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All about Stereo 2

Your guide to stereo from disc · tape · radio

by Clement Brown editor HI-FI SOUND magazine

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All about Stereo

WHAT IS HI-FI and why is its appeal so strong? How does one set about choosing equipment and ensure it is kept at peak performance? How does stereo work and what are its advantages? Will new developments affect the choice of system? Answers to such questions form the basis of these booklets. Written by Clement Brown, editor of *Hi-Fi Sound,* and closely linked with the policy of the magazine, these concise guides are of special value to the beginner but also meet the need of the more advanced amateur enthusiast for a survey of his chosen subject.

Titles to follow in this series are: Hi-Fi Planning and Buying, Using your Hi-Fi, and Practical Hi-Fi Guide. Introduction to Hi-Fi has already been published.

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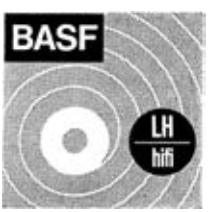

CONTENTS

1	KEEPING IN TOUCH	**11**
2	STEREO ON RECORD	**18**
3	PICKUPS AND SPEAKERS	**26**
4	STEREO BY RADIO	**33**
5	STEREO ON TAPE	**36**
6	THE IDEAL SYSTEM	**45**
7	QUADRAPHONICS	**47**
8	THE STEREO FUTURE	**55**
9	MAGNETIC CARTRIDGES	**57**
10	QUESTIONS AND ANSWERS	**61**
	USEFUL DATA	**62**

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1 KEEPING IN TOUCH

A CURIOUS title, for a start. Keeping in touch—with what? With the music, of course. Stereo is the development that made it easier for the music-lover to hear, in his own home, the natural sound of the performance, with all its detail. It is very much a matter of acoustics—of transmitting to the listening room the music *and* its setting. Whether or not the 'acoustics' are authentic (sometimes not, as it turns out) is hardly the point at issue at this stage in the explanation.

Looking at stereo in this way we have the key to the complexities of modern stereophonic sound reproduction. If, while listening to your favourite music, you care to imagine that the marvels of science have wafted you to the concert-hall or studio, your thinking is along the right lines. Sound reproduction of high quality does put you in touch in this way, creating an illusion that tends to make immediate surroundings unimportant. If you prefer to reverse the situation and think that the symphony orchestra has arrived in your home—well, there's not much harm in that so long as the result is convincing; but clearly there is not the slightest chance that the 102 musicians can be accommodated.

What about hi-fi, and does it have to be stereo? For practical reasons it *does* have to be stereo. It is difficult to find mono equipment, and there are few mono records. However, the point the would-be enthusiast should understand is that stereo is a means of obtaining higher fidelity. But it is possible to have stereo without hi-fi: in fact, it's easy—all you need is a conventional stereogram, as explained in *Introduction to Hi-Fi.*

Since the beginner is being asked to absorb first principles in order to grasp the essentials of stereo it is helpful to state what is wrong with mono. We are all accustomed to it, for single-channel sound is emitted by the great majority of radio sets as well as very many record players.

With mono, the music, all its parts and its acoustic setting, are mixed together and funnelled into one channel of communication—a single route, through wires, tape tracks, disc grooves, radio broadcasts, from studio to listener. At no stage is there any separation of the elements of the sound. It is not possible to separate the ingredients of the mixture, for the ears and brain are not presented with the right kind of information to enable them to do their work.

It makes not a bit of difference how many microphones or loudspeakers are used, the single channel resists any attempt to clear the congestion. One of many possible examples: movements involved in the programme, such as stage action, are reduced to differences in loudness, rather like to-ing and fro-ing in a tunnel extending behind the loudspeaker.

For realism we want the complexities of the sound sorted out and clearly presented in the listening room. We want detail, not muddle; and we want an illusion of space around the sound—the ambience of the place in which the music-making occurred.

Not surprisingly, as the interest in high fidelity increased, mono reproduction was brought to a high standard The limited size of the sound source in the room was improved to some extent by the use of omni-directional speakers,

which give a pleasing effect on mono due to the general dispersion of their output. Again, it was quite common to use two conventional speakers in parallel in order to broaden the apparent source. Artificial reverberation was added to recordings to give a more spacious effect at the expense of clarity.

But these tricks, however ingenious, cannot overcome the basic limitation imposed by mono's single channel. The requirement is a multi-channel system: the actual number of channels used may be large at the 'professional' end of the chain, though two channels have been the limit for the 'commercial' stages—the records and the hi-fi.

Using our ears

Our ears and brain constitute a complex system, receiving and interpreting information concerning the world about us. As we go about our everyday business we learn, quickly and surely and usually without much effort, about the positions of sound sources and their movements, and we can estimate distances of sources fairly well without having to stand and ponder the clues our brain receives. We make small head movements to check on what is going on overhead.

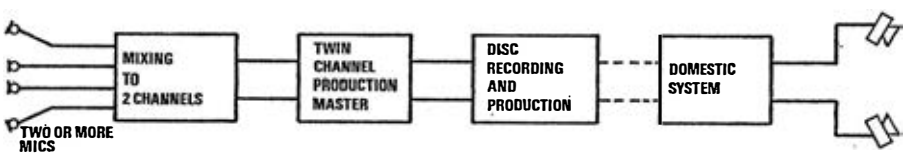
We collect information about directly received and reflected sounds. If we closed our eyes to exclude visual clues we could tell the difference between outdoors and an enclosed, quiet place—even a big one. That is by no means the end of the matter. In fact a human brain, more commodious and versatile than any computer, accepts and processes a never-ending flow of data about aural experience. It is very complex indeed—and we still have to cope with sight, smell and touch!

Much of the sonic activity mentioned here is relevant to musical enjoyment and to stereophony. For instance, the sorting-out of musical sounds and the 'acoustics'—all part of the recorded package deal we buy—is particularly important.

However, when the stereo pioneers first conducted their experiments they evidently had the simplest of the many requirements in mind. They wished to give an extra dimension to the reproduction—a horizontally spread sound-stage which would present the various elements of the sound-source in their correct relative positions. Information of the up-and-down variety was not among the possibilities, although we pick up such information in everyday life.

The earliest experiments, following the invention of the telephone but not related to recording, which was in the most primitive form at that time, concerned the relay of opera and theatre performances to telephone subscribers. In 1881 a Parisian engineer, Clément Ader, was granted a patent describing this binaural service whereby listeners were to use headphones to follow the movements of performers on the stage. This aspect, the location of sources on a sound-stage, is of course a feature of modern stereo.

These days it is acknowledged that the idea of space around the sound is outstandingly important. The requirement is the recreation of the spatial arrangement that applied to the sound sources—orchestral musicians, operatic singers, members of a jazz quintet, even a solo performer. If this



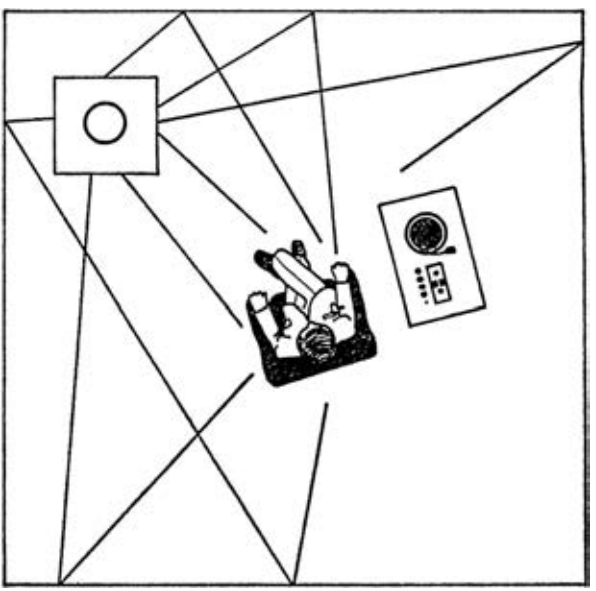
Main stages in stereo production. Multi-channel recordings are reduced to two channels for disc production.

requirement is satisfied, as it is to a great extent with twin-channel stereo, there will be separation of the individual sounds that comprise the whole, *and* the acoustic setting will be conveyed at the same time.

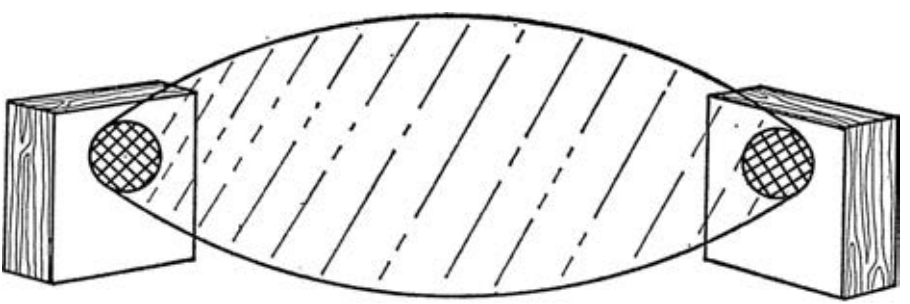
Although this stereo image involves only a lateral spread it embraces a great deal of information. The most important bonus is the opening-up of thick textures, so that tonal fidelity is improved. This is a result of the separation of the sources. While the transmission of ambience is essential to realism because the overall scene is presented more naturally, this advantage is also heard to affect the sounds that come from individual musical instruments. The extent to which this trick will be pulled off must depend on the excellence of the stereo engineering; but the ways and means are known and there is evidence that all the advantages can be realised. Any further advance takes us beyond the restrictions of twin-channel reproduction and towards the possible developments of the future.

Principal gains

Since so many listeners have never heard stereo at its best or have been misled over the nature of the development, it will be helpful now to summarise the principal gains that follow from the use of this twin-channel reproduction at



Non-directional speakers, giving a wide dispersion of output were popular for mono.



Twin-channel stereo adds a dimension. A laterally spread sound stage is the most obvious feature.

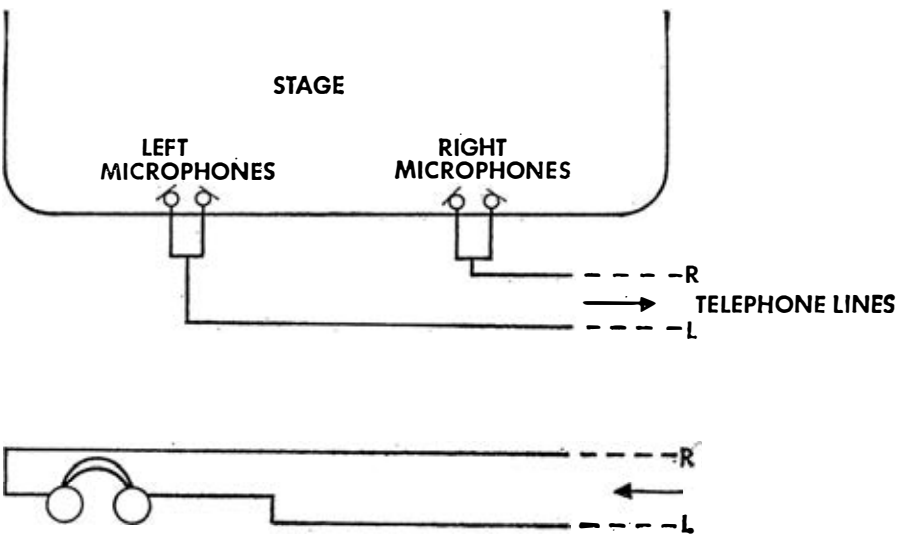
high fidelity standard. That is, we shall assume that we are enjoying stereo recording of the best kind and that we are going to some trouble to reproduce the records (or broadcasts) as they deserve. It is hi-fi and stereo together that yield the desired results.

Reference has already been made to the sorting-out process—the clearing of muddle and the opening-up of textures. Such attributes are noticed in the evenly spread sound, which places the various sources on a laterally spread image that extends between the loudspeakers and conveys also the impression of depth. Thus the extra dimension enables us to listen 'through' the obvious physical confines of the speaker arrangement, the sense of perspective opening the way to an appreciation of the broader scene of the original performance.

Where the physical layout of performers happens to be important, an impression of it will be conveyed to the domestic environment. Whether or not that is required, the advantages of separation always have a beneficial effect on the reproduction. A special aspect is the acoustical environment of the music and the projection of this quality in the listening room, where the character of the original sound is imposed on the domestic acoustics. Even a solo instrument sounds better in stereo for it seems to be the right size, and the setting of the instrument in its natural framework makes for a more rounded, convincing tonal character.

Detail is revealed all along the stereo image, a result of the way in which the studio microphones have covered the performance from numerous vantage points. Therefore it is possible to convey an illusion of movement on the sound-stage—an advantage that is firmly associated with opera but is also proving attractive in electronic music and popular entertainment. There is great scope for 'spectaculars' including recordings of railways and other outdoor activities. In all these things the revelation of fine detail, especially the transient nature of sounds, is vital for realism; and dynamic range, as judged subjectively, is influenced.

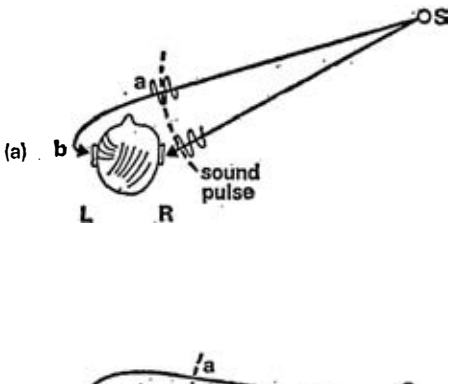
Misinformation about the main attributes, and complete confusion over the



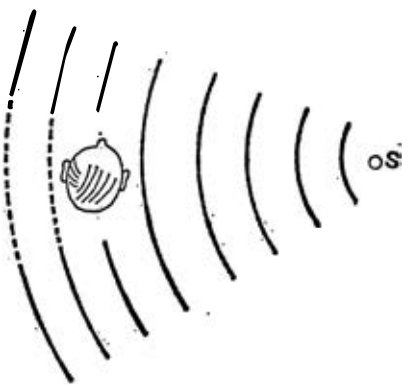
Ader's relay system using telephone lines.

more subtle aspects, have always abounded, though the most damaging critical comments are heard less often nowadays. At an early stage the dislike of many people for audio gimmickry was transferred to quite serious recordings. Strongly defined left-right effects were contrived so that the sound from the new stereograms could seem different from mono. But it was only too easy to dismiss stereo as a serious contribution, and the presentation of performers in their correct relative positions was not seen as an advantage central to the enjoyment of music. In fact this most obvious of features is bound up with all the others, and subsequent experience has proved that the most obtrusive of separation effects can be avoided without loss of stereo's more musical benefits.

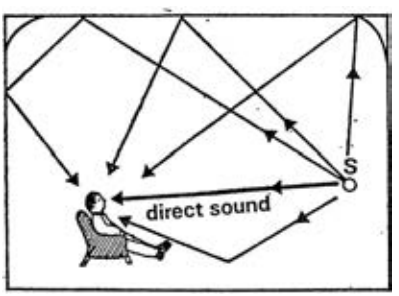
In view of the misunderstandings, some of them perpetuated over the years we have used stereo, it is hardly surprising that record companies have considered it a commercial proposition to reissue some of their older recordings of the mono era after subjecting them to 'electronic reprocessing'. These have been recut with stereo grooves following the application of technical tricks—a simple frequency range division, perhaps, together with some reverberation to gloss over the outdated sound quality and produce a more spacious effect.



A sound pulse takes a little longer to reach the left ear due to extra path length ab. Longest delay occurs when the source is opposite one ear. There is zero delay with the source in front of the listener.



