fitted in its plug and it would blow at that figure even though the socket itself would supply anything up to 13 amps.

Generally speaking your equipment should always be connected to the mains through a 3-pin plug because the third pin connects the frame of the unit to earth and prevents you from getting a shock if anything goes wrong. (If you have an obsolete 2-wire system, at least get an earthed 3-pin socket fitted where you plug in your set-up.)

The other two wires of the 3-wire system are the Live and the Neutral. These are not interchangeable on the plug pins

as so many people imagine. You must always connect the live wire (Red) to the pin marked L (this is the one on the left when you look at the back of the plug with the thicker earth pin at the bottom). And you must connect the Neutral wire (blue or black) to the pin marked N (on the right with the plug held as above).

There is a very good reason for connecting the Live and Neutral wires correctly. When you have a switch on a piece of equipment, it always breaks the Live lead when you switch it off. If you reverse the Live and Neutral leads, the switch will break the Neutral lead. It will switch the equip-



JACK PLUG. When you wire up a jack plug, use screened lead as shown at stripped portion with outer metal braid 1 and inner signal wire 2. Connect signal wire to tip, and braid to sleeve of plug by soldering or screwing to the connecting tags 3 under the cover. The sleeve of the plug 4 may carry an extra insulated metal ring to provide a connexion for the second wire in a twin screened lead.

ment off as before, but this time it will leave the works live and you might get a dangerous shock by poking around.

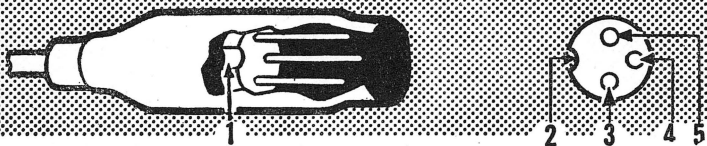
Next there are the plugs and sockets that you use to connect up the signal-carrying cables. There are three principal kinds: jack, 3-pin and phono. For mixed circuits with up to 8 leads manufacturers sometimes use standard International Octal valve base plugs and sockets.

JACK PLUGS are used on G.P.O. telephone switchboards, communications equipment, and so on. The business end consists of a hollow brass sleeve, $\frac{1}{4}$ in. diameter with an insulated conductor running down the middle to a round metal tip. This end is pushed into a socket fitted with two spring fingers, one making contact with the brass sleeve and the other with the insulated tip. The tip contact spring clicks into a groove to prevent the plug from slipping out of the socket.

Where there are two screened signal wires to be connected, you have to use a plug with an extra insulated ring between the tip and the sleeve. This makes contact with a third finger in the circuit.

You can add extra socket springs and contact fingers to the socket so that the plug makes or breaks other electrical circuits—*e.g.*, so that you can cut out a built-in speaker when you plug in an extension speaker.

3-PIN PLUGS are widely used on Continental equipment. They are larger than the jack plug because each contact is made by a separate pin. There are 4 and 5 pin versions, but



THREE-PIN PLUG AND SOCKET. To connect up a Continental three-pin plug, join the signal wire to 3 or 5, depending on circuit and metal braid to 4. No. 2 indicates the position of keyway in shield used for locating plug in socket.

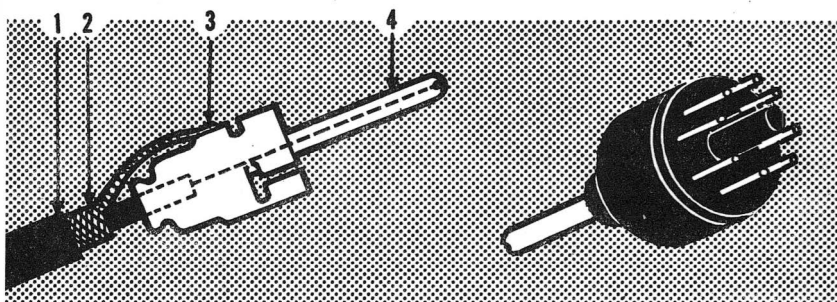
the 3-pin is commonest. You can use it for both 2- and 3-wire circuits. The 3 pins are set at 12, 3 and 6 o'clock, looking at the front of the plug, and the 3 o'clock is always connected to the screen—*i.e.*, the metallic braid. If there is only one signal wire you connect it to the 12 o'clock pin, if there is a second signal wire you connect it to the 6 o'clock pin. The plug is shielded by a metal sleeve which extends beyond the ends of the pins and has a dimple pressed in it at 9 o'clock. This dimple engages with a keyway in the socket housing so that you can only fit the plug in one way.

PHONO PLUGS were originally American, but because a lot of British high fidelity equipment is sold in the U.S.A., and so has to be sent out with phono plug connexions, manufacturers are starting to adopt it here. So far, you are only likely to find it used for 'back-of-the-set' connexions you don't want to interfere with very often—*e.g.*, aerials

and earth connexions, preamplifier inputs and outputs and so on.

