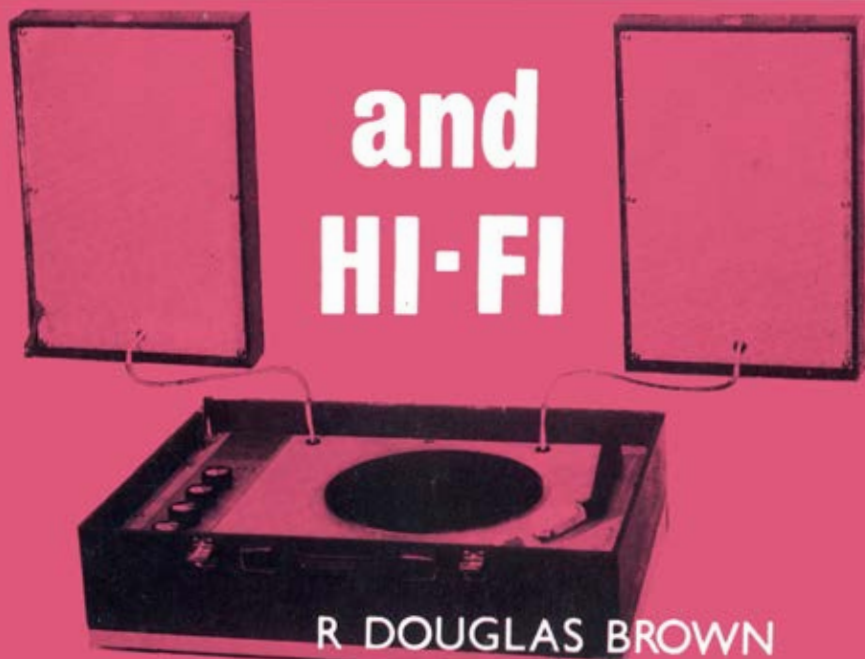




AN ARCO HANDBOOK



TAPE RECORDING



**and
HI-FI**

R DOUGLAS BROWN

This book sets out, in a simple, non-technical way, all the average reader needs to know about high-fidelity recording and reproduction of sound, covering both disc and tape equipment, and dealing fully with the latest stereophonic developments.

It describes the range of equipment available and the esoteric jargon of hi-fi is made intelligible to the layman. There is advice on the use and care of equipment and the fullest and most straightforward guide yet published on the varied ways in which amateurs may use tape recorders. Other subjects dealt with include the activities of recording clubs, the complex problems of copyright and the potentialities of tape recording when linked to photography.



**Deals with the complex
problems of copyright**

Jacket design by JOZEF GROSS

AN ARCO HANDYBOOK

Tape Recording and Hi-fi

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Tape Recording and Hi-fi



AN ARCO HANDYBOOK

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Introduction to hi-fi

THERE is a breed of men—they are often, I notice, men of lean and earnest countenance, very much the back-room ‘boffin’ type—who tingle with excitement whenever they encounter such phrases as ‘negative feedback’ and ‘signal-to-noise ratio’.

This book is not for them—unless they can enjoy it as a pioneer explorer might enjoy returning with a Cook’s Tour to the country he discovered long ago.

This is a book, rather, for everyone—man or woman—who liked, as a child, to shout in a tunnel to hear the echo of their voice; for everyone who may get a quiet satisfaction (which the psychologists can explain) by twiddling knobs or throwing switches on a not-too-complicated control panel, but who stops short of trying to solder wires into a circuit; for everyone who savours the best in quality, whether it be of clothes, or food, or music in the home.

Unless you are one of the comparatively small, but growing, company of electronic experts or of the even smaller, and shrinking, company of hermits and ascetics, there is matter in this book that can guide you to worthwhile activity and add immensely to your family pleasures.

Hi-fi—or, to give it its full name, high-fidelity sound recording and reproduction—is out of the phase of ‘gimmickry’. It now has to do with the furnishing and equipment of the average home. Once we all had to have TV sets if we were to be in fashion; later it was washing machines; today you cannot hope to keep up with the Joneses if you do not have a tape recorder. And with the

tape recorder there may go a whole range of marvellous associated equipment: microphones and loudspeakers, radio tuners and telephone adaptors, amplifiers and turntables.

A catalogue of available equipment may be a formidable thing, once you begin to examine the prices. If, therefore, it is important to you that you maintain your social status, we must consider how it is to be done at minimum cost.

If you adopt the altogether more sensible approach that you do not wish to miss any of the pleasures of life that are within your reach, so much the better. We may make an intelligent exploration of what is available to serve your needs, and so discover what will do it most satisfactorily.

Within the field of hi-fi you may operate in an active or in a passive role. For most people, it is still chiefly a matter of *listening*. You settle in the comfort of your own armchair, in your own familiar surroundings, with your feet up before the fire, and you experience the satisfactions and excitements of the concert hall.

There are people who will tell you that hi-fi is no substitute for the real thing and, of course, they are right. Though the sound you hear, with your eyes shut, may be almost identical to that you would hear from the best seat in the Festival Hall, the two experiences are not comparable. There is colour and excitement and glamour about *going to a concert* that you cannot hope to enjoy if you bring the concert into your sitting-room. Hi-fi addicts, unless they are fanatically irrational, do not stop going to live concerts; if anything, they go more often; certainly they go with heightened sensitivity and more mature judgement. But there are millions of people who may never have the opportunity to get to the Festival Hall, or to any other first-class

concert hall, and millions more who will never have the time or money to go as often as they might wish.

They are the hi-fi public. With a good-quality gramophone (or transcription unit—if we may begin to use the hi-fi language now) or a tape deck, linked with an amplifier and a loudspeaker unit, it is possible to reproduce any piece of recorded music with impressive fidelity. With two amplifiers and two speakers, stereophonic reproduction becomes possible; this gives to the reproduction a breadth and a depth which creates the illusion of reality in the concert hall.

It is early to be counselling caution, but I do so here. Mediocre stereophonic equipment will not give you better reproduction than first-class monophonic equipment; it will give you something that is *less* satisfactory. If it is the Joneses next door who worry you, buy a cheap stereo outfit, by all means; it will be sufficient to enable you to score a point over the garden fence, if they are stuck with single-channel reproduction. But, if they have high-quality equipment, *they* will enjoy the better listening.

If you are going in for stereo, do it properly. It will cost you money. If you cannot afford it, go for single-channel, monophonic reproduction and buy the best you can. You can always add a second channel later, by duplicating your amplifier and speaker, and thus you will graduate naturally and wisely to stereo.

Once you have the basic equipment to play records—which may take the form of discs or tape, although most of those sold today are still discs—the world of music is about your ears. Thanks to the post-war boom, record shops are among the most attractive places in the local High Street: usually bright, modern premises, well stocked and suitably equipped to enable you to sample the recordings you fancy before you pass over your cash.

The range of music now available on records is overwhelming. You will find it difficult to name any reasonably well-known or worthwhile composition that has not been commercially recorded. If you want Beethoven's Sixth Symphony, there are at least twenty-five different versions to choose from. If you want the twelve-tone compositions of Schoenberg, you will find recordings of them, too.

If your principal interest in hi-fi is as a listener to music, you will obviously wish to hear, as well, the concerts broadcast by the B.B.C. and other broadcasting organizations—and to hear them at the same level of quality as your other listening. The introduction of VHF transmission since the war will have opened your eyes (or ears?) to what fidelity in reproduction means today. Yet the probability is that you can do better than you are doing with your present radio set. If you are installing a hi-fi set-up, you will be well advised to consider radio as an integral part of it.

Your radio set consists essentially of a tuning unit, to bring in the signal, an amplifier and a loudspeaker, usually built into a single cabinet of limited size. But your disc- or tape-reproducing equipment must also include an amplifier and speaker. Why duplicate these items? If you buy a radio tuner unit, you can link it with the same amplifier and speaker that you use for your other activities.

Having thought it through to this point, a brilliant idea usually strikes the new enthusiast. Is it not possible to *record* the music included in broadcast concerts and so add those items to one's personal library? It is possible, and it is widely done with excellent results, but there are legal considerations to be borne in mind, with which I shall deal later in this book.

So we come to consider recording, as distinct from reproduction; and we pass from the passive hi-fi enthusiast to the active one.

There is an intense fascination in recording oneself, one's family and friends, and the characteristic sounds that represent one's environment. It is akin to the childish satisfaction of shouting in a tunnel or a cave to hear one's words echoed back. The same vanity that leads us to examine appreciatively the face in the looking-glass lends enchantment to the sound of our most commonplace words repeated from a loudspeaker. Can there be, perhaps, a deeper, psychological satisfaction in the thought that recording gives an immortality to our voices, which are, after all, a better evocation of personality than the visual likeness of a photograph?

Whatever the explanations, experience proves that every normal man and woman is enthralled by the sound of his or her own voice when reproduced. A statistical survey would doubtless establish that ninety-nine per cent of them immediately ejaculate: 'Is that me? . . . Oh, no, not really!'

At this point, the tape recorder is a mere plaything and, unless it is quickly used in a knowledgeable way, the owner will tire of it after a few days or weeks. It is, or should be, an instrument for creative activity which, at the lowest, may rank with keeping a scrapbook or a family snapshot album and, at the best, is already producing a new and distinctive art form.

You can concentrate on recording—and subsequently replaying—music. It can range from your child's efforts on the piano or a villager's rendering of an ancient folksong, at one extreme, to a full symphony by, shall we say, the Leningrad Symphony Orchestra, at the other.

Or you can get the villager talking about his memories of times past, and eventually you may gather the material for a rounded documentary feature in sound about life in Victorian times, or about countrymen and their ways today.

Once you get into this field of 'sound features', almost anything is possible. The B.B.C. will probably serve as your model. Think of the programmes they broadcast which lend themselves to imitation: features about people and places, about highlights of history, about social problems and hobbies, about sport.

Beyond the field of documentary programmes of this kind, there is that of dramatic recordings. Many amateurs have devised, scripted, produced and recorded their own plays; one such recording was judged to be 'The Tape of the Year' in the 1960 British Amateur Tape Recording Contest and subsequently won the Grand Prix in an international contest.

You can, of course, record amateur theatre or choral or instrumental groups with which you may be associated. You can record poetry. You can make a sound track and synchronize it with home movies, or with projected colour transparencies. You can make a record of your holidays in sound—with or without accompanying pictures.

You can learn a foreign language with a tape recorder to help you: there is no finer teacher, as language students in specialized institutions all over the world have discovered.

You can establish and maintain intimate contacts with relatives and friends in other parts of the country—or in other countries—by means of recorded messages.

Your recorder will enable you to devise entirely new party games. You can conduct interesting scientific experiments with it. You can record weddings.

Perhaps most ambitious of all, you may try to create a new kind of music—electronic music or *musique concrète*. I shall not go into the complexities of this activity yet. It is sufficient to point out that a good tape recorder, while capable of reproducing natural sounds with great fidelity, is also capable of distorting and changing them in a wide variety of

ways. Starting, then, with ordinary everyday sounds, such as the rattle of a penny in a tin or a human yawn, or alternatively, with notes and tones induced electronically, it is possible to manipulate the equipment in such a way as to build up an entirely new kind of music. Divorced from the tone patterns of conventional music, it has a futuristic, 'space-ship' quality. The more timid may find it unpalatable at first acquaintance, but it is being increasingly accepted as incidental music in the cinema and the television studio and, as these have become so powerfully the arbiters of public taste, it is a form of music that will become more popular.

The amateur whose enthusiasm runs to these lengths will find all his abilities fully extended in the creation of musical tapes of this character. Technical knowledge and creative ability find their complete marriage in this field.

There will, naturally, be a contrast between the degree of high fidelity achieved on an expensive stereo reproducer, using commercial records, and that resulting from the early efforts of an amateur recordist. The results achieved should be considered as of lesser importance than the intention and the aspiration. The keen recordist will seek the best results of which he and his equipment are capable: in that sense, he is a perfectionist, and so he qualifies for the company of hi-fi enthusiasts.

This brief survey does no more than indicate the scope of activity that is open to you. You may imagine that we have been standing on a high hill and that I have described the landscape spread out below us with a sweeping gesture and a few generalized phrases.

If the prospect has seemed attractive to you, we will go now into the territory that waits to be explored and make acquaintance with the details.

Reproduction equipment and its cost

IF you have never before considered hi-fi, the chances are that the audio equipment in your home at present will consist of a radio and, possibly, a gramophone, each neatly packaged in a single cabinet. The two could, of course, be combined in a handsome radiogram, perhaps even with auto-change facilities—though this is a vogue that seems to be passing.

I do not wish to say a word against these products, which usually represent good value for money and are well and soundly made. But rarely, if ever, do they represent hi-fi, and, if you are now in search of the best possible reproduction, you had better forget them and start afresh.

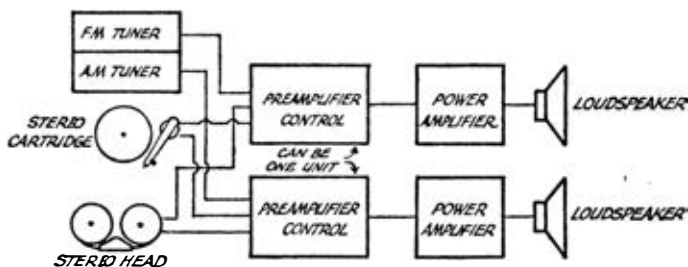
Let us imagine, for a moment, that kinship with a millionaire or luck in the football pools has freed you from all financial restraint. What would be the ideal hi-fi set-up? We shall suppose, of course, that you have available a good-sized room in which to install it.

You will not wish to deny yourself anything that will add to your enjoyment and satisfaction. These are the items which you will require:

- A turntable and pickup, to handle disc records;
- A tape deck, to play tape records and to make home recordings;
- A radio tuner, to receive broadcast programmes;
- An amplifier;
- A loudspeaker;

Microphone(s) and associated equipment, if you wish to make your own recordings.

Money being no object, however, you will certainly opt for stereo. That means that the amplifier and the speaker will need to be duplicated, in order to handle the two separate



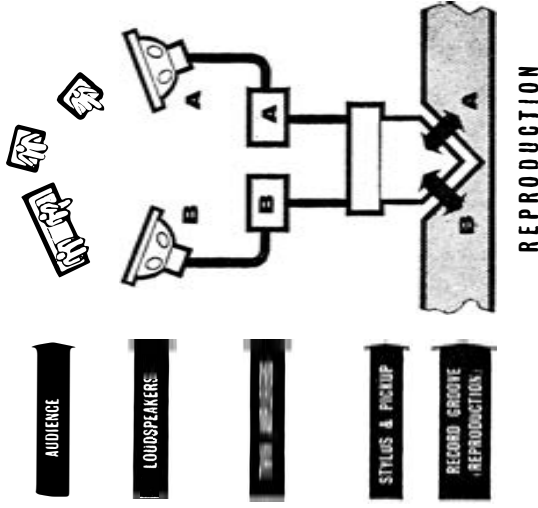
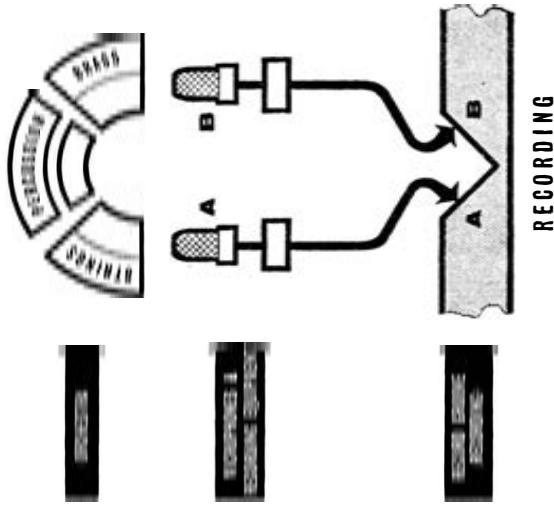
A COMPLETE STEREO SYSTEM

with three programme sources—radio, disc and tape, and two amplifying channels and loudspeakers

recorded channels on the stereo disc or tape; and the pickup and tape deck will need to be of the stereo type.

In the end you will be presented with a bill for several hundred pounds. If you install this equipment properly, in a room with suitable acoustical properties, you will get superb results. It will still not compare with the reproduction to which I listened recently in a professional theatre built by one of the leading recording firms: it had scientifically controlled acoustics and eighty-five speakers built into the walls and ceiling, and it must have cost thousands of pounds.

I relate this story in order to reconcile you to the fact that you will have to do with something less than the best. Nevertheless, it is sensible to take the best available equipment to which you have access as your standard by which



THE PRINCIPLE OF STEREO

The orchestra is recorded with two microphones, A and B, and the two signals are recorded on the two sides of the disc groove. On playback, the stereo stylus converts the groove modulations into voltages which are supplied to two amplifiers and thence to two loudspeakers. The listeners get the same sound image as they would have had if they had been sitting in the microphone position in front of the orchestra.

(Reproduced from This is Stereo Sound by permission of The Decca Record Co. Ltd.)

to judge. There are many large hi-fi stores at which you may hear demonstrations. Do not be shy; go to them and ask them to let you hear the best of which they are capable. This will give you a point of reference when you come to select the equipment which you can afford.

If the total cost of your ideal is £150, and you have only £75 to spend, you must not begin to look for amplifiers, speakers, tape decks and the rest each costing half as much as those you have heard. That way lies disaster. The pickup and turntable for your discs should be the best you can possibly afford. You may be able to save a few pounds on the amplifier. You may make minor economies on the speaker. But all of those are essential items on which you should spend as much as possible. Savings are best achieved by sacrificing some items altogether.

Several different approaches are open to you. The first, and obvious, one is to forgo stereo. As I have said already, a good-quality single-channel system is preferable to a second-rate two-channel one. An alternative policy is to forgo one or two units—the tape or disc deck or the radio tuner. A number of possible combinations will suggest themselves, but you will not be able to escape the need for an amplifier, a speaker and a playing deck either for tape or for disc. These represent the essential minimum. It is best, therefore, to spend as much as you can spare on them, and to wait until you have saved more before you add the other items.

You can, in this way, dip your feet in the shallow waters of hi-fi by spending about £60. You can manage a very satisfactory system on £100.

These references to so many separate components in a hi-fi system may be disconcerting to readers who may be apprehensive about even the fixing of connecting leads—and especially to wives who do not relish the thought of

items of equipment strewn in every corner of a living-room. Hi-fi is not a term synonymous with trailing wires. The whole thing *can* be arranged compactly and neatly. It can easily be housed in furniture that will embellish the most handsome room.

I have tended to dismiss units which are sold 'packaged' in cabinets—the models which are produced for the mass market. Tape recorders in this class sell at anything up to £100 and disc players at up to about £50. One great advantage they have is ease of installation and of movement from place to place. You have only to plug into a power supply and then to experiment until you find the best position in the room.

The drawback is that it is not possible to build entirely satisfactory speakers into the same cabinets as decks and amplifiers. In the case of the portable tape recorder, it is not possible to fit a sufficiently large speaker for optimum results. In the case of the disc player, the sound coming from the speakers will vibrate the cabinet and, though the deck may be sprung, some of these vibrations may reach the turntable, producing what is known to the experts as mechanical feedback (sometimes called acoustic feedback); loud bass passages of music can create cabinet resonances and so produce the most startling and unwelcome noises in the speaker.

We must recognize from the outset that loudspeakers have to be mounted in separate cabinets. If you buy a 'packaged' model, therefore, you will be paying something for a speaker which you may not need when your hi-fi system has been fully developed.

As a matter of convenience, nevertheless, many people buy tape recorders with built-in speakers in order to start their hi-fi activity and then, as soon as possible, they add a good external speaker in order to achieve the full reproduc-

tive potentialities of the machine. The built-in speaker is not wasted, as it can often be used for monitoring purposes (which I shall explain later) and it will be necessary, in any case, if you wish to take the recorder out of your home for use elsewhere.

We will consider tape recorders in more detail later. Let us look first at the other units available.

AMPLIFIERS

The amplifier is at the heart of any good system. Up to a point, it can compensate for deficiencies at other points along the line. Although, to the layman, it may seem one of the most complicated items, it is the one which should give least trouble. It is the view of the experts that amplifier design has reached its limit, in the sense that performance is now so near to perfection as to leave little to be desired. Even trained ears find it difficult to detect less than seven per cent of distortion from an amplifier, and today a distortion figure of 0·1 per cent at 100 watts is commonplace.

In sound reproduction, the purpose of the amplifier is to take a signal, which may come from a disc, through a pickup, or from a tape, via a magnetic head, or from a radio tuner, and to increase it to the point at which it is suitable for delivery to a speaker.

I have referred so far to 'the amplifier', but this is an oversimplification. There is more than one kind of unit involved, and we need now to understand what each is designed to do.

A *power amplifier* is required to operate the loudspeaker system. In the manufacturers' literature, you can recognize this unit—if the description given is not otherwise adequate—by the reference made to its output, in watts, and to its output impedance. Power amplifiers are available with maximum outputs of between 4 and 50 watts, but those of

10 to 20 watts predominate. This power output rating is an indication of the maximum audio power that can be supplied within prescribed limits of distortion.

There is room for debate on the power rating required for normal-level listening in an average room. It may need to be only 1, 2 or 3 watts. It is desirable, however, to have a good reserve of power available to handle the louder passages of music. It is analogous to cruising in a Rolls-Royce at 60 m.p.h.—you *could* do it in a small family saloon, but the Rolls's power reserve will give you a better ride!

Until a few years ago, power amplifiers often took quite a small input signal and they incorporated their own tone and volume controls. The fashion has changed. Most manufacturers today produce their amplifying units in two distinct sections: the main power amplifier in one cabinet or chassis and a 'pre-amplifier' or control unit in another.

A *pre-amplifier* is a tone and volume control unit, using valves or transistors and giving some degree of amplification, according to the requirements of the signal input. Multiple tone (frequency correction) circuits are included, to enable various types of pickup, record, radio, microphone and tape-recording signals to be controlled or corrected, as may be required to produce high-fidelity output.

The circuits required, for example, to secure the best reproduction of 78 r.p.m. discs are different from those needed for modern long-play records, and the different characteristics used in recording the various makes of LP also call for variations in circuitry during playback. The best pre-amplifiers provide 'equalization' to take care of this. Input sockets are provided for each of the facilities provided on the control panel, which may, at first glance, seem to carry an intimidating array of knobs!

It is possible to use, in conjunction with the power amplifier,

an external *tone control unit*, with tone and volume circuitry but without valves or transistors to provide amplification.

There is also a unit known as a *tape pre-amplifier*; it is not always given the prefix 'tape', with the result that confusion can be caused to newcomers to hi-fi literature. The signal from a tape pre-amplifier is usually only sufficient to drive the standard pre-amplifier, which in turn needs its power amplifier. But, if you are using tape, this third unit is essential, to provide the special high-frequency accentuation circuits needed during recording and the special low-frequency accentuation circuits needed for replay.

This may sound formidable at first and the novice may beat a hasty retreat to the portable recorder with all the necessary amplification circuitry neatly built in. Resist the temptation to believe, though, that manufacturers have artfully been proliferating units that are not essential: each of the units described above has a vital part to play in achieving top-quality reproduction.

Bear in mind that hum or noise generated in the first stage of amplification cannot be eliminated at a later stage. It is no good having a power amplifier with a performance specification far outstripping the tape pre-amplifier, for example; the amplifying chain is only as strong as its weakest link.

If you are prepared for some 'do-it-yourself' activity, very good amplifiers are now available in kit form, and this will help to keep down the expense. For a ready-made product, you must count on paying a minimum of £15 for power amplifier and pre-amplifier together. Prices of the popular models range up to about £40, and there are others in the luxury class for those who can afford them.

As already made clear, the amplifying chain must be duplicated for stereo reproduction. Special stereo pre-amplifiers are available and these can be linked to two

separate, matching power amplifiers, or to stereo power amplifiers in which the two units are built into the same chassis. As you might reasonably expect, the cost is approximately doubled.

So much for amplifiers, the heart of the system.

LOUDSPEAKERS

It is convenient to consider next the loudspeakers.

There is a vast amount of expert lore on speakers, and a number of schools of thought. When hi-fi enthusiasts refer to a speaker, they usually mean only the 'drive unit' and cone; the cabinet in which this is contained is called an 'enclosure'. And more than one speaker may be arranged in or about a single enclosure—must be, in fact, for the best results.

If you are to get genuine high-fidelity you must be assured of reproduction of frequencies at least between 40 and 12,000 cycles per second, with equal efficiency throughout the range. These technicalities will be explained more fully in a later chapter. The point to be made here is that not all of this range can be satisfactorily reproduced from one speaker. A good bass response demands a large cone; high frequencies require a smaller, lighter cone.

Many cheaper types of speaker involve a compromise, using a single speaker unit. The better method is to use two drive units. One will be an eight-, ten- or twelve-inch speaker handling the middle and bass frequencies, perhaps up to 8,000 c/s. The other will be a much smaller speaker taking frequencies from about 2,000 or 3,000 c/s and up to, perhaps, 15,000 c/s. The best method is to use three drive units: one for bass notes, one for the middle range, and one for top notes. These three types are often called a 'woofer', a 'presence unit', and a 'tweeter' respectively.

With such a multiple-speaker assembly, a 'cross-over

unit' is called for. Low and middle notes must be kept from the tweeter, and high notes should be kept from the woofer. Electrical filters are used for the purpose—a 'high pass filter' to prevent frequencies of less than about 2,000 c/s reaching the tweeter and a 'low pass filter' to keep the high frequencies from the woofer. The frequency at which one speaker 'hands over' the signal to the other is called the cross-over frequency. With three speakers, a three-way cross-over unit is required.

When, after careful listening tests with representative units at your hi-fi dealer, you have decided which suits your requirements best, you must consider the enclosure.

The design of enclosures is vitally important. Most speaker manufacturers supply suitable enclosures for their products and also recommend suitable specifications, so that you may construct your own.