Loudness differences are important. Shielding effect of the head makes sound louder at ear nearest the source. This is effective for short duration sounds and continuous sounds, but former can be localised on time and loudness differences.



Sound reaches the ears by direct and indirect routes. Using this scattered information we locate the source without difficulty. For direction finding we use the sound that arrives first.

These discs are mostly quite cheap and one can assess them as 'budget' products, ignoring the euphemisms about stereo effects and deciding whether they are pleasing in relation to price. However, they are mono recordings—and it is not possible to convert mono into stereo.

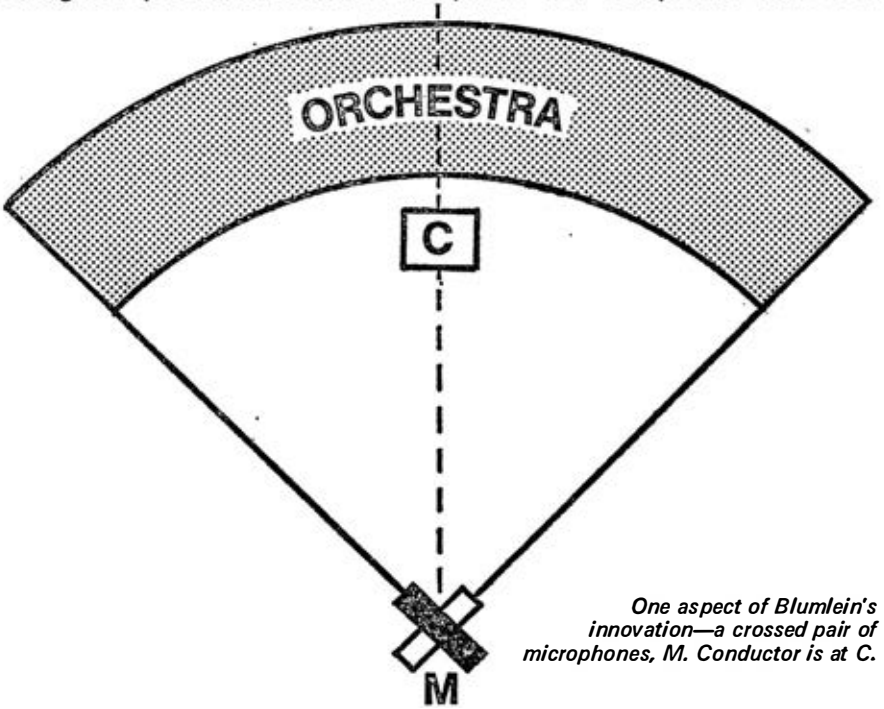
Similarly, the production of stereo from mono hi-fi systems is out of the question. Devices for attachment to audio equipment have been, and still are, introduced from time to time and one can view them in the same way as one views reprocessed recordings. If anything the claims made for such devices are more objectionable than those made for the records; but presumably the small interest in them will fade as more genuine stereo recordings become available at low prices, a field in which some headway has already been made.

Historical highlights

Reference has already been made to an early experiment in Paris with binaural transmission by wires—only a few years after the invention of the telephone. Other experiments of this sort were made early in the present century, and in 1925 a German engineer devised a more advanced system with which he aimed to convey good quality sound from performances at the Berlin Opera. Further, while acknowledging the disadvantage of a relay system involving telephone lines, he suggested that transmissions of stereo via radio would prove attractive.

This proposal for twin-channel stereo involved two separate transmitters—the arrangement that was used later in Britain for experimental purposes in the 1920's and again in the 1950's prior to the adoption of the present single-transmitter multiplex system, which was devised in the USA.

For present-day enthusiasts the phase of stereo's history that has special significance started in 1930. In the USA, at Bell Telephone Laboratories, experiments were undertaken with microphones inserted in a dummy head—leading to reproduction that was acceptable with headphones rather than



One aspect of Blumlein's innovation—a crossed pair of microphones, M. Conductor is at C.

speakers—and continued with spaced microphones and loudspeaker reproduction.

Another experiment of the 1930's was the relay via telephone lines of a concert in Philadelphia to a hall in Washington. Later developments were a twin-channel system for the cinema, a three-channel version of this for showings in the USA of Disney's film 'Fantasia', and a disc cutter capable of cutting two channels in a groove.

However, it was in Britain that the first stereo discs were made. In 1930, A. D. Blumlein of the Columbia Company (it became part of a complex we now know as EMI) devised and demonstrated a twin-channel stereo system which was complete in all respects, from microphones—the coincident pair arrangement that is still used on occasion—to 78rpm disc recording. A patent covering all aspects of this innovation was filed. Blumlein explained that interaural time differences, associated with the 'location' aspect of stereo, could be produced for the listener by two loudspeakers fed with signals having interchannel amplitude differences. It is important to note that the system employed loudspeakers and was conceived as stereophony: there was no mention of headphones.

The advance of sound recording in general was dependent on the development of magnetic tape, which became a German speciality. Professional recording on tape was to become as important for stereo as for mono; indeed, rapid development after the Second World War led to the use of wide tape on special machines to handle multi-track recordings.

The first commercial stereo recordings marketed in the UK were those made available on tape by EMI in 1955. These 'Stereosonic' recordings were the result of a post-war study of stereophony and a development of the work started by Blumlein. His coincident microphones, and indeed the whole system—with some modifications—yielded very good results, but the idea of playing open-spool tapes on fairly costly equipment did not gain general acceptance (resistance to this format has remained to the present day).

So the spread of stereo had to wait for the completion of work on the vinyl plastics LP record. Several methods of recording two sets of information in one groove were proposed, but the system adopted for international use was a development of that invented by Blumlein. This is the 45/45 system in which the channels are recorded at 45° to the vertical.

Pye released the first commercial stereo discs in 1958 together with players of simple design. Soon other companies marketed discs and the further development of recording and audio systems was under way. Limited stereo broadcasting on VHF/FM started in 1966.

2 STEREO ON RECORD

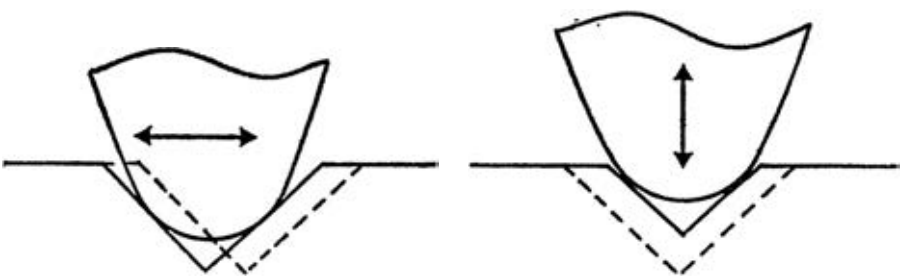
MANY BUYERS of records are familiar with at least some of the stages through which a recorded musical performance must pass before it can be reproduced in the home. In order to complete the story for the beginner, however, it will be as well to summarise the various operations.

It all starts in the studio, of course—or at least, it does if a suitable studio is available. In fact there is a shortage of studios big enough to accommodate large-scale performances and, while pop and light music generally can take advantage of the special facilities of medium-sized studios, large musical forces involving an orchestra and, perhaps, a chorus will most likely be deployed in one of the large halls favoured by the recording companies.

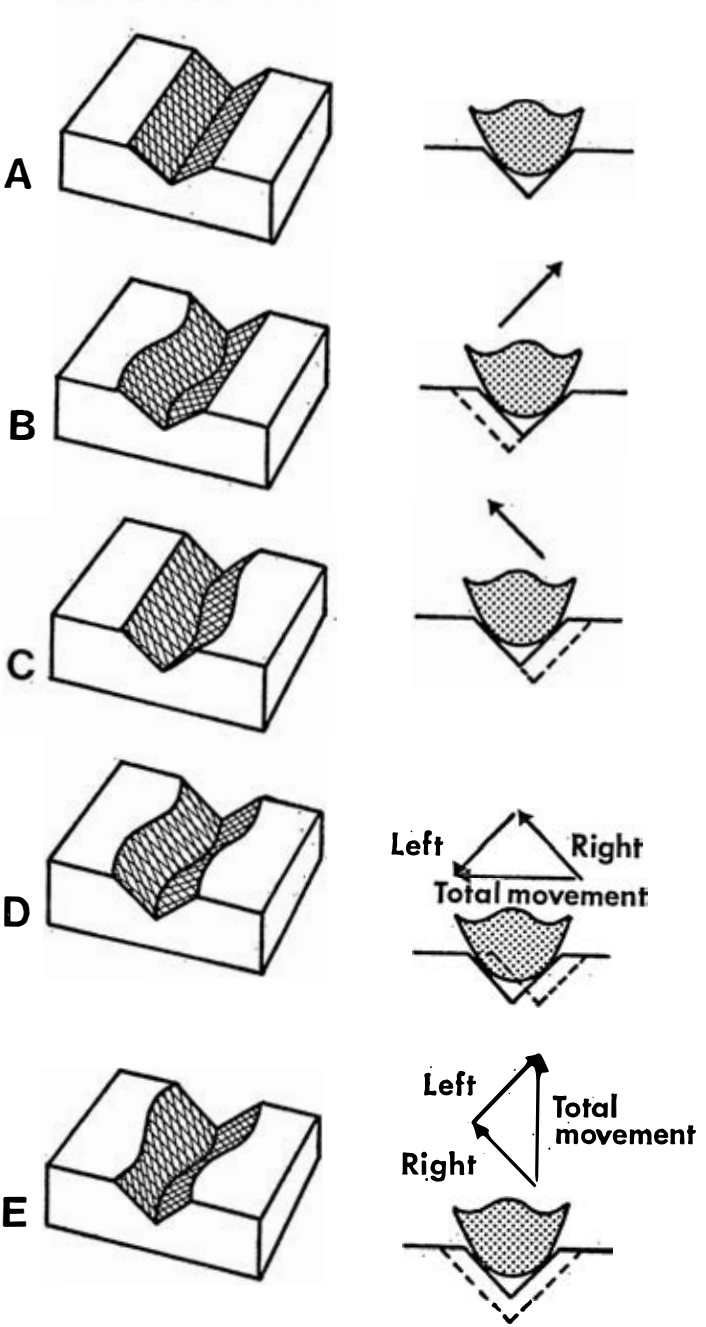
For many years such recording venues as the Kingsway Hall and Walthamstow Town Hall, in London, and Watford Town Hall, have yielded excellent results. Indeed, some halls of this kind were in regular use in the days of 78rpm records. Many recordings originating in other countries for release in the UK are also made in public halls—in Paris, Vienna, Berlin, Prague, Moscow—and in certain instances concert-halls prove suitable. The Concertgebouw in Amsterdam is an example. Other venues include stately homes, churches, palaces and university assembly halls.

Whether the recording is undertaken in a studio or in a concert-hall, joint responsibilities of the recording producer and recording engineers are first to position performers and microphones to produce the best result and then to ensure, by use of the recording equipment and its controls, that the required 'balance' is achieved and any special requirements met. When adjustments are made, and for on-the-spot criticism of the recording while it is made and subsequently, the stereo is listened to on monitoring loudspeakers, suitably spaced so that those present can judge what the buyer of the record will hear.

The word 'balance' in this context is used to describe the mixture of the parts contributing to the complete sound—sections of the orchestra, soloists, and the acoustic characteristics, or ambience, due to the hall. The proportions of direct and reflected sound picked up and conveyed via the stereo recording are important in establishing the general character of the reproduction; and those concerned in the recording will also be preoccupied with such matters as the balance between a soloist or a chorus and the rest of the performers, as



Introducing the idea of lateral and vertical recording. Left: in lateral recording (as mono) the groove does not vary in depth. The stylus is moved from side to side. Right: in vertical recording the groove depth varies constantly and the stylus is moved up and down. This was one possiblity for stereo discs, and the 45/45 system now used is the lateral/vertical arrangement turned through 45°.



The 45/45 stereo disc system. A, no modulation (blank groove). B, left channel modulated. C, right channel modulated. D, channels modulated equally and in phase. E, channels modulated equally and in opposite phase.

well as the prominence given to the strings, for example, or the brass section or percussion.

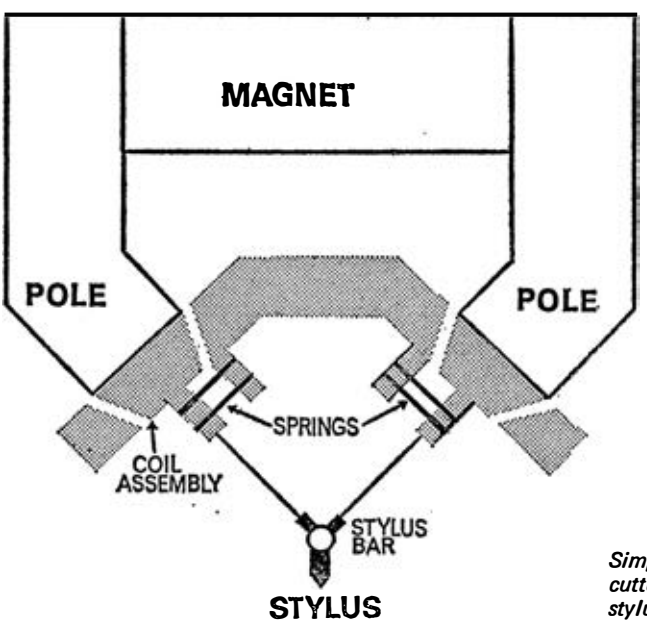
Obviously this kind of operation can become very complex, and it is not surprising to find, with experience of listening to records from different sources (USA, UK, Europe, etc.) that many different kinds of balance are favoured. Subjective judgments are made by producers holding various views on what constitutes the right stereo presentation for domestic consumption. We may consider some results are convincing and rather like a 'live' listening experience while others are spectacular or exciting but larger than life, or lacking in impact and too distantly balanced to expose essential details.

Contrasts

In stereo recording, which may fairly be called a competitive area and one that is also subject to changes of fashion, we find opportunities to hear the same music presented in almost violently contrasted ways. On the one hand we may seem to be thrust forward among the performers, exposed to detail that would not be very apparent if we were listening in the concert-hall. On the other hand, we can probably find a record of the same piece that masks a lot of inner detail and gives the impression that we are listening from outside the doors of the auditorium. However that may be, the important point is that these matters of balance are under the control of the producers. Manipulation of recording equipment and disposition of microphones can give dramatic changes of emphasis, affecting dynamic range, details of performance, our impression of the acoustics and much else besides.

In general it is true (if somewhat facile) to say that we want a natural effect from our stereo if we are to be reminded, in our homes, of how the 'real thing' sounds. Twin-channel stereo, intelligently engineered, can provide natural perspectives, notable features being well separated information—a natural disposition of performers between our loudspeakers and a convincing ambience to set off their contributions to best effect.

These desirable properties depend very little on the package—a disc record



Simplified diagram of stereo cutter head. A heated cutting stylus is used.

or cassette—we eventually buy, and very much on what happens at the scene of the music-making. The basic characteristics of the sound are built into the balanced information that goes onto a master tape in the studio. Subsequent processing, including the mass-production of records (or the duplication of tapes for cassettes), is supposed to preserve these characteristics in twin-channel form for our use.

At one time the best possible result would have been attempted with a pair of microphones—probably the coincident pair already mentioned, used to scan the whole assembly of performers. Or there might have been the addition of a microphone for a soloist, its output being mixed in with the rest of the information. Fairly simple arrangements of this kind are still used on occasion if the recording location is suitable.