The phono plug consists of a hollow pin mounted in an insulating base. The pin and base are held in a split metal band. To connect the phono plug you push the signal wire down the hollow pin and fix it with a spot of solder. You then solder the braid of the lead to the metal band.

The phono plug pushes into a socket which makes contact with the centre pin and the outer band. Phono plugs are about half the size of an ordinary jack plug but they are generally flimsier and not suitable for hard use—e.g., on microphone leads.

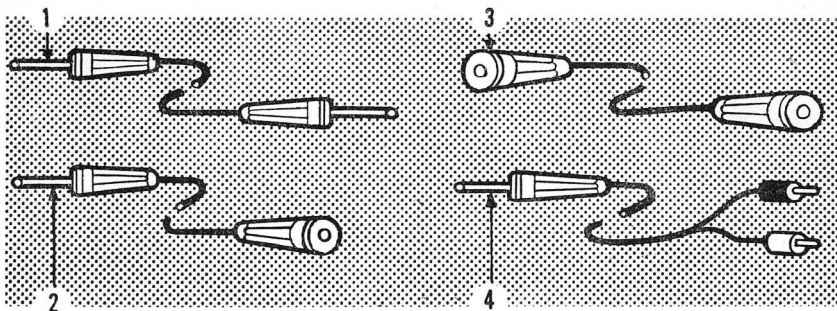


PHONO PLUG. Left: Generally used for semi-permanent back-of-the-set connexions. The insulating covering of the cable 1 is stripped back and the metal screening braid 2 is soldered to the outer sleeve of the plug 3. The signal wire is soldered in the hollow pin 4. The pin carries the signal and is insulated from the sleeve. VALVE BASE TYPE PLUG. Right: Plugs like this, with from four pins upwards, are used for connecting up a number of wires carried in a multiple lead—e.g., for all the control unit-to-power amplifier connexions. The wires are soldered to the individual pins.

VALVE BASE. When there are several leads to plug in at once—e.g., for a power take-off—manufacturers often use standard international Octal (8-pin) or other type valve sockets and terminate the leads on the corresponding valve base type plugs. The pin connexions depend on the job the plug is doing; the manufacturer always gives you a plug wiring diagram if you are expected to do any of the connecting yourself.

Making the plug and socket connexions

Some jack plugs have screw terminals to take the signal wires but most have solder tags to keep down the size of the plug. All 3-pin and multi-pin plug connexions are made to solder tags. If you want to do your own connecting up, buy or borrow a soldering iron with a pencil bit. The ordinary handyman's soldering iron is too big to solder one tag without running the risk of melting the solder on the one next to it. Don't use any of the patent easy-soldering fluxes or solder paints because these invariably corrode the metal junction in time. Use only a good brand resin-cored solder and when you have made the connexion, wash off the residue with a brush dipped in methylated spirit or industrial alcohol.



EXTENSION LEADS. Make up a set of connecting leads with all the terminations you are likely to need. The assortment shown is suitable for the following connecting jobs: 1 socket to socket, 2 socket to plug, 3 plug to plug, 4 socket to wander plug holes. You can get other combinations by coupling two or more leads—e.g., 3 and 4.

Extension leads

Normally you should keep all leads as short as possible for three good reasons: short leads are less likely to pick up hum, they are less likely to get tangled up and tripped over, and they do not add unnecessary resistance to the circuit. If at odd times you want to move a piece of equipment further away—e.g., to stand the speakers further apart

for a special session—insert an extension lead with a plug at one end and a socket at the other. You can buy special sockets to do this. They are the same as the fixed sockets in your set but made without a flange.

If you want to move the playing table further away from the speakers, always fit the extra cables between the power amplifier and the speakers, not between the playing table and the preamplifier. The connexion between the pickup and the preamplifier input should be kept as short as possible; every inch counts, whereas the speaker leads can be extended to 30 ft. and more without affecting the quality of the result.

Other Peoples' Rights

You may think your stereo equipment is *your* concern and nobody else's. But there are two or three points where you may get involved with other people and it is as well to know what they are.

COPYRIGHT. If you own a stereo tape recorder and you tape something from the radio or a gramophone disc—or even through your microphones—you may be infringing somebody's copyright—that is, their right to get paid for something they have created. Up to the present, the authorities have never brought an action against a private person for recording a broadcast item. They obligingly turn a blind eye to the use of your tape recorder for this purpose, so long as you only intend to play the record to an audience of your own family or friends. But that doesn't mean that you are completely inside the law when you do it. It takes no account of any action the performers themselves might be able to take if they feel like it. And—when you tape a broadcast of a gramophone record—it doesn't rule out possible action by the owners of the copyright of the recorded material.

There are several loose ends here that will have to be tidied up one of these days, but for the moment, so long as you keep your fingers crossed and only record 'for home

consumption', you aren't likely to get into trouble with the law.

PERFORMING RIGHTS. Quite apart from infringing copyright by *recording*, you can get into hot water for *playing back* if you do it for an audience outside your own home circle. This holds good whether people pay to listen or not. The common sense of the matter is that you mustn't take the bread out of somebody else's mouth, and you'd be doing that by letting the crowd at a charity bazaar hear something for nothing that they would otherwise have to pay to hear. And if they paid to listen to your record, you would be getting money for the other person's talent and hard work. In either case you are cheating the singer, composer, orchestra, recording company or whoever it might be.