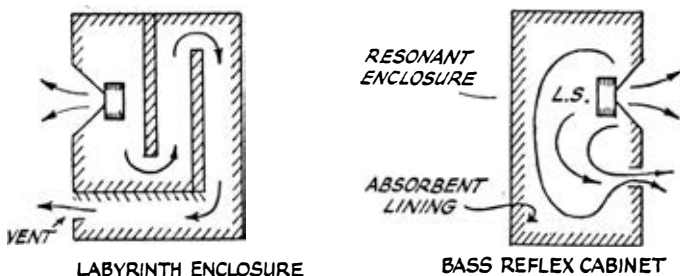
If one is to achieve satisfactory bass response, it is necessary to deal properly with the waves created on the back surface of the speaker cone. The speaker that is intended to handle bass notes requires to be surrounded by a horn, or a baffle, or an enclosure. The difficulty with horns, which would otherwise be a highly satisfactory solution, is that they need to be so large. To reproduce frequencies down to 40 c/s, you would need one about eight feet in diameter! There is, however, a modern development, known as the 're-entrant horn', in which the horn is, in effect, turned within itself in order to reduce the length. Such units are, none the less, rather large for most rooms and they are also rather expensive.

What about baffles? Size is again a big problem. Theoretically, you will need a baffle about ten feet square to handle the lower frequencies. Incidentally, baffles should be square or rectangular or irregularly shaped—never circular; the

speakers should not be mounted at dead centre, but on one of the diagonals.

There have been recorded cases in which enthusiasts have cut a hole in a wall in their homes and mounted a speaker in it, thus creating an 'infinite baffle'. The less ambitious often get by with baffles of four or five feet square, but even these are not popular with many house-proud wives, particularly as—in order to avoid resonance—it is necessary to use heavy one-inch timber or to have a hollow baffle which is then filled with sand. An alternative is to use bricks or concrete blocks!

Not surprisingly, the most popular solution has become the smaller type of enclosure . . . the 'bass-reflex' or the 'labyrinth' cabinet. In these, the vibrations from the front of the speaker cone travel direct to the listener, while those from the rear surface emerge from a vent or port in the cabinet. Dimensions, air-space and the use of sound-absorbent blankets inside the enclosure are of critical importance.



Two types of speaker enclosure

Recently, some interesting results have been obtained with so-called 'column speakers', in which the speaker is directed upward from the top of a narrow column, usually about three feet tall. Even drain-pipes have been used for

this technique, with acceptable results. One advantage is that this type of speaker takes less floor-space and this has become an important factor with the popularity of stereo, which calls for two speakers.

At the time of writing, news has just been released of a 'revolutionary', but rather mysterious, design of enclosure evolved by two researchers in Wales. It is described as 'an open-ended cabinet with a tilted lid, about three feet high and four feet long'. Early claims that it surpasses the performance of most orthodox enclosures at a total cost of only £5 have been widely challenged. It is agreed, however, that it is an interesting design and gives a good performance; it has certainly stimulated keen discussion about the principles of speaker design.

Meanwhile, a reasonably good full-frequency speaker unit can be obtained for as little as £5—or you can pay up to £70. Complete with enclosure, prices start at £12 or £15 and run up to some hundreds of pounds.

A few words of explanation are needed about the actual 'drive units'. The vast majority of those on sale are of the moving-coil type, which is reliable and economical. This uses a powerful permanent magnet and in the gap between the pole-pieces a coil of copper or aluminium strip or wire, attached to the apex of the cone, moves rather like a piston, vibrating the cone. The vibrating cone creates sound waves.

There is one well-regarded British full-range speaker that operates on an entirely different 'electrostatic' principle. This requires no enclosure or cabinet, but is bought complete as a standing unit. A frequency range of 45 to 18,000 c/s is claimed and the price is £52. The principle involved is that a D.C. voltage applied between two parallel metal plates causes them to become charged and an A.C. signal voltage,

superimposed on the D.C. charging voltage, will cause the plates to move in relation one to the other.

Tweeter units sometimes use this electrostatic principle, a few use crystals and some use ribbons.

A speaker should never be connected to other equipment until one is certain that its impedance and power rating matches the output impedance and power of the amplifier used. More will be said of this in a later chapter.

The loudspeaker and amplifier are the items which are common to any kind of hi-fi system. When you have settled on them, you will have to decide which actual sound source, or sources, you intend to use. The three possibilities are the radio tuner, the turntable and pickup ('transcription unit') and the tape deck. We shall consider these in turn.

RADIO TUNERS

Some of the tuners available are superb units that will give you a quality of radio reception, when connected to hi-fi amplifiers and speakers, that you have previously only dreamt about. VHF-FM broadcasts give very wide frequency range and low background noise, and they fully justify the cost of a tuner. Prices range from about £15 to well over £30.

A number of tuners are sold in cabinets or with front panels designed to match amplifiers from the same firms. Some have their own power pack built in, but others need an external power supply; be clear on this point when making a purchase.

A variety of visual tuning devices, to ensure perfect reception, is used on the various models, but some so-called 'switched tuners' are pre-set so that any one of three or four stations can be brought in at a flick of a knob.

TRANSCRIPTION UNITS

Transcription units for playing disc records can be purchased complete—turntable and pickup, or the two parts can be obtained separately. The most inexpensive complete unit, at the time of writing, costs about £10, but there is a big jump to the next modestly priced model, at nearly £19. First-class pickups, purchased separately, can cost £20, and good turntables as much again. Crystal pickups are available, however, from reputable firms at prices from £4 upward. There is a wide variation in the prices you can pay, and you need to study what it is you get for the extra amount. In your early hi-fi days, your ears may not be sufficiently well attuned to get the full benefit of the most expensive equipment.

Many 'packaged' radiograms include 'auto-change'—a mechanical device by which several records are stacked above the turntable and lowered one at a time, in sequence, to give a long period of almost continuous playing. With the coming of long-play records, there is less need for such a device; but, in any case, most hi-fi authorities believe that quality standards of reproduction are inevitably impaired if auto-change is included. It adds an additional mechanical complication, it requires a heavier pickup than is now considered ideal, and it introduces a danger of 'rumble'—low-frequency noise caused when mechanical vibrations in the motor find their way to the turntable. It is fair to say, however, that one very well-known firm has recently marketed a unit with auto-change which it claims will match the reproductive qualities of any comparable transcription unit. It may become necessary in the future to adjust current thinking on this subject; but, for the present, most authorities advise caution.

'Rumble', already referred to, and slight speed instability are the two principal weaknesses for which you must watch

in disc-playing units. To avoid them, heavy cast turntables and precision motors are used. The motor does not drive the centre spindle of the turntable; a rubber-faced idler wheel is interposed between the motor shaft and the outside rim of the turntable and so transmits power to it.

Transmission is arranged so that the turntable may revolve at three speeds: 78 r.p.m., the speed for the older type of single-channel disc, 45 r.p.m. for 'extended play' discs, and $33\frac{1}{3}$ r.p.m. for long-play discs. The latter speeds are those used for current micro-groove records. Constant speed is of vital importance. Transcription units are fitted, therefore, with the means of making minute adjustments.

How are you to know if the turntable is revolving a little too slowly or a little too fast? Some models have three sets of parallel black and white vertical bars marked around the rim of the turntable, one set for each speed. If the speed is true, the appropriate bars will appear to stand still when seen by the light of an electric lamp operated from A.C. mains at the specified frequency. If the bars appear to move contrarily to the turntable, the speed is slow; if they advance in the same direction as the turntable, the speed is excessive.

If a turntable is not marked with these stroboscopic bars, as they are called, you can buy a simple stroboscopic disc, which can be laid on the turntable and used in the same way.

Most transcription units operate at the three speeds already quoted. If you are starting from scratch now and have no old 78 r.p.m. discs, there is at least one good two-speed unit which, at £16, will save you a few pounds without loss of quality. There are also some units providing a fourth speed— $16\frac{2}{3}$ r.p.m. These are reported to be manufactured in response to popular demand, but, in fact, there are no disc records available at this speed; this provides an odd glimpse into the minds of some dedicated hi-fi enthusiasts!

PICKUPS

We must now consider the pickup assembly. As with speakers, there is an impressive body of lore attached to pickup design, as might be expected in view of the crucial importance of this item in achieving good disc reproduction. The development of stereophonic reproduction in recent years has presented manufacturers with a host of new and difficult problems.

The pickup consists of an arm pivoted beside the turntable, and a head assembly including the stylus (which is what you may have called, until now, the needle).

Some firms make and sell complete pickup assemblies. It is possible, however, to break down even this small unit into specialized parts and to buy an arm from one manufacturer and a head assembly from another. Some arms terminate in sockets into which can be plugged self-contained head assemblies. Others include a hollow head moulding into which can be fitted a so-called 'cartridge'.

If you decide to 'go the whole hog' and buy separate arm and cartridge units, consult your supplier about fitting them together, as it can sometimes prove puzzling to a beginner.

It is the job of the pickup, of course, to convert the impressions in the disc into electrical vibrations. In the case of stereo pickups, the stylus follows both right and left channel walls of the groove and produces two independent electrical signals to feed the two sound channels.

The two usual types of stereo pickup—for today most models are designed for stereo—are known as 'crystal' and 'magnetic'; the first category includes 'ceramic' pickups and the second category includes those described as 'dynamic' or 'moving-coil'. All of these types are capable of excellent performance, but the magnetic pickups are, usually, the more expensive.

Styli are usually of sapphire or diamond. Sapphire is the more widely used at present, because of its lower price, but wears about ten times as fast as diamond. Diamond needles, because they retain their original shape longer, involve less record wear, and so they turn out to be the cheapest in the long run. The old-fashioned steel, wood and bamboo needles have been banished entirely from the world of hi-fi.

The radius of the tip of the stylus and the pressure with which it tracks in the disc groove are of critical importance, and we shall consider the figures in a later chapter. Meanwhile, we must note that you cannot play the older type of 78 r.p.m. discs with the same stylus that you use for 45 and $33\frac{1}{3}$ r.p.m. records. A stereo pickup will also play the monophonic micro-groove discs, but claims that standard mono pickups will play stereo discs monophonically without harm should be treated sceptically. With equipment costing so much money, it is best not to take risks.

TAPE DECKS

The third type of sound source is the tape deck. At the present time, the number of these decks sold for building into hi-fi systems is not large, in proportion to the number of complete tape recorders. Some of the decks are designed for connexion to suitable amplifying units, others come with pre-amplifiers fitted. The prices, therefore, vary a good deal, according to what you are getting. The cheapest simple tape deck costs a little over £20. The most expensive mono-stereo tape deck, complete with pre-amplifier, costs nearly £100.

Not all portable tape recorders meet hi-fi standards, though many do. Unlike the components we have discussed so far, they are not exclusively designed for reproduction of sound. For these reasons, it will be better to deal with recorders in a separate chapter.

We can, however, now take an overall view of the possible cost of our complete hi-fi system.

Amplifiers cost between £15 and £40, and speakers between £12 and £100. These are the figures for single-channel, monophonic reproduction; if you want stereo, they can be doubled. A transcription unit—turntable and pickup complete—will cost at least £20. Radio tuners are priced at £15 to £30. A tape deck, if stereo, will cost at least £40. Some sort of cabinets will be necessary for all this equipment, and, even if you make them yourself, the cost will probably be £10 at a minimum.

Adding up these prices, we find that a comprehensive stereo system involves an expenditure of between £140 and . . . well, the sky's the limit.

If this minimum figure is more than you can contemplate, you must begin pruning. If you are satisfied to start with a monophonic system, switching to stereo later on, you can bring the minimum cost down to something like £85 straight away. Omit the radio tuner, and it becomes £70. Settle for *either* tape or disc, and you will reduce it nearer £50. Even if you have £100 available, it may yet be wisest to spend it all on the fewest possible components, spending more on each of them. Whatever you deny yourself at the start you will be able to add to the system later, when you can afford it.

There is, however, another approach which has become popular in recent years. This is to start the system with a complete portable tape recorder, which immediately provides facilities for a wide range of recording and listening activity and then, progressively, to add external speaker, a second channel for stereo, radio tuner, disc transcription unit, and so on. If you propose to follow this pattern, it is wise to buy a really good recorder as the basis of your future hi-fi.

Tape-recording equipment

A GOOD tape recorder will record any sounds that are within the limits of human audibility. The range of its uses is almost infinite: they extend far beyond the world of hi-fi. Engineers, scientists, doctors, salesmen, teachers, businessmen, the sick and the blind, housewives and children all find that the tape recorder can serve or amuse them. Yet a *good* tape recorder, linked to an external loudspeaker, may be regarded as a hi-fi system in itself.

I am regularly approached by friends who say: 'I am thinking of buying a tape recorder—which would you recommend?' They appear to expect me to reply, without hesitation, that the X machine is undoubtedly the best.

Not long ago the Consumers' Association, which tests and reports on products on sale in the shops, investigated tape recorders and bravely recommended one particular machine as 'the best buy'. I have a great respect for the Association and its work, but I feel that, in this case, its findings have a limited value. Undoubtedly it is possible to examine a variety of machines and to establish which offers the best value for money, in terms of materials and workmanship. It is possible to go farther and, by scientific tests, to assess relative performance statistically. But, ultimately, the only satisfactory way of judging which machine is best suited to a particular customer is by using it in the way in which the customer proposes to use it when he gets it home. And, so far as quality of reproduction is concerned, much depends upon entirely subjective standards.

It is a physiological fact that hearing deteriorates as we

grow older; many men of fifty hear little of frequencies above 8,000 c/s. To such a customer, then, the fact that one machine performs well up to 16,000 c/s and another only to 13,000 c/s is of academic interest. He is concerned with what he will hear. Furthermore, exceptional frequency response is usually obtained by some compensating loss of quality in another respect—signal-to-noise ratio, for example. To take another example, the person who intends to use a tape recorder almost entirely for recording speech needs something quite different from the person whose main interest is listening to music. To recommend to each of them a 'compromise' model that will do fairly well in both roles is of dubious value.

The prospective purchaser, therefore, must start by asking himself the question: In what ways will I use the machine? As you may not even be aware of some of the possible uses, chapter 11 describes a representative selection of them.

There is one specialized class of recorder which we will dispose of immediately: the office dictation machine. This has no possible place in a hi-fi system. It has been evolved for its special function as a robust, simple unit that is reliable and efficient, but lacking in flexibility. That is to say, you cannot use it for anything other than dictation of letters or manuscripts. In order to accommodate as much material as possible on a small reel of tape (thus helping to keep down the size of the recorder as a whole), recording and playback takes place at a slow speed. This means that the frequency range is strictly limited and reproduction, although clear and adequate for its purpose, does not possess high-fidelity. On some of these machines, moreover, speed is not constant and this means that there is no possibility of inter-changing recordings with those made on orthodox general-purpose tape recorders.

If, however, you propose to use a recorder solely for dictation, you will be wise to get one of these models designed for the purpose. They have a special switch built into the hand microphone which enables you to stop or start the machine, or to repeat or erase a phrase without touching the main controls. This is invaluable. They are equipped, also, with special stethophone (or earphone) and a foot-operated stop-start control, so that a secretary who is transcribing the material is left with both hands free. Another facility is a time-scale showing at a glance what point on the tape has been reached, and the tape itself is usually contained in a cassette, or magazine.

Not all of these facilities can be conveniently provided on all all-purpose recorders but it is, none the less, possible to use such a machine for ordinary dictation purposes if you wish. You must decide whether the other uses to which you can put it are such as to offset its disadvantages as a dictation machine.

If you are purchasing an ordinary portable tape recorder, you should begin by considering whether it will be used for recording speech and other simple sound effects, popular music or classical music, and whether you can afford stereophonic recording and reproduction.

Models suitable for speech and popular music cost from about £20 to £50. Those capable of giving high-quality recording and reproduction of classical music usually cost at least £50 or £60; and with stereo facilities, the price becomes at least £90 and may range up to £150. There are, of course, professional machines costing far more, but I am treating them as being beyond the reach of the amateur enthusiast.

There is a further class of tape recorder—the battery portable. It is necessary here to interpret the word ‘portable’ as it is used in tape recording circles. Most mains-operated

models are marketed as portables, meaning that they are self-contained and, with the lid closed, can be carried from place to place in their cabinet and plugged into any convenient mains socket. Some of them, however, are back-breaking if you have to carry them far. The cheaper recorders, having more limited facilities and using lighter materials—plastics, for example, in place of metal—usually weigh no more than 20 to 25 lb. The more complicated and expensive models often weigh nearly 50 lb. It depends, of course, on individual wind and muscle but, for myself, anything over 35 lb. cannot be moved very far, except on wheels.

In the last two or three years, however, an entirely different type of portable machine has become very popular—portable in the sense that it can be taken *and operated* anywhere, without having to be plugged into a mains electricity supply.

Current is supplied instead by batteries—usually the dry-cell types used in ordinary torches but in the case of one well-known model accumulator batteries which can be recharged from normal A.C. mains. The development of transistors to replace valves has played an important part in making possible genuinely portable machines, several of which weigh less than 10 lb. with batteries, and all of which can be carried on a shoulder-strap without strain.

There are many problems to be solved in the development of midget recorders of this kind; designers and manufacturers have achieved some remarkable results already, and we should regard this as a field with vast potentialities. The wealth of sound material suitable for recording which is opened up for the first time with this new ability to use a machine *anywhere* is exciting.

Battery portables vary widely in quality and price. Simple models, of limited value for recording music but otherwise

good all-purpose recorders for everyday use, sell at less than £30—and they are among the lightest in weight. Better machines, some of them capable of a quality that is acceptable to the B.B.C. for documentary programmes, can be bought at prices ranging from just under £60 to just over £70. Machines of professional quality cost a good deal more. A British machine which has for some years been standard B.B.C. equipment for outdoor news interviews has recently appeared in a new version at £124. A superb Swiss machine, claiming to be up to the highest broadcasting and cinema standards for any type of work, is supplied, to customer's order, in versions costing from £186 to nearly £300.

These portables are best regarded as recorders only. It is possible to play back tapes on them—they all have built-in speakers, but it means an additional drain on the batteries, and the size of the speakers naturally restricts severely the quality of reproduction.

Many people, therefore, equip themselves with both battery portable and mains machines and play back all tapes on the mains model. This is, undoubtedly, the ideal arrangement, but not everyone will wish to buy two recorders. Some manufacturers have tried to assist, in various ways. One supplies an external amplifier to use with the recorder, to boost reproduction. Another has introduced a machine which, at the flick of a switch, can be operated from batteries *or* mains. Others sell mains converters.

I shall discuss the operating speeds of recorders in the next chapter, but here it is necessary to point out that, if you are using a battery portable to record and a mains model to play back, they must have a common speed. There is one battery portable which does not operate at a constant speed and consequently tapes recorded on it cannot be played back immediately on other models. This model has, in fact, now

been superseded, but it is still on offer—at a reduced price—in some shops.

A tape recorder is part-mechanical and part-electronic, and the mechanical section is concentrated in the tape deck—the ‘transport system’ involving speed control, tape tension, fast spooling and braking. The design and manufacture of a good tape deck calls for great skill, substantial resources, and a reasonable production run. The consequence is that there are very many more models of tape recorder on the market than there are types of tape deck; in other words, you will find that a majority of recorders are built around a few standard decks. Quite a number of small specialist firms take decks from a manufacturer turning them out in quantity, and speakers and microphones from other manufacturers, and add amplifiers, cabinets and accessories to their own individual designs. In this way the full potentialities of the basic units are quickly explored and exploited and the customer is given a very wide range of choice. At the same time, however, it clearly becomes possible for the odd ‘smart guy’ to move into the business without any large expenditure of capital or undue sense of responsibility, either to make some quick money and get out or to fall down on the job and go bankrupt, but in either case leaving a number of customers wanting servicing, repairs—or their money back. It is sensible, therefore, to find out something about the standing of the firm whose products you propose to buy; the big majority of them, of course, are so well established and well known that the point does not arise.

At the time of writing—the situation changes very rapidly these days—there are well over 150 different tape recorders on the market. There are fewer than half this number of manufacturing firms or importing agents. Some firms make half a dozen different models, some import and market a

single recorder. Nearly one-third of all recorders use one of two mass-produced tape decks.

The customer has a choice of recorders manufactured in many continental countries, as well as in Britain, and there are one or two machines available here from America and Japan. It is a fact that the big 'break-through' which made the popular tape recorder possible after the war was made in Germany, but British manufacturers have since had the advantage of a buoyant, rapidly expanding domestic market to encourage their efforts; there is little they can be taught now by other countries. There are almost certainly more tape recorders in use per head of the population in Britain than anywhere else. Overseas sales of hi-fi equipment manufactured here represents one of the most successful sectors of the export drive.

Most recorders in the popular price range are sold complete with a reel of magnetic tape and a microphone. When comparing prices, it is good sense to check whether these are included. Eventually, if you become interested in serious recording, you may find that you need more than one microphone, and there are other recording accessories which can ease and expand your recording activity.

There are a number of different types of microphone and there is always one particular type which is most suitable for a particular job of recording. The qualities to look for in any microphone are compactness, robust construction, high sensitivity to desired signals and rejection of unwanted sound such as background noise and hum, uniform response to all frequencies and suitable directional properties.

The four basic types which the amateur will be concerned with are known as crystal, ribbon, moving-coil and condenser microphones.

Ribbon microphones are of the 'velocity' type, which

means that they are actuated by the movement of air over a ribbon element. They pick up sounds from front and back, but they are 'dead' on either side. The shape of the field they cover leads them to be described as 'figure-of-eight' pattern microphones.

The other three types are known as 'pressure' microphones—they are worked by changes in pressure caused by sound waves. All of them respond equally to sounds from all sides and are, therefore, known as 'omni-directional'.

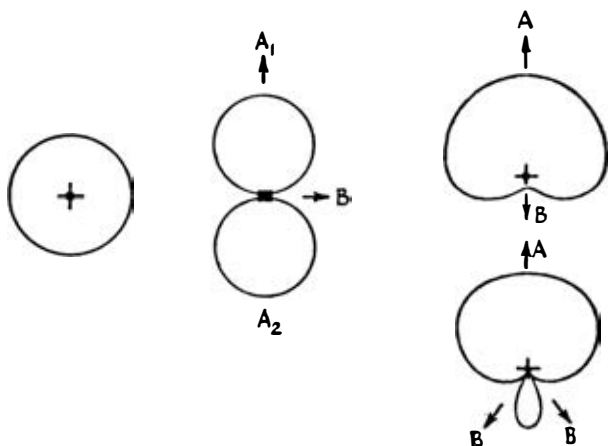
Some microphones operate with a combination of pressure and velocity, and the heart-shaped field from which they collect sound is said to give them a 'cardioid' characteristic.

Some of the advantages of the various types will be readily apparent. An omni-directional microphone is required to record a group of performers sitting in a circle. A figure-of-eight microphone is best suited to record a discussion between two people sitting opposite one another. A cardioid microphone may be desirable to record an artist on the stage and to suppress unwanted sound from the orchestra pit or echoes from the back of the auditorium.

Most microphones supplied with a recorder at the time of purchase are of the crystal type and, therefore, omni-directional. They give good results when used for interviewing, group discussions, natural sounds or music. Ribbon microphones, which many amateurs add to their equipment once they gain experience, are good for commentating against a noisy background and for hi-fi recording indoors of speech or music. If used out of doors, they must be shielded against wind and rain.

Crystal microphones have a high output and may be connected directly to the grid of an amplifier, but other types may need a pre-amplifier or transformer, and some

also need a polarizing voltage to be applied. When a matching transformer is necessary, it is often fitted within the microphone case, but a low-impedance ribbon or



MICROPHONE FIELDS

On the left is the 360° directional pattern of an omni-directional microphone. Centre shows the figure-of-eight pattern, with the axes of the microphones at A_1 and A_2 and the dead areas at B . Right above, the cardioid pattern and right below, hypercardioid, with axes at A and dead areas at B

moving-coil microphone will call for a matching transformer fitted near the recording amplifier—connected by about nine inches of screened cable. It will then be possible to use a longer microphone lead than the nine feet which would otherwise be about the maximum. With a crystal microphone, shorter leads are inevitable. If you increase the length of the lead supplied with the microphone, you will suffer loss of treble frequencies and of output.

For stereo recording, of course, at least two microphones are called for. They must be carefully matched or they may take the form of two identical elements mounted together in a single case.

As you become ambitious, you will not be satisfied simply to hold the microphone in your hand or to place it at the centre of a table. At that stage, you will find a wide range of stands available with which you can set up a microphone at any desired point in a room.

Crystal microphones are available priced at less than £2. Moving-coil microphones can also be purchased quite cheaply, but range over a wider price field. For about £10 you can get one with a cardioid field, and if you are prepared to pay up to £20 you can get an excellent microphone with a really first-class performance. Ribbon microphones cost from about £8 upwards—you can pay as much as £40 if you wish. Most condensers are very expensive, costing £100 or more, but one type sold for use with a domestic recorder is priced at six guineas. It needs a special type of input, however, to provide a D.C. voltage to polarize the microphone.

Other tape accessories which are valuable, if not essential, will be dealt with in later chapters, when we discuss the techniques which they make possible.

Buying your equipment

THERE are several ways in which you can gain useful advice and valuable experience before you part with your money in exchange for hi-fi equipment. There is one danger to avoid: the half-informed amateur bursting with dogmatic assertions. You know the type? You tell him you've bought an X transformer and he says, 'Oh dear, didn't you know? X transformers *always* overheat.' So you mention the turntable you've chosen, and he looks at you hard and declares with utter confidence, 'But there's always a terrible *rumble* on Y turntables.'

Avoid like the plague all the know-alls who have a black-or-white opinion on everything. The best you, or anyone else, can hope to do in this field is to collect the printed evidence and, if possible, a variety of opinions and to weigh them carefully in the balance to reach a judgement of your own.

The usual starting-point is provided by the advertisements in the magazines dealing with hi-fi and tape recording. You may not believe all that they say, but they provide a good preliminary guide to the range of equipment on the market and the principal differences between models. Advertisements by hi-fi dealers often have a special value, in that they list various classes of equipment in ascending order of price.