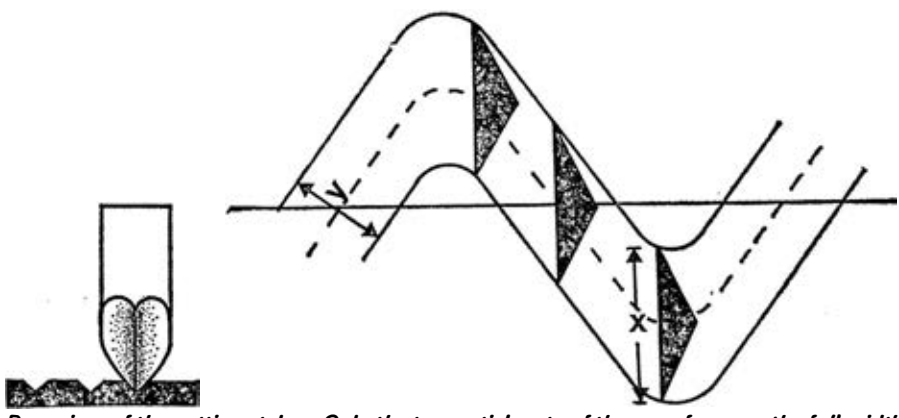
Multi-mike

However, multi-microphone techniques are more common nowadays. For large-scale performances the engineer may use two dozen microphones, some of a highly directional type and some not, to cover a large orchestra, a chorus, soloists, etc. and transmit ambient information of the sort required. The rest of the recording equipment is even more elaborate, and multi-track machines (these often employ 1in. tape) are used in association with complicated multi-channel mixing consoles. Although record buyers sometimes suspect that all this elaboration leads too directly to gimmicks and unnatural effects (and sometimes there is evidence that their fears are well-founded), it is nevertheless true that skilled producers and engineers can use their facilities to give us an integrated sound that is free from disembodied effects yet rich in stereo information (that is the real advantage) and with a natural spread and perspective.

Once the balances are approved the recording is mixed down to two channels, finishing in the form of a two-track master tape, or a series of tapes on which editing jobs can be done. Two tracks now incorporate the multi-channel information, in a form suitable for transfer to disc. Signals are fed via amplifiers and equalising circuits to the cutting lathe on which a master disc is cut as the first stage in record production.

Making records

The operation of the cutting lathe may be semi-automatic or full automatic and programmed for such features as the run-in groove, bands between



Rear view of the cutting stylus. Only the tangential parts of the waveform are the full width of the cutting tool.

musical items and the finishing groove. Variable groove pitch (spacing) is an important feature of the automatic cutting sequence, bringing the grooves cut in the lacquer disc close together during quiet passages and spacing them out for louder passages, where the lateral movement of the cutter is of course greatest. Although this effect is not easily visible on a record that has so many fine grooves (of the order of 250 per inch) the variations are in fact considerable. This technique depends on the use of an extra head on the studio tape replay machine to pick up advance information concerning the signal that is about to reach the cutter. Thus automatic variation of pitch and depth of cut can be obtained.

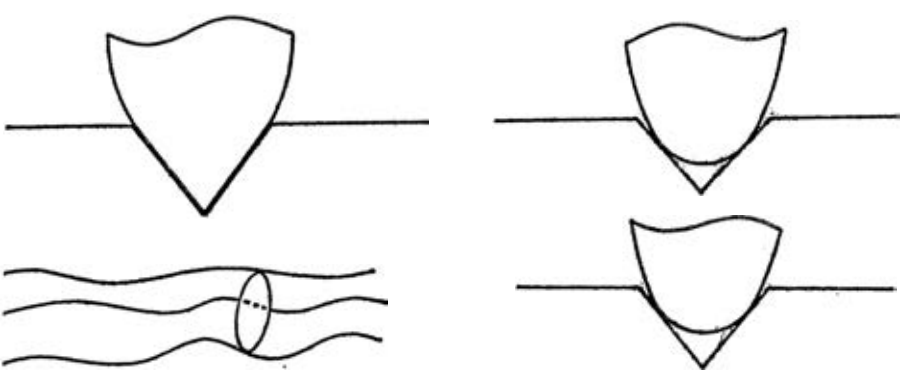
There have been steady improvements in quality of the disc-cutting process. Signal-to-noise ratios have been improved and distortions reduced. Frequency response is typically 25-16,000Hz ±1dB or better, with further extension of the range showing slightly greater departure from linearity. (This is a smaller departure than that imposed by many pickups.)

Record manufacture involves several stages of finely controlled electroplating during which negative and positive copies of the original disc are made. The final metal matrix copies are the stampers used in the record presses. Prior to that stage the preparation of intermediate copies enables extra stampers to be produced quickly if the output of a record has to be stepped up (by use of more presses) or if some damage has occurred.

The records are made from prepared and weighed amounts of vinyl plastics with carbon black, etc. specially compounded for the purpose to ensure smoothness and thus the best possible signal-to-noise ratio in reproduction. This material is placed in the press together with the labels and subjected to a fairly rapid heating and cooling cycle during which the plastics flows into the disc shape and then sets. A degree of automation is applied in modern record manufacture.

We have our disc and we wish to play it to the best possible standards. Of course, a very large proportion of a record company's output goes to customers who use small players. They treat this high-precision product in scandalous fashion and the sound reproduced can only be described as a travesty.

Looking at our own, superior area of the market we find that some record-collectors, proud of the hi-fi systems they have so carefully assembled, maintain that the quest for perfection is really nothing more than a search for records fit to place on the turntable! It is certainly the case that discs of indifferent quality come the way of most people from time to time. However,



Illustrating the difference in shape between the sharp chisel-shaped cutter and the pickup stylus (top). Tracing distortion arises from this difference but can be minimised by the use of an elliptical (bi-radial) stylus tip, which is a closer approach to cutter shape.

it remains true that the best of today's stereo discs embody information which corresponds remarkably closely to that present on the master tape. In making this claim we must set aside—at least for the moment—possible processing faults or damage after manufacture.

Only the most advanced audio systems can reproduce all that is conveyed by such discs. Unpalatable though it may be, very many hi-fi systems do not reveal everything: they do not, for instance, reproduce the widest possible dynamic range, nor do they generate the very deep bass that is impressed in the grooves of many recent records. From a hi-fi viewpoint it is surely unwise to forecast an early end to the disc when its potential is realised by so few users I

Key to quality

If we want to make the best of stereo on disc we must start with the pickup, for this component is the key to quality. The pickup and its stylus must follow an incredibly tortuous path, encountering along the way musical waveforms of great complexity and enormous accelerations associated with sudden changes of direction. Although no component is perfect, the best pickups respond very faithfully by vitrue of the high degree of precision in design and manufacture. In particular, extremely small and light working parts and the greatest possible accuracy of fit of stylus tip in the groove are of the utmost importance.

Reduction of distortion is a basic hi-fi requirement, and an objectionable form of distortion with which designers have had to do battle is 'tracing distortion', arising from inaccuracy in the stylus/groove relationship. This in fact is the built-in hazard of disc reproduction; while it is possible to over-emphasise its effects, it is certainly true that we find no direct counterpart in recording and reproducing methods employing different principles.

Since a disc rotates at constant speed and carries a groove in the form of a continuous spiral, the speed at which the waveforms pass the stylus tip must be different at all points across the record surface. This is the same thing as saying that for a given frequency the physical wavelengths of the groove modulation are subject to change—that is, they reduce as the centre of the disc is approached.

The circumference of the outside spiral of the groove is over twice that of the inner spiral, nearest the label. On a 12in. disc playing at 33$\frac{1}{3}$rpm, a fragment of the sound lasting a second will take up 19 inches at the outside and eight inches or so at the end of the side. Despite this change and the compression of the waveform towards the inner groove, we expect the stylus to trace the signal efficiently.

We have noted that records are produced by copying a master—a disc formed from acetate spun over an aluminium blank. The disc-cutting stylus is of sapphire, heated to make the acetate flow slightly and ensure a smooth and quiet cut, and shaped rather like a chisel. Dimensions and sharpness are critical.

The width of the groove cut by this tool must vary with modulation and only the tangential parts of the waveform are the full width of the tool. As everyone knows, the ordinary pickup stylus has a conical shape and its tip—the only part of it involved in the groove/stylus relationship—is spherical. This cannot fit the groove at all times. Therefore we have a choice: we can use a stylus tip that correctly fits the widest part of the waveform, or one that suits the narrowest part. Any tip with a diameter greater than the minimum groove width must sometimes be pushed upwards in the groove.

This is called the 'pinch effect', which produces unwanted output in the vertical plane and gives us tracing distortion because the pickup stylus cannot follow precisely the same path as that cut by the recording stylus. The

distortion is worst when the modulation has the largest curvature—at the inside groove. Also, it is most objectionable when high and low notes are sounding together at high level—just what we expect to encounter at the ends of many record sides where loud and complex chords bring the music to an exciting end!

In practice the end-of-side sound is rarely as bad as the description of the problem may suggest. However, we should pursue the matter in order to understand the modern, hi-fi approach to stereo disc reproduction. If the stylus fit is poor, why not use a smaller tip? This can indeed make a difference to tracing distortion but it also leads to the problem of 'bottoming' at the wider parts of the groove. Since the groove is not perfectly V-shaped all the way down but has a small radius and possible roughness at the bottom, there is the danger a very fine tip may try to trace the unpredictable shapes and even some dirt lying in wait down there. If we are to use a spherical-tip stylus, we have to settle for a tip radius of 0.0005in. (half-thou. or about 12 microns in the case of some imported products). In fact this half-thou. size has been very widely used in hi-fi stereo pickups.

Elliptical tip

Although reduction of spherical tip size below that mentioned presents difficulties, we can make a worthwhile compromise by changing the tip shape. The so-called elliptical stylus reduces the effective size of the tip as seen by the recorded modulations. This tip sits more sensibly in the groove: it is supported correctly as viewed from front and rear, but it has a smaller dimension in contact with the waveforms. The illustrations in this chapter show how this works. The tip is not truly elliptical, but that is hardly an important matter for any shape with acceptable major and minor axes is a little closer to the shape of the cutting stylus. The advantage is that the elliptical tip (or 'bi-radial' as it is sometimes called) can fit more snugly into the waveforms.

If this reduces tracing distortion it is worth the trouble—or rather, the expense, since ellipticals cost somewhat more than sphericals. In fact the use of ellipticals has been found valuable, and tips of this kind are fitted to the majority of high-grade stereo cartridges. It is interesting to note that elliptical styli were used over 20 years ago for 78rpm records (Decca promoted the idea in association with their ffrr records and the XMS-series pickups). However, it is the modern high-grade pickup, with its low tracking weight, that most clearly qualifies.

Indeed, the tracking weight and tip size must be considered together. If tip dimensions—or the minor radius of the elliptical—are to be reduced, the downward pressure also must be kept within bounds if deformation of the groove, making nonsense of improved tracing, is to be avoided. As things stand an elliptical tip having major and minor radii of 0.7 and 0.3 thou. is practical and quite widely employed, but to minimise wear it should not be used in a cartridge requiring a tracking weight greater than 1.5gm.

This works out all right in practice since really good pickups, with a performance good enough to make reductions of distortion a real consideration, do track under 1.5gm. provided the arm is equal to the task. Those with an even smaller minor-axis radius often track at around 1gm. as is true of a few recent American cartridges. (Even then the pressure in the groove under working conditions is about 50 tons per square inch!)

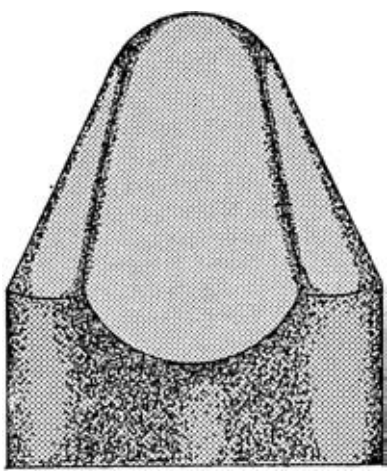
Beginners please note, however, that this is *not* a matter of reducing the pressure on a pickup head to allow the elliptical tip to be safely used! The pickup has to be one that is designed for very low tracking: then the elliptical tip can be employed to good effect. A final warning: the elliptical tip has

become fashionable, even if its role is not always properly understood, and some quite cheap cartridges, designed to track at 2gm. and higher, have gone elliptical. It is rarely possible to prove any advantage, and in some cases it is only too likely that wear is accelerated. In the right pickup, though, the elliptical stylus tip is well worth having as an extra feature.

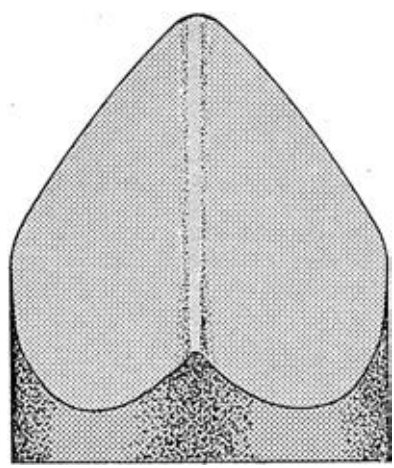
Stylus innovation

To round off this lengthy discussion of one of the most vital aspects of hi-fi, we should acknowledge two related developments. At the time this publication was being prepared the Japanese Victor Company announced the invention of a new type of stylus, claiming a substantial improvement over the elliptical tip. The 'Shibata' stylus, as it is called, has been devised with an eye on the emergence of four-channel discs but its curious shape—another move towards the cutting-tool shape—is clearly advantageous for all records. Claims are: resonances are raised and the hf response thereby extended; inner-groove response especially is enhanced; contact area with the groove is increased and record life therefore prolonged; stylus life is extended; and signal-noise ratio is improved.

We must note, too, that 'pre-distortion' techniques are used by certain recording companies in disc-cutting. The aim is to provide an approach to ideal replay conditions when stylus tips of specific sizes are used. Since information on such technical tricks is not readily obtained it is not at all easy to relate them to what is already done to reduce distortion. It remains to be seen whether such techniques are modified in the light of new disc recording and replay methods or even overtaken by events, but undoubtedly we shall hear more of the subject as development proceeds.



Elliptical stylus tip



Shibata stylus tip

A new stylus shape: the Shibata stylus (right), a Japanese invention, contrasted with the elliptical stylus at present in common use.

3 PICKUPS AND SPEAKERS

THE CHAPTER heading links pickups and loudspeakers. What about the bits in between? Why not complete systems? In fact the transducers, each on its own or both interacting, have the biggest influence on the stereo—its presentation, stability, consistency, possible shortcomings. When later we come to consider sheer quality, particularly power and the ease of reproduction that is a hallmark of hi-fi, we shall have to include the electronics.

Groove-tracing, a precision operation performed in a minuscule world where everything is gauged in thousandths of an inch, offers some problems as we have seen. So does the dynamic functioning of the pickup. Even if the discrepancies arising in tracing the waveforms have been reduced to the stage where they no longer worry us, we still have to consider whether the pickup is actually *tracking* the disc securely. The safest, most secure tracking implies constant contact between the stylus and the modulations that are doing their best to interrupt that contact.

With high fidelity this security of tracking is expected if we give the pickup a chance to do well—that is, if we put the cartridge in a suitable arm and set it up properly for optimum performance on discs that are in a fit state to be played on a hi-fi system.