So don't risk the wrath of the watchful Performing Rights Society by playing tape records of radio dance music for your Rambling Club's annual ball, or entertain your local Musical Society with an evening among the classics without making sure that your Club or Society has paid the necessary fees in the right quarter.

NEIGHBOURS' RIGHTS. Finally, there are the people next door. You may enjoy listening to the 1812 overture on a quiet summer evening with all your windows open and 12 watts going out on both channels. There are probably still some parts of the Hebrides where you can get away with it, but in most places you have to allow for the fact that there are people around. At the moment it is a fairly tricky business for them to bring a successful action against you. But a Bill now going through the British Parliament is going to make things easier for them. And it specifically mentions noisy loudspeakers. So before you demonstrate what your new stereo installation will do with the dampers really open, make sure your windows are really closed.

Glossary of Stereo Terms

- A.F.** Audio Frequency. Applied to the signal currents in the power amplifying stages of a radio receiver.
- AMPLIFIER.** A piece of equipment that increases the strength of a weak electronic signal—*e.g.*, as from a radio tuning stage, a microphone, a gramophone pick-up, or the sound head of a tape recorder.
- AMPLIFYING UNIT.** The part of a tape recorder that includes the distribution panel, bias/erase oscillator, record and playback amplifier, equalising circuits, tone correction and all associated controls.
- A.M. (RADIO).** Abbreviation of 'Amplitude Modulated'—one of the ways of transmitting a radio signal by causing it to vary the amplitude of the carrier wave. This type of radio is more subject to atmospherics and interference than Frequency Modulated transmission.
- ARM.** The swinging rod or tube at the side of a gramophone turntable which holds the pickup head and guides it across the record.
- AUDIO FREQUENCY.** The frequency (speed of vibration) of a sound wave that can be heard by the human ear. The range of these audible waves lies between 30 and 15,000 cycles per second.
- AUTOMATIC STOP.** Mechanism incorporated in a tape recorder to disconnect the tape transport mechanism automatically when all the tape has run off the spool.
- BAFFLE.** Flat rigid surface in which a speaker is mounted to increase its efficiency.
- BALANCE.** Essential quality in a recording of multiple sounds—*e.g.*, an orchestra—signifying that all sources are recorded at their true levels of intensity irrespective of their distance from the microphone(s).
- BALANCE CONTROL.** A kind of volume control—usually on the stereo pre-amplifier—for adjusting the volume of one stereo speaker in relation to the other. It increases the volume on one channel at the same time as it cuts it down on the other.
- BIAS.** A steady electrical voltage—A.C. or D.C.—applied to an electronic circuit to make it operate more efficiently.
- BINAURAL.** Term applied in sound reproduction to the sensation of direction and 'depth' produced by listening with both ears.

B.S.R.A. British Sound Recording Association.

BULK ERASER. A device for erasing recorded signals from the whole of a tape or a number of tapes at once. It generates an alternating magnetic field in the same way as the erase head on a tape recorder, but of much higher intensity. It does the job in a second or two and avoids the lengthy process of erasing by running through the sound head.

CAPSTAN. One of the pair of pressure rollers which grips the tape and draws it through the sound head at a constant speed. The capstan roller is driven by a motor and is the one that actually moves the tape; the other turns freely on its spindle.

CARTRIDGE. The 'works' of the pickup, built as a separate self-contained unit that you fit into a holder (the head shell) on the pickup arm. Most cartridges are interchangeable in most head shells.

C.C.I.R. Stands for Comité Consultatif International des Radiocommunications. This international body has published a recommended specification for recording characteristics.

If your tape recorder conforms to C.C.I.R. standards you can expect a satisfactory standard of reproduction from tapes recorded on other machines which are constructed to the same standards. Normally your recorder does not need to conform to any particular standard to be able to play back its own tapes, since any misalignment of the heads, for instance, will automatically cancel out on playback. But if you want to play commercial pre-recorded tapes, or tapes recorded on other machines, you may have trouble unless both machines are manufactured to C.C.I.R. specifications. (Pre-recorded tapes are always to C.C.I.R. standard.)

French and American specifications depart from the C.C.I.R. recommendations, but not enough to make any practical difference to the ordinary tape-recorder user.

CELLULOSE ACETATE. Plastic made from cellulose and used as the flexible base for some types of magnetic recording tape.

CHANNEL. A complete chain of equipment for either recording a signal or playing it back. There must be at least two separate channels in a stereo sound set-up.

CONTROL UNIT. The unit in a sound amplifying system carrying the controls for adjusting the inputs, tone, volume, balance, speaker switching, etc. Also known as the pre-amplifier.

CONVERTER. Piece of electrical or electronic equipment which converts direct into alternating current.

COPYRIGHT. The right of the author of a creative work to enjoy the rewards of his efforts; in particular the right of a musician to the proceeds of the work he has composed or recorded as defined by the Copyright Act.