Financial considerations will probably be paramount in helping you to narrow your choice to half a dozen or fewer models in each category. You then write to the various companies asking for their full descriptive literature. A stamped addressed envelope should be sent with the request

and it is some indication of what sort of after-sales help you can expect if the information is sent promptly—or otherwise.

When it does arrive, spend half an hour enjoying the attractive photographs and the colour printing, and the remainder of a whole evening by the fireside carefully analysing the information given in the detailed specifications.

If you are to secure the highest-fidelity reproduction you require uniform response throughout the audio-frequency range (say from 30 to 16,000 c/s), a satisfactory hum and noise level (say better than 50 dB), proper control of other forms of distortion, adequate power output, and speed stability in the movement of disc or tape.

It is not difficult to produce splendid results in one or two of these respects at the cost of inferior performance in the others. It is not easy to produce a good overall picture. One of the most popular fallacies about tape recorders, encouraged by some advertising, is that a good frequency response is all-important, even at the sacrifice of other qualities.

As frequency response is so often given undue prominence, we will consider it first. Every sound has a frequency reference: the frequency of the recurrence of the vibrations which cause sound waves. This is expressed in terms of cycles per second, and the number can be measured. Middle C on the piano sends out 261·6 c/s. Frequency, it will be seen, corresponds to musical pitch.

The piano covers a frequency range from $27\frac{1}{2}$ to 4,000 c/s and the fundamentals of most musical instruments are contained within this range (but a pipe organ may reach down to 16 c/s and cymbals up to 16,000 c/s). Musical notes, however, are made up of fundamentals and overtones, or harmonics, and these latter are multiples of the fundamental

frequency, ranging up to 16,000 c/s for the principal instruments.

It is not necessary for hi-fi equipment merely to reproduce these frequencies; it must reproduce them at a certain constant quality. Even poor equipment may give *something* of the frequencies at either end of the sound spectrum, but it will not do it satisfactorily.

All frequencies must be passed to the listener without diminution, without substantially altering their relative amplitudes. Success or failure in achieving this is measured in decibels (dB), a measure of relative sound intensity.

An intensity change of 1 dB is barely perceptible to the average ear; a difference of more than 3 dB would be readily noticeable. Good reproduction, therefore, requires not merely the reproduction of frequencies between 30 and 16,000 c/s; this must be done with no greater variation in the intensity or volume of the sound than is represented by 3 dB.

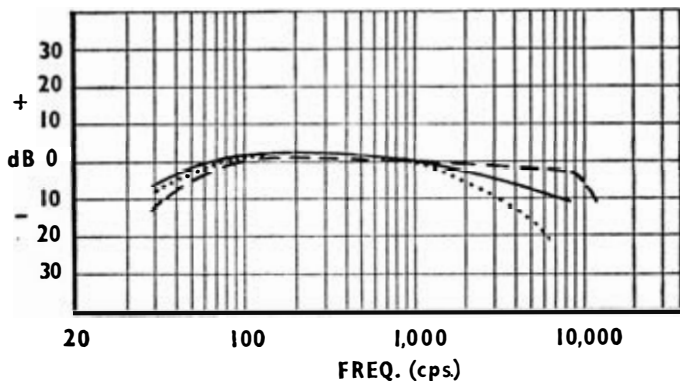
If the manufacturer's literature claims for a piece of equipment a frequency response of 50 to 10,000 c/s plus or minus 2 dB and/or 30 to 16,000 c/s plus or minus 3 dB, and if it lives up to this claim, it certainly qualifies, in respect of frequency response, as hi-fi.

Sometimes a frequency-response graph is printed and from this you can see at a glance the dB variation at any particular frequency.

This variation should be measured relative to a reference frequency—which is usually 1,000 c/s. Using an output meter across the loudspeaker terminals of an amplifier, adjustment is made to secure a reading of zero at 1,000 c/s. Other frequencies are then fed in, without any change being made in the input signal level or the amplifier gain control, and the output meter will give plus or minus readings for

each. In this way the frequency-response graph can be plotted. When studying frequency-response claims, always look to see if the reference frequency is given.

The decibel is used again as a means of measuring background noise and hum. All amplifier valves and transistors and all resistors generate some noise and the slight ripple in a D.C. supply, obtained by rectifying A.C. mains voltage, also contributes hum. In the early days of stereo discs, some pickups gathered hum from turntable motors, but this problem has now largely been solved. As I have already suggested, a signal-to-noise ratio of better than 50 dB is



FREQUENCY RESPONSE GRAPH

The performance of a recorder has been plotted at three different speeds on this graph, with 0 dB at 1,000 c.p.s. as a reference. The broken line shows response at $7\frac{1}{2}$ i.p.s., the unbroken line at $3\frac{3}{4}$ i.p.s. and the dotted line at $1\frac{7}{8}$ i.p.s.

desirable. Sometimes it is expressed as minus 50 dB (— 50 dB). This means 50 dB below the level of the true signal, and thus it is an expression of the noise-voltage at the output terminals of an amplifier relative to the full output.

There are other forms of distortion which arise in amplification, such as intermodulation, which is often caused by overloading. In effect, two frequencies 'add together' to create a third one that was not present in the original signal. Intermodulation distortion up to two per cent at peak power is not normally noticeable.

Power output is another important factor. I have stated earlier that for listening in an ordinary room an output of 2 or 3 watts may be adequate, but that there will be definite benefits if 10 watts are available. Many domestic tape recorders deliver only 2 or 3 watts from their internal amplifiers, and this is as much as their built-in speakers are capable of handling. Many hi-fi power amplifiers provide 20 or 30 watts. You will need at least 10 watts to handle bass reproduction of 30 c/s. For stereo, 5 watts for each channel should be satisfactory.

You will probably find in manufacturers' literature a number of other specification details, such as 'push-pull output' and 'negative feedback'. Splendid; practically all hi-fi amplifiers use these techniques nowadays to reduce distortion. You do not have to understand the theory behind them.

Specifications published for loudspeakers are among the most puzzling of all to the layman. Claims about the frequency range covered are easily understood, of course, but what are we to make of such information as 'flux density, 14,000 gauss'? Well, the gauss is the unit of magnetic induction—but stop worrying about it. You must not be blinded by science; insist on being guided by your own subjective experience—buy the speaker that sounds best to you!

When you come to link together various units, you must see that they match. In the manufacturers' literature you will

see references to impedance, with measurements given in ohms.

In any A.C. circuit, various factors combine to impede the flow of current. The effect is termed impedance. The importance, for the user of electronic equipment, lies in the fact that the impedances of units which are to be linked must match. A loudspeaker may have an impedance of 3, 5, 10, 15, 20 or 800 ohms. A microphone may have a low impedance, say 20 or 30 ohms, or a high impedance, measured in thousands of ohms (kilohms) or millions of ohm (megohms) or it may have an impedance in an intermediate range, such as 600 ohms.

In general, there are two broad ranges of impedances—low and high. If you always connect low-impedance units to low-impedance inputs, and high to high, you are not likely to get into serious difficulties. You can also connect a low-impedance output to a high-impedance input quite safely; you may then find, however, that there is not sufficient power properly to load the other equipment. Impedance mismatching can also lead to distortion and loss of bass response in speakers, but if you do have to use a 3 ohm speaker on a 10 ohm output you should get acceptable results.

You must be careful when using any microphone with a recorder other than the one supplied with it originally. Ribbon microphones are low impedance and should be plugged into the appropriate socket; crystal microphones are high impedance and feed into a different socket. Similarly, if you are transferring a recording from one tape to another ('dubbing') the output from the first (playback) machine must match the input to the other (recording).

Fortunately, manufacturers usually provide adequate information about impedances and you should have no difficulty in matching. When necessary, it is possible to

obtain matching transformers to deal with difficult cases.

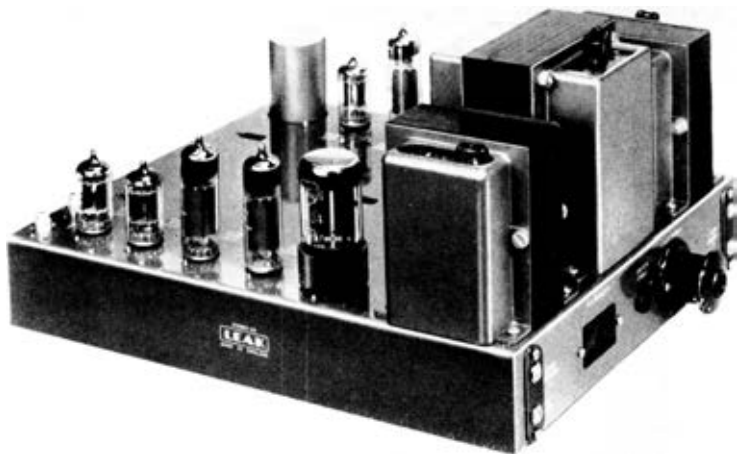
There are some circumstances, when linking different hi-fi units, in which you will also have to pay careful attention to what is called sensitivity—the relationship between input required and stated output. Normally pre-amplifiers match amplifiers, and amplifiers match speakers, without difficulty. You may have to watch, however, that microphones or pickups are suitable for the tape recorders or amplifiers with which you propose to use them. Here again, manufacturers usually provide all the information you need to guide you. The problems involved are nothing like as complicated as they may sound when set down in detail here.

In your study of specifications you will, of course, pay attention to the information provided about the various controls incorporated in amplifiers and recorders. You will need volume and tone controls (preferably separate treble and bass controls) and a balance control when handling two channels for stereo. Stereo units may have separate controls for each channel, or they may be 'ganged' so that they operate together.

You may find some units provided with 'filters' to exclude high-frequency stylus-scratch or low-frequency rumble.

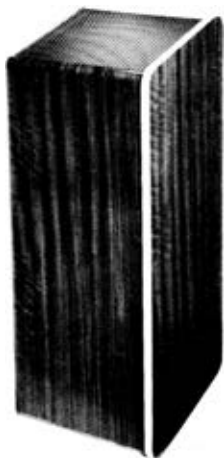
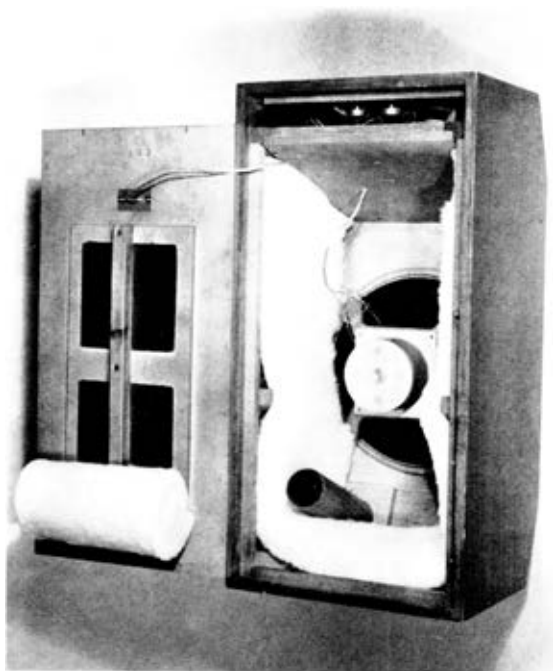
If you are buying disc-playing equipment, you must study information about stylus radii and pressures. These have assumed a new importance since the advent of stereo. Stereo discs call for a stylus tip less than two-thirds the size of those used for monophonic reproduction. This smaller tip will, of course, ride deeper in the groove and so tend to cause more damage at each playing of a disc—unless the pressure, or tracking weight, can be reduced.

Today styli for stereo have radii of 0.0005 or 0.00075 in., known among hi-fi enthusiasts as 'half-thou' and 'three-

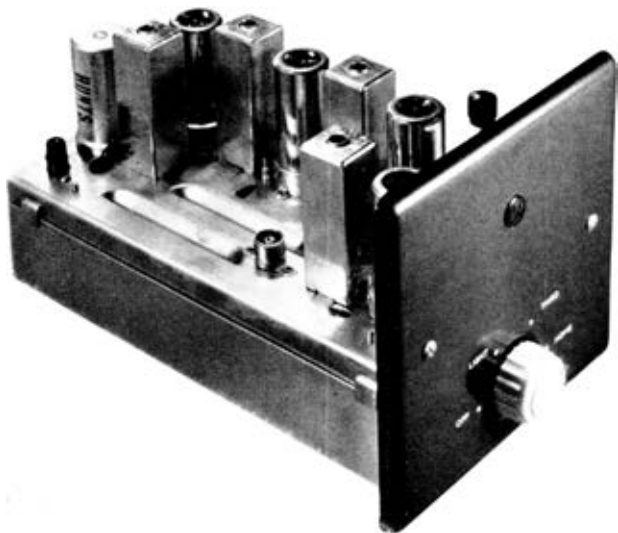


Above: A stereo power amplifier designed to handle two sound channels. (H. J. Leak & Co. Ltd.). Below: Speaker-drive unit—this is a 10-inch model, with a paper cone. (Goodmans Industries Ltd.).

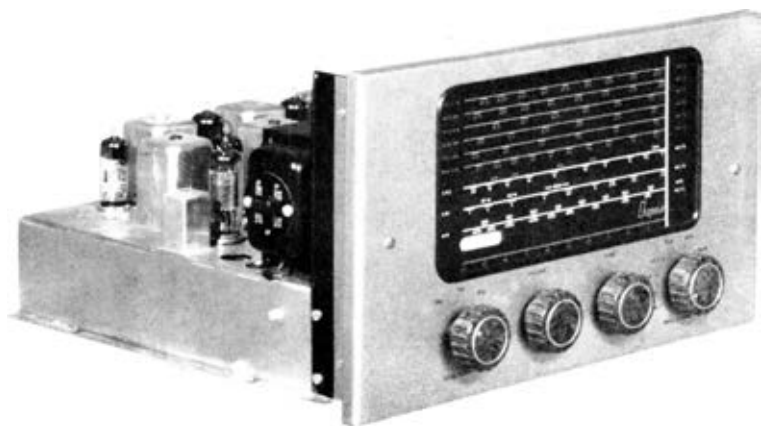




Above: Interior of enclosure incorporating three-speaker system, showing construction and damping materials. (Wharfedale Wireless Works Ltd.). Left: Column speaker—this model stands 37 inches high and incorporates three drive units. (Rogers Developments Electrical Ltd.).



Above: A switched radio tuner—this model provides reception of the three British programmes (Rogers Developments Electronics Ltd.). Below: AM/FM radio tuner (C. T. Chapman (Reproducers) Ltd.).





Above: A stereo amplifier and control unit—the Emisonic-Orthotone 555, one of the most ambitious units of its kind on the market, which has 14 input positions and supplies 10 watts per channel. *Below:* Stereo pick-up arm and cartridge—a model designed for the keen enthusiast at an intermediate price (*The Gramophone Co. Ltd.*).





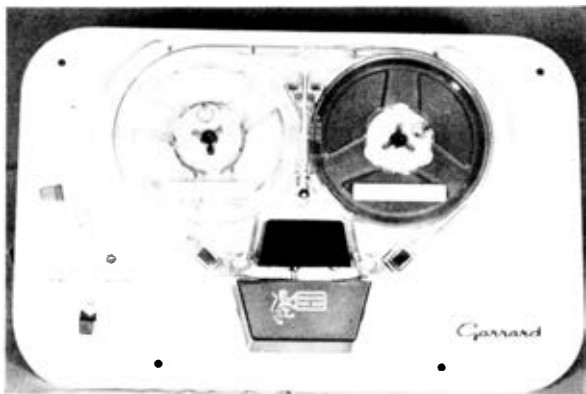
Above: Magnetic stereo cartridge designed for half thou diamond stylus (Burne-Jones & Co. Ltd.). *Below:* Variable speed disc transcription unit—this model has a variable speed control and can be operated at between 30 and 80 or between 15 and 18 rpm (Goldring Manufacturing Co. (Great Britain) Ltd.).





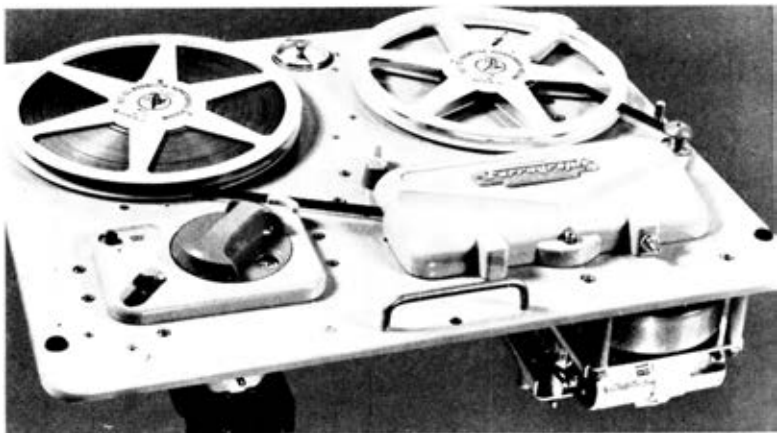
Above: Medium price tape deck—a three-speed ($7\frac{1}{2}$, $3\frac{3}{4}$ and $1\frac{7}{8}$ ips) deck used in many medium-priced domestic recorders (*Collaro Ltd.*). *Below:* Modestly priced tape deck—a single-speed ($3\frac{3}{4}$ ips) deck incorporated in a large number of recorders at the lower end of the price range. (*Birmingham Sound Reproducers Ltd.*)





Above: Tape magazine deck—the first British-made deck to use tape loaded in plastic magazines or cassettes. This deck has been used in several modestly priced recorders. (*Garrard Engineering & Manufacturing Co. Ltd.*). *Below:* Battery portable recorder—one of the smallest and lightest battery portables offering quality recording at $7\frac{1}{2}$ ips and speech recording at $1\frac{7}{8}$ ips (*Fi-Cord Ltd.*).





Above: Semi-professional deck—one of the best-known British tape decks, offering semi-professional standards (*British Ferrograph Recorder Co. Ltd.*).
Below: Semi-professional recorder offering wide range of facilities; chassis suitable for rack mounting or fitting into carrying case (*Pamphonic Ltd.*).



quarter thou'. Tracking weight with the smaller radius should not exceed 2 grammes and with the larger radius it should not be more than 4 grammes. With clever balancing technique, we may soon have available pickups offering considerably lower tracking weights than these.

Specifications for pickups (and also for stereophonic tape recorders) are also likely to quote a figure for 'cross-talk'—meaning the leakage of signal from one channel into the other. This, if serious, can destroy the stereophonic effect. At 1,000 c/s the cross-talk figure should be better than 20 dB, which would mean that the unwanted signal on each channel would be less than one-tenth the true signal.

Whether you are buying disc- or tape-playing equipment, you need to pay very careful attention to the speeds provided and to the tolerances quoted in speed stability. Disc turntables need to operate at $33\frac{1}{3}$ r.p.m. and 45 r.p.m. to handle modern micro-groove records, and at 78 r.p.m. for the older type of record. Tape decks may be built to operate at one single speed or at two, three or even four different speeds. The most popular tape speeds for the amateur are $7\frac{1}{2}$, $3\frac{3}{4}$ and $1\frac{7}{8}$ in. per second. For work requiring very high standards, 15 i.p.s. is still used; for speech recording, some recent domestic recorders have been equipped with an ultra-slow speed of $\frac{1}{16}$ in.

I shall consider presently the relative value of these different tape speeds. Here I want to discuss long-term speed stability and slight, sudden speed fluctuations known as 'wow' and 'flutter'. Wow is a relatively slow fluctuation in pitch (up to five times each second) and flutter a high-speed fluctuation. Both are particularly noticeable on slow piano music, or you can check more accurately with a steady 3,000 c/s tone on a test disc or tape.

Wow and flutter of less than 0.3 per cent are tolerable—

at that level, in fact, you will have difficulty in detecting it, except on piano music.

One of the best-known quality tape recorders in the under £100 price range quotes these figures, which may be taken as the kind to be aimed at: operating speed within two per cent of nominal; long-term speed stability, better than 0.5 per cent; wow and flutter, less than 0.2 per cent at $7\frac{1}{2}$ i.p.s.

We must consider now those mechanical details which will appear only in the specifications of tape recorders: speed, number of tracks on the tape, reel size, rewind time.

Something has already been explained about tape-recording speeds. The higher the speed used, the better will be the quality. You must decide, therefore, what uses you are likely to have for your machine. If you want it to record good music with the utmost fidelity, one of the recorders that operates at 15 i.p.s. will be worth your while. If you want it mainly to listen to recordings of classical music, $7\frac{1}{2}$ i.p.s. is the best speed—it gives excellent reproduction and it is the speed at which the majority of tape records have been made available. If you are more interested in popular music and well-reproduced speech, $3\frac{3}{4}$ i.p.s. will be satisfactory.

If you are only concerned to record speech, and economy is more important than fidelity, the slow speeds of $1\frac{7}{8}$ or even $\frac{1}{8}$ i.p.s. may prove quite adequate. Many people, of course, find a happy compromise by purchasing a machine with two speeds: usually $7\frac{1}{2}$ and either $3\frac{3}{4}$ or $1\frac{7}{8}$ i.p.s.

The faster the playing speed, the more tape you will use to record a given piece of music or speech. You must pay attention, therefore, to the size of tape reels that can be accommodated by different machines. Some battery portables will take only 3 in. diameter reels; many mains-operated models accommodate only 5 in. or $5\frac{3}{4}$ in. reels. There are obvious advantages in those which handle 7 in.,

or even $8\frac{1}{4}$ in. reels. Operating at $7\frac{1}{2}$ i.p.s. and using the thinnest 'double-play' tape, you can get 32 minutes of uninterrupted recording or replay from each track with a 5 in. reel, but 64 minutes—just twice as much—with a 7 in. reel.

Another factor concerning tape economy is the number of recording tracks on the tape. The tape itself, of course, is identical, whether a single track, two, or four tracks are provided for: always it is a quarter-inch-wide plastic tape coated with ferrous oxide. Whether recording is two-track or four-track is determined by the recording and replay heads fitted to the tape recorder. Naturally, each time you double the number of recording tracks, you halve their width.

Four-track recording means that you will get twice as much material on to a given spool of tape as with two-track. There will, however, be some disadvantages. The signal-to-noise ratio will be less satisfactory than with a two-track machine, unless the amplifier circuitry and the screening arrangements are improved—and this costs extra money. The outside channels in a four-track system use the tape right up to its edges and both because of manufacturing problems and normal wear in daily use the edges may have slight imperfections that will affect the quality of recording and playback. Another difficulty is that the tape transport system must be of very high quality to ensure that there is no serious 'up and down' movement of tape as it passes the heads. Yet another consideration is that tapes cannot be edited by cutting and splicing—a technique with which we will deal later—if you have to safeguard material recorded on several tracks.

Two points emerge from all this. Four-track recording is very attractive if you wish to record economically: for example, long conference sessions. It is very suitable, too, if

your main use of a tape machine is to play lengthy passages of uninterrupted music. It will, however, be wise to spend your money on good basic quality, rather than the dispensable 'extras', if you decide to buy a four-track model.

Another item in the specification of a tape recorder which should be examined seriously is the 'fast rewind' time. When the full length of a tape has been passed through the machine, moving from left to right, on record or playback, it will end up spooled on the right-hand reel. On the majority of machines, it is then necessary to do one of two things. Either you lift off both reels, turn them over and reverse them, so that the tape is again on the left-hand reel and ready to be passed through (but with another track opposite the magnetic heads), or, if you do not wish to use a further track, you must rewind the tape back on to its 'parent' reel. This latter operation is performed with the fast rewind facility.

Similarly, in order to simplify and speed up the finding of any particular point on a recorded tape, 'fast forward' movement of the tape is provided for.

Taking 1,200 ft. of standard tape on a 7 in. reel as an example, fast rewind in anything less than one minute is extremely good—assuming, of course, that the spooling is smooth and that braking is positive. Some machines, however, operate at much slower speeds, taking between two and three minutes for this length of tape. One minute more or less may not be considered very important, but it is surprising how impatient you can become!

Manufacturers' specifications for recorders usually set out a variety of other built-in facilities, the significance of most of them fairly obvious. There will be details of the various inputs and outputs. Other points which may be listed are:

monitoring, mixing, superimposition, level indication, place-finding and safeguard against erasure.

Monitoring is the ability to listen through earphones or a built-in speaker to the signal you are actually recording on the tape. It is an extremely useful function, though the vast majority of amateur recordists cannot or do not use it.

Mixing is the ability to feed two or more signals into a recorder through different inputs and to have independent control of each so that they may be faded in and out and 'mixed' as required. Again this is a valuable facility and a number of domestic recorders now provide it. For those that do not, separate mixers are available; they accept three or more different inputs and provide a single output—the 'mixed' signal—to the recorder to which they are connected.

Superimposition is a simpler method of blending two signals on a single track, but, in general, a less satisfactory one. It involves putting one recording on top of another, by cutting out the normal erase function while the second recording is made. Unfortunately, many of the machines which provide for superimposition do not allow the original recording to be heard while the second recording is superimposed. It is possible, of course, to superimpose more than once on the same channel. Theoretically, you can record yourself playing the piano, then the violin, and then singing an accompaniment, so that you end up with a recording on which you are apparently doing the three things simultaneously; in practice, you may find it a tricky operation.

Every tape recorder has some form of level indicator. In effect, these indicate the current in the recording head. If there is too little, then your recording will have an unsatisfactory signal-to-noise ratio. If there is too much, the result, in terms of distortion, can be serious. Most domestic recorders have a 'magic eye' type of indicator, with luminous

segments which converge on loud passages. They should just touch on peaks. Some recorders, including all professional models, have, instead, level meters on which precise peak volume readings are shown.

It is often very important to be able to find quickly a particular passage on a tape recording and most recorders are fitted with some type of 'place indicator'. Usually it is a digital counter, giving a straight statistical reading, like a cyclometer or the mileage indicator of a motor-car speedometer dial. Sometimes, it is a clock-type dial giving a reading corresponding to the revolutions of the spools.