It is as well to acknowledge at the outset, though, that no pickup yet made will track every last bit of recorded material with complete and utter assurance. What we *are* looking for is a pickup that will sail gracefully through the maximum number of awkward recordings, making sweet sounds practically all the time and causing the least possible audible fuss when any momentary mistracking occurs. Note the 'momentary': the loss of security of tracking with a very good pickup is fleeting, and any obvious and sustained distortions or funny noises indicate a lo-fi or faulty pickup, not a component of the type on which emphasis is placed in this booklet.

Mechanical impedance

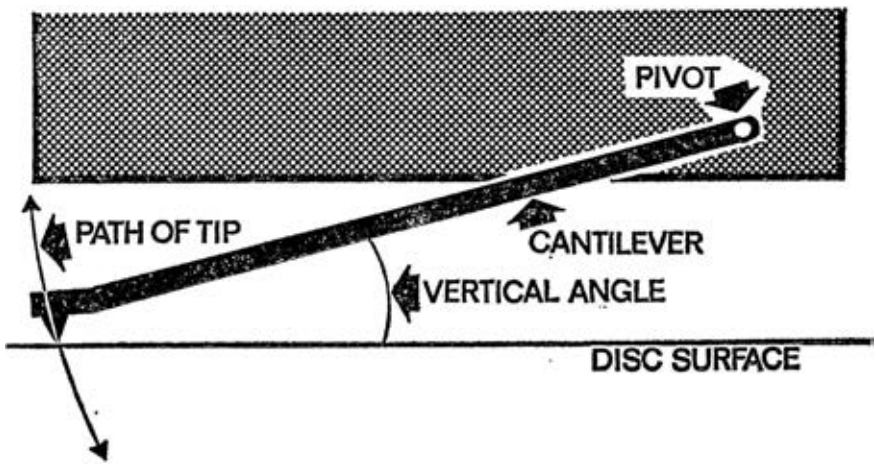
Tracking ability is usually expressed in terms of the tracking weight required to keep the stylus in contact with the groove under certain conditions—a certain level (strength) of recorded modulation, particularly. Of course, the stylus has to be hurled about by a strongly modulated groove while music is reproduced, and it is bound to offer some opposition to this treatment. This opposition is the pickup's mechanical impedance, which incorporates inertia and stiffness.

The inertia is there because of the effective mass of the cartridge's moving part—a mass that has to be moved by the recorded modulation as it passes the stylus tip. It is the mass of the stylus tip, cantilever, armature or whatever, as it affects the groove (i.e. the mass reflected at the tip) and it must be made very small if we are to have hi-fi in the upper part of the frequency range. The stiffness of the mechanism is usually looked at the other way round and termed 'compliance', a property that is not outstandingly interesting or important but affects behaviour at the low end of the range.

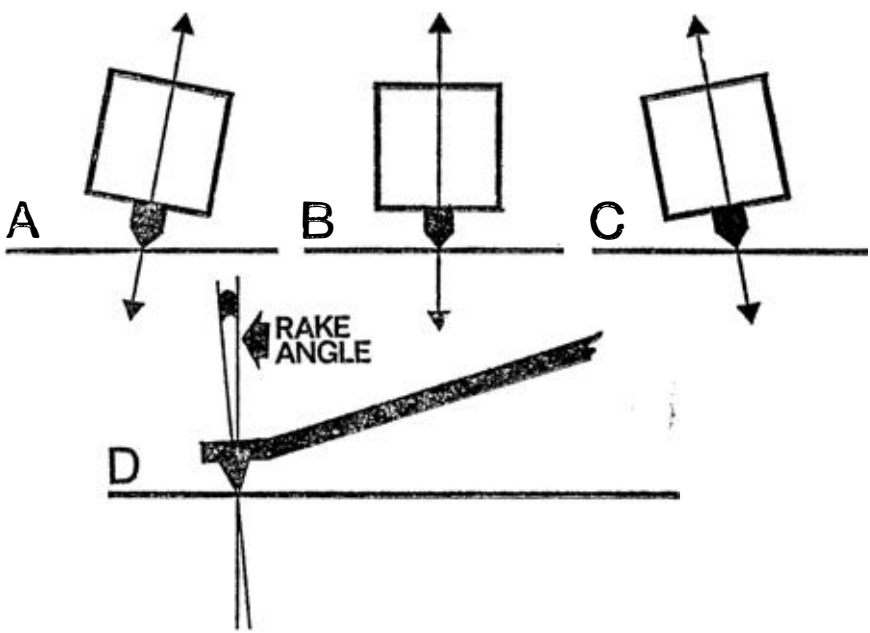
These and other specification points were brought together in the first booklet in this series in order to introduce high fidelity pickups and encourage familiarity with the technical figures involved. At that stage the data reflected the progress made with high-grade magnetic pickups. Reference to manufacturers' literature and magazine test reports will show that claimed figures

of 25 compliance units (or more) and effective tip mass of about 1 milligram are common.

Good examples of magnetic cartridges with specifications of that sort are found to track most material at around 1gm. while ensuring extremely long record and stylus life. In fact, we can practically forget about groove-wear if the discs are kept clean, and our attention can be transferred to the stylus, which we are likely to replace in due time, not because of extreme tip wear (this would be apparent only after thousands of record sides) but because



Vertical tracking angle and path of stylus tip motion.



Side view of cutting head. A, trail on vertical cut; B, vertical cut; C, rake on vertical cut. D shows rake angle of pickup stylus, not to be confused with vertical tracking angle.

fitting a new stylus assembly brings the pickup back to its original condition (or even a superior condition if the manufacturer has upgraded the assembly in some way since the cartridge was purchased).

As for the records, recent experience shows that many hi-fi enthusiasts will have already lost interest in at least some of their discs and be ready to trade them in against new ones long before wear needs to be considered ! However, we must repeat the obvious: the advantages are realised only if the pickup is correctly installed, and adjusted under dynamic conditions for optimum tracking, with bias correction precisely arranged. Hi-fi means no half-measures, especially in disc reproduction.

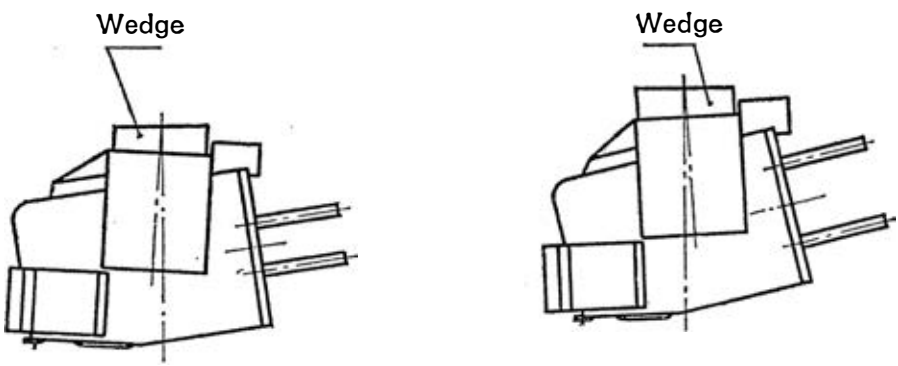
Vertical tracking

This is a convenient point at which to mention vertical tracking angle. More interest has been shown in this parameter recently and there is a clearer understanding that distortion due to the error can occur in much the same way as lateral tracking error causes distortion if the pickup arm is badly adjusted. Vertical tracking angle relates to the angle of plane of movement subtended between the stylus assembly and the record surface (see illustration) and has nothing to do with the angle at which the tip appears to enter the groove. Ideally the vertical movement (actually an arc) should correspond to that of the cutter that made the disc; otherwise there is an error.

There have been moves to standardise at an angle of rake of 15°, although precision is difficult to attain, as is the measurement. Recent tests have indicated that few cartridges claiming 15° actually give motion in this plane, the angle usually being greater. However, the attempt at standardisation is a step in the right direction, and users should take it seriously by setting-up the cartridge with care. Requirements include squaring-up the cartridge in the headshell and adjustment of the pickup to make the arm parallel to the record surface. These requirements are met easily enough with high quality pickups but are difficult, and often impossible, to deal with in cheaper products lacking a range of adjustment.

Separation

So far we have only looked at isolated mechanical matters, but that is because they are outstandingly important in record reproduction. For stereo we also require adequate channel separation or, to put it round the other way, rejection of crosstalk, in the interests of good width and definition of the stereo image. Designers generally achieve a separation of 20dB or more in the mid-



Some equipment manufacturers seek to improve accuracy of vertical tracking under different conditions of use. For example, a wedge is used on Elac cartridges to alter the position from that for auto players (left) to that for manual units in which the arm is adjusted to be parallel to the record surface. An alternative method involves an adjustable cartridge-carrier in the headshell.

range, with a worsening to 10dB or less at the extremes of the range.

To this we can add: close channel balance, low distortion due to the internal workings of the cartridge, extended and smooth frequency response and—to be practical—enough output voltage to avoid problems of signal-to-noise ratio in the working system.

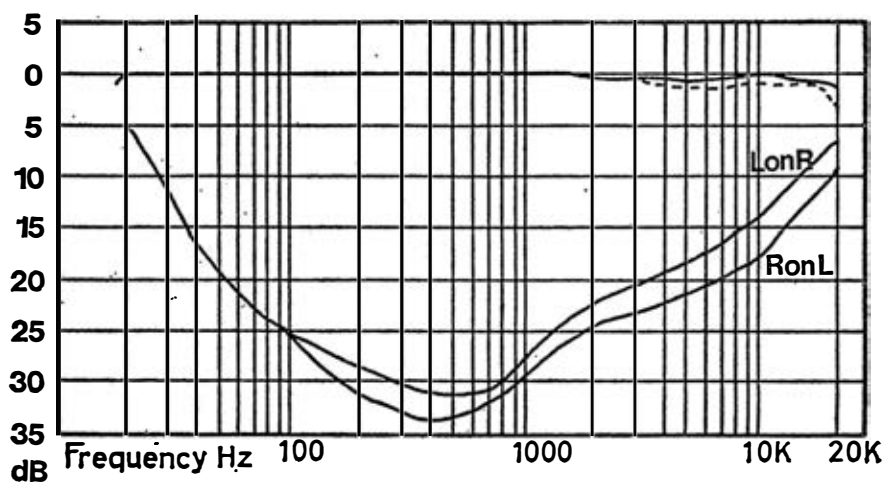
When we come to listen to hi-fi under domestic conditions using practical (rather than ideal!) equipment, we realise that avoidance of obvious response peaks—and especially peaks making themselves heard in fiendish collaboration with certain forms of distortion—is of immense importance. One of the very worst possible conditions is that in which we have a clash of peakiness in pickup and speakers. And that leads us to examine the other side of the picture.

A good standard of hi-fi would be much more easily achieved by a larger number of listeners if they could depend on smoothness of response in loudspeakers. But in fact speakers generally exhibit bigger fluctuations in response (not to mention their other idiosyncrasies) than do other audio components. A study of test reports and other published criticisms of speakers should make it apparent to potential buyers that smoothness of output allied to other desirable attributes such as good power handling capability, low distortion and wide response will usually be found in the more expensive products!

Let us dwell on this question of frequency response. Perhaps this aspect of performance should stand the best chance of being understood, but still it seems to attract some curious judgments and positively misleading advice.

Sweet and low

For instance, very many enthusiasts, setting up home music systems, think first of the bass. They like organ records and big orchestras, so they demand bass—and plenty of it. They seek advice, casually mentioning that the budget allows £50 a pair for the speakers. Well, the fact of the matter is that you will have to search hard to find *one* speaker at £50 that generates very low frequencies at all accurately. On the other hand you can buy boom-and-thump at low prices—it's only too easy. Or you can buy nicely made bookshelf speakers which give limited bass but sound smooth and agreeably balanced,



Frequency response and crosstalk curves obtained with a Decca 4RC cartridge.

so that you have at least secured realistic value and taken a worthwhile step in the hi-fi direction.

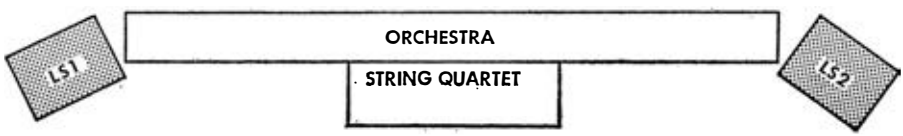
Of course, well designed and well behaved speakers would be as attractive for mono. What has all this to do with stereo? Quite a lot, we find, when we take the main aspects of performance into account. The best stereo records (and the best records *are* stereo) carry some sounds of remarkably low frequency. Stereo reproduced to high fidelity standards, with freely generated bass extending to 30Hz or even lower, provides a thrilling experience.

It is daunting to find, then, that some commentators have stated that really deep bass does not matter so much with stereo. On the contrary, it matters very much, and the bass must be naturally presented as part of the stereo scene.

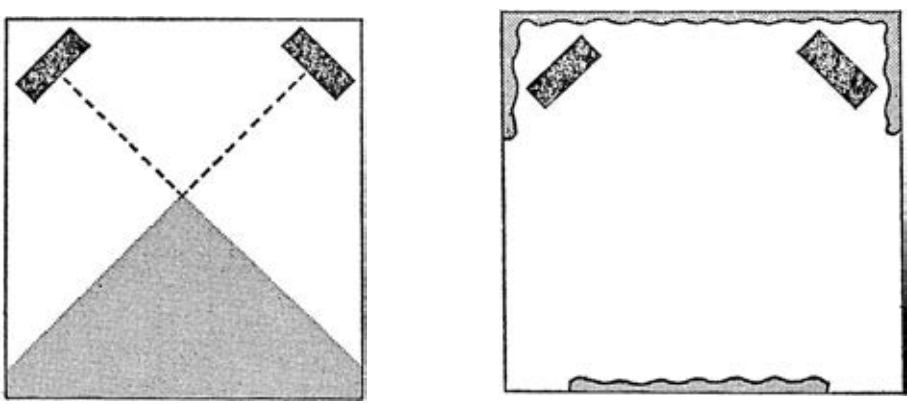
It is said, too, that a good bass response is difficult to live with in anything but a very large room; and it comes about that the best (that is, rather big) speakers become firmly associated with spacious lounges where justice can be done to those organ records. It is far more useful to acknowledge that, for a number of good technical reasons, large rooms *need* hefty speakers. But a speaker that is efficient in the bass and has an extended response will sound good in any room.

Reasons for the popularity of 'bookshelf' speakers for small-room stereo can be summed up in two words—cost and convenience. A pair of small speakers will usually fit the budget many people consider appropriate for a system that can be accommodated in a small room.

An interest in high fidelity implies a determination to enjoy better standards—an idea that was introduced in the first booklet in this series. There may be economic or technical problems but the general aim is clear enough. With loudspeakers we listen for such features as good response to transients—a lively and well detailed account of the programme; good power handling



In stereo reproduction these are the possible relative widths of a large orchestra and a quartet.



Listening and speaker positions are found by experiment. One possible arrangement is to listen within the shaded area. If necessary for control of room reflections, use sound absorbing material such as drapes or soft furnishings behind and to the sides of the speakers. This treatment can be extended to the wall opposite the speakers and may take the form of a curtain.

capability, sensibly related to the system and the room; and an overall sound that is free from obvious emphases, so that the speakers seem natural on all kinds of programme.

Then we should like the distortion to be as small as possible, though this is a tricky point to deal with as facts and figures are not very plentiful. The listener can appreciate the 'sound' of low-distortion speakers as he gains experience. A reasonably broad and consistent radiation pattern is another plus-point where stereo is concerned.

Radiation patterns

We shall return to these and related topics when questions of choice and use of equipment are discussed. However, there is one subject—the dispersion of acoustic output—that is intimately bound up with the presentation of stereo in the listening room and should therefore be introduced at this stage.