CROSSOVER FILTER. An electrical filter circuit which divides up the output of an amplifier into two or more frequency bands. Each band of frequencies is then fed into a separate speaker specially designed to handle that particular band. The results are

generally superior to those produced when a single speaker has to handle the whole range of frequencies.

CROSSTALK. Transfer of traces of the signal from one stereo channel to the other. You measure it in decibels referred to the true signal in the same way as noise level (p. 52). Crosstalk degrades reproduction quality and tends to spoil the stereo effect.

CRYSTAL. A slice of Rochelle salt or ceramic (barium titanate) which develops an electrical pressure between its faces when it is bent out of shape. Used as the sensitive element in pickups, microphones and speakers.

CYCLE. A musical note and a radio signal are the result of regular vibrations resembling waves. Every wave passes through the same 'life history'—it starts at zero, rises to a maximum value, falls to a minimum value and then starts all over again. The sequence of events from beginning to end is called a cycle. The number of such cycles that occur every second when you strike middle C on the piano is 261·6.

DECIBEL (dB). Unit commonly used for measuring sound intensity. By coincidence, one decibel is the smallest change in the volume of a sound that can be detected by the human ear.

DISC. Another name for a gramophone record.

DISTORTION. Discrepancy between the sound reproduced by a piece of equipment—*e.g.*, an amplifier—and the original signal. It is stated as a percentage difference between a particular type of input wave and the resulting output. Some manufacturers also state the power and frequency at which it is measured. A distortion of 0·1 per cent over the whole frequency range of an amplifier at its maximum rated output is satisfactory and up to accepted high fidelity standards.

DISTRIBUTION PANEL. The panel in a tape recorder carrying sockets or terminals for connecting to external equipment—*e.g.*, mains, microphone, amplifiers, speakers.

DUBBING. Transferring a recording or parts of it from one tape to another by using two tape recorders.

DYNAMIC RANGE. The ratio between the softest and loudest signals (measured in decibels) that sound equipment can reproduce without distortion.

EARTH. An electrical path to the ground—usually via a connexion to a large body of metal, such as a water main, in contact with the earth mass—which offers practically no resistance to the flow of current.

EDITING. Technique of improving original recordings by the removal of unwanted sections, the insertion of new material, and the introduction of special effects.

ELECTRO-MAGNET. A coil of wire exhibiting the properties of a magnet when a current of electricity is passed through it. The presence of magnetic material—*e.g.*, iron—in the centre of the coil greatly increases the effect.

ELECTRONIC. Associated with the controlled flow of electrons as in thermionic valves, cathode ray tubes and transistors—*e.g.*, amplifiers, radios, TV sets.

EQUALISATION. Automatic electronic correction applied to a signal before or after recording to compensate for disproportionate amplification of upper and lower frequencies. Pre-amplifiers provide separate equalising circuits to deal with various types of gramophone pickup; a tape recorder circuit is designed to boost the higher frequencies in a recorded signal and suppress them during playback.

EQUALISE. Add components to a circuit to adjust its electronic character—*e.g.*, as when you adjust the input stage of a pre-amplifier to accept signals from pickups with different inputs.

ERASE. To remove the recorded signal from a magnetic tape by exposing it to a powerful magnetic field—usually one alternating at high frequency.

ERASE CUT-OUT. A switching arrangement which disconnects the erase head so that a second signal can be recorded on the tape without wiping out the first.

ERASE HEAD. The first head that the tape passes over in the sound channel of a tape recorder and which automatically erases any previous signal when the instrument is set to record.

EXTENSION SPEAKER. An independent speaker connected to a tape recorder, gramophone or radio set to relay the sound to some other place or to substitute a larger and better speaker for the one built into the equipment.

EXTERNAL AMPLIFIER. An amplifier connected to the output of sound equipment to increase the power or quality or both of the signal. Generally, when an external amplifier is plugged into the equipment it takes the entire output and the built-in speaker is cut out.

FEEDBACK (ACOUSTIC). The build-up of the signal that takes place when a microphone is connected to an amplifier and speaker in the same room. Sound waves from the speaker enter the microphone and are amplified. They emerge from the speaker louder than before and 'feed back' into the microphone. The final effect is a loud, high-pitched, continuous squeal from the speaker.

FEEDBACK (NEGATIVE). An electronic trick for reducing distortion. Undesirable frequencies in the output stage of the amplifier are looped back to an earlier part of the circuit and fed in, as it were, upside down. The amount of feedback is adjusted until it exactly cancels out the distortion. Negative feedback is also used to 'throttle down' the amplifier when there is only a small load on the output stage.

FLUTTER. A rapid wavering in the sound from the speaker when playing back a tape recording, often caused by some irregularity in the tape drive—*e.g.*, a shred of tape stuck to the capstan roller, or a spot of grease on the friction surface.

F.M. (RADIO). Abbreviation of 'Frequency Modulated'—a method of transmitting a radio signal by causing it to vary the frequency of the carrier wave. This type of transmission is practically free from interference from other stations or from atmospherics.