Most recorders now have some form of safety catch to prevent accidental switching to the 'record' position, which might result in erasing treasured recordings. It must be counted a deficiency in any domestic machine if such a facility is omitted.

With the information provided in this chapter, it should prove a straightforward matter to comprehend and to assess the details given in the manufacturers' specifications for various items of hi-fi equipment. You should be able to make a preliminary choice of units which are worth further investigation in your particular case.

The next step is to ascertain whether any of the chosen equipment has been tested and reviewed by the magazines covering hi-fi and tape recording. Test-reviews appear in all of them regularly, so that over a year quite a number of models are dealt with. The judgement of independent reviewers will be extremely valuable, particularly their measurements of frequency response, signal-to-noise ratio, and suchlike, which can be set against the manufacturers' claims.

And now it is necessary to call upon your dealer. You should choose him with care. Many small dealers provide an

excellent individual service and will spend a lot of time talking over the pros and cons of various items of equipment. If they have become genuine hi-fi specialists, their opinions, based on experience, should be given considerable weight.

As against these advantages, some of the smaller dealers may not have the ideal listening conditions in which you can compare the performance of various units. Some big hi-fi centres in the large cities have now installed 'comparator' units—an ugly name, I think, for a very valuable service. A wide range of all types of hi-fi equipment is linked up in such a way that various combinations of amplifiers, speakers, pickups or tape decks can be heard, and compared, by the flick of a switch or the change of a jack-plug. The swift comparisons which are thus made possible are of tremendous value in forming a judgement—unless you have an exceptionally acute ear and retentive memory, in which case these new-fangled aids may not seem necessary!

When listening to music, concentrate on the lowest and highest frequencies. The big bass drum, the organ and the cello can provide some music at the lower end to help your judgement. The violin and the piccolo are suitable for assessing the higher frequencies. Listen to a recording of vocalists in order to judge the middle register. Hear some slow piano music to check for speed instability. And try a fortissimo passage from, for example, Beethoven's Fifth Symphony, to test for distortion.

It is a good idea to test disc equipment with a record of your own or, at any rate, one you know well. For one thing, this will enable you to see what the controls on the amplifier are capable of achieving.

With amplifiers or complete tape recorders, turn them up to full volume and see whether the hiss or hum level (when no record is being played) is obtrusive.

If you are buying an expensive pickup, try blowing gently from one side of it. If it is likely to track freely, it should float out towards the centre of the turntable and come to rest gently (this floating action may be reduced, however, if some type of fluid is used at the pivot, as is the case with certain expensive models).

If you are buying a tape recorder, you should operate its controls yourself at the demonstration in the dealer's shop. See that they are positive. Is the spooling of tape on fast rewind smooth and even? Is braking instantaneous, without any spilling of tape? Use all the controls.

Then check that the input and output sockets are easily accessible and try tape loading to see that it is simple and straightforward.

Finally, and this is vitally important, insist on hearing a replay of recordings made in your presence on the microphone supplied with the machine and, preferably, do this at all available speeds. Playback of pre-recorded tapes is insufficient.

If you do all this, with courtesy and understanding of the dealer's point of view, as well as insistence on satisfying yourself, you should find yourself, in due time, with a first-class hi-fi system—the best that your money, in the quantity in which you can afford to spend it, will buy.

Fitting it into your home

THERE are more jokes and cartoons about hi-fi wives than there are about golf widows. The very first thing you have to do, if you are a married man, before contemplating a hi-fi system is to get your wife on your side!

Your hi-fi system will have to be set up in a room of your home and, unless you are fortunate enough to have a fair-sized study which is suitable, it will probably have to be the sitting-room. In order to get the best results from the system, it may prove essential to rearrange some of the furnishings. I need say no more!

On the other hand, there is one apprehension that most wives have that you can remove immediately. Hi-fi does not entail trailing wires all over a room, or knobs and switches looking incongruous among the polished surfaces of contemporary tables and cabinets. All the 'working parts' can be concealed from sight.

When you get your equipment home from the dealer and set it up, you will almost certainly find that it sounds quite different from the reproduction it gave in the shop. Every room has its own acoustics, and they affect considerably the reproduction you get. To give yourself some understanding of the importance of this, try playing your radio or gramophone or tape recorder in your bathroom and then in a softly furnished room of similar size, and note the contrast.

The polished surface of the bath, the tiled walls and the absence of upholstery or heavy curtains will give your bathroom excessive liveliness. On the other hand, a small room

with wall-to-wall carpeting, heavy velvet curtains and upholstered furniture is likely to be too 'dead' for satisfactory reproduction.

It is all a matter of the 'reverberation time', the experts explain. When you listen to sound reproduced, you hear not only the direct sound from the speaker, but also reflected sound from walls and other surrounding surfaces. It is common sense that sound waves will bounce back off a polished surface, such as glass or ceramic tiles or plain walls, with little diminution in strength, whereas much of the sound will be quickly absorbed if it reaches thick carpets, curtains and cushions. In the first case, then, the sound will travel back and forth from one surface to another for some time before it fades out completely. The reverberation factor of a room is the time it takes for a sound to fade to one-millionth of its original volume. In the average sitting-room it should not exceed half a second.

If there is insufficient reverberation, music will sound thin and lifeless; if there is too much it will blare. I have heard that the ideal set-up would be a room about 25 ft. long, 15 ft. wide and 10 ft. high, with carpet covering two-thirds of a wooden floor, a moderate amount of furniture, and two-thirds of the walls left plain. Few people will have such ideal conditions.

Solid floors of brick or concrete make it very difficult to get satisfactory reproduction of bass notes; on the other hand, a springy wooden floor, with another room underneath it, might provide excessive bass response—and cause trouble with the people underneath.

These are some of the problems you may encounter. But it is more probable that, if your sitting-room is an average one, you will quickly get good results after a minimum of experimentation with speaker placing.

Deciding the best place for the speaker—or speakers, if you are to have a stereophonic system—calls for careful thought. Your room may be an odd shape. It may not be possible to use any of the corners in it. A corner speaker, which will give a good sound spread over the whole room and is often the best type for monophonic reproduction, would, in such a case, be impossible. You might have to settle for a speaker at one end of the room—near one of the shorter walls if it is an oblong room.

Wherever you place your speakers, see that the wall immediately behind is uncluttered, so that the sound waves that travel backwards from the unit get plenty of opportunity to be reflected back into the room.

Consider the placing of speakers in relation to the most convenient listening area. Many speakers are directional, spreading their sound in a fairly narrow beam. You certainly don't want to sit outside the area defined by two imaginary lines projected forwards at right angles from the centre of the speaker. Neither should you sit too close to speakers. The best listening position will be at least six feet away, and this becomes even more important when listening to stereo.

In many rooms, of course, choice will be severely limited by doors, windows, radiators or fireplaces, and the like. Rarely will you be able to use the ideal positions; you must do the best that is possible in your own particular circumstances.

Manufacturers have tried to be helpful. They have produced 'bookshelf' speakers which, as the name suggests, can be accommodated on any convenient shelf; 'column' speakers, which occupy very little floor-space and from which the sound is projected upwards and dispersed equally in all directions; and, in the case of 'tweeters', units that will

stand on top of larger enclosures or can be suspended from a wall.

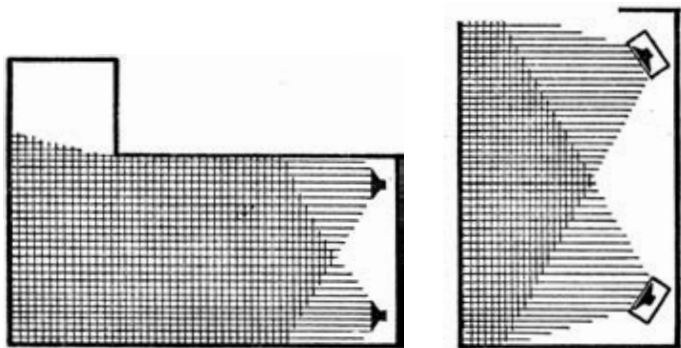
When you come to arranging a stereo system, with two speakers arranged in a fixed pattern one to another, and both in special relationship to the listening area, quite complicated planning may prove necessary. Though it may seem now to be excessively troublesome, you may find it extremely useful in the long run to draw and cut out, using stiff paper, scale plans of your principal items of furniture and of the hi-fi equipment to be accommodated. Draw a scale plan of the room and 'juggle' with the cut-outs within the available area until you devise the most satisfactory theoretical positioning. Then try it out in practice. It is much less tiring and irritating to move around small pieces of paper than large pieces of furniture.

The most usual arrangement of stereo speakers is to have them near the corners of a room, at each end of one of the shortest walls, pointing down the length of the room. They may face directly forward; they may be aligned towards one another, so that the axes of the two speakers intersect somewhere near the centre of the room; or they may be arranged facing outwards, so that the sound is reflected off the side walls (this is often a good arrangement in a small room). The only way to discover the best arrangement is to experiment with different angles, until you find the one that provides the best stereophonic spread of sound over the maximum area of the room. You should aim to secure it over at least half of the floor area. This listening area will always be larger if the speakers are placed on a narrow wall than if they are placed before one of the lengthwise walls.

If you have a room that is L-shaped or has deep alcoves, you are unlikely to be able to extend the stereo effect into the recesses. Arrangements may be found, by experiment, to

cover *a part* of the second half of an L-shaped room, but there are limitations to what is possible.

In many homes, I am sure, stereo speakers are placed on either side of the hearth, as this may be the only convenient



PLACING THE SPEAKERS FOR STEREO

More of the room will get the full stereo effect if the speakers are positioned against a short wall rather than a long one. You cannot hope to extend stereo effect into deep alcoves

arrangement. The chances of getting good stereo over an appreciable area of the room are not too bright in such cases.

When setting up speakers for stereo reproduction, by the way, you must make sure that they are in phase: that is, that the diaphragms of the two units are vibrating in concert. Unless this is so, you will not get the true stereo effect. To check, feed an identical signal into both channels at identical levels and see if the sound appears to be located midway between the two speakers. If you are in doubt about it, change over the connexions to one of the speakers. When you get the best result, the speakers will be in phase.

Thus far we have considered only the placing of the loudspeakers, but your hi-fi system includes also amplifier,

disc- or tape-playing deck (or tape recorder), and perhaps a radio tuner as well. Where are they all to go?

It will be most convenient and tidiest if they can all be put into a single cabinet. If you are starting with a portable recorder or gramophone, of course, it is likely to be contained in an acceptable cabinet or carrying case, and the whole thing can be placed on an occasional table, preferably with storage space underneath to accommodate discs or tape. If, however, you have built up your system with a number of units from different manufacturers, you will need to bring them together in a cabinet made by one of the firms which specialize in hi-fi furniture. These are usually not cheap—anything from twenty guineas upwards—but most of them are superbly well made and will fit in with the smartest contemporary or period styles.

The most popular type of cabinet appears to be the long, low coffee-table type, with a hinged lid or flaps which rise to give access to turntable, tape deck and amplifier controls. But there are cabinets of all types, enabling the various items of equipment to be assembled in any desired way. There should be no difficulty in getting everything into a single cabinet—except for the speakers which, as I have pointed out, should be in separate enclosures for performance reasons.

Many enthusiasts, of course, build their own hi-fi cabinets, and their task has been greatly simplified by the variety of the materials now available on the market for 'do it yourself' constructors.

There will have to be a power lead from the mains supply to the main equipment cabinet, and other leads from the amplifier to the speakers. Make sure that they are arranged in such a way that no one is likely to trip over them, possibly disembowelling the equipment in the process! I had to have

a new power point fitted when I installed my equipment and I took the opportunity, while the floor-boards were up, to have my speaker extension leads drawn under the floor from the point at which the equipment cabinet stands to the positions for the two speakers. In this way I have avoided any loose leads in the room. A simpler alternative, of course, is to tuck them under the edges of carpets or fasten them, with insulated staples, to skirting boards. If there is a spare length of lead and you have a good reason for not wanting to cut it back to the appropriate length, wind it around a simple reel, or coil it and slip a rubber band over it to prevent it trailing.

If you get this far in organizing a smart, tidy housing for your system, don't spoil the effect by neglecting to provide for some of the smaller items that you will inevitably collect: discs or tapes, of course, and accessories such as disc-dusting devices, stroboscopic discs, magnetic head depolarizers, microphones, mixing units, and so on. Some of these items will go into any convenient drawer, but certainly discs and tapes deserve proper storage facilities.

Discs should be kept in their dust-covers and preferably in a dust-proof cabinet. They should be kept upright and never allowed to rest at an angle. If, because there are insufficient discs in a compartment to keep them upright, they are liable to topple over, use books or something similar to pack the excess space. Otherwise you will find they have warped.

Similarly, tapes should be kept dust-free, preferably in metal cans or sealed boxes, and stood on edge.

When you have collected sufficient of either, you will doubtless wish to compile a catalogue; proper storage cabinets then become essential if your filing is to follow any scientific principle.

How it works

As with a motor-car, so with a hi-fi set-up: you can, if you choose, operate the controls and get the results you desire without comprehending fully how everything works. But it is altogether more satisfying to have at least an elementary knowledge of the principles upon which the apparatus functions.

A brief historical survey will provide the best framework for this explanation.

Sound was first reproduced on a working gramophone devised and constructed by Thomas Alva Edison in 1877. The sound track was engraved on tinfoil wound on a cylinder which was rotated by hand. Once the basic idea had been evolved, improvements followed quickly: first, the use of a wax cylinder and, in 1888, the earliest flat round discs, copies of which could be pressed in very much the same way as today.

For the recording process, a large horn was used, the small end of it sealed with a piece of mica, to which a needle was fixed. When sound waves picked up in the horn caused the mica to vibrate, the needle transferred the vibrations to the wax record. For reproduction, of course, the method was reversed.

This was acoustic recording, without the aid of any of the electronics which have now revolutionized the business. And almost until the eve of the last war, there were many hi-fi enthusiasts who swore by the acoustic gramophone and its large horn and scorned the new electrical techniques.

Science, of course, eventually overwhelmed such conservatism. Microphones and magnetic disc cutters took over in the recording studio, valves were used for amplification, the magnetic pickup was devised to transform the groove contours into an electrical current, electric motors brought a new stability and longer running time to gramophone turntables.

The first electrical revolution in the world of hi-fi was complete long before 1939.

During the war, a second revolution was carried through. For many years—for almost as long as the life of the gramophone—research had been going on in the field of magnetic recording, using wire or steel tape drawn past magnetic heads. But not until the Germans produced a suitable plastic tape was the way opened for the manufacture of the tape recorder of the kind with which we are now familiar. By 1945 German radio stations were transmitting whole programmes with machines that were basically similar to those now used.

Progress continued on the disc side. A new compound became available for the manufacture of the discs, but at first it seemed too expensive for general use, though it possessed the substantial advantages of being unbreakable, relatively noiseless and giving superior wearing quality. In 1948, however, the availability of such discs became all-important when the technique of micro-groove recording was perfected and it became possible to impress forty-five minutes of recording on a single disc. This justified the higher cost of the basic materials and in June 1950 the first long-play records of an entirely new type were marketed in Britain.

Pickups with lighter tracking weights were called for, but research had been going forward on this front, too, and the

necessary equipment was quickly available, using sapphire and diamond styli. Big improvements in studio recording techniques came along at about the same time.

Then followed stereophony. Again, the idea was not a new one; back in 1931 a British genius, Alan Dower Blumlein, had patented details of a disc stereo recording and reproducing process which is essentially that in use today. After the last war, stereophony was introduced on tape—a vastly simpler business. The two sound tracks could be recorded side by side on the tape and played back without running into the complex design problems arising with discs. Stereo tape records were on sale in Britain and the United States by 1955. In America they had a considerable success, so that within two years over 100 new titles were being added to the catalogue each month; but Britain moved more slowly and cautiously.

By 1958 the problems of making and playing stereo discs had been solved (with the aid of tape 'masters'). The discs were pressed in the same way as long-play records, and they sold at approximately the same price. As stereo tapes could not be duplicated as quickly or easily as discs, the economic advantage was with the latter and, in addition, there were more people equipped—or partly equipped—to play discs. To date, therefore, the stereo disc has enjoyed a considerable triumph over tape but, as slower tape speeds and, possibly, four-track recordings achieve good quality, the balance may change significantly.

Such is the bare story of the progress that has produced, in the course of little more than eighty years, the impressively high-fidelity equipment of today.

The main principles of recording and reproduction with discs will have emerged in what I have already written, and I do not intend to go into a great deal of technical detail,

for the number of enthusiasts who consider this worth while is small.

When you place a commercial recording on the turntable of your gramophone and set it revolving, the pickup transforms the mechanical vibrations it registers into electrical impulses. These are passed back to the amplifier and so to the external loudspeaker.

We have already considered briefly the need for a light playing weight at the stylus, for otherwise your discs will quickly wear and deteriorate. At the same time, a pickup must be mechanically robust and it must trace the disc groove accurately and without tending to jump out during loud passages.

There are great difficulties in devising a pickup arm that will track with the necessary fidelity. As the stylus moves along the groove towards the centre of a disc, the angle at which it rests in the groove inevitably changes, for the arm is on a fixed pivot. This variation in angle is reduced by using a curved pickup arm and also by increasing the length of the arm.

In the case of stereo discs, of course, the stylus registers two sets of vibrations from the groove, representing the two sound channels. The two walls of the groove, each at 45 degrees to the surface and at 90 degrees to the other, register the two channels—one on each wall. The right-hand stereo signal is engraved on the groove wall nearest the edge of the disc and the left-hand signal on the wall nearest the centre.

The stereo pickup must be able to translate these two independent modulations into independent voltages. It is not necessary to comprehend all the technicalities to appreciate that this is a considerable achievement. The movement of the stylus simultaneously generates voltages in each of two crystals: movement induced by one groove wall produces a

voltage in only one crystal and movement in the second groove wall only affects the other crystal.

It is crucially important that the two signals do not become mixed by 'leakage' from one channel to another. If that happens to any excessive degree, the stereo effect is destroyed. This fault is known as 'cross-talk'; a figure of -23 dB at 1,000 c/s is necessary to achieve hi-fi quality.

A problem that has worried some newcomers to stereo who already had monophonic equipment is summarized by the single word 'compatibility'. It will seem obvious from what I have written in the few preceding paragraphs that you cannot play stereo discs with a monophonic pickup. In fact, some manufacturers have suggested that this is possible; maybe . . . but I strongly advise against it. You will be placing valuable discs in jeopardy.

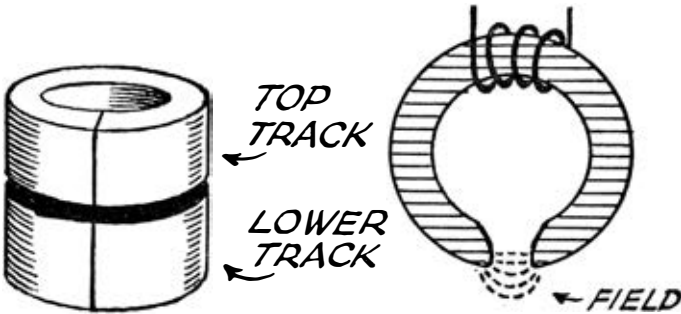
It is possible, however, to play monophonic discs with a stereo pickup. A stereo installation does not make your monophonic library of discs obsolete. The effect of playing a mono disc through stereo equipment will be to appear to produce the sound from an area midway between the two speakers. You will almost certainly find the result more pleasing than straightforward reproduction through a single speaker.

Now let us turn again to tape recording and examine its essential principles. The magnetic tape, coated with ferrous oxide, moves from one spool to another across a magnetic head—a ring of magnetic material, wound with a coil of insulated wire. The ring—usually of 'mu-metal'—is broken at the front by a gap, the width of which may be no more than 0.00012 in. When an electric current is passed through the coil, a magnetic field is created across this gap.

Tape passed through this magnetic field acquires varying degrees of magnetization. The pattern on the tape as the

minute crystals of iron oxide react corresponds to the field pattern produced at the head gap. The intensity of current in the coil is related to the sound waves supplied to a microphone, which of course, transforms them into electrical current.

During playback, this process is reversed and the varying intensity of magnetization of the tape induces in the head



Magnetic recording head

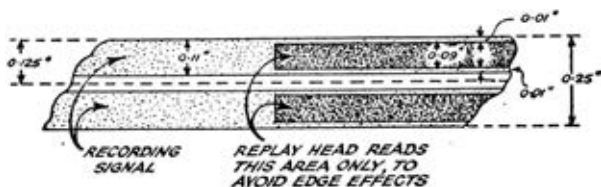
winding varying voltages. Thus, an electrical output is provided by the coil, identical with the original electric current fed to it during recording.

In domestic recorders the same magnetic head is often used for recording and playback, and sometimes the same amplifier, too. When separate heads are provided, one advantage is that you can monitor the signal a fraction of a second after it has been put on the tape.

Almost all recorders, however, have an additional head provided for erasing. This is supplied with a high-frequency alternating current, creating a strong alternating magnetic field which removes any signal from the tape. A high-frequency oscillator is incorporated in every recorder to

generate a suitable current for this purpose and to supply a magnetic 'bias' during recording. Without this bias applied to the tape before the recorded signal, distortion would occur.

The gap in the record replay head must be at right angles to the line of travel of the tape, or treble response will be sacrificed. Fixing the head at this precise angle is known as



Recording and replay tracks on tape

'azimuth adjustment'. When not correctly made, quality will always suffer, though this will not be as obvious if you replay only those tapes made on the same machine as it will be immediately you try to play a commercial tape record and any other tape recorded on a machine with perfect azimuth.

In the early days of tape recording the full quarter-inch width of the tape was used for a single sound track and most professional machines retain this feature. Domestic models, however, changed over to dual-track (or half-track) operation immediately technical progress made it possible to secure satisfactory performance with the narrower track width involved. And, more recently, we have seen the introduction of four-track (or quarter-track) recording on an increasing number of machines.

Different types of record/replay heads are required, according to the number of tracks handled. You cannot play a tape which carries four recorded tracks on a machine with

heads designed for only two tracks; the result will be an incoherent gabble or a formless noise, for what you will be doing is hearing two tracks simultaneously—and one of them played in reverse!

If you have a recorder that handles the narrow quarter-track, however, you will be able to play on it any tapes which have been recorded single-track or dual-track; you should get an acceptable result, but you will not get the full quality available if such tapes are replayed using the full width of the recorded signal.

The availability of two or four tracks running parallel along a tape opened up the way to stereo. At first, two separate heads were used—one recording or replaying the top track, another, close beside it, handling the bottom track. This was known as the 'staggered-head' system. With the development of heads capable of handling two tracks simultaneously, there was a general change to the so-called 'stacked-head' principle.

When a tape carries only one recorded channel, or dual stereo channels, it will be played from left to right and, at the end, will need to be fast rewound on to the 'parent' spool. With two-track monophonic or four-track stereophonic tapes, this is not necessary. When the tape has been played from left spool on to right spool, the spools are reversed, so that the tape is again on the left side and ready to be played again, handling the other track(s). After two (or four) playings, the tape is, of course, back on the parent spool again.

There is not, at the present time, any general international agreement on standards for four-track. The vertically stacked heads are all of one general pattern, each in two sections, one playing the upper outer quarter track and the other the lower inner quarter track. But track numbering

follows a different pattern with different manufacturers and there are variations in track width. It is very desirable that confusion should be cleared up quickly.

Whatever system of track numbering a particular manufacturer selects, in fact tapes made on one four-track machine can usually be played back satisfactorily on any other four-track machine.

There is lively debate among the tape *cognoscenti* about the wisdom of this switch to four-track. The main aim is, of course, economy in the use of tape. An alternative approach to economy is in the improvement of recording quality at slower tape speeds, and a great deal of effort has been put in on this front—with notable success. Naturally, some folk would like to have the best of both worlds and hope to enjoy hi-fi with four-track tapes playing at $3\frac{3}{4}$ i.p.s.

Well, it is reasonable to suppose that we shall, in due time, achieve satisfactory results in this form. Recording and reproduction has already reached a very good standard—adequate for speech and for some popular types of music. But genuine hi-fi still demands higher tape speed or wider recording track.

Magnetic tape

WHEN you buy a tape recorder, you will, almost invariably, have a reel of tape provided with it. It is possible to use that one reel over and over again, erasing one recording as you make another; quite a few people, probably, never get farther than that. If you learn to use a recorder properly, realizing its full potentialities, you will want to buy more tape; you may well end up with a shelf full of tapes beside the machine.

If you set out to build up a library of tapes, you will have to decide which type best suits you and your recorder. Magnetic tape looks a very simple, straightforward product, but you will find that there is a bewildering variety of brands, types, thicknesses and lengths to choose from.

The most important classification can be made into degrees of tape thickness. The three varieties now available are standard (0.002 in.), long-play (0.0015 in.) and double-play (0.000825 in.). Standard having enjoyed a good start over the others, it has been the most widely used tape to date, but long-play has already overtaken it in popularity with keen tape-recording amateurs, and we are likely to see this pattern repeated now that double-play is universally available.

The thinner the tape, the more can be accommodated on any given reel, and the longer the available uninterrupted recording or playing time. For any given length, long-play tape provides fifty per cent more playing time than standard tape, and double-play—as its name suggests—gives twice as much.

The reduction of tape thickness has been the result of the development of suitable new base materials.

The first tape was produced in Germany with a homogeneous mixture of polyvinyl chloride (P.V.C.) and iron oxide powder. It was expensive, however, and the quality of recording was not the highest.

Development switched, therefore, to tape in two 'layers': a base material carrying a coating of iron oxide. The firms which moved into the field were those already manufacturing products which could easily be adapted to the new requirements—one which made paper tapes, others which manufactured photographic film or plastic foil for packaging.

Some early tapes, then, used a paper backing and pioneer enthusiasts in Britain had some experience of them: they could still occasionally be found in some shops in recent years. They lacked strength and sensitivity.