We can to some extent consider this in isolation. At least it is true to say that we can make up our own minds about the 'quality' of the sound from a number of good loudspeakers—taking into account distortion, peakiness, colouration—and still be left with a decision to make regarding the accuracy of the stereo.

The twin-channel stereo image is strongly influenced by the radiation pattern of the speakers. As things stand we have a choice between front-facing loudspeakers (the majority) and a smaller but recently increased number of speakers with entirely different radiation patterns, some of the latter being omni-directional and designed to bounce sound off walls and ceiling, the rest having a reflective behaviour—not omni, but not very directional either.

Such non-directional speakers were popular with mono because the general dispersion of output helped counter the sense of congestion in single-channel reproduction and put some space into sound that would otherwise seem very focussed and restricted.

With stereo the laudable aim of many has been to achieve a spacious, airy effect without loss of accuracy of the stereo image. However, the amount of detail in modern stereo recordings can be very considerable, and the ambient information—the setting for the sound—is often very marked. Much of this mixture can be masked and virtually wasted if the loudspeakers are not equal to their task. That unmusical situation may arise for various reasons: the speakers may be cheap, or designed by people who know nothing about stereo; or they may be carelessly installed; or there may be a completely wrong approach to the design of even expensive speakers.

It is important to understand that stereo resides *in the programme*—the record, tape or broadcast—and that the system, not least the speakers, should reproduce the information. The speakers should have radiation patterns that sharply reveal the twin-channel mixture without giving the impression that the listening area is very restricted. Evenness of dispersion of the acoustic output is an essential feature.

At the present stage of development we find it is possible to make front-facing speakers which recreate sharp, detailed stereo, behaving as if they are transparent to the original musical scene, and which at the same time are self-effacing to the extent that the listener can enjoy a consistent, broad image without being unduly aware of the confines of the sound and its left-right electrical boundaries.

Hole-in-the-middle

There have of course been poor stereo recordings just as there are inadequate stereo reproducers. One feature of both is a hole-in-the-middle effect. Omni-directional speaker protagonists have seized on this when extolling the virtues

of their products. They say, with every justification, that omnis prevent the effect (meanwhile forgetting that the aim should be to engineer a full stereo image).

They say also that omnis give you an unrestricted stereo listening area; but this simply will not do, for the messy combination of programme ambience and room effects confusing the ears and brain cannot really be called stereo at all. If the listener accepts this result as a kind of concert-hall acoustic, ignoring the often severe loss of twin-channel detail, that is his affair—but it does mean that he is not enjoying the stereophony in the programme.

Recent developments have also embraced partially reflective speakers of several kinds. But with all such approaches the speaker designer appears to misunderstand and even come into conflict with the aims of the sound engineer and recording producer. However, the situation is not static, and the latest moves in recording are concerned with more convincing concert-hall presentation in the stereo. Perhaps quadraphonic recording may convince the omni designers in a way that twin-channel stereo has failed to do.

4 STEREO BY RADIO

AT THIS stage it can be taken for granted that the audio enthusiast, actual or potential, knows that VHF/FM radio, although on occasion something less than ideal, generally provides programmes to hi-fi standard. AM radio (medium and long waves) with jostling stations, interference and poor frequency response, is useless for serious listening and is in decline as a serious system of communication.

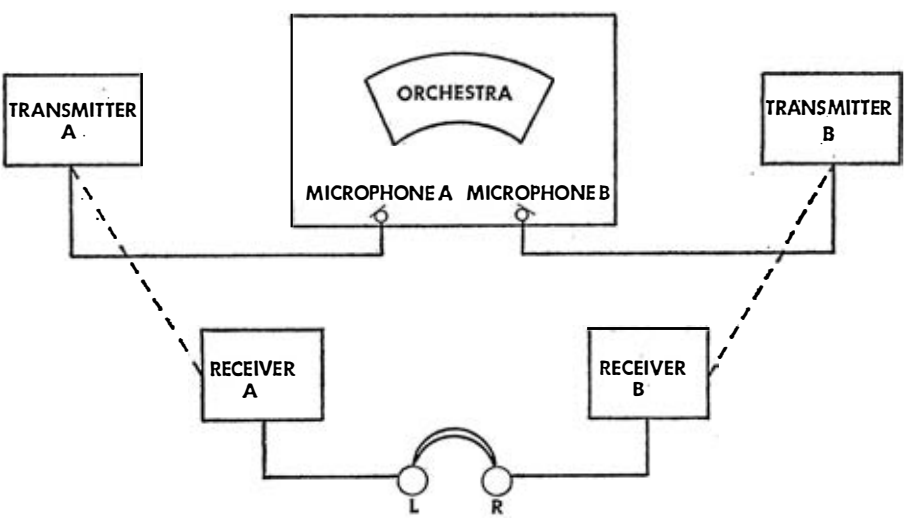
Again, perhaps we can take it as read that a limited stereo service is offered by the BBC on Radio 3 frequencies, shown in *Radio Times.* The transmitters used are those at Wrotham (for London and the South-East), Sutton Coldfield (Midlands), Holme Moss, covering northern areas, and Isle of Wight.

Mono FM can of course give great pleasure and there is the advantage that radio is a cheap hi-fi source. Some listeners continue for a long time with a radio tuner as their only programme source. The inclusion of stereo facilities should make their pleasure complete—and they can hardly fail to be won over by the idea if they hear a broadcast 'live' from a concert.

However, we have not long been able to enjoy the present stereo FM system. At a much earlier stage there were experiments with two separate transmitters using one for the left channel and one for the right. To sample this rather hit-and-miss stereo the listener had to use a FM receiver and a television set for the two channels.

Zenith-GE

Later a single-transmitter method was devised by General Electric and Zenith in the USA, and this was given the go-ahead on its home ground about 10 years ago. This Zenith-GE system came into international use and is the one employed by the BBC. There are some minor technical differences



Broadcast stereo using two transmitters—an early experiment.

between UK practice and that in other countries.

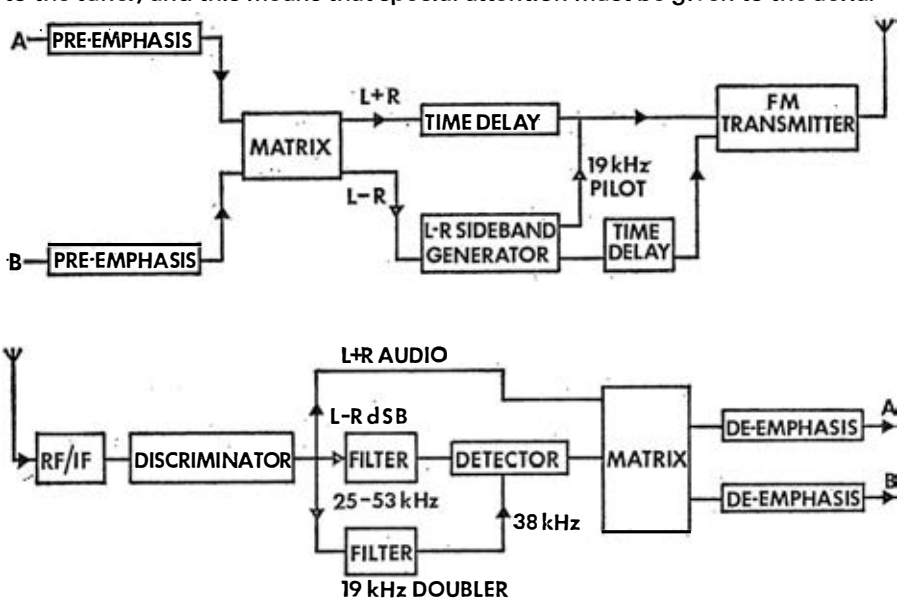
It is a compatible system: the stereo can be received as mono on FM tuners and receivers that are not equipped to cope with twin-channel information. For stereo left and right signals are modulated on a single channel and a specially equipped receiver is needed to decode and retrieve the left/right information before it is passed on to the hi-fi system for reproduction. This simultaneous transmission of normally separate signals is called multiplexing and could be achieved in various ways. The Zenith-GE system is only one possible method, and others were at one time considered in Europe.

Put in the simplest way, stereo broadcasting involves transmission of the sum of the signals (L+R) and the difference (L−R). The sum is actually the same as stereo channels reproduced monophonically; the difference signal undergoes an encoding process, eventually emerging at the sorting-out stage prior to reproduction. This latter process is such that the sum signal is unaffected and can be received as mono.

The difference signal is modulated onto a sub-carrier at a frequency that has to be outside the audible range—38kHz in practice. This signal is derived from a 19kHz pilot-tone source and doubled for the sub-carrier frequency. The information is given enough room to ensure the transmission of an adequate audio response. At the receiving end a detector circuit makes available the difference information so that it can be presented along with the sum signal to provide twin-channel reproduction. A feature of the receiver is a decoder section which provides the audio channels in sorted-out form.

Aerial

A stereo receiver working on a stereo signal is subject to a reduced signal-to-noise ratio because of the complications of conveying stereo information on the transmission. In comparison with mono there is a worsening of S/N of around 20dB. It follows that the biggest possible signal must be supplied to the tuner, and this means that special attention must be given to the aerial—



Top: Zenith-GE stereo system. Sum and difference signals are derived from A and B inputs and added to a pilot carrier. Bottom: in the receiver, matrixing restores the original signals for left and right channels.

assuming that the listener is in an area where he might expect to receive stereo reliably.

Indeed, many complaints about mono FM arise from inadequate aerials, even when the local reception conditions would permit good, interference-free results. With stereo it is especially important to obtain local advice on prospects of dependable reception. For mono and stereo a suitably sited dipole aerial is essential. Although this item is usually simple and cheap for use within a service area. a more elaborate type may be appropriate for fringe-area conditions—and it may tip the scales where there is some doubt about the prospects of stereo.

The majority of hi-fi radio tuners and tuner-amplifiers come from countries, such as Japan and the USA, where stereo FM is in widespread and constant use. Consequently there is no difficulty in choosing a unit with built-in decoder, ready for stereo and mono reception. Either automatic or manual switch-over between stereo and mono may be featured, and several types of device are used to indicate the presence of a stereo signal.

A very few tuners are marketed in stereo-convertible form, the decoder being made available as an optional plug-in accessory which the user can fit. Certain mono tuners can be converted to stereo but this requires the expert attention of a specialist in this kind of work, and in any case it is best to seek the manufacturer's advice as a first step.

5 STEREO ON TAPE

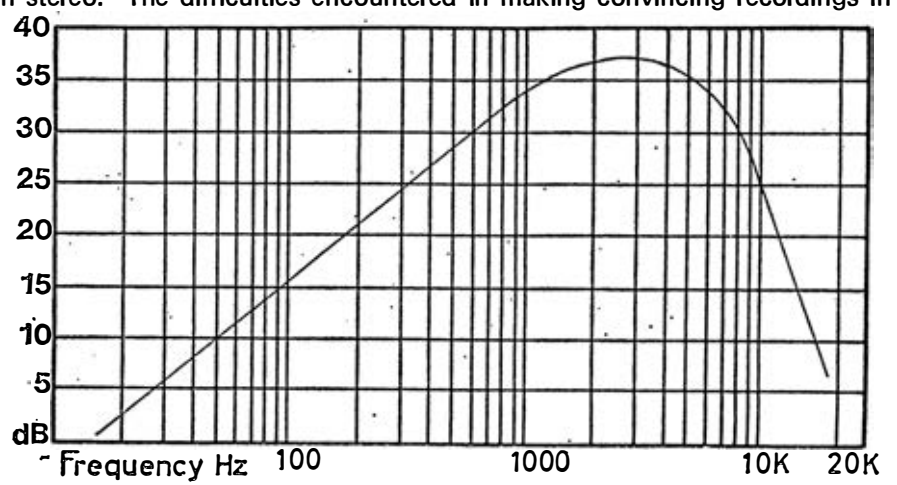
ALL STEREO is on tape before it starts its long journey along the channels leading to the listener! If it was not for the development of magnetic tape recording we should have no domestic sound reproduction of any great merit, and possibly we should still be in a position like that existing when the early 78rpm discs were produced. If the audio enthusiast wishes, he can emulate the professionals and use tape all the time, to the exclusion of discs, for both stereo and mono. In doing so he can enjoy a very high standard of sound quality—provided he is prepared to accept that the cost is high.

At the high fidelity level any attempts at cheapening are likely to lead to disappointment. However, while the means are there for those keen to exploit them, it is a fact that relatively few enthusiasts make a good job—or any sort of job at all—of hi-fi tape recording and reproduction. Of course, tape recorders—useful and fascinating machines that they are—come in for some hard use for family recordings, language study, dictation, music practice, home-produced plays and other activities; but music-lovers starting to assemble hi-fi usually think of disc records first, for perfectly good reasons to do with cost and variety of recorded repertoire. For every serious hi-fi user of tape there are hundreds who prefer discs.

Creative use

In fact the attraction of tape for the sound enthusiast is *recording*, not the simple business of putting on a record and listening to some music. (The emergence of cassettes does of course change this to some extent.) Those who make the best use of costly and versatile tape machines usually become adept at creative recording, which implies a great deal of handling of tape. Editing and some fairly intricate work with recorders and accessories will be involved.

Much of this work is done in mono but a minority of enthusiasts record 'live' in stereo. The difficulties encountered in making convincing recordings in



Typical frequency response of a tape replay head.

twin-channel stereo are by no means negligible; the problems of quadraphonics with four channels have yet to be considered by most tape users! With creative recording the aim is not necessarily to achieve hi-fi, although the experienced user of tape may well have enough skill to produce a signal-to-noise ratio that can qualify.

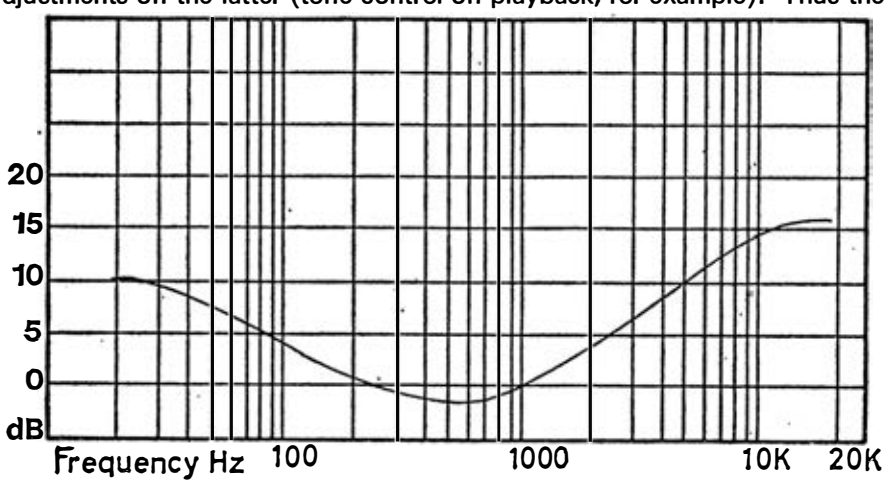
Stereo tape records (a better term for these LP-equivalents than 'pre-recorded tapes', as they have often been called) have been marketed during a number of years without any great success. The first EMI stereo releases were in the form of Stereosonic tapes, and in more recent times there have been open-spool music tapes at $7\frac{1}{2}$ips and $3\frac{3}{4}$ips, twin-track and four-track systems being used by different manufacturers.