FREQUENCY. Applied to an alternating current or electromagnetic field means the number of complete cycles occurring every second. The note to which orchestras tune their instruments, A, has a frequency of 440 cycles per second.

FREQUENCY RESPONSE. Measures the ability of a piece of sound equipment to reproduce signals varying from the lowest to the highest frequencies that are audible to the human ear. This is commonly given in the form of a graph showing the relationship between input and output volume from about 40 cycles per second to 15,000 cycles or more. If the circuit amplifies all frequencies in the same proportion, the graph takes the form of a straight horizontal line and the equipment is said to have a 'flat response'. In practice this statement is qualified by some such phrase as 'plus or minus so many decibels'. An amplifier with a frequency response of 15 to 20,000 c.p.s. + or - 1 decibel or 15 to 30,000 c.p.s. + or - 2 decibels is up to good high fidelity standards.

GAIN. The 'amplification factor' of an amplifier—*i.e.*, the number of times the volume of the output signal exceeds that of the input.

GAP. The space separating the poles of a tape recorder head at the point where the tape passes over it. The effect of the gap is to produce a concentration of magnetic flux in the magnetic coating of the tape. There may be a second gap on the opposite side of the ring formed by the two halves of the core, known as the back gap. On average heads the normal gap is .008 in. for the erase head, and .0002 in. for the record/playback head, and .0005 in. for the playback head.

GRAMOPHONE. A machine that reproduces sound recorded in a spiral groove—usually impressed on a flat disc.

HEAD. One of the electromagnets in the sound channel of a tape recorder which either erases, records, or plays back the signal. A separate head is always used for erasing; the record and playback heads may be separate or one head may be made to do both jobs.

HIDE. An erection of natural or artificial screening material used by bird and wild-life observers or recorders to let them get close to the subject.

HI-FI. Short slang for high fidelity, a term used to describe sound reproduction equipment which gives a completely faithful representation of the original sound over the whole range of audible frequencies.

H.T. Abbreviation of 'High Tension'. Term applied generally to the anode power supply in an electronic circuit.

HUM. A steady noise of low to medium pitch present in the reproduced signal as a result either of a definite fault or simply poor

design or construction. The commonest type of hum comes from the A.C. main supply where smoothing arrangements or circuit design are inadequate.

HUMDINGER. An adjustable resistance bridge connected across the valve heater circuit in such a way that it cancels out any hum present in the amplifier output by injecting an equal and opposite amount of 'artificial' hum.

IDLER. Alternative name for pressure roller.

IMPEDANCE. Measure of the opposition offered by a circuit to the passage of an alternating current. It is measured in ohms and is the combined effect of resistance to *flow* as encountered in direct current circuits and resistance to *change* in strength (known as *reactance*) which is peculiar to fluctuating currents. Impedance is important when connecting two pieces of electronic equipment such as a tape recorder output to an external amplifier input.

INPUT. The signal fed into a piece of electronic equipment—*e.g.*, a tape recorder or an amplifier.

I.P.S. Abbreviation of 'Inches Per Second'. Unit for measuring the speed of magnetic tape through the sound channel when recording or playing back.

INVERTER. Name sometimes given (principally in the U.S.A.) to a rotary converter which runs off a D.C. supply—*e.g.*, a car accumulator—and generates alternating current for energising A.C. mains equipment.

JACK. A socket fitted with internal spring contacts which enables two electrical circuits—*e.g.*, a tape recorder and an external amplifier—to be connected via a fitting plug. The wires of one circuit are connected to the contacts of the jack which 'make' on the tip and sleeve (or tip, ring and sleeve) of the plug. The corresponding contacts in the body of the plug are connected through the flexible plug lead to the appropriate points in the second circuit. This arrangement provides a quick and foolproof method of connecting pieces of equipment.

LEVEL. The average strength at which the input signal is maintained when making a tape recording. It should be such that only occasional intense volume peaks rise above the value at which distortion is known to occur.

LEVEL INDICATOR. An instrument (microammeter or magic eye) mounted on a tape recorder which gives a visible indication of the strength of the signal being recorded on the tape. It helps the user to adjust the level control to the highest level short of the point where distortion begins.

LIVE. At a high electrical potential with respect to earth, usually the positive side of a circuit.

LOUDSPEAKER (or simply SPEAKER). Device for converting an electrical oscillation into an audible sound comparable in loudness to the original sound.

L.T. Abbreviation of 'Low Tension'. Term applied generally to the heater current supply in an electronic circuit.

MAGIC EYE. A visual indicator used as a guide to correct signal level adjustment. It is formed by a pattern of fluorescence at the end of a special type of thermionic tube. The fluorescence usually takes the shape of one or more segments of a circular disc. When the segments close up and fill the whole of the 'eye', the signal is at the maximum permissible level short of distortion.

MAGNETIC TAPE. The sensitive material on which the tape recording is made. Originally paper, now p.v.c. or polyester tape coated with a magnetic iron oxide.