Most of the early standard tape used cellulose acetate as base material, and it remains popular today. It lacks sufficient strength for use in long-play tapes, however, and P.V.C. and polyester have been increasingly used. P.V.C. is tensilized—or stretched—during the process of manufacture and possesses great strength; it has less tendency to curl than acetate. Sometimes, however, the stretching may produce surface defects known as 'pin-holes' or irregularities in thickness, but these faults are detected during the rigorous factory inspection and removed. Polyester is a particularly tough and flexible plastic with many properties similar to P.V.C. Both are particularly suitable for use in tropical climates.

Other, somewhat similar, plastics are used for certain brands of tape. In the United States, 'Mylar' (the trade name of a synthetic resin manufactured by one particular firm)

has proved popular. From Germany comes another plastic base known as 'Luvithern'.

Magnetic tape should not break under any load of less than 4 to 5 lb. and permanent stretching after application of half this load should not exceed 0.2 per cent.

So much for the base. Even greater care, skill and specialist knowledge is involved in the production of the magnetic layer, which is generally composed of about seventy per cent iron oxide and thirty per cent binder. On standard tape this coating must not exceed a quarter of the total thickness of 0.002 in.

Needle-shaped crystals of iron oxide measuring between two hundred thousandths and four hundred thousandths of an inch in length must be dispersed evenly through the coating. Upon the success of this operation will depend the smoothness of the tape, the degree of contact as it passes over the magnetic heads, and the quality of recording and reproduction.

When the base material has been coated, it is polished and then passed through a slitting machine, which produces from a wide roll of film anything up to sixty quarter-inch tapes. The maximum tolerance permitted in width is 0.002 in.

The magnetic characteristics of tape are measured as 'coercivity' and 'remanence'.

Coercivity concerns the magnetic hardness of the material and is expressed in oersteds. Low-coercivity tapes (up to 200 oersteds) provide a poor frequency response and signals are easily erased. High-coercivity tapes (300 oersteds and over) give good, clear recording of the higher harmonics.

Remanence is a measure of the flux available to give a signal to the replay head—it expresses residual magnetism and sensitivity.

Improvements in coercivity and remanence have played a

vital part in making possible lower tape-operating speeds. Tapes produced in 1948 with a coercivity value of something like 120 oersteds needed to be played at 30 i.p.s.

The performance of a tape cannot be divorced from the machine on which it is used. It is usual, as I have said, for manufacturers to supply a particular brand of tape with their machines: it may be assumed that the machine has been adjusted in order to achieve optimum results with that brand. You may find, however, that other types perform equally well; it is sensible to experiment.

During recording, as explained in the previous chapter, a high frequency bias is applied to the tape and this bias should be determined by reference to the magnetic coating on the tape used.

Of equal importance to type and thickness of tape, when you are buying, is length. Magnetic tape is spooled and sold in varying lengths between 175 and 3,600 ft. The smallest reels are of 3 in. diameter and are used on battery portables or for the exchange of short tape messages recorded on mains machines. The most popular sizes on domestic mains-operated machines are 5 in., $5\frac{3}{4}$ in. (a continental standard) and 7 in. These reels will take, respectively, 600 ft., 850 ft. and 1,200 ft. of standard tape. Larger reels of $8\frac{1}{4}$ and $10\frac{1}{2}$ in. diameter are available, but not many domestic recorders are capable of accommodating them.

Prices of tape vary, according to brand. At the time of writing, 3 in. 'message' reels of 150 ft. are available at 5s 6d; 1,200 ft. of standard tape costs between 27s and 35s, 1,800 ft. of long-play tape about 50s and 2,400 ft. of double-play about £4—the last three on 7 in. reels.

Although few people are likely to choose their tape by the design of the reel on which it is wound, this is not an unimportant matter. It is a familiar argument in the trade

that women are discouraged from using tape recorders because of the apparent difficulty of attaching a loose end of tape to the hub of the take-up spool. For myself, I have never found this particularly tedious and it occurs to me that women are a good deal more skilful than men at threading a needle.

Many types of reel are available. Most are of transparent plastic, although it is possible to buy aluminium reels. The important thing about any reel is to see that it does not become deformed so that it scrapes the tape deck or catches the edge of the tape and so prevents it winding evenly. Metal reels are less likely to develop such defects but are, of course, more expensive.

Many reels provide a long slot from the outside edge along one 'spoke' and into the centre hub. This enables one end of the tape to be drawn through the slot to the hub, instead of having to push it between the two flanges and manipulate it towards the centre. At the hub, the tape end can be anchored in a small round recess or a slot or, in the case of the metal reels referred to above, by a spring-clip.

Whether all this ingenuity is sufficient to save the orthodox reels in face of the challenge from tapes entirely contained in 'cassettes' (or magazines) is yet to be seen. In this country only one design of cassette has been produced so far, but it has been incorporated as the standard on a number of different recorders.

It aims at the utmost simplicity of operation; the cassette is dropped on to the tape deck as simply as a disc is placed on a gramophone turntable. Two 4 in. spools are enclosed in the transparent plastic casing. Automatic anchorage is provided to prevent tape spilling.

No reliable figures are available of the consumption of magnetic tape, but it is clear from the number of firms which

have newly entered the market in Britain, and from the obvious expansion of production of the more familiar brands that sales have been rocketing.

At the same time, the technique of recording television images on magnetic tape has been perfected and special 2 in. wide magnetic tape has become widely used in TV studios.

In computers, programming devices, electronic information-storage apparatus and machine-tool operation, magnetic tape is also being increasingly used. It has played a vital part in bringing automation to industry, at the same time as it has helped to change the pattern of modern leisure. Few products of such apparent simplicity have had such far-reaching consequences.

Taking care of your equipment

THE hi-fi perfectionist can easily be presented as a figure of fun. A cartoonist has portrayed him looking like a surgeon in an operating theatre, bent over his turntable, dressed in white overalls and breathing mask and snapping at his wife (dressed like a nurse): 'Dust-bug . . . anti-static fluid . . .'

The unsympathetic layman may become bored or impatient however, when he encounters personally the elaborate preliminaries to be mystically performed before the hi-fi acquaintance is prepared to 'play some music'.

Is all this fuss really necessary?

If you have spent a lot of money on a high-fidelity set-up and if you want to enjoy the full potentialities of the equipment, then the greatest care must be taken. It is mainly a matter of common sense; failure to apply it is usually the result of insufficient knowledge about the equipment.

The grooves on a modern long-play or stereophonic disc are as thin and as delicate as a hair from your head. Very little is needed to damage them. If you are foolish enough to wipe the palm of your hand across the surface of a disc you may harm it in three ways. You will push any dust on the surface down into the grooves, where it will act as a grinding powder. You will transfer from your hand a thin film of natural oil (the sort which produces finger prints on clear surfaces), and this will attract and hold more dust. And, if there happens to be any minute speck of anything hard or brittle on your hand, it will scratch the grooves.

Modern discs do require the most delicate and careful

handling. They may be unbreakable, but they are very easily damageable.

The record companies do their part by selling them packed in polythene inner covers and strong (and colourful) outer sleeves. When not being played, they should be kept in these, the open end of the inner cover being pushed first into the sleeve. In this way, an efficient barrier against dust is maintained.

Dust is the great enemy. Because of the nature of their material, microgroove discs have electrostatic dust-attracting properties. In any normal room there is soft, fluffy dust and hard, abrasive dust. Most of the first kind can be gently blown off a record. The abrasive dust must be cleaned off with one of the gadgets or preparations sold for the purpose: a slightly moistened plastic sponge, a specially treated cloth or tissue, or a 'dust-bug', which is a nylon bristle tracking in the groove in association with a velvet pad moistened with cleaning fluid.

If discs are played when dusty, damage is done in two ways. The impressions on the groove walls will suffer, and the sapphire or diamond stylus will wear and deteriorate quickly, acquiring the character of a chisel, and destroying yet further the groove undulations. Your disc will lose its hi-fi quality in no time.

Even if you combat dust effectively, the stylus will still wear with usage, of course, and it is of crucial importance that you should judge correctly when it needs to be renewed. This is not easy to decide. You may examine the stylus regularly with a microscope, but few people want to go to those lengths. You can do it by ear—by waiting until you hear some deterioration in playing quality; but there is a danger that, by that time, some irreparable damage will already have been done. Finally, you can do it by rule

of thumb; you can replace the stylus after so many playings.

Unfortunately, a lot of contradictory advice has been given on the matter of how much use can safely be made of a stylus. One manufacturer suggests that a safe life is 200 12 in. diameter LP sides with a sapphire stylus and thirty times this life with diamond points. A qualification is added: 'If a very high performance with regard to distortion is the criterion, then the above figures may have to be halved.'

A second manufacturer reports that the period of 'absolutely undistorted' production with a sapphire is about 25 hours, but that most people will be unable to detect a falling-off in quality in fewer than 75 hours, while adequate protection for discs will be secured if sapphire styli are used for up to 125 hours.

If you take this advice—either 200 sides or 125 hours—regard the figures as maxima. If you use a diamond needle, you can multiply these figures by at least ten. With care, it can be used for several thousands of playings.

If you look after your discs and stylus in this way, your long-play and stereo discs should last indefinitely. Certainly, you should be unable to detect any significant deterioration after 200 playings.

The pickup arm must, of course, move freely so as to avoid unnecessary side pressure in the groove, and the tracking weight of the needle must be kept to a minimum.

The other rules for keeping discs in good condition are the obvious ones. Store them away from heat, keep them out of the sun's rays, do not leave them in too dry an atmosphere. Once you have more than a dozen or so records, keep them stacked on edge, all those of one size together, and all kept scrupulously upright—never at a slight slant. When your library begins to grow, start to catalogue the discs, so that

you are able to find the one you want without handling all the others in a major shuffling operation.

The last paragraph applies equally to the care and storage of magnetic tapes. They, too, must be kept dust-free, preferably in polythene bags contained inside boxes or metal cans. They should be kept in a stable temperature, as close to 60° Fahrenheit as possible.

It is important that the edges of tape should not be chafed or damaged and spools should be discarded and replaced if their flanges become deformed out of plane.

All spooled tape should be kept away from stray magnetic fields, as otherwise recordings may be damaged. Cases have been known of tape records despatched by air mail from one country to another which have arrived with no surviving signal! Store your collection well away from your loudspeakers or any other equipment likely to have an associated magnetic field.

A problem that is peculiar to magnetic tape—but which need not arise if you take precautions—is called ‘print-through’. This is the transfer of a signal to other parts of the tape which are adjacent when the tape is spooled. Four or five layers of tape on each side of the signal may be affected in serious cases, and ‘pre-echo’ and ‘post-echo’ are heard when the recording is played.

The trouble usually arises with loud passages which have been over-recorded. The first need, therefore, is to watch the level indicator when making a recording, to see that you do not over-record. Store the tapes carefully and at intervals of not more than a year put them through your recorder on ‘fast forward’ and ‘fast rewind’.

How long can a recording be preserved if all these precautions are taken? No one yet seems to know the answer to that—tape recording is too young an activity to have pro-

vided us with the practical experience. A few years ago the Rockefeller Foundation financed research by two American scientists into the best methods of preserving and storing recordings. They reported: 'While the short history of the use and storage experience with modern sound recording materials is a distinct handicap to the formulation of precise conclusions as to the future behaviour of these materials, the results of this study indicate that the potential storage life of existing sound recordings in ordinary library environments is somewhat longer than would be expected by the scientist and considerably shorter than is desirable to the librarian.'

In less portentous language, recordings seem to store well, but for just how long we don't yet know!

The tape recorder also needs careful maintenance. Record/replay heads must be kept properly aligned, and they must be kept clean. The slightest deviation in the position of the heads from a right angle to the direction of tape travel will result in loss of treble response. With a test tape, it is practicable (though not easy) for amateurs to adjust the heads; if you are doubtful about tackling it, consult your dealer.

The heads may become coated with iron oxide from the tape and with dust. Remove the protective cover which normally surrounds the heads and wipe them over with a soft rag or brush. If the manufacturer recommends it, use a cleaning agent (e.g. carbon tetrachloride); not otherwise, as it might possibly harm the casing or part of the head itself.

After considerable use, a head may acquire some permanent magnetism, resulting in increased tape noise. Demagnetization is done with a 'defluxer' or 'degausser'—several models are available at a modest price, or you can have it done in a moment by your dealer. This should be

routine practice at regular intervals; otherwise you will find you are putting background noise on to any tapes you play and you will never be able to restore them to their original quality.

The speed of a recorder is governed by a capstan and an associated pressure roller or pinch-wheel. One is rubber-surfaced and the other is smooth; the tape passes between them and they are only brought into contact when the machine is switched to the record or playback positions. When not in use, the two should never be left in contact, or the rubber-coated wheel will be deformed and wow or flutter will result.

It is equally important that no dirt, dust, oil or grease should be allowed to get on to either capstan or pinch-wheel.

The pressure pads must also be kept clean and properly adjusted, though no difficulty should normally arise with them.

These are simple and fairly obvious rules, but they are easily overlooked when one feels relaxed or lethargic, or impatient to record or to listen to music. It is foolish, however, to invest the considerable sums required for hi-fi and tape equipment unless you are prepared to take time and trouble to maintain it at a peak of efficiency.

The music

THE range of music which you can now hear in comfort in your home is astonishing; its availability is the result of one of the most exciting, yet least recognized, revolutions in the world of entertainment during the last forty years.

There are, first, the radio programmes—providing music of every possible type during many hours of each day. Not only can you keep in closest touch with all the latest developments in the world of ‘pops’ by listening to the B.B.C. Light Programme; if you tune in to the Third, you will hear a wide repertoire of music which is aimed at the connoisseur and the specialist. In recent years, the B.B.C. has become adventurous in introducing lesser-known works into its famed symphony concerts, so that today, without doubt, the listener has a choice of music for listening such as has never before been available.

Future possibilities are even more exciting. Regularly, on alternate Saturday mornings, the B.B.C. transmits a programme of music stereophonically. The left-hand channel is sent out on the Network Three medium-wave and VHF transmitters, and the right-hand channel is handled by the B.B.C.’s television sound transmitters. Anyone who possesses both a radio receiver and a TV set is thus able to sample stereophony. The fact that the two amplifiers and speakers will not be matched will make it difficult to secure really first-class results, however, unless you are able to use a full stereo hi-fi arrangement.

That will mean taking the two signals and feeding them into your hi-fi pre-amplifier and so to your two speakers. If

you use a radio tuner, it will already be incorporated in your system and it will provide the left-hand stereo channel. There are four ways in which you can add the right-hand channel. One manufacturer sells a special tuner for the purpose. If you are game to try some home construction, you can easily secure the circuit diagram and the parts with which to build one yourself. Or you can take the signal from your existing TV set.

This may appear to be the obvious and easy method, but there is a difficulty. On most TV sets the chassis is live and any attempt to make a connexion may end up with your being electrocuted. Your dealer, however, will have no difficulty in modifying the circuit for you. The fourth alternative is to buy a secondhand B.B.C. television set cheaply and to extract and arrange as a separate unit the sound channel receiver. A dealer, again, will be able to help you

Stereo broadcasts are unlikely to become more frequent for some time, but my own forecast is that they will be a principal feature of broadcasting by the middle 1960s. Much pioneer work has been done. The B.B.C. carried out stereo experiments in 1926 and its present series of broadcasts began in 1957. They are, however, admittedly of a temporary nature, designed to provide working experience for studio engineers as much as to introduce stereo to the listening public. It is not practicable frequently to 'borrow' two wavelengths to transmit one programme, as is done for these sessions.

The future lies with a system with which two separate signals are transmitted simultaneously from one transmitter and received and separated by a single receiver (but, of course, using two loudspeakers). At the same time, it must be possible to pick up and reproduce the programme

monophonically on an ordinary single-channel radio receiver.

This is a considerable technical problem, but it has already been largely solved. In fact, there are a large number of alternative systems undergoing trial. We are unlikely to hear stereo programmes more frequently until these trials have reached a point at which agreement can be reached internationally on the best system to be adopted. The optimists appear to believe that the European Broadcasting Union may be able to reach a conclusion by late 1962.

Stereo, it is now widely admitted, has got off to a somewhat shaky start in this country. It is doubtful if it will come into its own until stereo radio is available to supplement stereo disc and tape as a source of musical programmes. When that happens, however, the initial cost of installing a full two-channel system will appear reasonable to many more people.

The B.B.C., for its part, should not hesitate, because the numbers who now possess stereo hi-fi are limited, to press forward as boldly as possible.

A number of amateur enthusiasts have used the present Saturday morning experimental broadcasts in order to make stereo recordings.

The technique is basically the same as for recording an ordinary radio programme. With a radio tuner incorporated in a hi-fi system or linked to a tape recorder, it is only a matter of throwing the right switches. If you have only a radio set and a recorder, you need a line from the extension speaker socket of the radio set to the radio input of the recorder (you can never record satisfactorily by placing the microphone in front of the radio loudspeaker).

If the tape recorder is of substantially better quality than the radio set, it will pay to tap the radio signal direct from

the volume control of the receiver. This is again a job for an expert, for it may mean making a connexion with a live chassis.

If you take a little trouble in arranging the best possible method, if you experiment in order to get the right level each time you record, and if you use a tape speed of $7\frac{1}{2}$ i.p.s., the results should be outstandingly good. You may not wish to record announcements between various items. If you are agile, you may be able to get to the recorder in time to use the pause control and so to eliminate them. I find it less tiring and less of an interference with the mood which music creates to cut out the unwanted pieces of tape later, using the editing technique described in a later chapter.

There are certain types of performance which, recorded in this way on tape, produce a more satisfactory result than that achieved in studio performances arranged by the commercial recording companies. A *rapport* can be built up between orchestra and audience. Many jazz-men have been known to speak sadly about the uninspiring conditions for free improvisation offered by the average studio.

In general, however, most of your listening is likely to be done from commercial records—discs or tapes. With these, you can build up your basic library of the music you like. They ensure you flawless performances, with the world's greatest artistes, recorded in technically perfect studio conditions.

The catalogues of the major recording companies reveal at a glance what a wealth of material is available today. Four times each year *The Gramophone* publishes two record catalogues—one listing classical discs and tapes and the other light, dance and jazz issues. Each catalogue is a bulky volume of several hundred pages. The latest classical catalogue to hand at the time of writing lists many thousands of

records. The issues of works of composers such as Bach, Beethoven and Mozart fill many pages.

The interests of minorities are well represented. The student and the teacher will find series of records produced to trace the growth of musical form—from the chanting of Tibetan lamas to the twelve-tone compositions of Schoenberg. Some of the smaller companies have unearthed works which might otherwise have remained undiscovered. It is now possible to gain a comprehensive impression of baroque music from discs; similarly, certain composers have been made the subjects of diligent and relentless campaigns by particular companies, so that everything they composed—whether good, bad or indifferent—has been recorded for posterity.

You may not wish to spend your money on these more esoteric recordings, but you may be able to borrow them from the record libraries which are now coming into existence in most parts of the country.

Despite all that has been said above, titles do sometimes disappear from the catalogues which seem to most of us sufficiently important or interesting to deserve continued production. The companies' choice can sometimes be capricious. This is merely an argument, however, for acting quickly to secure the records that particularly appeal to you.

Tape records were first produced commercially in this country in 1954 and less than a year later came the first two-channel stereophonic tape records. Today several hundred titles are available, divided about equally between classical and popular music.

This is, of course, a small selection when set beside the disc catalogue, but the popular pieces are all included—the Mendelssohn Violin Concerto, the 'New World' Symphony,

the Strauss waltzes, and the like—and there is a particularly good selection of operatic pieces.

Progress in marketing and popularizing tape records has been bedevilled by uncertainty about future standards. The first records were two-track, playing at $7\frac{1}{2}$ i.p.s. A few years ago some issues were made, by newer firms in the field, at $3\frac{3}{4}$ i.p.s. No sooner was the market settling down on this basis than the advent of the first four-track recorders raised the question whether tape records should be made on a four-track basis. The great handicap of the tape record has been its relatively higher production cost, for it cannot be copied as easily and quickly as a disc. There were some, therefore, whose thoughts turned longingly to the idea of four-track $3\frac{3}{4}$ i.p.s. as a desirable future standard; it would enable sufficient material to be contained on a single tape to bring the price into line with that of discs. Unfortunately, we are not at all sure yet that satisfactory high-fidelity reproduction is possible with this arrangement.

Within the last year or so, other possibilities have been introduced, in the form of tape records contained in magazines or cassettes. Early in 1960 C.B.S. Laboratories in the United States announced a new tape playback system, using a tape only one-seventh of an inch wide and contained in a cartridge (yet another word for magazine or cassette!). The tape plays at only $1\frac{7}{8}$ i.p.s. and provides sixty-five minutes' reproduction without interruption. The whole cartridge is only 3 in. square and $\frac{1}{8}$ in. thick and several can be stacked up and lowered in turn on to the playback deck, as with an auto-change gramophone.

This new type of tape record has been promised in the shops in America during 1961 and European concerns have acquired rights to market it later.

Will it revolutionize the reproduction of recorded music?

It is too early to be sure. Another giant American concern has decided, as a matter of long-term policy, to standardize on quarter-inch tape carrying four sound tracks and playing at $7\frac{1}{2}$ i.p.s. My own view is that the two systems—miniature-cartridge playback decks and orthodox tape recorder-reproducers—will go forward side by side for many years yet.

All of this experimentation, although perhaps inevitable and indeed desirable, has created some confusion in the public mind. The sooner the industry is able to reach firm conclusions about the future, the better for everyone.

At the same time, the customer who decides to 'wait and see' before buying his equipment may find himself waiting a long while. By the time he decides to proceed, the chances are that advancing age will have brought a deterioration in his hearing so that he will have missed full-frequency-range hi-fi for ever!

Joining a club

HUMAN beings are gregarious, but many of us in this country are unenthusiastic about organizing ourselves in clubs. The man or woman who enjoys the personal pleasures of listening to good music well reproduced is probably a self-sufficient, philosophical type with less inclination than the average to look for 'organized enthusiasm'.

There are, however, some very good reasons why the newcomer to tape recording and high-fidelity reproduction should associate himself with others who have knowledge and experience.

There are gramophone clubs all over the country for those whose interest is limited to the playing of discs and to music appreciation in general. Many of them are old-established. Their members include pioneers who have acquired a store of wisdom about equipment, recordings and wider musical matters that may be freely drawn upon. Lecturers keep the membership informed on current developments. Co-operation enables everyone to keep in touch more fully with the latest programmes of the recording companies.

Tape-recording clubs are newer, and their scope is much wider. At the beginning of 1961 there were well over one hundred evenly distributed over the country, and others were being formed at the rate of several each month. Their activities are co-ordinated by a Federation of British Tape Recording Clubs which is, in turn, affiliated to an international organization known as the *Fédération Internationale des Chasseurs de Son*.

The first tape recording clubs were formed in the United

States, but claimed an international coverage and recruited some members in Britain. By the early 1950s, enthusiasts here had formed their first national organization. As the ownership of domestic recorders increased, the natural unit of organization became the local town club and the movement to organize on this basis began with a swing in the autumn of 1957.

The international and national clubs still exist, but they have developed into clearing-houses for the names and addresses of individuals who wish to exchange message tapes with each other. Each organization produces regularly a detailed register of members, with personal information designed to assist in the selection of a suitable 'tape-spondent' with whom to communicate.

In this way, many thousands of people all over the world have established contact and are regularly exchanging tapes which contain not only verbal messages but much documentary and feature material about ways of life. I know several enthusiasts who are regularly in touch with three or four continents and the quality of friendship and understanding which results from such communication should not be underrated. This type of activity should be particularly valuable when undertaken by schools.

It is not essential to join a club in order to participate in these exchanges, for the names and addresses of willing tape-spondents are published regularly in the tape-recording magazines.

The local tape-recording club does not normally concern itself with tape-sponding. It is interested in equipment and its most effective use, with the achievement of the highest standards of performance. Lectures are arranged, but there is also a good deal of practical work with members' equipment. Not only can useful comparisons be made between

different recorders, but certain types of recording activity which would be difficult or impossible, working with a single machine at home, can easily be undertaken on a co-operative basis. The most obvious example is that of copying (or 'dubbing') tapes from one machine to another.

Members can also arrange a pool of associated equipment—microphones, mixer units, test tapes and so on—which will help to enlarge the experience and activity of each individual.

We shall discuss later the various forms of tape feature which may be recorded. Here it is only necessary to emphasize how much more confidently one will tackle such a project if there is a fellow enthusiast at hand with whom problems can be discussed as they are encountered.

Since 1957 there has been an annual British Amateur Tape Recording Contest, and this is now organized in close association with the Federation of British Tape Recording Clubs and includes special categories for clubs and schools, as well as for individual entries. Several times in recent years the winners of prizes in this contest have been relative newcomers to the hobby; yet they have sometimes gone on to win awards in an international contest with which the British event is associated.

There is one special kind of organized club activity that should have a strong appeal to many people, for it is a form of social service. It is the production of programmes on tape for the aged, the sick and the blind. In many districts churches, Toc H groups and other similar organizations have begun this type of work, with the enthusiastic support of tape amateurs. In other centres, the tape clubs themselves, or groups of individuals within them, have taken the initiative.

One of the simplest examples of what can be done is the recording of church services. This is now widely performed,

and the tapes are then taken, with a recorder, to the homes of the sick and the infirm and played back. It is a simple task, but it requires the sort of organization which a club can best provide.

In the case of hospital patients, more ambitious schemes have been started. In East London, for example, one group meets twice a month in a civic theatre and records a thirty-minute programme which is distributed to thirty hospitals. Light entertainment and religious programmes are included. Local artistes and celebrities take part. Everyone gives his or her services free.

There are still many hospitals which are not able to provide radio for the patients. Those that do are often able to distribute a tape feature programme over the headphones provided at each bed. After the customary diet of radio programmes, many patients welcome something with a local angle. In particular, there is often considerable psychological value in letting a patient who may have been in bed for some time hear familiar sounds from outside—the characteristic noises of the market-place or the football ground or the inn.