Obviously, in this connection, a tape record has a built-in disadvantage compared with discs: stereo requires twice the length of tape needed for mono in that, say, mono quarter-track makes available four separate tracks while stereo uses two pairs (a pair in one direction and a pair in the other direction of travel), whereas stereo and mono discs are physically the same. In production, too, there are snags—the high cost of the tape itself, and the cost and time involved in copying tapes from a master. Although high-speed duplicating can be used, the process is nothing like as simple as the mass-production of discs.

Assuming that the enthusiast wishes to link tape facilities with his hi-fi system, mainly to play tape records but also to do some recording, he will find there is no shortage of machines. A notable feature is the large variety of models from Japan, a country with a huge electronics and radio industry and a substantial export trade. European machines are also in evidence together with models from the few manufacturers active in this field in the UK.

Tape units

Although those who have many uses for tape will probably prefer a complete recorder, equipped with speakers and, perhaps ,some specialised accessories, the hi-fi enthusiast will find it more convenient to install a tape record/replay unit, probably one of those in a wood plinth to match the other audio units. This type of machine has no output stages or speakers but is linked by input and output connections to the hi-fi system and is usually subject to some adjustments on the latter (tone control on playback, for example). Thus the

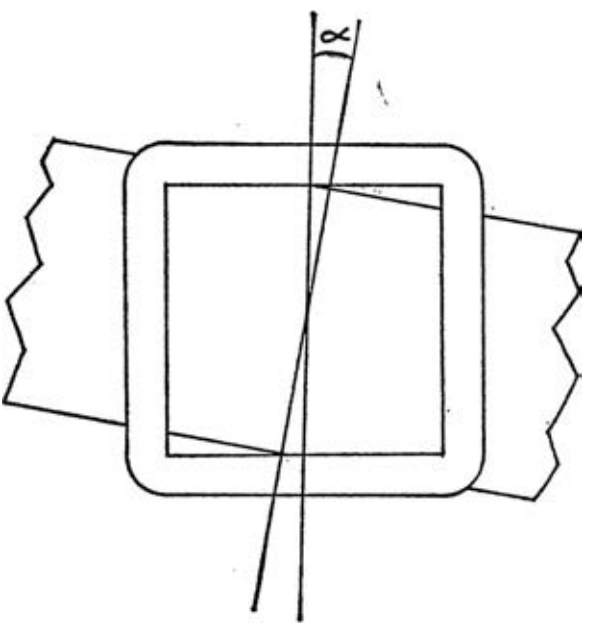


Treble pre-emphasis and a small degree of bass lift are common with recording amplifier stages of modern domestic tape machines.

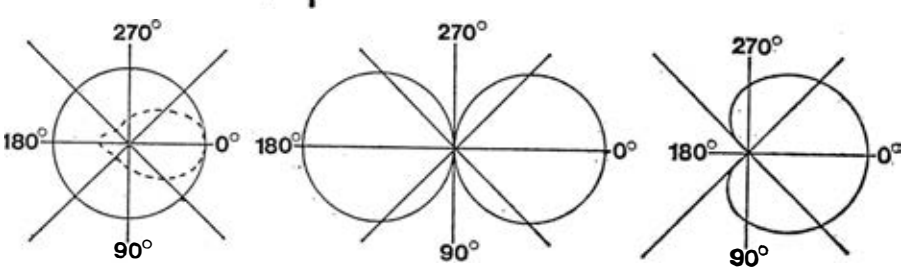
tape unit is intended for permanent installation and is of limited use away from the hi-fi. It comprises the mechanical parts of the recorder and the circuits needed for recording and replay.

The approximate price range for stereo tape units using spooled tape is £75 to £200 or more. Those at the lower end of the range can give pleasant results in conjunction with a hi-fi system, but enthusiasts determined to equal or surpass the results achieved with the best discs and pickups will have to spend a good deal more. Fine results are obtainable with semi-professional machines but even today the tape speed is usually $7\frac{1}{2}$ips, so the cost of the tape must not be forgotten when the audio budget is being examined.

There is some international confusion over tape-machine terminology. In particular, tape record/replay units are sometimes called 'tape decks'. A 'deck' suggests the top surface of something, and so it should prove in practice if one thinks about the hardware. As far as *Hi-Fi Sound* is concerned, a tape deck is the mechanical section of a recorder—the top plate with its tape transport mechanism (motors, spindles, capstan, etc. plus the heads). Using a tape deck only one could play tape records by connecting the replay head



Azimuth accuracy is important. A tilt of the replay head in relation to the tape causes a high-frequency loss.



A B C

Three types of polar response. A omni-directional, but with some directional effect at high frequencies as indicated by the broken line. B figure-of-eight, or bi-directional (e.g. ribbon microphone). C cardoid, with highly directional effect.

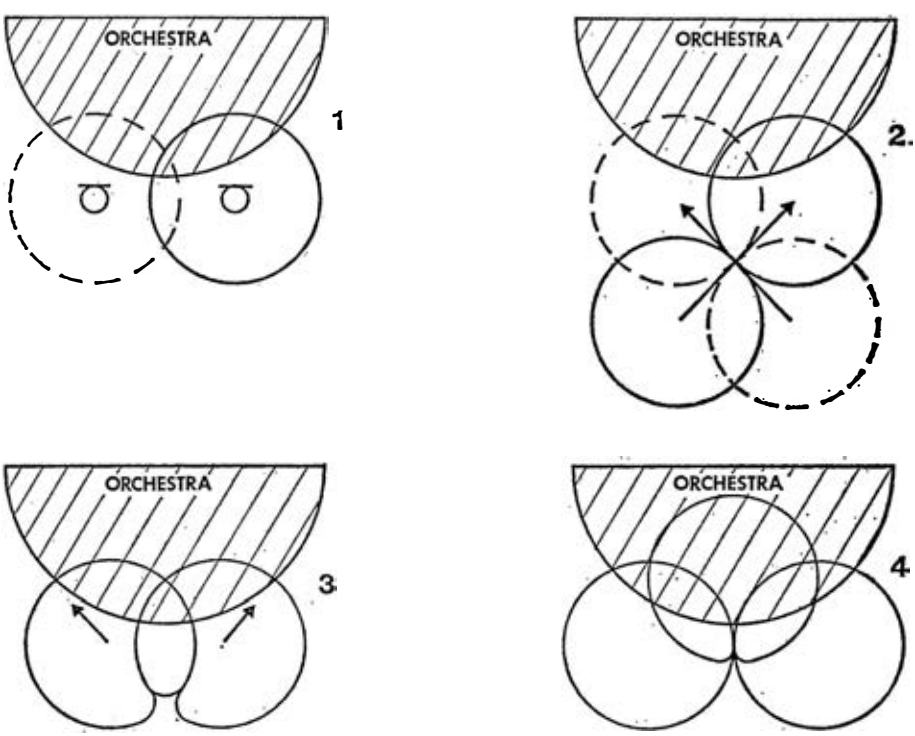
(the only one needed) to an amplifier having the appropriate high-sensitivity input and tailored response equalisation. However, it is not a very attractive proposition in view of the cost of tape records and limited repertoire. Moreover the small number of decks once marketed have dwindled further through lack of demand, and few manufacturers of hi-fi amplifiers bother to include tape-head inputs.

We can sum up at this stage by saying that the hi-fi user can derive a great deal of fun and some very good sound from a tape unit if he budgets for it as he would for a turntable and pickup of outstanding quality. Running costs will be rather high if a lot of use is made of the equipment.

Noise reduction

The maintenance of the best possible signal-to-noise ratio is of paramount importance in sound recording and reproduction—that much should be clear to all listeners who wish to enjoy music in the home at high fidelity standard. Sources of noise are many and varied, of course, and they include recorded background noise arising in the tape recording chain. Professionally, the most successful assault on the problem has been made by the Dolby noise-reducing system.

What is now called the Dolby A processor has been used for some considerable time by the recording studios to bring about a substantial reduction in noise content, and the benefits have been passed on to the music-lover, who gains a better signal-to-noise ratio built into his LPs, which of course embody the basic characteristics of the master tape from which they were produced.



Some directional microphone arrangements: 1, *spaced microphones, omni-directional.* 2, *crossed bi-directional microphones.* 3, *crossed cardioid.* 4, *bi-directional and cardioid.*

Recently the advantages of the system have been realised in a somewhat simpler form in the Dolby B processor, which now appears as a 'black box' accessory for existing tape machines and as an integral part of certain tape recorders, including cassette machines.

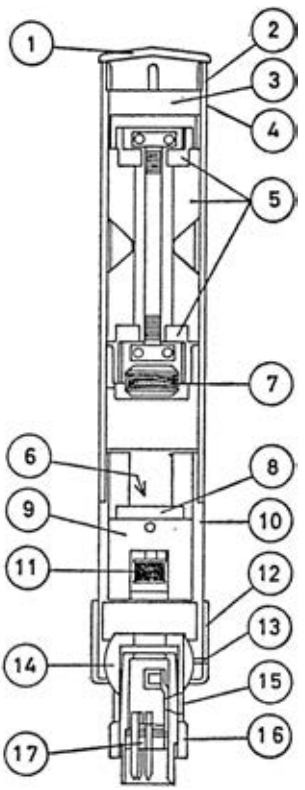
This fully complementary system is also used in the production of cassettes, for example the LP-equivalent cassettes marketed by Decca, and thus an attempt to conquer tape hiss is made where it is most needed. Existing cassette machines employing this processor are fairly expensive—typically a little over £100—but they do of course permit recording on cassettes as well as replay of music cassettes.

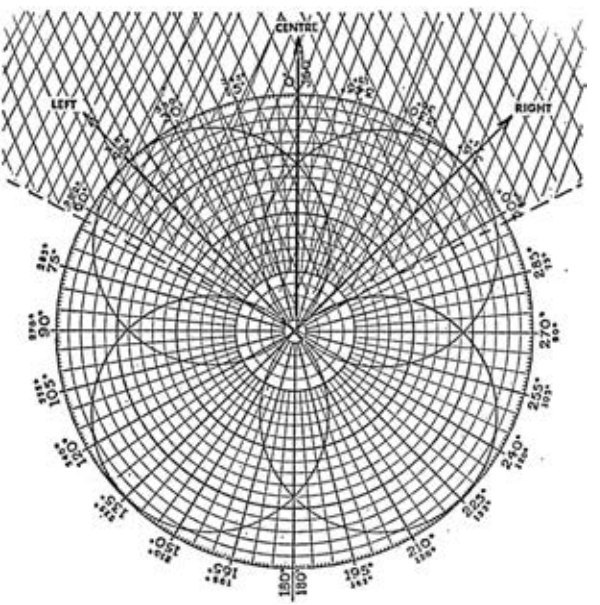
The approach is to process the signals before recording to raise low-level, upper frequency signals well above the noise threshold of the tape. On replay these signals are appopriately depressed—and with them the hiss.

There are already signs that some potential users anticipate a general clean-up of sound reproduction encompassing aspects of performance that are nothing to do with Dolby processing. So beginners please note: the aim is a worthwhile improvement of S/N ratios, and the Dolby processor is not a cure-all for general defects in audio performance.

IC Dolby

Applications of this system are likely to be developed in some interesting ways. Dolby Laboratories and Signetics Corporation (USA) recently announced joint design of an integrated-circuit version of Dolby B, to be made





Internal assembly of B&O stereo microphone. 1 Cover. 2 Microphone housing. 3 Nine-pin socket. 4 and 5 Ribbon unit assembly. 7 Transformer. 6 and 8 Phasing and response switches. 9-16 Lower assembly which also houses the field coil. 17 Connector.

Polar response and stereo coverage of B&O stereo microphone (above).

available to Dolby licensees in 1972. Thus the manufacturing effort is likely to be well spread, and we can expect that the integrated-circuit devices will turn up in receivers and tuners as well as in tape equipment.

There are other noise-reduction systems, ranging from simple circuits with a filter action (which of course is just what the amateur would formerly have expected to use to reduce high-frequency noise) to more elaborate schemes. The most promising of the latter—at least it stems from the most high-powered source—is the system announced this year by Philips. This involves an active noise-reduction suppressor, effective on replay. It is a steep low-pass filter in the absence of high-frequency information and is activated by hf only, so that signals above a certain level will bypass the filter action.

We should note in passing that new tape coatings—chromium dioxide, probably followed by cobalt/ferrous oxide substances—lead to fresh appraisals of S/N performance. However, noise reduction, though immensely important, is but one aspect of performance improvement. Nowhere is this more apparent than in cassette recording and replay, where attempts to achieve hi-fi status have come up against very substantial, though not necessarily insuperable, mechanical and electrical problems. In principle these problems are found in any compact system working at low tape speed. If high fidelity is the aim, improved signal-to-noise ratio must link with other features, notably adequately low distortion and speed fluctuation as well as maximum frequency response.

Cassettes

As already mentioned, the equivalents of LP stereo discs are served up in tape form. At one time the open-spool tape record was the only format, and such tapes are still marketed by EMI (they are on 5in. spools and employ the quarter-track system at $3\frac{3}{4}$ips). However, a feature of public resistance has been the objection to the fiddly job of tape threading and manipulation. The same objection to tape recording is made more generally, of course, and it is the quality-conscious enthusiast who most readily accepts open-spool tape because of its versatility and other advantages.

In recent times small, housed tape devices have become popular, overcoming the objections to the 'mechanics' of using tape. Click them into place and they are ready to play. These cassettes and tape cartridges are issued as LP-equivalents and widely used as neat and convenient entertainment packages but the systems on which they are based are also suitable for domestic recording. A vast array of record/replay machines, mostly small and often designed for operation on both batteries and mains, comes from manufacturers in several countries, with Japan and Europe leading as far as the UK is concerned. Many of these recorders are the music-on-tape counterparts of transistor portable radios, and others *are* radios—with a cassette section.

The term 'cassette' could well cover any device consisting of a tape in a housing, but in practice the tape 'cartridge' also comes into the picture. A cassette is a Philips compact cassette, a plastics housing containing two spools in an arrangement that is similar in principle to that used on any conventional recorder. This Philips device, used all over the world, employs $\frac{1}{8}$in. tape carrying four tracks (two pairs for stereo) and runs at $1\frac{7}{8}$ips. The two pairs of tracks are adjacent, not interlaced, so that a half-track mono cassette machine will play a stereo cassette as mono—i.e. the head on such a machine scans and responds to both stereo tracks.

The absurdly named tape 'cartridge' is a plastics housing containing an endless loop of tape. There may be 300ft or more of lubricated tape, $\frac{1}{4}$in. wide running at $3\frac{3}{4}$ips. There are eight tracks, used as four stereo pairs, on this American device, and the replay machine provides switching for programme

selection. The cartridge is not designed for fast winding and, because it is a loop, the programme goes on to repeat itself—but this probably matters little in its 'background music' applications in cars, boats and other mobile installations. It has not been shown to be a contender in the hi-fi market, although particular examples have sounded reasonably good in respect of frequency response.

The same doubt about quality has to be expressed in the case of the cassette as far as low-cost 'popular' uses are concerned, but recent developments have led to renewed interest in this system at the hi-fi level. This interest is likely to be maintained as new tape-coating materials come into use.

Since convenience in use is a serious claim on behalf of the cassette, the details of practical use bear some examination. It is of course a neat litte device, and turning it over to play the stereo tracks on the other side is a quicker operation than handling a pickup and turning over a disc. Further, the accident-prone listener is less likely to have a serious mishap with cassettes.

On the other hand there may be some conflict between programme lengths on the two sides of a cassette, and it may be necessary to fast-wind the tape left as side 1 before turning over to side 2, or perform some other operation. Obviously the disc is more convenient in this respect. Indeed, programme selection is easier on disc. A cassette machine may have a digital counter making for accuracy in selection, but the reading has to be noted and winding or rewinding done.