MAGNETISM. A natural phenomenon of attraction found in certain substances—*e.g.*, 'magnetic' iron ore—and which can be produced by passing an electric current around a coil of wire as in the recording head of a tape recorder.

MICROPHONE. Any device that converts sound waves into electrical signals. There are five principal types—carbon, moving coil, crystal, ribbon and condenser.

MIXER. A sound recorder accessory which enables signals from several different sources of different impedances—*e.g.*, radio, pick-up, microphone—to be separately controlled and then mixed in any proportion to give a single signal at the required level. The number of inputs that the mixer will handle at one time is indicated by referring to it as a so-many channel mixer. Some tape recorders have built-in mixing facilities for two channels; the commonest commercial product is a four-channel mixer.

MODULATION. Transmitting or recording a signal by imposing it on a uniform medium—*e.g.*, a radio carrier wave.

MONITOR. To maintain a running check on a signal that is being recorded or transmitted. Some tape recorders have facilities for monitoring the signal through a speaker or headphones either before it is recorded on the tape or immediately after.

MOTOR BOARD. The panel on the tape recorder or gramophone that carries the tape or disc driving equipment with its motor or motors.

NEGATIVE FEEDBACK. Method of improving the quality of an amplifier by feeding back part of the output. See Feedback.

NOISE LEVEL. The level of unwanted noise—*e.g.*, hum, tape, hiss, background noise—present in a recorded signal in relation to the level of the signal alone.

ONE-WAY TAPE DECK. A deck in which the tape can be recorded and played in one direction only.

OSCILLATOR. The part of a tape recorder electronic circuit that supplies the high frequency alternating current used for (a) erasing the tape and (b) biasing the signal being recorded.

OUTPUT. The power delivered by sound reproducing equipment to the speaker. It is measured in watts. A statement of the output of an amplifier—*e.g.*, 10 watts—implies that an undistorted signal of that power is available at the output terminals.

PATCH CORD (U.S.A.). A connecting lead fitted with suitable plugs or other connectors for joining two pieces of electrical equipment—*e.g.*, a tape recorder output to an amplifier input.

PENTODE. A type of thermionic valve with good power handling ability, usually employed in the output stage of an amplifier.

PHASE. A recurrent point in a regular cycle of change—*e.g.*, in the rise and fall in air pressure that accompanies a sound wave. When two waves rise and fall exactly 'in step' they are said to be in phase. If their ups and downs don't happen at exactly the same time, they are said to be out of phase. If one reaches its greatest positive value at the same time as the other is at its greatest negative value, the two are said to be in opposite phase.

PHASE SPLITTER. An electrical or electronic device used for splitting up a signal into two components in opposite phase.

PITCH. The musician's way of describing the frequency of a musical note.

PICKUP. The part of a gramophone set-up that converts the record in the groove of the disc into electrical signals that can be amplified and reproduced through the speakers.

PLAYBACK. The operation of reproducing a tape record. There is a control position marked 'Play' or 'Playback' on every tape recorder. With the controls in this position anything recorded on the tape is reproduced through the speaker.

PLAYBACK AMPLIFIER. The part of a tape recorder amplifier unit used for amplifying the signal 'read' off the tape by the playback head, applying the necessary equalising compensation and feeding it to the speaker.

PLAYBACK HEAD. The head in the sound channel of a tape recorder responsible for converting the magnetic pattern recorded on the tape into an electric signal which can be amplified and then reproduced through the speaker. The playback head is usually situated last in the sound gate. On many recorders the signal plays back through the head that makes the record.

PLUG. A fitting that connects the conductors in a flexible lead to the appropriate contacts in a jack. It consists of a metal sleeve with an inner insulated conductor terminating in an insulated metal tip. In the body of the plug there are metal extensions of the sleeve and tip to which the flexible lead conductors are connected either by screws or soldered tags. The terminals are protected by a cylindrical cover of metal or plastic. Some plugs have a third contact in the form of an extra insulated metal ring between the end of the sleeve and the tip.

The two-way plug is suitable for connecting a single screened cable—the cable being joined to the tip terminal and the screen to the earthed sleeve.

The three-way plug is used for twin screened cables. In this case the extra cable is connected to the insulated ring terminal.

Some types of plug have a separate pin for each signal wire and one for the earth connexion.

POLYESTER BASE. Flexible base of a magnetic tape made from polyester instead of acetate film. This is stronger and stretches less than acetate. It is used for the thinner 'long play' tapes and for carrying sound tracks for synchronising with cine films where stretch in the tape would put the sound out of step with the picture.

POLYVINYL CHLORIDE (P.V.C.). A tough plastic used as a base for magnetic recording tapes.

POWER (or MAIN) AMPLIFIER. The amplifier that steps up the weak signal from the playback head to the level required to operate the speaker.

PRE-AMPLIFIER. A piece of electronic equipment connected between an amplifier or tape recorder and the various input signal sources—*e.g.*, radio tuning unit, pickups of various electrical characteristics, microphones of various impedances and tape recorder outputs. The pre-amplifier is equipped with circuits which will equalise, amplify or weaken (attenuate) any of the input signals to produce a signal with characteristics suited to the amplifier or tape recorder. Most tape recorders and some amplifiers incorporate pre-amplifier circuits capable of handling the more important inputs—*e.g.*, radio tuner and high and low impedance microphones.