Sometimes, too, it is possible to bring to sick or aged folk recorded messages from relatives who are unable to visit them. There have been many cases where this service has been provided quickly, without cost, across frontiers and oceans, as a result of the efforts of tape clubs.

The special value of tape to the blind will be evident. For several years a number of individuals, groups and clubs have been preparing special programmes for circulation among blind contacts. Recently the Royal National Institute for the Blind has announced that between 10,000 and 20,000 blind people are likely to be equipped with a special type of tape reproducer during the next few years. This will enable them to be regularly supplied with 'talking books', in the form of

cassettes containing tape sufficient to provide twenty hours of playing time.

Though this ambitious scheme is now getting under way under the auspices of the R.N.I.B., the opportunities for the individual and the club remain immense.

There are few fields of activity in which membership of a club can provide such scope for artistic endeavour, technical experiment and useful service to one's fellows.

Tape-recording ideas

A TAPE RECORDER requires to be used with considerable self-discipline. It inevitably starts life as a novelty to its owner, who is impatient to record and replay something . . . anything. Therein lies the danger. If it is treated as a toy the chances are that you never will record much that is worth while. If you treat it as a tool for creative activity, you will find that its potentialities are almost limitless.

When you first take the machine from its packing, you will take a quick glance at the instructions, plug into the mains supply, switch on and begin recording. Everyone does. You will, however, have few ideas of what to record, so you will begin by reading some of the manufacturer's literature, or you will say 'This is Jim Jones testing his new recorder' and then dry up, or you will try to pass the responsibility to another member of the family, with the result that all you will get on the tape will be a reiterated appeal to 'come on, say something'.

All this is excusable on the first day, but be firm with yourself after that. Do not start recording unless you have a clear idea of what it is you are seeking to put on the tape. Give every tape programme you record a shape and pattern, and a planned content.

If you use the machine for tape-spontaneity, there are no difficulties and only one danger. That is that you will go on talking too long. Use the smallest size of spool and do not feel yourself obliged to fill all of the tape. I have suffered. When I first established a magazine for tape-recording enthusiasts, many of the readers felt it was appropriate that

they should send all communications to me in the form of tapes. Unfortunately, some of them insisted on using five-inch reels of tape and they recorded on both tracks. The result was that it took me over an hour to hear what they had to say and there was no means, as with the written word, of skipping through and detecting the salient points. Life became purgatory. I had to rig up a tape recorder in the bathroom, so that I could listen to tapes as I shaved and bathed each day.

So, when recording messages on tape, keep them brief. Always begin by identifying yourself and giving the date.

The same problem of verbosity arises when one uses a tape recorder to compose articles or talks. There have been a number of successful authors who have dictated their books—Edgar Wallace was one—but I believe they will always be exceptions to the general rule. Good writing requires a discipline which is almost impossible when facing a microphone.

If, however, you have to speak in public, a practice run on tape will be extremely valuable. You know how long you will have when you face your audience. You can time yourself at your rehearsal in front of the recorder, and you can look for the faults when you listen to the playback. I hope you will not suffer the fate of the clergyman who sent *himself* to sleep!

A recorder is sometimes useful when interviewing. You may have noticed the appearance in the Press in recent times of a new form of extended interview, in which the text of questions and answers is quoted fully throughout. In this way, nuances and speech characteristics are captured in order to help to create a picture of the personality interviewed. At the other extreme, there may be occasions when

it is a matter of simple efficiency to secure a recording of a short business interview in which facts or figures are cited.

In this latter category comes the recorded telephone conversation. It is possible to buy quite cheaply an induction coil which is placed near the telephone, or attached to it by a suction cup, and which will monitor both ends of the conversation. The coil is plugged into the microphone socket of the recorder. As well as recording the two-way conversation, it is possible, if the recorder has straight-through amplifying facilities, to 'broadcast' it through the recorder loudspeaker to anyone else who may be in the room.

A fairly obvious home use of a recorder is to record radio programmes broadcast at inconvenient times. If you can arrange for someone else to switch on in your absence, or if you care to fix up a time-switch mechanism, the programme can be 'captured' and listened to later.

If you have the right kind of family, you may also find it worth using a recorder to leave messages for one another when personal contact is impossible.

All of the above may be classed as utilitarian functions of the tape recorder. There are other uses which may be termed educational and recreational.

Examples of educational activity are recordings made to help in speech training, in learning foreign languages and to assist at singing or music lessons.

The essential thing, in all these cases, is that the pupil hears and usually recognizes his mistakes immediately the recordings are played back. The effect is much greater than can be the criticism offered by a teacher. Few people do not suffer shock when they first hear their own voices played back. Accents, slurring of words, excessive sibilance, these and other faults that may have passed unnoticed will

suddenly become obvious. And you will find that there is an entirely new incentive to improve.

The same considerations apply in learning a foreign language. It is possible to record the speech of a native, breaking it into convenient phrases or sentences and leaving sufficient blank tape between each section to record your own efforts at matching the original. By playing the whole tape back you will be able to make direct comparisons. When the faults have been noted, you can try again, on the same tape, until you have satisfied yourself.

Already the teaching of foreign languages is being revolutionized by these methods. They are used in London, for example, to train missionaries in some of the more difficult African and Asian tongues.

For the music student, tape makes it possible for the first time to concentrate on listening to a performance without the effort of playing, or singing, at the same time. This makes all the difference. Mistakes are seen immediately. Teachers no longer need to interrupt pupils; the deficiencies can be discussed during playback.

Soloists can accustom themselves to playing with orchestral accompaniment. They have unlimited opportunities to gain self-confidence in handling new and unfamiliar pieces and they will quickly hear which are the passages on which to concentrate their practice.

Finally, we may look at some of the entertainment possibilities of the tape recorder. It has hobby uses. You may go into the country and collect bird-song in a way that was never possible before. I know several enthusiasts who have built up wonderful collections. One of the winners in the British Amateur Tape Recording Contest a few years ago stayed up half the night to capture a recording of a nightingale in a Kentish wood. Others have succeeded in recording

the sounds of life in a blackbird's nest for the first two or three weeks after the birth of young.

I am myself interested in railways and I have recorded characteristic sounds of railway operation in many parts of Britain and in several continental countries. My most satisfying item is a recording of the pounding wheels and the long, low, husky moan of the whistle of a huge Russian locomotive carrying me between Minsk and Moscow. It is evocative of the lonely, echoing sadness of those vast open spaces. Recordings of steam locomotives seem to me to be particularly worth while, for we are moving rapidly towards the day when there will be none left; unless we secure recordings, some of our grandchildren may never know the exciting noise of the steam-hauled 'Flying Scotsman'.

This is equally true of many other subjects suitable for amateur recording. All over Britain, in her villages and in the back streets of her towns, there is much ancient lore and regional music, song and dialect that deserves to be preserved for posterity. Until a few years ago only professionals, with cumbersome equipment, could do anything about it. Today any competent amateur can make good recordings.

If you do not want to go out in search of such material, you may find that there is a wealth of it waiting to be tapped in your own family. Old folk frequently become garrulous and reminiscent in their conversation. You will be surprised how much of their talk acquires a new value and interest if it is considered as recorded material. With suitable editing, reminiscences on tape can often become social documents.

A fascinating development is to compose a tape programme on the lines of the famous television series called 'This is your life'. Get the person for whom the tape is being made to talk freely about his or her life, and record it fully. You will then be able to map out the pattern of the career

and to draft a scheme. Contact someone who has known your subject well during each phase of his life and ask them to contribute recorded reminiscences or comment. Then, by careful editing, you will be able to blend together a single narrative, containing recollections by the subject himself, contributions from his old friends, and a running commentary which you can supply yourself. In some cases, it may even be possible to work in appropriate sound effects. Such a tape will make a really exciting present on a birthday.

A variant of this is to produce a family scrapbook on tape. It can be thought of as very similar to a snapshot album: it will contain items which will capture and recall memorable moments in the life of your family. I think you will find that these sound snapshots will, in fact, prove more evocative than the visual kind.

Do not restrict yourself to the obvious items, such as your child's early efforts at reciting a poem. You should include that, certainly, as well as his excitement when he first sees the sea, his citation when he carries off a prize at school, and his speech at his wedding reception. But there are many less hackneyed ideas worth seeking. What are the characteristic sounds of your home or your neighbourhood? Perhaps the call of the early morning milkman, or the daily greeting over the fence from a friendly neighbour, or a distant clock striking, or bird-song from the garden, or the creak of the stairs, or the rattle of the windows, or the poking of the fire? Sit down and think of the most appropriate sounds in your case, and then set about recording them.

You will see how the simple, straightforward recording exercise can quickly lead one into the more complicated construction of a documentary feature. More information about this technique will be given in the next chapter.

There is one other popular use for a tape recorder that

should be mentioned here, and that is its role at parties. I cannot hope to cover all the possibilities. Firstly, it can be used in a variety of ways to provide music—interrupted music for children playing musical chairs, low-level background music, or suitably selected music for dancing. You can, if you wish, interrupt the music with special announcements directed at each of your guests in turn.

You can have a quiz, playing different sounds recorded beforehand, and asking those present to identify them. Try some disguised voices, or well-known pieces of music played backwards (if you have a recorder on which this is possible).

You can also record on tape a series of questions and leave plenty of blank tape between each to record replies from your guests. The questions you put to the guests will not, in fact, be the ones you have previously put on to the tape. For example, you may record the question: 'How would you set about washing, cleaning and polishing a car which has been long neglected?' But at the party, having set up the recorder so that you may switch it on at the right point on the tape to catch the guest's reply, you ask her: 'How do you set about bathing a three-weeks-old baby?'

Doubtless you will be able to think up a lot of other promising sets of questions!

If you are running a children's birthday party, record a roll of drums or a fanfare of trumpets and then a dramatic announcement on these lines: 'Here is a programme specially devised for the ninth birthday of Jennifer Ann . . .' Members of the family can be introduced by the 'announcer' to recite their greetings, and you can collect other voices of friends and relatives by recording from the telephone. Introduce some innocent fun. If Jennifer Ann is just learning to swim, provide a 'commentary from Dover beach' on the final

moments of her 'fantastic swim across the Channel—without water wings'. But, after the leg-pull, be sure to end up on a note of sincerity.

One more idea should be sufficient to suggest the endless possibilities. You can construct a simple set-up to test the reaction times of individuals. Make and erect beside the recorder a small cardboard screen with a small vertical slit in it. It should be possible to view the movement of the tape through the slit, but to see only about a quarter of an inch of its length at a time. Now stick two or three small pieces of splicing tape of different colours, each about a quarter of an inch long, on to the outside of the recording tape. Set the machine to record, with the microphone within range of the person viewing through the slit. Switch on at the fastest available recording speed and tell the viewer to rap on the table when he spots a particular colour. Rewind the tape, switch to the playback position and move the tape past the replay head by hand until you find the sound of the rap on the table. Measure its distance from the coloured tab and you can calculate the reaction time.

You can, you see, make your use of a recorder as simple or as complicated as you choose!

The tape feature

WE have seen how elementary forms of recording lead naturally to the more complicated business of blending together a number of different recordings, made at different times, into a single, rounded feature programme. Such a programme may take several forms.

The simplest is reportage. You capture the sounds of something that has actually happened—a football match, a procession, or the arrivals and departures at a big airport—and instead of replaying the jumbled collection of sounds in the form in which you originally recorded them, you rearrange them, cut some out altogether, and link up the final selection with a connecting narrative.

All this is essential if you are to produce a result that will be acceptable to those who were not with you when you made the first recordings. Without editing of this sort, the tape will be boring at best and, more probably, unintelligible.

One of the first things you will discover is that you need at least thirty minutes of recordings in order to end up with a lively and interesting finished tape of five minutes' duration. If you record a band playing for several minutes, it is unlikely that you will want to include more than about forty seconds of it if the final tape is to be fast-moving, so that it sustains interest. If you interview someone, there will inevitably be a lot of chit-chat that adds nothing significant. It will have to be ruthlessly eliminated, leaving the main points and just sufficient 'trimming' to convey something of the personality of the person interviewed.

Once you have done the obvious cutting, you must

devise the best method of assembly of what remains. The order in which the sounds were first recorded is irrelevant. You are out to produce a tape which will be an artistic whole, the product of a creative imagination as well as a factual report on events.

In the final shaping of the tape you may use music, as well as a running commentary. When you have considered all these elements and their probable arrangement, prepare a linking script.

This will contain the full text of the commentary, with an indication of each point at which part of the original recording or added music is to be brought in or ended. It is then a matter of assembling all of these different sections in the right order. The techniques to be used to achieve the most satisfying results are fully described in chapter 16.

By this time, it will probably have occurred to you that the making of sound features of this kind is a large part of the business of the British Broadcasting Corporation. The B.B.C. is, indeed, the model for recording amateurs who wish to use the medium in a creative way. Every type of feature you may think of producing has been done many times by the B.B.C. and the best possible guidance is obtained simply by listening carefully to radio programmes.

Beyond the simple effort at reportage described above, there is the documentary feature tape. The element of fact and of straightforward description remains, but the imagination can be given freer rein. The 'treatment' of the theme is of paramount importance. Individual interpretation determines the quality of the final product. The analogy is not with the photographer, but with the painter.

Once you have selected your subject, you need to reflect on the sort of programme you are aiming at and the impression which you intend to convey. You think of the human

material you would like to include—the characters and the voices and the things you would like to hear said. You think of the sounds that would be most graphic in evoking a sense of place and time and atmosphere. Make a note of all your ideas.

Then go out and start recording.

Never record anyone without their knowledge and permission. As this means you must draw attention to your recorder, it is best to carry on a conversation for some time before you actually begin to record. If this means that you miss something that is attractive, it is usually possible to steer your subject back over the same ground. ‘What were you saying just now about . . .?’ you inquire. Later on, you can edit your question out of the tape.

Try to record people in surroundings in which they feel at ease—that means, usually, at home. If you have to ask questions, keep them brief. Let the other person do all the talking. If the interview takes a form in which the replies can later be welded together into a continuous narrative that does not require the question-and-answer form, avoid sitting on either side of the microphone with your subject. Walk about the room as you listen to him. This will cause him to speak up and to be less conscious of the microphone.

Whenever you are recording someone speaking against a background noise, make a recording of the noise alone. When you come later to edit and reassemble material, this may prove of very great value.

In all this interviewing, scripts should be avoided. You want people to talk naturally and unrehearsed. When you come to write the linking commentary, a script may sometimes be advisable. If so, remember that there is a vast difference between the written and the spoken word. All the time you are writing the script, speak the words inside your

head, as it were. Think of the *sound* of them being spoken, all the time. This means that you will usually write 'don't' and 'you'll', instead of 'do not' and 'you will'.

Many people, when they try to produce a dramatic or lively script, fall into the use of multi-syllabic words and elaborately formal phrases which they would never dream of using in ordinary speech. Be on your guard, for this will ruin your tape. Generally speaking, the shortest and simplest words are best. Sentence length and construction, however, must depend upon your usual mode of speech. Some people naturally have a sharp, staccato style; others speak in a smooth and sinuous fashion. The finished tape must sound like your natural self. You should try to speak during its recording as you would speak in relaxed conversation with two or three friends in your sitting-room.

The most ambitious type of tape feature is the play—the 'radio play', as it is sometimes loosely called. Here the imagination has full and unrestricted play and many of the recorded sound effects are artificially created.

If you are ambitious, you can devise the plot and write the script yourself. Or you can use a published play—provided it does not depend too much on visual impact only obtainable in a stage production. A compromise is to adapt a short story—science fiction, ghost stories and fairy tales are particularly suitable, as they offer wide scope for effects. Whatever your choice, you will be wise to aim at no more than fifteen to twenty minutes' duration for your first effort.

It will be sensible, too, to choose something with a small cast. When selecting the performers, remember that only the voice quality matters, and you should judge by the voice you get on the tape at a rehearsal, rather than the evidence of a live performance.

You need now to have a full and detailed script of the

type used by the B.B.C., providing instructions to the producer and studio engineer as well as to the performers.

There is one advantage the amateur enjoys. Having no tight production schedule, no worries about studio bookings, and (usually) no deadline by which he must complete the tape, he may put it together a little at a time. Record the dialogue only, scene by scene. Record the effects and music on another tape. During editing, as will be described later, the two can be married together.

By this method, it is not necessary even to assemble all the cast together at one time. The memorable tape, called 'The Rest is Silence', which won for Mr Norman Paul, of London, first prizes in the British and International Recording Contests of 1960 provides a splendid example of how the task can be faced.

Mr Paul described his methods in an article in *Tape Recording Fortnightly*. He devised the story and wrote the script in less than a week. As he was going to do all the recording himself, he recruited a friend as producer and his cast was found among the members of an amateur theatre club. There were fifteen of them, many of them very busy, and it proved impossible to get them all together for recording sessions. The fifteen-minute script, therefore, was divided into twenty-two sections, some of them no more than two or three lines, and each was recorded separately. This was done in six recording sessions, spread over three weeks. The various sections were assembled and edited later. The whole of the work was done in Mr Paul's bed-sitting-room and kitchen.

'The Rest is Silence' was a moving production that impressed professionals and was broadcast in full by the B.B.C. I have heard many other excellent tapes produced by amateurs. Some years ago a group of the Oxford University

Experimental Theatre Club, led by Mr Harold Rottesman, produced several outstanding adaptations of short stories. I heard, during a visit to Oxford, Mr Rottesman's tape productions of two James Thurber stories, 'The White Deer' and 'The Thirteen Clocks'. Both were brilliant and 'The Thirteen Clocks' was broadcast by the B.B.C.

When the amateur reaches this degree of proficiency, his work gives a tremendous satisfaction and thrill. The tape recorder has ceased to be an amusing piece of gadgetry and has become a powerful medium for self-expression and artistic achievement.

Sound effects

TAPE features require proper use of sound effects to create atmosphere. You may record some of these in the orthodox way—a telephone ringing, a car passing, or footsteps on the stairs. But if you live in Rutland, it will be expensive to secure your own recordings of the sea-breakers, and a recording enthusiast in Penzance may not wish to travel to Scotland to get two minutes' background music from bagpipes.

It is possible to buy sound effects from firms which specialize in this type of recording. They are not cheap, but they are of professional quality. Some firms sell them only on disc, some on tape or disc. You pick the items you require from a catalogue and, when the recording arrives, you cut it into the tape carrying your own recordings.

It will be much more enjoyable, however, to endeavour to build up your own library of sound effects. Many people have become so fascinated by this activity that it has become a hobby in itself.

In the 'Western' at your cinema, it is never a *real man* who plunges to his doom down the wall of the Grand Canyon. Similarly, if your tape drama is to include a shooting scene, you do not require a real revolver to produce the authentic sound. A ruler slapped down smartly on a well-upholstered leather chair will, in fact, sound much more realistic!

Good sound effects must convey an accurate impression, rather than reproduce the identical noise. This is an important distinction. When we see, as well as hear, something, the aural impression is attenuated by the visual. The impressions we collect through our ears are adjustable; we can concentrate on listening or we can 'close our ears', as we sometimes

say. A microphone has no such selectivity; it captures everything.

It is difficult to provide a set of rules for those who are going to start experimenting with sound effects. You must proceed by trial and error.

Collect an assortment of miscellaneous articles: brown paper, Cellophane, rice grains, a cup, a bowl of water, a balloon, a biscuit tin, and a bell. Spend an evening recording all the sounds you can produce with these things—Cellophane crumpled in the hand at varying distances from the microphone, rice swirled in the cup and dropped in the tin, air escaping from the balloon and the sound of a finger drawn over its surface when inflated, and so on. Repeat each sound twice, once at normal recording level and once with the microphone volume well up. Each effect should be recorded for at least ten seconds and instantaneous sounds should be repeated several times.

Before each effect, record on the tape what it is you are doing. Otherwise, you may find some difficulty in recognizing some of the sounds when you come to play them back! That is exactly as it should be. Sit back and listen very carefully and consider what the sounds suggest. The crumpling Cellophane may give a vivid impression of heavy rain, the air escaping from the balloon may conjure up a gale wind over the sea. Make notes of the way in which you created a sound and of the impression which it creates. You will find that the experience you gain will suggest routes towards other effects.

From the beginning, organize your collection of sounds properly. Eight or nine tapes full of assorted noises in no particular order may be of some use if you have an exceptional memory; otherwise you will never be sure what you have, nor where to find any particular item.



Above: Stereo recorder-reproducer with separate speakers (Grundig (Great Britain) Ltd.). Below: Modestly priced domestic recorder (Philips Electrical Ltd.).





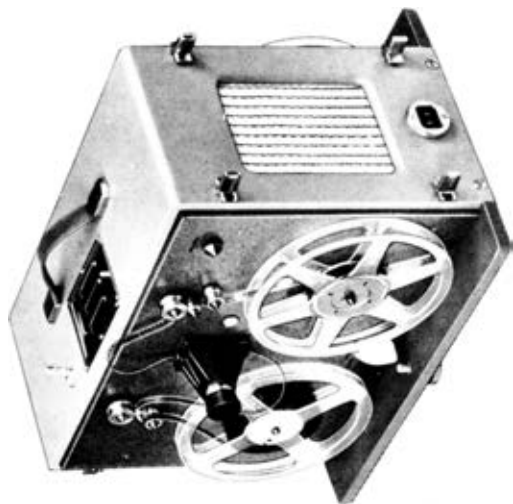
Above left: Ribbon microphone (Lustraphone Ltd.). Above right: Condenser microphone (Grundig (Great Britain) Ltd.). Below: Crystal stereo microphone (Cosmocord Ltd.).



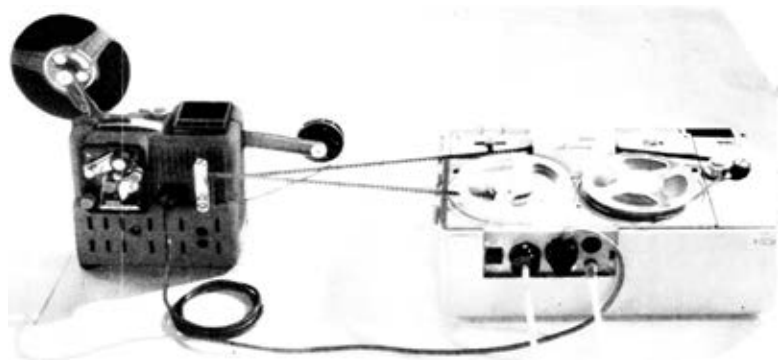
Right: Telephone adaptor—this is attached to the side of the instrument and enables both ends of the conversation to be recorded (*Cosmocord Ltd.*).

Below: Ceramic microphone—this popular model is supplied with many recorders in the lower and medium price ranges (*Cosmocord Ltd.*).





Combined projector-recorder—in this unit the projector is on one side and the recording deck the other (*Dominus (England) Ltd.*).



Above: Perforated magnetic tape—this recorder has been specially designed for cine enthusiasts and uses perforated tape that is directly linked with the projector to ensure perfect synchronization (*K.G.M. Electronics Ltd.*). *Below:* Mixer-fader—this provides for two microphones and a radio input (*Dektron*).





Above: The Gram-Deck—a novel design of deck which slips over the central spindle of a gramophone turntable to provide recording and playback facilities on tape. (*Andrew Merryfield Ltd.*) *Below:* A compact cabinet—tape, disc and radio are accommodated in this simple cabinet design—and there is storage space below.





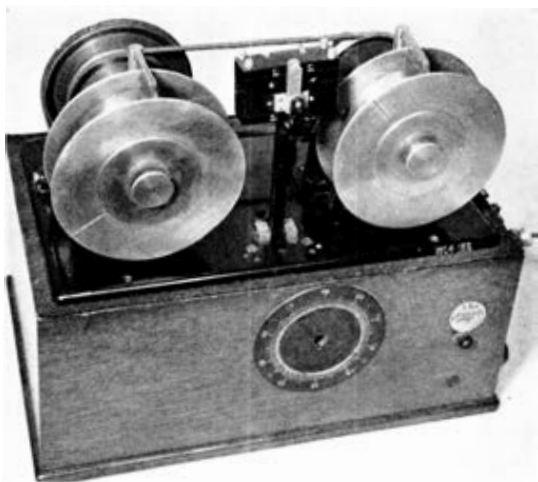
Above: Stereo tape carriage system developed in the CBS Laboratories in America—a strong candidate as the standard music reproduction system of the future.
Below: The contemporary line—provision for disc, tape and radio is made in this long, low modern cabinet (*E. Gomme Ltd.*).



Right: The 'Telegraphone' of 1907—a wire recorder that was the forerunner of the modern tape recorder. (Crown copyright: Science Museum, London).

Below: The Edison 'Gem' phonograph, using a wax cylinder, made about 1905.

(Courtesy of B. W. Harley)



It is possible to group various sounds in broad categories, each of which may be assembled on one tape.

Sounds of crowds or small groups of human beings are frequently needed in tape features. These sounds can vary enormously. Listen to broadcasts of sporting events or public ceremonies and you will quickly appreciate the range. A crowd may murmur, or chatter, or cheer, or sing. Smaller groups may sound animated and gay, angry and excited, or formal and solemn. The effects are quite different, according to whether the people are gathered indoors or outdoors.

Another broad category of sounds can be grouped together as 'street noises'. There is the general background of traffic and pedestrians, the colourful *pastiche* of the market-place, the individual sounds of shop-door bells or striking clocks.

Bells may make a category by themselves. There are so many varieties—on fire engines and ambulances, on telephones and doors, in church steeples and on buoys at sea. It is possible to produce several effects using only one type of bell, if you use all the resources of your recorder. An alarm-clock bell slowed down to half-speed will sound like an ambulance—but of the results of adjusting recording and playback speeds, more later.

The horse is a familiar friend in the world of sound effects. Tap out the rhythm of his hoofbeats on a smooth surface with half coconut shells. For the effect of racing on turf, cover the shells with a soft material—or use tennis balls instead.