A big catalogue of music on cassettes has already been built up. Many releases are stereo, and they cost a little more than discs of the same programme. (Some double-length cassettes are equivalent to double-album disc issues.) With such a cassette in position a mechanical device in the machine prevents use of the recording circuits; but it is possible to arrange for erasure of recordings so that the tape can be used again, and there are plenty of unrecorded cassettes by leading tape suppliers.

Cassette recordings in general have compared unfavourably with discs. Principal snags are restricted dynamic range and high noise level, limited frequency response and higher distortion. Above-average examples reproduced on above-average recorders have sounded quite pleasant; but the fact remains that a top limit pushed up as far as 12kHz is still a lot short of hi-fi—and a system introducing distortion of several per cent, much of it in objectionable forms, is obviously less than ideal.

Typical specification

As for stereo machines, a typical specification of a recorder costing around £70 and having power output stages to drive external speakers (with only 4 watts, though) has such features as a frequency response of 60-12,000Hz, within 6dB; signal-noise ratio —45dB (DIN); wow and flutter not exceeding 0.35%. Not surprisingly, distortion figures were conspicuous by their absence. Facilities, less well thought out than on some open-spool machines, included tone controls.

However, there is more to be said about cassette reproduction. Reference has already been made to the use of the Dolby noise-reduction system in recording and replay. Trials of commercial cassette records issued by Decca and Pye, using suitably equipped and rather expensive machines, have produced encouraging if not very consistent results. The Dolby has been found to work well, often reducing hiss to a level nearer to the almost non-existent background accompanying properly reproduced discs. As for quality generally, the best disc 'sparkle' has been approached on occasion—never really equalled —the low frequency end of the range remaining less satisfactory than from discs.

Rather specialised kinds of distortion have been noticed all too frequently, as has the restriction on dynamic range. To be able to express surprise at what can be achieved at $1\frac{7}{8}$ips is one thing (it would not have been possible until very recently) but successful noise reduction does not guarantee hi-fi. There are various mechanical and electrical factors to consider. The aspect of recording and reproduction discussed here does, however, remain important and further development can be expected to yield some improvements.

Open-spool recorders

A typical stereo machine in tape-unit form for direct connection to a hi-fi system will cost at least as much as a turntable/pickup assembly of very high quality. A few popular units from Japan and elsewhere sell at around £75, and a number of machines with more facilities are priced at £100 or more. Nearer £200 are the units that fall into the semi-professional category, though some good examples cost more than this. The critical owner of a high-grade audio system is hardly likely to be satisfied with anything less than a semi-professional unit, or at least a machine that has some important professional features—largely because of the robustness and precision that money buys—and he will also be looking for a superior signal-noise ratio. In this connection we should note that the Dolby B system is now being incorporated in fairly expensive spool-to-spool machines.

The intending user must decide which tape-track system he requires. A very few machines are equipped with interchangeable head blocks, enabling the user to change from quarter-track to half-track, the latter being favoured for high quality recording with the best possible signal-noise ratio. Where the majority of popular stereo tape units are concerned, heads for one system or the other are fixed to the deck, and the quarter-track system is by far the most common. (We should avoid calling this 'four-track' unless all tracks are used at once, as in quadraphonics.)

If the half-track system is employed for mono, one track is used at a time and the full take-up spool (on the right) is turned over and placed on the left-hand hub for use of the second track. However, for stereo the system becomes twin-track and the recording runs the length of both tracks—top track for left channel and bottom track for right channel.

With the quarter-track system both halves of the record or replay head are in use. Left and right channels are recorded on tracks 1 and 3 in one direction of tape travel and on tracks 2 and 4 in the other. The user who wishes to play the available commercial tape records *and* practice reasonable economy when recording other material 'live' or from FM will require the quarter-track system. If serious recording is the only aim, the choice between the two track systems must be made having regard to the technical attractions of one and the greater economy of the other.

Typical unit

As an example of tape record/replay units for use with average hi-fi systems, the following features of a Japanese machine are worthy of note. Selling at a little over £100, this stereo unit offers $7\frac{1}{2}$ips as the highest of three speeds and, as one would expect at this price, has a fairly simple mechanism and one motor. (It is more sensible to use one motor and devise a dependable mechanism than to use more motors and impose other economies to hold the price down.)

It employs the quarter-track system and has separate record and replay heads, permitting direct or 'off tape' monitoring. The designers' aim has been to please the user who is mainly interested in music—from tape records and via home recording—but there are a few features to attract the creative tape

enthusiast and hobbyist. For instance, track-to-track transfrer and reverberation effects are possible.

This unit caters for inputs from microphones and other sources such as a tuner or the special outputs provided on many amplifiers. Its line outputs are intended for direct connection to a hi-fi amplifier. The usual arrangement would be to leave all inputs and outputs permanently connected, using coaxial cable.

Deck features include record-level meters, pause control and digital counter. Overall record-to-play noise level at top speed is about −53dB below a 1kHz signal at 0dB as shown on the meters. Channel separation is of the order of 60dB. Frequency range at 7½ips is a claimed 25-25,000Hz but no dB limits are quoted. Wow and flutter are reckoned to total less than 0.1% at 7½ips with significant worsening at the lower speeds.

Microphones

As with pickups, there are microphones working on the piezo-electric principle as well as electromagnetic types. In the first category are the crystal microphones, with characteristics that include high impedance, high signal voltage output and low cost. This type is often supplied with inexpensive tape recorders. For hi-fi the dynamic (electromagnetic) types are used. One or two may be supplied with a recorder, or the manufacturer may decide to save the cost of these items and leave the user to choose his own should he wish to take an interest in 'live' recording.

Most often used is the moving-coil microphone, usually of low impedance. In principle this type is like a loudspeaker, for it consists of a very light diaphragm to which is attached a coil the latter being supported in the field of a magnet. The diaphragm is influenced by sound-wave pressure changes. Another type favoured by amateur users is the ribbon microphone, which is related to the moving-coil microphone but instead of a coil has a piece of aluminium foil. This ribbon, supported in a magnetic field, is exposed to the air on both sides and thus is influenced by pressure differences at front and rear—an effect that depends on velocity of the air.

In fact we can label popular types of microphone in two ways. The ribbon type just mentioned is a 'velocity' transducer, for it is affected by differences in the velocity of the air particles jostling to and fro in the sound wave. The moving-coil is a 'pressure' device, affected by pressure changes.

Often used by professionals, and occasionally by amateurs, is the condenser microphone. Whatever the type, the stereo enthusiast can use a pair for experiments and will be wise to seek the advice of leading manufacturers concerning the microphone characteristics (operating principle, impedance, etc.) most suited to his needs. Accessories include special supports for spaced-microphone arrangements used in stereo. Prices of microphones for serious recording cover a fairly wide range, but many people spend at least £20-£30 on a moving-coil model.

6 THE IDEAL SYSTEM

AFTER SOME careful thought and a little study, more to gain confidence in the quest for value than to absorb a lot of technical information he may never need again, our music-loving reader has heard a couple of good equipment demonstrations and noted the important part played by recordings and broadcasts, convincing himself that the most lavish expenditure of trouble and money on a hi-fi system will produce disappointment if the programmes are of poor quality. Finally the equipment has been chosen and installed—his version of the ideal system.

Of course, it may not be everyone else's ideal. But the budget has not been too cramped, so our music-lover has not only been able to include FM radio as well as disc equipment but has also ensured that an outstanding requirement is satisfied—the system is generously rated in relation to the fairly big room in which it is used. The advantage is immediately apparent: the reproduction is clean, secure and effortless, even at the highest output levels, and gives a 'more where that came from' impression.

The free-standing speakers were positioned after a little experiment with spacings and the degree of inward turn, and a reasonable listening area was found at a comfortable distance from the speakers but near the controls. The speakers have been kept away from the room corners but are near a wall. Bass is fairly deep, firm but unobtrusive—all there when it is wanted. Above all it is free from thud and boom; the speakers accept big inputs and are low on distortion.

The stereo image is well defined and spread and packed with detail, and the impression of depth and perspective gained from the best discs and stereo broadcasts is unambiguous, adding immensely to listening pleasure. Small groups are projected in a convincing way, rounded and nicely integrated while scaled down a little as is to be expected, and large orchestras fill—often seem to go beyond—the sound-stage created by the loudspeakers.

This system should be easy to live with, for it has a smooth mid-range and a welcome lack of false emphases. No listening fatigue here. The pickup contributes with its secure tracking, smooth response and general delicacy of reproduction. Listening contentedly, our record-collector thinks of small but vital matters which have been taken into account. The elliptical stylus is accurately set in the high-class cartridge, which itself is precisely installed in an arm of suitable quality. The pickup as a whole has been precisely set-up with the aid of a test disc and is tracking nearly everything in a sure-footed style at just over a gram. Awkward moments, on rather poorly recorded stuff, arise only occasionally and hardly detract from the general excellence.

Records are kept under cover and there is no spectacular dust problem. Over-enthusiastic cleaning is avoided but steps are taken to remove obvious dirt. The odd pop or click can intrude even with the best systems and record collections—a disc manufacturing fault, perhaps—but generally the music is reproduced against a silent background, for the noise level attributed to the motion of vinyl plastics past diamond stylus tip is so far below the levels of the reproduced music.

Fortunately the system makes the best of the situation: it is free from peaky effects that would promote crackly accompaniments to the sound. Easy avoidance of interference is a characteristic of the best hi-fi. We must not forget

the turntable, a silent servant generating a rumble level so far below the wanted signals that is is not noticed on the quietest passages of music.

Radio reception is clear and dependable. The listener reflects that the BBC's claims for FM are largely justified. But then, he is giving it a chance with his sensitive receiver, fed by a dipole mounted and correctly orientated in the loft —fully adequate in this instance where the district enjoys a good signal. He has tried AM (medium-wave) and dismissed it as far as hi-fi is concerned; it is of no use for entertainment—and not much better for basic communication.

Audio and radio controls have been pronounced adequate, and the user has been pleasantly surprised to find how slight is the temptation to fiddle with the bass and treble. In fact they stay at their mid-positions most of the time. The rather feeble filters provided on so many control panels appear again on this one; but there is very little need for them while the better quality records are given priority by a serious listener. That brings us back to where we started —the programme. High fidelity involves a search for superior quality, not acceptance of inferior standards.

7 QUADRAPHONICS

TWIN-CHANNEL stereo adds a dimension and gives us more detail, and at its hi-fi best it can provide a pleasing illusion—and a powerful reminder of what it is like to be present at the live performance. But no-one claims it is all we can do to shorten the links between concert-hall and listening room. Further improvements are prompted by comparisons between reproduced sound and the music as heard in its natural surroundings. What we require is a more convincing recreation of the subjective effects of being present where the music-making takes place.

This implies that we must reproduce in the right proportions a mixture of direct and reflected sounds—the mixture, characteristic of the hall, we would hear from our seat in the stalls. Thus an all-round representation of the auditorium's acoustics would be a more obvious feature of domestic sound reproduction than it is with the picture-window, front-located presentation of twin-channel stereophony. There are other requirements, too. In particular some impression of height should be gained, and clearly this is not produced by ordinary stereo with its horizontally spread image.

A number of leading manufacturing and research organisations are moving into the next phase of stereo, seeking to apply new multi-channel techniques to sound reproduction at virtually all levels of quality in much the same way as was done with two channels in the 1950's. The extra channels enable the directional information to be conveyed more convincingly, and a large number of them would be helpful.

In practice is is found that four channels, each carrying the correct elements of the original sound for subsequent amplification and reproduction. are practicable in that they can be recorded on tape and disc. Loudspeaker placement is likely to be fairly critical and more experience must be gained in producing optimum 'surround' effects that will recreate a natural-sounding ambience and permit the unobtrusive quality that will one day become accepted as another big step in the hi-fi direction.

New label

Four of everything, including speakers, is the magic figure: hence the new label 'quadraphonics'. (It is not an elegant term, but at least 'quad' will suggest 'four' to most people.) Genuine quadraphonic sound involves four channels of reproduction and demands a suitably designed pickup or tape machine.

The first reaction of many listeners is likely to be one of dismay; they may well ask whether the limitations of twin-channel stereo impose any really serious barrier to the enjoyment of music in the home; and there may even be suspicions that doubling-up the channels is a ruse to improve the sales of speakers and find an outlet for the electronics specialists. Such suspicions are hardly surprising, for the promotion of the quadraphonic idea so far has been very weak and demonstrations mostly unconvincing, due to poor recordings and inappropriate loudspeakers.

However, it is useful to look ahead and try to understand how the new techniques will be applied. We can expect that more convincing demonstrations will be offered and that eventually the merit of multi-channel systems will be more widely appreciated. After that it will be a matter of economics as

well as a consideration of concert-hall realism and special effects ! It should be made clear, too, that the innovators are claiming complete—or in certain instances almost complete—compatibility for their systems. Obviously it is necessary to be able to play a quadraphonic recording on an ordinary stereo system and obtain a front-located stereo image.

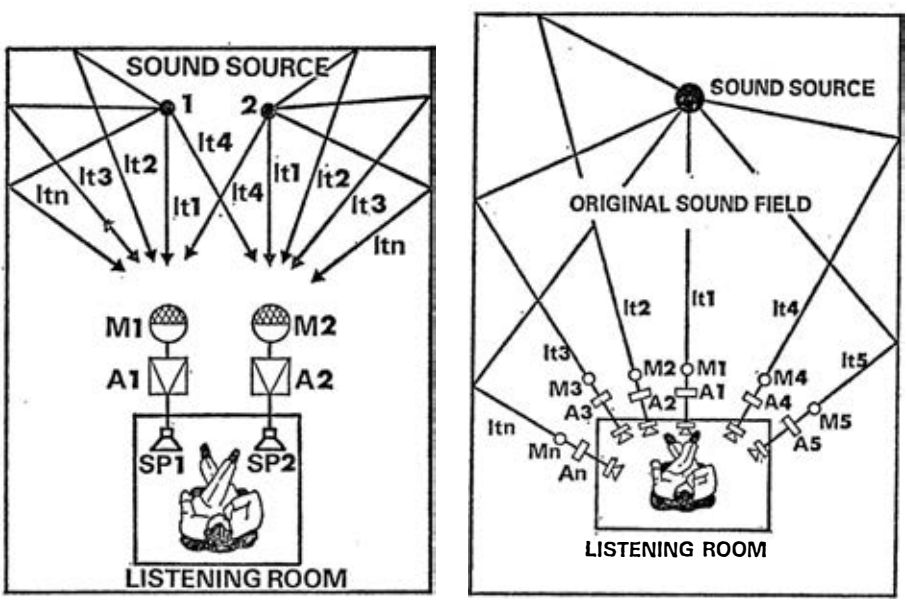
Four-channel discs

To very many listeners it is rather surprising that two channels can be accommodated in one record groove and traced in such a way that the information can be translated into a spread image. All the more extraordinary, then, to be confronted by a four-channel disc, still with the familiar V-shaped groove but carrying the information representing a balanecd mixture of signals derived from the direct and indirect sounds. Such discs—and the necessary reproducers—have been developed in the USA and Japan, and we are already at the stage where details of standards have to be worked out and arrangements made for international marketing of the products.