PRE-RECORDED TAPES. Commercially recorded magnetic tapes sold by certain recording companies and serving the same purpose as ordinary disc records.

PRESSURE PADS. Spring-loaded felt pads which hold the magnetic tape in close contact with the heads in the sound channel of a tape recorder.

PRESSURE ROLLER (or IDLER, PINCH WHEEL, CAPSTAN IDLER, PUCK). One of the pair of rollers that grip the magnetic tape and draw it through the sound channel at constant speed when recording or playing back. The pressure roller is free to rotate and is simply there to back up the pressure exerted by the motor-driven capstan.

PRINT THROUGH. Transfer of the more heavily recorded parts of a signal to the adjacent layers of tape on the spool. The effect is more pronounced at high temperatures and with the thinner grades of tape. It is unlikely to happen if the recording level is kept below the distortion point and the tape is stored in normal room temperature.

P.V.C. Abbreviation of Polyvinyl Chloride.

RAW (BLANK) TAPE. Tape before recording.

RECORD (TAPE). A plastic tape carrying a magnetic recording made by sounds which are reproduced more or less faithfully when the tape is played back on a tape recorder.

RECORD (GRAMOPHONE). A circular plastic disc carrying a sound record moulded on the walls of a continuous spiral groove on its surface.

RECORDING AMPLIFIER. The part of the tape recorder amplifying unit—usually the first stage—used for amplifying the signal to be recorded on the tape.

RECORDING HEAD. The head in the sound channel of a tape recorder that converts the electrical signal to be recorded into a magnetic pattern on the tape, the pattern forming a record which can be reproduced by playing back the tape. On many recorders the recording and playback heads are one and the same; on others the recording head is separate. Where there is a separate recording head, it comes before the playback head in the sound channel.

RECORDING LEVEL. The level to which an input signal is controlled so that only very occasional peaks rise above the point where 'overloading' of the tape and consequent distortion of the recording begin.

RECORDING LEVEL INDICATOR. A visual indication of the signal level; generally a magic eye or meter.

RECORDING SENSE. The disposition of the recorded signal on the tape. In so-called Continental recording the signal is recorded on the bottom track with the tape (wound coated side in) running from left to right over the head. In international recording (now practically universal) the recording is made on the top track with the tape (wound coated side in) running from left to right.

REFLEX CABINET. A popular form of speaker mounting in which the sound radiation from the back of the cone passes around an enclosure and out of a port, emerging in phase with the direct radiation from the front of the cone.

RELAY. An electrical switching device in which a comparatively feeble current is made to release a more powerful one.

REMOTE CONTROL. An accessory available with some tape recorders that allows them to be operated from a distance through a flexible lead with a separate control unit at the end. This facility is more often met with in an office dictation machine, where the remote control for volume, stop, wind back, and record is built into the hand microphone.

RESIDUAL NOISE. Noise remaining on the tape after it has passed over the erase head and appearing as a background to the new recording. Sometimes a good deal of it can be removed by passing the tape through the sound head with the control switched to record, the volume turned right down, and nothing plugged into the input jacks.

REVERBERATION. The more or less gradual dying away of sounds in a room caused by successive reflection of the original sound from the walls, floor and ceiling.

R.F. Radio Frequency. Applied to the high-frequency alternating currents in the first stages of a radio receiver.

R.I.A.A. Radio Industries Association of America.

R.P.M. Abbreviation of Revolutions Per Minute; a measure of speed of rotation.

SCREENED CONNECTING LEAD. Lead connecting two pieces of electronic equipment which has a sheath of metallic braid enclosing the insulated conductors. The sheath is connected to earth and this acts as a screen which prevents the inner conductors from picking up electrical interference.

SELF-POWERED RECORDER (U.S.A.). A battery operated portable tape recorder.

SIGNAL. The electrical oscillations received from microphone, pickup, radio, etc., which make the recording on the tape or which are generated by the playback head, amplified and reproduced by the speaker.

SIGNAL-TO-NOISE RATIO. When a tape recording is played back there is always a certain amount of background noise accompanying the recorded signal. The ratio of the strength of the loudest undistorted signal that the tape can reproduce to the strength of the background noise is the signal-to-noise ratio. It is a measure of the quality of the tape recorder because good manufacturers try to arrive at a high signal-to-noise ratio by careful circuit design, elaborate screening measures and the use of first-class components.

SINGLE (FULL) TRACK RECORDER. Some early tape recorders and a few modern machines for extra high quality reproduction record a single track down the centre of the tape. Most other tape recorders make two records on one tape, one record along each side.

SOLENOID. An electrical device used for remote control. It consists of a coil in which slides an iron core. When current is passed through the coil the core is drawn into the centre with sufficient force to operate mechanisms like switches, tape transport controls and so on.