Weather effects are usually recorded under cover, using imagination rather than reality. Thunder is unlikely to roll forth obligingly just as you have set up your equipment to record: don't worry, for a large sheet of tin waved back and forth and occasionally given a *thwack* will give perfect results. If you want rain, try rolling peas around in a tin tray, or pour rice grains slowly on to a metal plate, or play a hose-

pipe against a wall—so long as you can keep the recorder out of range.

It is impossible to suggest the procedure for every type of sound, but the examples given should be sufficient to stimulate your imagination and curiosity. The real enthusiasts get around to building special equipment with which to create particular sounds—revolving corrugated drums against which roller skates can be held to simulate train noises, for example. But you *need* not become involved in anything so complicated. Press your forefinger horizontally against your lips. Draw your breath in, allowing the air to enter at each *side* of the mouth. Don't make a lot of noise about it, but do it fairly close to the microphone. When you play it back, you can imagine yourself at sea in a storm, for you will have a most realistic wind effect.

I have already made a passing reference to the possibility of recording at one speed and playing back at another. It will amaze you what can be achieved simply by doing this. If you have a three-speed recorder, make all your sound effects at the middle speed and play them back at each of the three speeds in turn. Each 'step-up' in tape replay speed, i.e. from $1\frac{7}{8}$ i.p.s. to $3\frac{3}{4}$ i.p.s. or from $3\frac{3}{4}$ i.p.s. to $7\frac{1}{2}$ i.p.s. will raise the pitch of the recorded sound by one octave. If you record your wife's voice at $3\frac{3}{4}$ i.p.s. and replay it at $1\frac{7}{8}$ i.p.s., she will sound like a grumpy old man. To put matters right, play it again—at $7\frac{1}{2}$ i.p.s. That will make her sound like a breathless nine-year-old schoolgirl! You will appreciate, therefore, that the result when you vary the speed of play-back of some of your sound effects may be quite startling. New lines of exploration should be opened up.

You may, eventually, accumulate a very fine set of recordings. When you come to make a documentary feature or a sound play, do not stuff in as many effects as possible in

order to demonstrate your skill. Sound effects must be used with restraint if they are to serve their proper purpose. They must be relevant and they must help to carry the story forward.

If you begin a play with sounds of a car drawing up, door opening and closing, a man walking up steps, fumbling through pockets for key, door being unlocked, and so on, you are doomed to failure. The sounds may be of excellent quality, but they are bound to be dull to the listener because they will continue for too long in unbroken sequence. Introduce a second character and the sounds can then be married to conversation between them, and the whole thing can be made to come alive.

Think of your sounds as 'background' and 'foreground' effects, depending upon their significance in the development of the story. Never allow 'clever' effects to dominate a tape production.

The prize-winning tape 'The Rest is Silence', already described, provided a splendid example of the sort of restraint that is required. Mr Norman Paul, when he made it, wanted about twenty bars of rock 'n' roll singing at one point. Because of copyright difficulties, it was specially composed by a friend and recorded to guitar accompaniment. Many enthusiasts would have been so proud of this achievement that they would have given prominence to this original composition. Not Mr Paul. The piece was incorporated as a background sound and, as such, became indistinguishable from a hundred other rock 'n' roll songs—which was exactly what Mr Paul intended.

The possibilities are endless and the pleasure to be obtained is limitless. Yet, as we shall see, proficiency in creating sound effects need not be an end in itself; it can lead you on to wider, more complex, fields of recording activity.

Recording indoors

THE quality of the recordings you make indoors, with your mains machine, will depend on two principal factors: the room in which you record and the microphone and the way you use it. I have already said something about room acoustics and the reverberation created by reflected sound (see chapter 5) and something about the various types of microphones available (see chapter 3).

Unfortunately, the room that is best suited to high-fidelity reproduction is not ideal for recording. Far less reverberation is required in the listening room. If, therefore, you have an attic or a spare room available, it will be better to use it as a separate recording studio. If this is not possible, however, you must adapt one room for listening or recording as required.

This may prove inconvenient at times, but it is not difficult. For good reproduction, you need carpets, curtains and soft furnishings. For good recording, you need the curtains drawn well back from the windows, the carpet rolled up, painted walls—and everyone who is not directly involved out of the room! In order to achieve the best balance between absorbent and reflecting surfaces, you can make yourself a special screen. A blanket of fibre glass hung in a simple wooden frame, six feet high and three feet wide, makes an effective screen to cut down reverberation; but it will absorb high notes more readily than low notes, and so it must be used with discretion.

As with so many other things in this business, you will have to experiment. Acoustic environment, as it is called, is

a complex science embracing mathematics. You can apply yourself to its study, if you wish; others have spent a lifetime at it and do not claim to know all the answers yet. But the simple process of trial and error should lead you to extremely satisfactory recording results, if you are patient.

The average sitting-room, in a quiet residential neighbourhood, should be suitable for recording speech. It will probably have a reverberation time of about 0.4 seconds, and the ideal for speech recording is somewhere between 0.5 and 1 second. With the carpet rolled back and upholstered furniture out of the way, a good-sized room should give satisfactory results, too, if you record a piano or a small group of three or four instrumentalists.

You should try recording in several rooms, however, in order to make comparisons. In a small, relatively bare hall or bathroom, you will get a great deal more reflected sound. Try, also, recording with the microphone at varying distances from the sound source, i.e. the lips if you are recording speech.

The microphone responds to the indirect, reverberant sound as well as to that which reaches it directly. The relative proportions of direct and indirect sound picked up will greatly influence the quality of the recording. If you speak into the microphone at a few inches distance, the reverberant sound will make very little impression. The recording will lack 'acoustic perspective' and will be exceedingly dull. It will be impossible for the listener to gauge the surroundings in which it was made. A good recording should provide such information: you should know immediately whether the singer is in his bath or in a concert hall, whether the footsteps are on an open country road or in a high-walled city alley. This information is provided by the proportion

of reverberant sound captured by the microphone during recording.

When recording speech, you should keep the microphone at least one foot away from the speaker. If you are using a ribbon microphone, a distance of two feet will be better. The speaker should sit at a cloth-covered table, with the microphone either suspended in front of him or placed on a foam-rubber pad in the centre of the table-top, as nearly as possible at the level of his lips.

If two speakers are being recorded, sit them opposite one another at the table and use a microphone with a figure-of-eight polar pattern (see page 39). If you are recording a group of people, an omni-directional microphone will be required and they can then sit in a circle around it.

Singers should be recorded at two to three feet from the microphone—except crooners, whose technique is often dependent upon whispering into it at close range.

For choirs, cardioid microphones, which cover 180 degrees on one side only, are the best. An alternative method is to arrange the choir in a circle around an omni-directional microphone or a cardioid with the sensitive side suspended above their heads so as to be non-directional.

When you are recording music, the microphone should be much farther away from the sound source. Beauty of tone depends upon a large proportion of reflected sound. You will have to find the best positions by experiment; there are no simple rules or short cuts.

To record an upright piano in an average room, set up the microphone at a height of about two feet six inches and about a yard away, slightly on the treble side. Open the top of the piano a few inches and do not play it too loudly. Now make test recordings, moving the microphone back and forth and from side to side, until you get the best results.

One of the most difficult exercises in home recording is to handle a soloist accompanied by piano. Unless you are very careful, the accompaniment will be overwhelming. Keep the top of the piano closed. Use the pedals as little as possible. If possible, the microphone should be a foot to eighteen inches from the mouth of the singer and yet three feet from the piano—a difficult arrangement if the vocalist is to read from the score on the piano! One possible method is to suspend a ribbon microphone above and in front of the singer, tilted at an angle of 45 degrees to the keyboard.

The recording of full symphony orchestras or of choirs with orchestras is unlikely to fall to the amateur with limited practical experience. More than one microphone will be required and it will be a job calling for great skill and knowledge.

It is possible, however, that a tape enthusiast will be asked to record an amateur dramatic production. If so, he should abandon any thought of doing it at an ordinary performance on the stage. Different scenes will call for different acoustic environments. You can suggest a valley in the mountains with scenery, when the audience is sitting in the stalls, but you will have to create the impression acoustically in your recording. It will be best to make the recording, a little at a time, in the manner outlined in chapter 12.

I have been considering, so far, monophonic recordings with a single microphone. There are now available, however, a number of tape recorders which operate stereophonically, and amateurs are getting to grips with the new and challenging problems of stereo recording.

It is generally agreed that a good stereo recording is infinitely more satisfying than a monophonic one and the ordinary domestic subjects, such as children playing in the garden or a small group taking part in a play-reading, are

among those that gain most. There is, however, much less experience in this field and, if you embark on stereo recording now, you may consider yourself to be one of the pioneers among amateurs.

In professional studios, there are two different techniques. In America two or three microphones are usually used, spaced across the width of the sound source being recorded. If there is a third one, it is equidistant between the others and its signal is divided equally into the two recording channels.

The British system is to use two 'coincident' microphones—that is to say, they are arranged as close together as possible—sometimes one immediately above the other in the same casing, and their axes are disposed at an angle one to the other. In some cases this angle is adjustable through an arc of 100 degrees; in others it is fixed at 90 degrees.

The amateur who wishes to experiment may begin with either technique. If he chooses the American 'spaced microphone' method, it will be necessary to have two identical microphones and to link one with each recording channel. (Incidentally, it is standard practice to record on the upper tape track the output from the microphone which is on the left when facing the sound source. For playback, the upper track is connected to the left-hand loudspeaker.)

It will be best to try recording with the microphones at varying distances from each other and to learn from a careful analysis of results. If you position the two microphones close together, try the effect of placing a cushion, or other sound-absorbent screen, between them.

If you prefer to use the coincident microphone technique, there are two models on the market, and at least one more is expected to appear during 1961. One of those available comprises two ribbon microphones, the other two cardioid moving-coil microphones. Figure-of-eight or cardioid polar

patterns, it should be said here, are much more satisfactory for stereo recording than are omni-directional microphones.

If your coincident microphones are adjustable, they will produce an ordinary monophonic result if their axes are brought into line. To record an orchestra or large choir stereophonically a wide angle is used. If, however, you use an angle that is wider than that necessary to pick up the best signal, the result may be to produce on playback an image of an orchestra compressed into a space less than the distance between the two loudspeakers!

If, on the other hand, you are recording a single speaker who is near to the microphone, he should be placed well off-centre. Otherwise, the result, on playback, may be a man with a mouth as wide as the speakers are apart.

A stereo microphone in which the axes are fixed at 90 degrees will reduce the margin of error which is possible during your early experimental days.

You will have to reconsider all the rules of monophonic recording when you turn your attention to stereo. Distance of sound source from the microphone, in particular, often needs to be quite different.

With two microphones, you will obviously pick up more reverberant sound and this must be taken into account when deciding the microphone placement that is likely to provide the right balance of direct and indirect sound to provide acoustic perspective. The difficulty is that the resulting microphone position may not suit the stereo effect.

The problem can be illustrated by the example of a stereophonic recording of piano music. If you place the microphones too close to the piano, it will occupy the whole 'acceptance angle' between their peak-sensitivity axes. On playback, the piano will appear to be as wide as the distance between the speakers. If, on the other hand, you keep the

microphones sufficiently far away from the piano to avoid this form of illusion, then you will get too much reverberant sound on the tape. The solution is to tackle the latter problem, by creating a fairly 'dead' acoustic in the recording room; drape blankets from the walls, use a fibre glass absorbent screen of the kind already described, or gather an audience—provided they will keep quiet. Use a recording level only about two-thirds of that you would use for a mono recording.

If you successfully handle the problem, your stereo recording of piano music will be a great success. Nothing demonstrates the value of stereo more clearly than recordings of percussion instruments, which are among the most difficult things to record monophonically.

So far we have considered only microphone technique. You must also be sure that you are recording at the correct level. Domestic recorders are equipped with a 'magic eye' or a meter indicator. With the former, the two segments should touch only on the loudest passages; with a meter, the needle should never pass the indicated maximum value. If you overload the tape, you will get distortion that will ruin the recording; you may also suffer from 'print-through' when the tape is stored.

On the other hand, if you record at too low a level you will not get a satisfactory signal-to-noise ratio. There should rarely be any problem in determining the correct level, but if you are recording a piece of music which you know well and which contains heavily contrasting loud and soft passages, it is permissible to adjust the volume control, slowly and smoothly, in anticipation of these extremes.

In the case of stereo recordings, there are, of course, two levels to think about. Some machines provide a separate indicator and control for each channel; others have a single

control which adjusts both channels simultaneously (the input signals need to be balanced beforehand); and yet others have two controls, but only one indicator, so that you switch in turn to each channel during adjustment.

Always keep the recorder as far away from the microphone(s) as possible; ideally they should be in separate rooms, as at a B.B.C. studio, but a good compromise at home is to arrange a screen in front of the recorder.

I have avoided, until now, any consideration of recordings made with more than one source of sound. It is often necessary to use two or more microphones when making a monophonic recording. When recording a choir, for example, it may be necessary to use one microphone for the whole group and a separate one for the soloist. On other occasions, you may wish to blend into a single recording speech delivered to a 'live' microphone and music or sound effects being transferred from an earlier recording.

The simultaneous recording of two or more different signals calls for the use of a mixing unit. Some domestic recorders have two separate inputs, each with its own controls, so that two signals can be 'mixed'. Those that do not possess this facility can be linked with a unit providing three or four inputs and a single output. Two microphones and the output from a disc or tape or from radio or television can be connected to the inputs. The controls will enable each signal to be faded in and out or to be held at any desired level. The resulting 'mixed' signal will be passed, via the output, to the recording head.

Obviously this is a skilled business, and it is necessary to monitor, through headphones, the final combined signal that is being recorded. In the case when live performance before a microphone is being combined with music or effects recorded earlier, a detailed working script is required.

This will indicate to the person who is recording where fades begin, where recorded inserts are brought in, and where a cue should be given to the live performers to begin speaking. Only the recordist, it must be remembered, will hear the final signal going on to the tape. Performers in front of the microphone will not hear the music and effects, and so they cannot know when these are ending. The recordist, therefore, must operate a cue light as a signal when the performer must come in again.

By this time, of course, the amateur is beginning to follow professional practice fairly closely. But, I guess, he will be enjoying himself far more than any professional can ever hope to do.

Recording out of doors

So long as tape recording could not be carried out away from a mains supply, it suffered severe limitations. Many of the most attractive recording subjects were inaccessible. It was difficult, for example, to make recordings at a number of different places during a journey, as on a holiday. Consider how restricting it would be if available cameras were only suitable for indoor photography; the whole character and scope of the hobby of photography would be transformed.

So it was with tape recording until fairly recently. It was possible to buy converters which enabled mains-operated machines to be run off 12 volt car batteries. It was also possible to set up a recorder near an open window and to run a long microphone cable into the garden. Some enthusiasts used these methods, and obtained very good results, but they were troublesome and tedious.

Today there are more than a dozen different battery-operated, transistorized tape recorders on sale which can be taken anywhere and operated in almost any conditions. Most of them have been introduced only during the last two or three years; although the number of battery-portable owners is increasing rapidly, they are still a minority. It is my conviction, however, that they will become the majority and that tape recording as a hobby will be dominated by their out-of-doors activity.

Information about the types of machine available has already been given in chapter 3. Although they cannot be expected to offer the same facilities as the larger mains models, many of them today are capable of good-quality

recording that will reproduce very well on fixed hi-fi equipment.

It will be necessary, however, to study carefully the special problems encountered in outdoor recording. When you step outside your home you make an automatic adjustment in your listening; you focus more on some sounds than on others. The microphone cannot do this.

It is desirable, therefore, to use directional microphones. A good-quality moving-coil microphone with a cardioid field will be best. Ribbon microphones can rarely be used, for they pick up wind noise, which will sound like thunder when replayed. A strong wind may actually damage the ribbon, and sun and damp will do it no good.

A wind-shield over the microphone is often necessary. If you do not wish to buy one, it is possible to make one yourself, using foam rubber or a suitable material wrapped over the diaphragm. If, however, you plan to do a lot of outdoor work, it is worth spending money on the real thing.

Professionals use a special kind of lip ribbon microphone, with a shield. It is held very close to the mouth, which would normally accentuate the bass, but this is corrected by the use of an acoustic impedance. With such a microphone, the commentary is recorded without interference from background noises; in fact, if something of the background is required to provide 'atmosphere', it is usually picked up on a separate microphone and mixed in.

Such microphones are expensive and may be beyond the reach of the average amateur, but he can learn something from the way in which they are used. If you want to cut out background noise when recording out of doors, set the level well below normal and hold the microphone close to your lips, at an angle, so that you talk across it. Then speak quite normally, disciplining yourself not to raise your voice

to compete with the surrounding hubbub. The resultant recording will probably be entirely satisfactory.

For interviewing, point the microphone slightly towards your subject—give him a little more than his ‘fair share’ of it! Rest your elbow on your hip and hold the microphone out, with your forearm extended. This is a comfortable position and it will enable you to keep the microphone in the same relative position if you swing round to face another person to be interviewed. Look at your subject directly, over the microphone. This will enable you to encourage him or her by showing interest in your facial expression (resist the temptation to make reassuring noises like ‘I see’); it will also keep the subject looking at you, and so speaking directly into the microphone.

There are, of course, no controlled acoustic conditions out of doors, as there can be in a prepared room or studio. There are many factors which are entirely outside the influence of the recordist, so that his best endeavours may be in vain. Not even the skilled professional can cope with the situation if an airliner flies low overhead when he is in the middle of a recording.

But the echoes that result from surfaces of stone and glass, the special problems associated with the concentration of sound in an alleyway or in a railway cutting—these are the problems that can be solved if you experiment sufficiently. You will find, out of doors, more sudden changes in the volume of sounds; where possible, use the control to adjust recording level accordingly.

If you require to beam a distant sound into your microphone, avoiding noise from other directions, you can use a parabolic reflector—a simple bowl with the microphone mounted at its centre, facing inwards. The sound is collected and reflected on to the diaphragm of the microphone. It is

not difficult to make such a reflector, using sheet metal, but one model, designed to work with a particular battery portable, has now been placed on the market.

The parabolic reflector has been used for a long time by those specialists who collect bird-song. I recently heard a tape of a bird singing at the top of a forty-five foot tree; the reflector had been directed straight up at it and the recording sounded as if the performer had been within a couple of feet of the microphone in perfect studio conditions.

The use of parabolic reflectors need not be restricted to bird-song, of course. How I wish I had had one with me several years ago, in Southern Italy, when the tempestuous driver of a *carozza* began a midnight argument with a passenger near my hotel. For minutes he declaimed in uncontrollable passion; then his voice trailed off, only to rise again in renewed indignation. Eventually, he climbed back to his driving seat, took the reins, and the horse clip-clopped back down the hill to a sustained background of wrathful grumbling.

This was before the days when portables were plentiful. I had with me only a small wire recorder, intended for office dictation purposes. I kept its small, inadequate microphone stuck out through my bedroom window, but the results were disappointing. With a parabolic reflector, however, that fiery Italian might have overloaded the wire!

Over-recording is, in fact, a danger to safeguard against with the newer portables. Some of them provide only a neon light to indicate level; it flashes when there is peak loading. As much outdoor recording must be performed with the microphone in one's hand, which calls for extra concentration, it is not easy to keep an eye on the level indicator. Before recording, therefore, make a few trial runs with sounds comparable to those you intend to capture.

The battery portable has introduced one evil feature into recording activity: it makes possible sneak recordings, made without the knowledge of the subject. This is a matter on which I feel very strongly. I believe it to be the case that the first midget recorders were used in Germany by the Gestapo. Microphones were disguised as wrist-watches; I have one in my possession and it is a superb imitation.

Recently an American manufacturer has advertised a recorder which is entirely contained in a despatch case, with a microphone camouflaged as one of its fastening clips. No secret is made of the fact that it is intended for 'secret' recording.

To my mind, such activity takes us a giant step nearer to George Orwell's nightmare 1984. If widely practised, it is bound to impart an unpleasant flavour to tape recording as a whole. Fortunately, I detect no inclination in Britain to go after sneak recordings. For the health of the hobby, I plead that one basic rule is always obeyed implicitly: never record anyone without express permission.

In my experience, most people are delighted to be asked, so that you will not miss anything worth while by observing normal courtesies.

Editing techniques

UNTIL you begin to use a razor-blade to cut your tapes about, you cannot consider yourself a serious recording enthusiast! All good tapes require editing. You cannot hope to be sufficiently selective or fortunate during your recording sessions to eliminate all unwanted sounds. Anything that detracts from the overall value of the recording must be ruthlessly cut out.

Editing can be a very fine art. You can cut out all the 'ums' and 'ahs' and false starts, so that no one will be able to detect that they were ever there. You can go much farther. For fun, you can decapitate words of the initial 'h' and so cause consternation to the person you have recorded. If you are unscrupulous, you can rearrange the order of words recorded, so that people are made to appear to say something quite different from what they did say. In a recent experiment, a clergyman's sermon was edited in this way to produce a tape of Hamlet's 'To be or not to be' soliloquy.

It is because of the facility with which tape can be manipulated that recordings carry only limited weight as evidence in courts of law.

Before you begin to cut a treasured recording, it is advisable to make a copy of it. If you do make mistakes, you will not have lost something that cannot be repeated. Copying, or dubbing, tapes is simple and straightforward; but it does, of course, require two tape recorders. It is here that membership of a tape-recording club will prove useful.

For copying, you need a length of screened lead, with a plug at each end. One goes into the extension speaker socket of the first recorder, the other into the radio input of the

second recorder. The recording is then played on the first machine, with the second machine switched to record. If you are only concerned to make a straightforward copy to be played back at the same speed as the original, you may be able to speed up the dubbing process. If, for example, the tape is recorded at $3\frac{3}{4}$ i.p.s. but you have two recorders that can be operated at 15 i.p.s., set them both at this speed for dubbing purposes. The copy will be made in a quarter of the time and will play back normally at the original $3\frac{3}{4}$ i.p.s. speed.

If, however, you want to adjust the recording levels of the original recording, you will be able to do it by using the volume control of the second (copying) machine—provided you work at the original recording speed and you are able to monitor the input to the second machine. You will also be able to fade in or fade out at any point you wish.

It is possible, of course, to edit in this way, without cutting the tape at all. But it is a more difficult and tedious procedure. You will need to prepare a script listing the sections of the original recording you need, with the revolution counter readings to show where they begin and end. You can then transfer these sections, one at a time, in any order you wish. If, during the same process, you want to record between the different sections a spoken narrative, you can do this by using a microphone plugged into the second input of the recorder which is being used for copying. Fading and mixing of the two inputs—tape playback and live microphone—is then possible, but you will find it needs a good deal of practice to become adept at it.

Let us suppose, however, that you decide to use the razor-blade method of editing, to start with.

First, you must recognize that it is only possible to edit one track on a tape. If you have four recorded tracks and you start cutting the tape in order to edit track one, the

other three will be useless, for you will destroy their continuity. This is an additional reason why you should make a dubbing of the track you wish to edit and carry out all further operations on this copy.

The minimum equipment required to splice tape is an ordinary razor-blade (or scissors) and a roll of adhesive tape—not the popular general-purpose tape, which uses a soft adhesive that will ooze and spread to adjacent layers of tape in the reel and cause endless trouble, but the special tape-splicing variety which is coated with hard adhesive.

It is a wise investment, however, to buy one of the several splicing blocks which are now on the market. Professionals usually prefer a very simple device consisting of a piece of metal in which a channel is machined just wide enough to hold the tape firmly. A slot at 45 degrees to this channel (and sometimes a second one at right angles) serves as a guide for the razor-blade when cutting. All cuts are normally made at the 45 degree angle, for it results in a stronger and a noiseless joint. When unwanted tape is cut out the two ends of the tape are brought together in the channel—it is important that they butt exactly—and a piece of the adhesive jointing tape is laid across the joint and pressed down, using your nail if necessary to ensure that no air bubbles remain. The jointing tape is usually three-quarters of an inch or one inch wide (which will be lengthwise to the joint) and it should be trimmed so that none protrudes over the edges of the magnetic tape. It is better to cut into the magnetic tape slightly than to risk an excess of adhesive jointing tape.

The magnetic tape should always be placed in the channel of the editing block coated side downwards, shiny side upwards. Take care how you slip it in and out of the channel or you may damage the edges; this would affect performance if it is subsequently used with a four-track recorder.

Some editing blocks are more elaborate and provide various methods of anchoring the tape on either side of the cut while jointing proceeds. Some of them also incorporate a blade which is brought down with a chopping effect.

If the joint does produce any sound on playback, draw the tape slowly past the erase head to eliminate it—and demagnetize your scissors or use a new razor-blade.

The use of a fine talcum powder over joints is sometimes recommended; I have never felt it necessary myself but, if you try it, be careful not to use too much. Carbon tetrachloride is also suggested if a joint needs cleaning up, but I feel it wisest to avoid this if possible, as it can cause damage to some tape coatings.

If you are doing a lot of cutting and rearrangement of the order of items on a tape, you will find the task greatly simplified if you use a couple of empty reels. They will enable you to 'shunt' the pieces of tape from reel to reel, until you have them all assembled in the right order.

Some of the comprehensive editing kits which are now on sale for amateur use include, in addition to editing block, adhesive tape and cutter, a selection of coloured 'leader tapes'. Every magnetic tape should have a length of leader tape—two or three feet of it—attached at either end. If you make it a standard practice to use one colour tape at the beginning of the top track and a different colour at the beginning of the bottom track, it will provide you with a useful code. If, for any reason, you want to assemble disconnected recordings on a single reel, you can splice in white leader tape between each one. Leader tapes can be written on, so you will be able to record a description of each piece.

There is another method of splicing tape, using cement to weld the two ends, but it is a messy and more difficult

procedure and few amateurs need to go beyond the simple adhesive tape joint.

The speed at which the tape is played will be of some importance in editing. The higher the speed at which the recording has been made, the simpler your task will be. A normal two-syllable word will occupy about half an inch of tape, played at $7\frac{1}{2}$ i.p.s. That does not give you much to play with—it would be easier if you had an inch, as you would with 15 i.p.s.; but a recording at $1\frac{7}{8}$ i.p.s., which is now a popular speed for speech, reduces the amount of tape to one-eighth of an inch or less.