SOUND. Audible vibrations, usually of the air, set up by any form of rapid cyclic movement having a frequency lying between 20 and 20,000 vibrations per second. Strictly speaking, vibrations of a higher frequency are not sound, although they are often referred to as sound, and in fact, although inaudible to the human ear, can be perceived by various animate creatures—*e.g.*, bats, insects.

SOUND CHANNEL (or SOUND GATE). The raised part of the tape deck lying between the spools which houses the erase, record, playback (or record/playback) heads and the capstan/pinch roller assembly. The heads are protected by a metal or plastic cover with a slit running along its length to allow the tape to be slipped into position in the channel.

SOUND HEAD. General term for record/playback heads.

- SPEED CONTROL.** A control lever or knob on the tape deck that gives a choice of two or sometimes three tape speeds. On some battery operated models there is a continuously variable speed control to compensate for drop in battery voltage with use.
- SPLICE.** A join in a length of magnetic tape formed either by butting the ends together and fixing them with adhesive jointing tape or by overlapping the ends and welding them together with jointing compound. Splicing is an essential operation in editing tapes.
- SPLICER (or SPLICING BLOCK, SPLICING JIG).** An accessory for making the job of splicing easier and quicker. The tape ends are overlapped and held in a channel which carries a guide for a cutting knife, and prevents the tapes from slipping out of register while they are being spliced or welded.
- SPLICING TAPE.** Special transparent self-adhesive tape made for splicing magnetic tape. The adhesive does not tend to ooze out at the sides of the joint and cause tape sticking—a nuisance that cannot be avoided with ordinary cellulose adhesive tapes.
- SPOOL.** The flanged core on which magnetic tape is sold and loaded on to the tape deck.
- STATIC.** An electrical charge on the surface of a gramophone disc that makes it attract dust and fluff. It is set up by friction—*e.g.*, when you rub the disc to clean it or slide it in or out of its protective sleeve.
- SQUAWKER.** Slang term for a speaker that handles the middle range of frequencies in a three-speaker assembly. See *Woofers*, *Tweeters*.
- STEREO.** Abbreviation of *Stereophonic* (or *Stereosonic*) sound: sound reproduced through at least two sets of speakers from synchronised records made by two or more microphones so that the combined effect closely resembles the sensation of listening to the actual sound.
- STYLUS.** The pointed needle that rides in the groove of a gramophone disc and translates the recorded impressions in the groove into movements of the sensitive element in the pickup.
- SYNCHRONISM.** The condition of being 'in step', as when a sound recording is played back to coincide exactly with the corresponding sequence of events in a projected cine film.
- TAPE DECK.** The part of a tape recorder which takes care of the physical operations of transporting the magnetic tape from supply to take-up spool through the sound channel.
- TAPE GUIDES.** Posts of non-magnetic metal placed at each end of the sound channel so that the tape enters the sound channel at the same angle irrespective of the amount of tape on the reel.
- TELEPHONE ATTACHMENT.** An electro-magnetic pickup which can be attached to the side of a telephone instrument to record both sides of the conversation.

TEMPORARY STOP. A tape control used for short pauses in recording or playback. It simply disengages the capstan and pressure wheels, leaving the capstan running but out of contact with the tape. The normal stop/start controls are not involved.

TEST TAPE. A magnetic tape pre-recorded with a range of continuous tones and other items which enable the performance of a tape recorder to be checked by actual trial. Test tapes are listed in most pre-recorded tape catalogues.

THREADING SLOT. The slit along the length of the sound channel cover which allows the tape to be slipped into position in the open channel.

TONE CONTROLS. Controls on the tape recorder amplifier to adjust the relative balance of frequencies either before recording or on playback. There may be separate controls for lifting or cutting bass and treble independently, or there may be only one control giving treble cut. By designing the circuit to give excessive treble with the control at maximum, a single control can be made to give a range of tones from shrill to 'boomy'. Single control is only used on the less expensive popular models.

TRACK. The actual area on a magnetic tape that carries the recording. A tape may have one, two or even more tracks, although at present two tracks are standard for normal recording tapes.

TWEETER. Slang term for the small speaker used in conjunction with the normal speaker to improve high frequency response.

TWIN TRIODE. A single thermionic valve enclosing the effective components of two separate triode valves.

TWO-WAY TAPE DECK. A tape deck which has a sound channel equipped with two sets of heads and the other mechanisms necessary for recording or playing back in both directions—*i.e.*, left to right on track 1 (top) and right to left on track 2 (bottom).

VOLUME CONTROL. A continuously variable resistance inserted in a circuit—generally associated with either input or output—to give a progressive increase or decrease in signal strength. The resistance is designed in such a way that movement of the control produces a roughly proportional change in signal strength.

WELDING. Joining magnetic tape by the use of a liquid cement.

WOOFER. Slang term for a large diameter speaker devoted exclusively to the reproduction of the lower frequencies—*i.e.*, 30 to 800 c.p.s.

WOW. Fluctuation in the pitch or volume of a signal when played back. Wow is similar to flutter (above), but it is slower and comes from other causes.

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