If you do start your editing, then, by making a copy of the original recording, the copy should be taken at the highest available speed.

The next problem is to know where to make the cut. This is greatly simplified if you have a recorder on which the playback head is accessible. On some machines the cover over the heads can be removed from the deck, on others it cannot.

If you have one of the first type, remove the cover before you start your editing session. Play back the recording and press the stop button immediately you reach the point on the tape at which you want to cut. You will probably need to play back the section several times before you get it exactly right. On some recorders, it will be possible to pull the tape backwards and forwards by hand in front of the replay head until you have the precise point for the cut lined up.

When the cutting point has been brought into line with the replay head, mark it with a chinagraph pencil, which will write easily on the tape surface. Draw the tape through sufficiently to slip the appropriate section into the channel of the editing block and proceed as described earlier.

If the head covers on your recorder cannot be removed,

you must go through an additional preliminary exercise. Using a torch, if necessary, peer into the slit provided for the tape and locate the replay head (the manufacturer's literature will probably include a sketch or photograph which will make identification easier). Stick a small sliver of white adhesive tape on to the magnetic tape and draw it through the slot until the white indicator is in line with the centre of the replay head.

Close your thumb and first finger over the tape at the point at which it leaves the head cover after passing the heads. Draw the tape through and measure the distance between this point and the white indicator. You should now engrave a scale on the deck of your recorder showing this distance.

When editing, stop the tape, as already described, when you reach the point at which a cut is needed. Take the tape between thumb and forefinger at the end of the head cover and put this point on the end of the engraved scale on the deck. The other end of the scale will then indicate where to make the cut.

Sometimes it may be difficult to cut out a section of a tape if it combines two separate elements, as, for example, speech against a background of characteristic noises. The speech may flow smoothly after the cut has been made, but a change in the rhythm of the background noise may give the game away. In such cases, it may help if you have available a recording of the background noise alone; with this, you may be able to build up a natural bridge. Alternatively, you can fade out the first section and then, after a brief silence, fade in the second. Similarly, it is often desirable to fade out music in order to shorten overall length of a tape.

If you wish to avoid re-recording, the answer is the wiping fade. Some recorders provide facilities for cutting out the erase current to the head and then bringing it back gradually.

This will have the effect of fading out the recording. On other machines it may be possible to hold the tape away from the erase and record heads as it runs through and then to let it move gradually back into contact at the point where you desire the fade.

When you feel yourself to be proficient at editing, you may be tempted to attempt the composition of *musique concrète*. This is an entirely new form of musical composition freed from conventional forms, vaguely futuristic, redolent of space travel adventure.

You start, not with normal notes, but with recorded sounds—any sounds. You use all the editing techniques in order to build up patterns from the basic sounds. You may use repetition; if you cut off a short section of recorded tape and splice the ends together, you have a tape loop, which can be run continuously through the machine to provide a basic theme. You may use pitch variations, by re-recording the original at lower or higher speeds. You may break up the original sounds by cutting parts of them away; for example, you can edit out the front half of those sounds which make a sharp initial impact and then die away. You may add echoes.

Naturally, there are no set rules. It is up to each man's ingenuity and his creative genius. Some musical knowledge may prove helpful, but you need not be disqualified without it.

I have heard many tapes composed in this way; some have sounded weird, some have been effective surrealism. Others have included elements of recognizable reality, tension or impact being created by deliberate distortions merging into purely impressionistic sound.

Electronic music, the creation of which uses basically similar techniques, is built up using sound created artificially on a generator.

Tape and photography

THERE is a natural affinity between sound recording and photography. An increasing number of enthusiasts are moving from one field into both. The making of sound films is a subject for a book, and this chapter seeks to do no more than point out the possibilities.

The projection of colour transparency slides has become extremely popular in recent years and the problems of combining this with tape recording are fewer than those involved with ciné. A slide show to an audience, even a small family audience, requires a spoken commentary. This may be fun the first time, interesting the second time, tolerable the third time . . . but it will simply be tedious after that. And a good set of slides will get many showings.

If you use a tape recorder, a script should be carefully prepared and delivered. Musical background can be provided, if appropriate. So can sound effects. I have one set of colour transparencies brought back from a trip abroad for which I am making a sound track which will include music, train sounds, and the descriptions of buildings shown on the slides as delivered by the local guides—all this in addition to my own commentary.

My projector is hand-operated and the method I have adopted is to divide my tape into sections each of one minute or less. Between these sections I allow myself a brief interval to change slides. There are, however, automatic means of linking sound and picture which simplify operations considerably.

Some of the automatic projectors provide a remote

control. You sit in your armchair and when you are ready to change slides, you press a button. Obviously, if you are using such a machine you press the button when the tape playback reaches each appropriate point. If you think it necessary, you can incorporate some inconspicuous sound on the tape recording to guide you.

There are more elaborate systems available in which a foil on the tape or a recorded pulse will automatically operate the slide-change of the projector. As these automatic projectors usually include magazines to hold thirty-six slides, a continuous performance of sound and picture lasting half an hour is possible and this is the ideal length if you want to retain the interest of your audience.

Producing a sound track for a ciné film is a more ambitious project. It is not *impossible* to achieve something close to lip-synchronization, but it is foolish to pretend that it is not difficult. There are no cameras on sale in Britain, at the time of writing, which offer amateurs the chance to record sound and ciné simultaneously, but a start with this type of equipment has been made by the Americans.

Here, for the present, we must proceed in two stages: first shooting the picture and then recording the sound. A good deal of the second stage—possibly the whole of it—can be done, of course, at a later date than the filming.

There are two different techniques available to the amateur. In one, a stripe of magnetic coating is added along the photographic film, between the picture and the perforations. It is not expensive to have this done, but there are drawbacks to the system. If you use 8 mm., your camera speed will probably be 16 frames per second, and this gives a linear speed of only 2·4 in. per second, which is low if you want quality sound. This magnetic stripe cannot be recorded or played back on a standard tape recorder. A new magnetic

sound head will be required for your projector, with an associated amplifier. You will need, further, a loudspeaker, but this will already have been looked after if you have a hi-fi system.

The great advantage of magnetic stripe is, of course, that synchronization will always be perfect.

It is possible, however, to buy synchronizers to link orthodox tape recorders and ciné projectors, and the manufacturers now claim an accuracy of 100 per cent. With this method, you have the advantage that the sound track may be recorded and played back at any speed and top quality secured. A loop is provided in the film, so that projector speed can be automatically varied, as required to keep it in step with the recorder.

A recent development in this field was the introduction during 1960 of a tape recorder using perforated tape. Perfect synchronization is achieved by taking a tape loop from the recorder through the projector. There is remote control of tape stop and start, a switch to start projector and recorder simultaneously, provision for fading, and controls and markings in white to aid identification in dim lighting.

A great deal of thought is now going into future development and the association between photography and sound recording is certain to grow closer. I have no doubt that each will continue to enjoy a healthy life of its own, but the partnership is bound to be beneficial.

Sound recording for use with photography does not always follow the same rules as are observed when it is approached as an individual art-form. The differences are those that are found in a comparison of sound radio and television. The information conveyed by picture and sound must be supplementary. Sound effects designed to create

'atmosphere' will often become unnecessary when a visual impression is available. Some types of sound may distract attention from the photography. It is obvious that purely descriptive commentary will become superfluous when the audience is able to see things for themselves.

Although perfection should be sought in all things, it is a fact that the quality of the sound may deteriorate a little without affecting the overall standard, provided tape and film are married into a satisfactory artistic whole.

The home constructor

IF your abilities run in the right direction and you take the trouble to study the proper procedures, you can save yourself money by building some items of equipment yourself, at home. The sums you will save will not be vast, however, so if you are reasonably certain that you are no handyman, you may as well save yourself disappointment and irritation.

If you *think* you may be able to achieve something, however, have a go. Start on something relatively simple; there is nothing like an early success to encourage one to more ambitious effort.

Naturally, I cannot provide full details and working diagrams for building particular items of equipment. If you want them, you will have no difficulty in getting them, for such information is published regularly in the specialist magazines and there are a number of books available.

A good example of a simple additional facility for a tape recorder is a monitoring device. You purchase an extra playback head, fit it to the deck, after the recording head, and wire it up to a small external amplifier giving sufficient output for earphones. If your recorder does not provide monitoring facilities, this addition will be of immeasurable value. And if you should fail to achieve first-class results, you are not likely to do any serious damage to your equipment in the attempt.

Fading and mixing units offer opportunities to progress to something more complex. These are of two types, the simplest using potentiometers, the better ones incorporating pre-amplifiers. They will provide you with experience in

constructing a chassis and wiring in a neat and orderly way.

If you get this far, you should be confident to tackle a design which incorporates all the general electronic principles. Buy a kit with which to construct a preamplifier. These kits include all the necessary components, including printed circuits (thus eliminating most of the wiring problems), and they are accompanied by very comprehensive and detailed instructions. You will find many such kits advertised. They provide an ideal means of familiarizing yourself with constructional and electronic problems.

Finally, you can buy a kit with which to build a power amplifier. A number of models are on sale and you will save a few pounds by buying in this form and building yourself. It is not the saving, however, that should be considered, so much as the satisfaction of acquiring knowledge and experience.

Beyond the made-up kits there are infinite possibilities. You may end up building amplifiers to your own design. You may feel bold enough to try to build a VHF tuner, which is not an easy proposition.

Or you may decide to build yourself a complete tape recorder. Several freelance designs have been published during the last few years, both for mains-operated machines and for a battery portable. At the time of writing, the first design produced for a stereophonic mixing unit is being described in a series of articles in one specialist magazine.

The psychological barrier to experiment may be expressed in the protestation: 'But I've never used a soldering iron.' Well, why not try? It is a simple enough operation, which can be learned in a quarter of an hour. But you do need to know how to do it properly.

You cannot use the type of iron with a copper bit that is

heated in a gas jet, for these radiate too much heat, but a good electric iron can be bought for less than one pound.

If, to take one example, you want to solder the end of a wire to a tag—the sort of thing you will need to do many times when you begin construction—you begin by heating the iron. Then ‘tin’ it—that is, apply a little solder to the flat face of the bit and then wipe it clean again with a rag. Roughen both sides of the tag with emery cloth and apply the hot iron to one side only. Heat will be conducted until the whole of the tag reaches the temperature of the iron. Then apply solder to the other side of the tag, where it will melt. When a thin coating has spread, remove the iron and any excess of solder, being careful to see that any large blobs of it are ‘bled’ off with the iron. Next, roughen the wire with emery cloth, melt a little solder on the face of the iron and pass the wire through it.

These preparations completed, pass the wire through the hole in the tag and bind it round to make a secure mechanical joint. Finally, apply the iron to the joint and melt on a little more solder.

If you follow this simple procedure, you will avoid the embarrassment of a ‘dry’ joint—the result of not properly tinning the various components.

It is often necessary to flick solder off the end of the iron when cleaning away excess. Be sure that none of the little globules drops into the work you are doing, for they could conceivably get across the H.T. line and cause a short circuit, or worse.

When soldering small resistors or capacitors into a circuit, care must be taken to see that they are not damaged by heat from the iron. Heat travels quickly along a wire and it can affect the value of a component. If you hold the wire with long-nosed pliers between the component and the point at

which the soldering iron is applied, the plier jaws will act as a 'heat shunt'.

If you hesitate to embark on such activity, you may be happier to try some carpentry. Speaker enclosures are not difficult to construct, using the detailed instructions which manufacturers make available. If you spend, say, £5 on the speaker unit and about £3 to £4 on materials, you should be able to produce a very good result which will transform the quality of reproduction provided by the built-in speakers of a tape recorder or record player.

Very little will be required beyond a saw, drill, chisel, screwdriver, ruler and square. The necessary materials are timber or blockboard, a few screws, damping material for the interior, and a gauze to fit over the speaker cone. Make sure that it is possible to inhale and exhale freely through the gauze, as otherwise you will not get effective sound radiation.

You need not worry about the appearance of the enclosure, if your wife is content to have it in a simple utilitarian state! If, however, you finish it off handsomely, you will have proved your ability to advance to a more ambitious project—the construction of an equipment cabinet.

You buy a cabinet in kit form, costing about £15. That is the rock-bottom price, unless you start from scratch and design it yourself. If you decide to do that, you can simplify your task by using one of the veneered boards which are now on sale.

A few general principles must be borne in mind. There must be free circulation of air under the components that are to be mounted in the cabinet. Accurate dimensions are needed when providing for a turntable and tape decks to be fitted. You must decide whether to keep all the controls out of sight, in order to achieve a sleek contemporary appear-

ance, or whether you want them conveniently handy; in any case, there is a lot to be said for having an indicator light visible at all times when the amplifier is switched on. It will be wise, too, to provide some excess space in which you can hide miscellaneous equipment, such as headphones, editing kit, defluxer and so on.

Constructional activity of the sort described here may not appeal to the same people as the creative artistic activity outlined earlier. This is the joy of audio activity: it offers pleasure and satisfaction to everyone.

An eye on the law

YOU may use your tape recorder's potentialities to the full for years, within the privacy of your home, and the problems of copyright may never arise. But if you take it along to the local church hall to record the choir singing an oratorio, and if the local newspaper publishes the fact that you have done so, you are likely to get an official-looking letter from the Mechanical Copyright Protection Society within a few days. You will probably have broken the law by unauthorized recording of copyright work.

There seems, at the time of writing, to be a state of finely balanced truce between the parties in the conflict over copyright, and it is difficult to offer advice to clear up all the doubts that may arise in your mind. I have spent much time and effort in an endeavour to bring some clarity to this matter; I have discussed it with the M.C.P.S. and its legal advisers, with independent counsel, with some of the big recorder and tape manufacturers, with club officials and with individuals. No one can deny that the law is precise in forbidding many kinds of recording, but that the law is very widely—almost universally—ignored.

When a discrepancy between law and practice on this scale is recognized, it is usually considered time for some adjustment of legislation; otherwise the law falls into disrepute. I am afraid, however, that we shall have to await some sort of test case before the courts before this situation is sorted out.

One or two cases have come before the courts, here and abroad, but none of them has been of a character to enable

the whole subject to be opened up for discussion. I believe that there are a few countries where copyright fees are included in the selling price of magnetic tape. In America, manufacturers are still advising amateurs that they can copy radio programmes, for example, provided they do not use the resulting recording outside the home and family circle.

This was, until two or three years ago, the generally understood situation in Britain, but the M.C.P.S. has now made it abundantly clear that this is not a correct interpretation of existing law.

The position is governed by the Copyright Act of 1956, which came into force on 1 June 1957. It defines a sound recording as 'the aggregate of the sounds embodied in, and capable of being reproduced by means of, a record of any description . . . ' and this copyright is effective for fifty years.

Unless permission has been obtained, it is an infringement of copyright to make a record embodying such a recording, to cause the recording to be heard in public, or to broadcast the recording.

One section of the Act creates a copyright in broadcasting and lays down that it is an infringement to record a broadcast 'otherwise than for private purposes'.

Another section extends the Dramatic and Music Performers' Protection Act of 1925 to make it a criminal offence, punishable by a fine, knowingly to make any record of any dramatic or musical performance without the written consent of the performers, or to perform publicly such a record, or to sell, hire or distribute it for the purposes of trade. But it is a defence if the record was made for 'private and domestic use only'.

Let us try to summarize the main points that emerge from the legal jargon.

There are three different kinds of copyright. There is

copyright in an actual musical, dramatic or other similar work—the copyright which protects the author or composer. There is independent, subsidiary copyright in any sound recording of such a work—the copyright that protects the commercial recording company concerned. There is independent, additional copyright in a broadcast of such a work—the copyright that protects the broadcasting company transmitting it. The first named copyright also protects the author or composer against both unauthorized reproduction or unauthorized public performance.

We may consider these three different types of copyright in turn. The last one is looked after in a helpful statement issued by the British Broadcasting Corporation which indicates that, provided a recording is made for private and domestic use only, and provided also that permission is obtained from the author or composer in respect of his copyright in the material, you may proceed without committing an offence.

Concerning the copyright subsisting in a particular recording (which protects commercial recording companies), it is quite clear that it is illegal to re-record on tape any disc or tape record issued commercially. It would be equally illegal whether you re-recorded direct or from a radio broadcast of a disc. The fact that you may have bought the disc yourself and may wish to copy it on to tape in order to preserve the disc in mint condition would be irrelevant—an offence would be committed by the act of copying.

We return now to the first copyright, designed to protect the author and composer. It is effective for a period of fifty years, so that any work created over fifty years ago is 'out of copyright'. The copyright-holders are represented by the Mechanical Copyright Protection Society. With the rapid development of domestic tape recording, the M.C.P.S. made

it clear in 1959 that, in its view, copyright would be infringed if music was recorded from the radio without licence or the permission of the copyright-owners, even though it was intended for use only within the immediate family circle.

At about the same time the M.C.P.S. proposed to a number of tape-recording clubs that such recording might be regularized by the issue by the Society of an annual licence, and an annual fee of two guineas was tentatively suggested. After consideration, this proposal was rejected by the Committee of the Federation of British Tape Recording Clubs. In their statement, they argued that tape-recording clubs were not concerned with the replay of copyright material but with the creative uses of recorders. 'There are no grounds for entering into any agreement which involves payment by member clubs for "rights" which they do not desire or which they already possess,' they added.

Another interesting point made by the Federation was this: 'Everyone has the right himself to perform copyright music in private. The recording of such performances for the immediate or subsequent enjoyment of the recordist, in private, is such a minor extension of the existing right that the Committee sees no reason why this should involve payment of a fee.'

No further action has been taken on either side, but it seems unlikely that we have heard the last of the matter. The individual who does not belong to a club is, in any case, left in difficulty by the M.C.P.S. proposal. 'At this stage, we can see no practical way of authorizing the recording of copyright music by the individual who is not also a club member,' a M.C.P.S. spokesman has said. 'But the copyright-owners reserve unto themselves the right to take whatever action they may think fit in protection of their interests, should occasion arise.'

That is where we stand today. There can be no legal clearance for the individual amateur to use his recorder in all the ways which have been described in this book; on the other hand, tens of thousands of people are known to be doing most, if not all, of these things at the present time. The position of the copyright-holders is clear and understandable. Authors and composers live on their royalties, just as radio engineers live on their salaries. Recording companies who spend vast sums on ambitious projects depend upon a certain minimum sale of the discs to recoup the cost, and an unauthorized recording of their issues will rob them of their fair return.

The present position is unsatisfactory, but it may require some years more of practical everyday experience before a sensible solution is evolved.

The exciting future

SOME audio experts behave on occasions as if we have almost reached the ultimate in equipment and performance. It is a curious human foible to be so pleased with one's achievements as to discount the possibility of further dramatic advance. In 1914 a distinguished German conductor was ready to greet one of the first recordings of a complete symphony as genuine hi-fi. 'The reproduction of vocal or instrumental music is absolutely true to nature from an artistic standpoint, and the sensation it produces is simply overpowering,' he gushed.

The pace of progress is constantly accelerating. It is nearly eighty-five years since Edison produced his phonograph. It is thirty years since Blumlein laid down the principles of stereo recording and reproduction. It is fifteen years since the first domestic tape recorders became available. It is little over ten years since we had the first microgroove discs, six years since the first stereo tape record, three years since the first stereo discs and radio transmissions . . .

Some indication of the next expected advances has been given in this book. Although the disc undoubtedly has a long life before it, I believe myself that there will be increasing use of tape decks, probably using midget cassettes and auto-change mechanisms, for reproduction of music. These may well be simple playback decks, which do not offer recording facilities. Those who wish to record will continue to use machines similar to existing recorders. If, however, we do see a breakdown into playing decks and recorder reproducers, I would expect the latter to adopt two recording tracks

as the standard. The attraction of four tracks is an economic one, for it enables twice as much material to be stored on a given length of tape, available for playback. On the other hand, as we have seen, the extra tracks are a hindrance to creative tape-recording activity, as they make editing difficult.

The use of printed circuits and transistors will increasingly lead to more compact designs for equipment of all kinds; it will, of course, play a vital part in the development of genuinely portable, battery-operated tape recorders selling at a popular price. Within a few years they should become as widely used as 35 mm. cameras.

Adequate facilities for linking different pieces of hi-fi equipment are becoming standard practice. All tape recorders should certainly be provided with output sockets for external amplifier and external speaker. A control to enable tape to be 'inched' slowly past the replay head while it is monitored is invaluable during editing; very few recorders provide such a facility at present.

The extension of facilities and concentration on producing units to precision instrument standards may occupy our attention for some time. If high quality output transformers, rumble-free turntable decks and narrow-gap magnetic heads can be produced more cheaply, the quality of the lower-priced units will improve.

Pickup design is receiving close and continuous attention in the laboratories of all the firms in this field. Three or four products have appeared in the last few years that have brought an entirely new standard of high-fidelity; but they are expensive. Further achievement can be anticipated—claims of even lighter tracking weights are already heard from America.

If there is a long-term future for the disc, we may see yet

narrower grooves, so that there will be more playing time. That would involve, however, a stylus with even more microscopic radius playing tip.

I am sure that the future lies with stereo. It has had the misfortune to be hailed as a gimmick which transforms the reproduction of music. If it is considered in sensible proportion, it takes its place naturally as an enlargement of the illusion of reality. Multi-track stereo is used in cinemas; home equipments using three or more tracks are technically possible at any time. It would be a grave mistake on the part of manufacturers to embark on any new venture of this kind in the immediate future. The public requires a period of stability and consolidation, during which to absorb information about current equipment and to assess its performance. Research should now be concentrated on improvement of the present two-channel techniques.

There is probably scope for advance in loudspeaker design. Many fine brains are engaged on the problems. One of the most interesting ideas developed in recent years is that of the ionic speaker, which dispenses with the familiar cone. It has no vibrating member to provide a mechanical coupling to the surrounding air. Instead, molecules of air are 'ionized' in a quartz chamber and so given an electrical charge. If such a speaker can be developed on a commercial basis, it may provide us with improved reproduction of high frequencies.

In general, however, I expect the most sensational achievements in the future to come in the world of tape. If one allows imagination to run riot, the possibilities are scarifying. The blind are already using tape books and communicating with one another with tape letters. Computers have been brought into use which store information—which hitherto needed to be in written form—as pulses on magnetic tape. Thirty million characters can be stored on a

single spool of tape and they can be transferred from the tape to an electronic 'reading' system at a speed of 100,000 characters a second. This is equivalent to reading an average novel in ten seconds. At the other end of the scale, nursery rhymes, fairy stories and music for children are now sold on tapes, so that the business of bringing up the new generation is made conveniently automatic!

Is it beyond the realm of possibility that this generation will grow up to a world in which reading and writing are dying arts? When books can be heard (complete with sound effects), when news comes by television, when letters are dictated and replayed, how *necessary* will the written word become? Will literature survive, as we know it?

This may sound extravagant, but already books and magazines are on sale which link printed text with plastic sheets providing sound reproduction. These normally take the form of lightweight discs, very cheaply produced, which can be played on any ordinary record player. But in Japan and in Germany magnetically coated sheets are now being used and it may soon be possible to draw a small, pencil-like instrument along the printed lines as you read them and so to produce in an earpiece the appropriate supplementary soundtrack.

Tape recorders are today circling the globe in outer space. They have been sent up in rockets and space-ships and their signals have been transmitted back to earth and been re-recorded. Indeed, techniques have now been evolved whereby the recorders can be switched on and off from ground stations as they pass overhead. This opens up the possibility of an entirely new form of communications system. Messages may be beamed to a space-ship's receiver and recorded as it passes over one continent and then be played back and re-recorded as it passes over another one a few minutes later.

One of the most fascinating developments of recent years has been the introduction of video tape and the associated equipment with which it is now possible to record and to reproduce immediately television pictures. Video tape is essentially similar to sound-recording tape, but it is two inches wide and coating tolerances are much closer. Recordings can be erased and the tape used again; the recording and reproduction processes are instantaneous, as with sound.

Before video tape, television programmes which were to be repeated had to be filmed and the film had to be processed. Delays were inevitable and the final result was easily distinguishable from a live telecast. Today it is virtually impossible to know whether you are watching a live performance or a tape recording. The tapes are capable of handling colour or black and white, though at present colour is unnecessary in the absence of transmitting and receiving equipment.

Electronically, there is little difference between the taping of video signals and the recording of sound—both involve feeding magnetic impulses through the heads on to tape. In fact, one or two amateur enthusiasts in Britain have constructed their own equipment with which they have recorded pictures on standard quarter-inch sound tape and achieved clearly defined—though not high-quality—pictures on playback through a standard domestic recorder.

In the United States, one firm has already demonstrated a magnetic 'hear-and-see' tape machine that will take a recording of a TV programme—sound and picture—and play it back later on a domestic TV screen. It may be ten years before such equipment is available to the public, but the possibilities are unlimited. You may be able to hire TV tapes or to borrow them from public libraries and to play them on your set at home. You may get daily tape-news-

papers, with an hour of news and features in pictures and sound.

After that there could conceivably come a revolution that will undermine present photographic techniques. I quote an executive of one of the leading American tape-manufacturing firms: 'Electronic movie cameras will shoot magnetic tape, rather than film, eliminating processing.'

So one day you may be able to go out with a portable recorder and bring back a sound-movie which can be immediately played over your domestic TV equipment.

Such is the promise of the exciting future. Meanwhile, the achievement of the present is so great that amateur enthusiasts may find in the field of high-fidelity sound recording and reproduction as great a challenge to their creative ability, as wide a variety of possible activity, and as satisfying a standard of musical experience as any man or woman can reasonably expect.

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Douglas Brown had an intimate association with the world of audio during its exciting development in recent years. He is the editor of *Tape Recording Fortnightly*, which he founded in 1957. In 1959 he founded a sister publication, *Stereo Sound and Music Magazine*. Since the beginning of 1961 he has been the regular compère of the BBC programme, *Sound*. He is a Fleet Street journalist of wide experience who is well known as a commentator on current affairs.

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