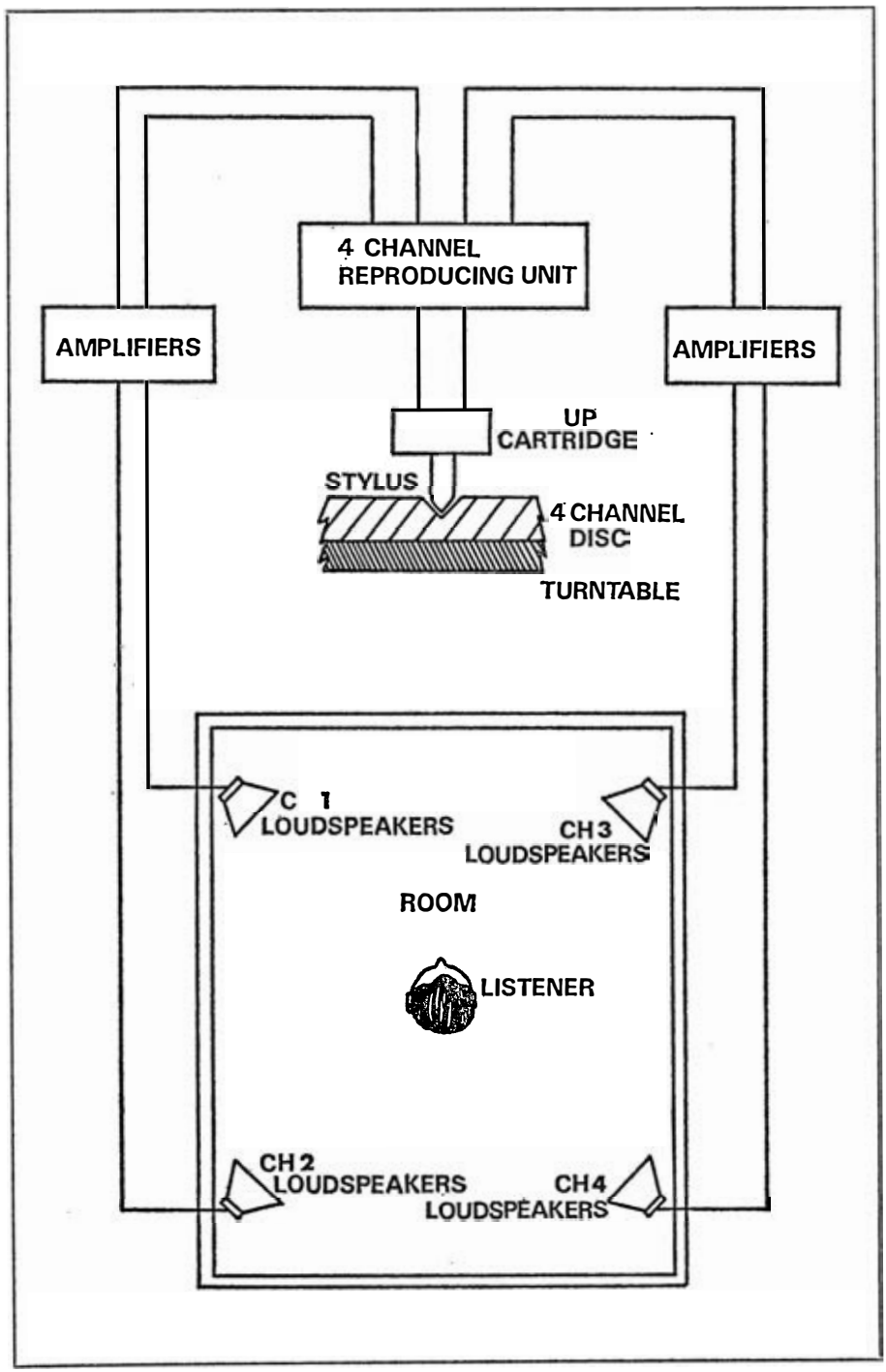
In the USA, CBS Laboratories have developed a compatible system known as SQ, which predictably is short for stereo quadraphonic. This organisation explains that, in the studio, recordings are made on multi-track machines, similar in principle to those used for all stereo, and the result is mixed down to a four-channel master tape.

Four-channel information has to be embraced within the geometrical system devised for two channels (the V of the groove, that is) and with SQ the four/two conversion is effected by an encoder which produces four specific modulation patterns in the groove. These modulation patterns can be separated into four channels by means of a decoder for reproduction via four loudspeakers placed in the corners of the listening area (or in other positions that experience may suggest are preferable).

The system can be explained by reference to the twin-channel groove



Sansui's basic diagram of two-channel system (left) and preferred system involving a large number of channels.



JVC four-channel disc reproduction system.

modulation arrangement depicted in Chapter 2. SQ retains the basic stereo modulations of the 45/45 system but the 'left' modulation becomes the left-front channel and the 'right' modulation becomes the right-front channel. Two new modes of modulation are introduced for the rear channels.

When the master disc is cut, all four channels of a quadraphonic master tape are passed through the encoder. This preserves the front signals but also produces two new modulations, the stylus moving in a circular mode as viewed along the length of the groove. Thus as the disc rotates, a clockwise helix is produced for the left-rear channel and an anti-clockwise helix of the right-rear channel.

CBS explain that centre front sounds are recorded just as in ordinary stereo and result in a lateral groove modulation. The sound can be panned between front left and right speakers as with twin-channel reproduction. This similarity is the basis for the compatibility between SQ and existing stereo. Again, sound can be made to move between any adjacent pair of speakers, and any sound at centre rear is fully reproduced and accurately placed in quadraphonic replay. This will also be reproduced in stereo replay but without location. (In mono it is attenuated in level.)

For reproduction the output from a suitable pickup is fed through a decoder, which yields four signals. These are applied to four power amplifiers and four loudspeakers. It should be obvious that, as with conventional stereo, the reproduction can be at the 'gramophone' level of quality or at any higher standard. For hi-fi results the four channels would have to be of appropriate quality throughout, and therefore quadraphonic sound at its best is likely to be expensive.

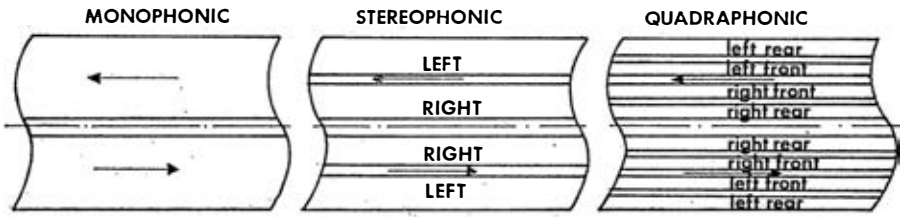
A record produced by this system can be broadcast as if it were a conventional stereo record. A listener with a normal receiver hears the broadcast in the usual way. Quadraphonic reception can be obtained if an SQ decoder is included in the FM receiver. Four-channel tapes can also be broadcast, of course. Quadraphony by radio has been the subject of experiments in the USA and Japan, and we are sure to hear more news of such developments before long.

Up to the time this publication was prepared the information on the CBS disc innovation had not included details of pickup requirements. Japanese Victor Co (JVC) have been more forthcoming and have indicated that a pick-up response to around 60kHz is required for their CD-4 (compatible, discrete four-channel) disc system! Such a bandwidth implies a great deal of new thinking about pickup design and seems to promise a significant step forward in performance, perhaps yielding pickups that stand in relation to stereo cartridges as existing pickups to earlier mono devices. That might be the position if the system were to win wide acceptance.

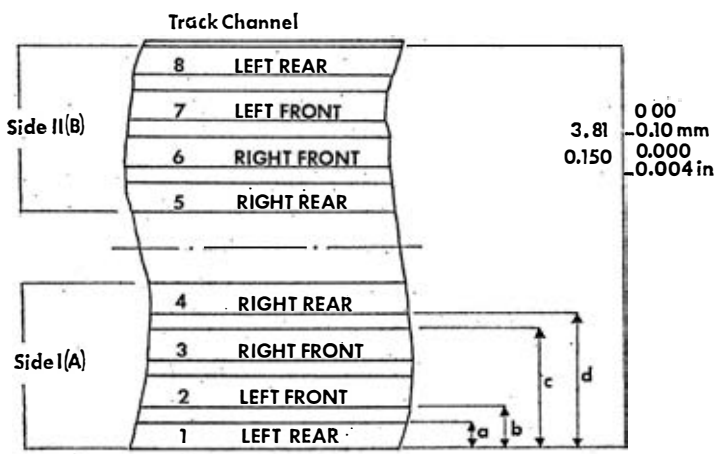
The extended response is required because of the nature of this rather complex system. CD-4 again employs the V-shaped groove but two signals are recorded on each wall. One is the sum of the two channels and the other is a frequency-modulated difference signal. During recording the four-channel signals are encoded—a process of conversion into sum and difference signals through matrix circuits. Sum signals are modulated as with ordinary stereo; difference signals are modulated (carrier frequency 30kHz) and added to the other information. The ranges lower than 800Hz and higher than 6kHz are frequency modulated and the middle range is phase modulated.

During replay the signals are fed into a demodulator to decode the difference signals and produce an audio output together with the sum signals. Matrix circuits convert the products to four channels which are amplified separately to drive four speakers.

Special features of CD-4 include new disc-cutting methods designed to



VIEW ON COATED SIDE



VIEW ON COATED SIDE

	millimetres	inches
a (8X)	0.25 ± 0.02	0.0098 ± 0.0008
b (2X)	0.38 ± 0.03	0.0150 ± 0.0012
c (2X)	1.15 ± 0.03	0.0453 ± 0.0012
d (2X)	1.28 ± 0.03	0.0504 ± 0.0012

JVC proposal for four-channel cassette tracks.

reduce wow, flutter and noise level, claims for reduced distortion and improved dynamic range, and a waveshaping system which appears to have something in common with Dynagroove. Since unusually high frequencies (short wavelengths) are involved in the cutting process, a new noise-reduction arrangement has been incorporated. The Shibata stylus, referred to earlier, has been proposed for playback, the objectives being extended high-frequency response, less wear, lower distortion and better signal-to-noise ratio.

A pickup cartridge designed for CD-4 is of the moving-magnet variety and will reproduce four-channel and twin-channel records. Frequency range (without dB limits) is said to be 10Hz to 60kHz. Crosstalk rejection is 20dB at 30kHz and 30dB at 1kHz. Output balance is claimed to be better than 0.5 dB. Output is reasonably generous and the recommended tracking weight range higher than expected at 1.5-2gm.

Four-channel cassettes

Up to the time of writing there have been a few demonstrations of quadraphonics using four-channel tapes, but no recordings have become generally available in that format in the UK. Four-channel cassettes also have been developed in Japan but not generally released. It seems reasonable to suppose that tape in cassetted form will find some use in view of the increased interest in, and improved performance of, twin-channel cassettes.

Included in this section is a diagram of the JVC proposal for a discrete four-channel (eight-track) cassette system, claimed to be the world's first compatible system of its kind. Such a cassette can be played on a suitably designed unit with four-section head to give quadraphonic output for amplification, or on a conventional stereo cassette unit to give twin-channel stereo.

We must note that tape, without any of the geometrical and mechanical complexities of the disc, accommodates the tracks and keeps them separate in straightforward fashion, as is required for genuine multi-channel recording. However, there is a space problem, particularly on the Philips-type cassette with its $\frac{1}{8}$in. tape, and this must affect noise levels, channel separation and other aspects of performance. Existing twin-channel cassettes (four tracks) are often of doubtful technical quality, at least from the hi-fi viewpoint, and we can hardly expect four-channel versions to be better!

Figures published by JVC suggest that a frequency range of 30-12,000Hz is possible—about the same as for twin-channel cassettes but not in any case a very hi-fi figure. Crosstalk rejection is quoted as 23dB (adjacent channels) and signal-noise ratio as not worse than 45dB.

By the time this booklet appears in print few readers will have seen a four-channel tape or disc, and few will have heard a demonstration of quadraphonics. Moreover it is very doubtful whether any record suppliers will have any detailed knowledge of the subject. In other words quadraphonics are more talked about than practised. Those planning new systems, especially of the more advanced type, are perhaps unlikely to be much influenced by what is obviously a development that still has to be fully justified and given time to generate a range of competitive equipments. There is at least the thought that the emergence of any good four-channel discs will not complicate matters, for it they are truly compatible they can be played on twin-channel systems until the time for change has clearly arrived.

Synthesised quadraphonics

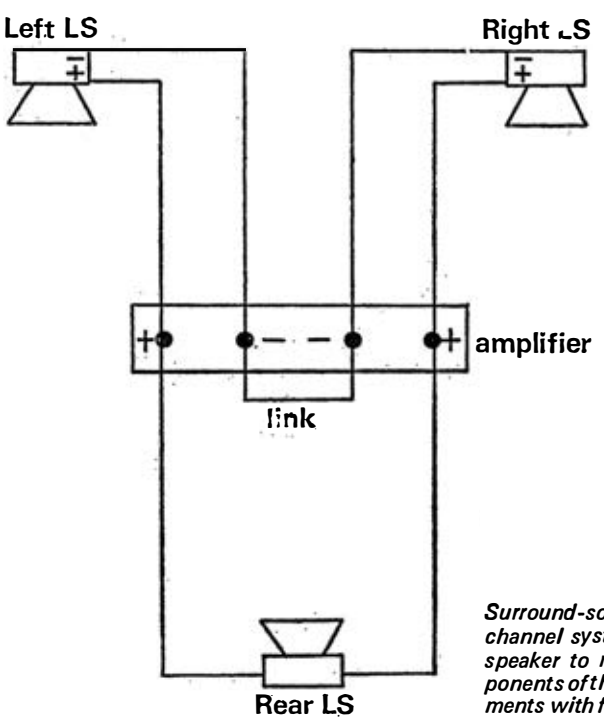
The word 'discrete' is much used by the four-channel protagonists with good reason, for a genuine quadraphonic system requires separately active channels. However, we have not reached the stage where everyone can make

their own assessments of the merits of four-channel systems based on the use of the genuine article. At the present stage a few companies have chosen to promote a sort of compromise system that will synthesise four-channel effects from twin-channel programmes.

In Japan both Sansui and JVC have been active in this area and point out that their systems are compatible. They make it possible to derive from twin-channel sources a surround effect 'comparable with that from discrete four-channel sources' (a questionable claim); and again should all programmes come out in four-channel format in the future, the systems are still useful as a means of reproduction. Indeed, certain amplifier/matrix units are four-channel equipments incorporating circuits which take on the 2/4-channel synthesiser role.

For example, introducing their QS matrix system for four-speaker reproduction (not to be confused with the SQ of CBS) Sansui point out that twin-channel recordings (and broadcasts) contain in-phase, out-of-phase and random components associated with various elements of the sound including the important reverberation content which can enhance the concert-hall realism in a natural way if used to best advantage. The aim, in using the QS system, is to allow direct sound components to be distributed in the front channels and indirect components at the rear, to give a surround-sound effect.

Conversion of four-channel programmes to two channels is achieved by encoding. Japan is the first country to broadcast FM single-transmitter quadraphonics using the encoder. Four-channel music tapes as well as announcements and special effects picked up by multiple microphone arrangements are converted to two-channel stereo for broadcasting by FM multiplex in the usual way. Decoding at the listener's end produces surround sound.



Surround-sound experiments with twin-channel systems can start with one extra speaker to reproduce out-of-phase components of the stereo information. Arrangements with four speakers also are possible.

A simpler approach

Systems mentioned so far are fairly complex, and in particular the use of equipments which, although elaborate and costly, still have the label 'synthetic' attached to them may well be questioned by enthusiasts. However, it is worth knowing that in some ordinary twin-channel stereo records (and in some broadcasts) there is 'concealed' information that can be extracted—and by much simpler means than any mentioned earlier. Indeed it is surprising, though true, that surround effects of a pleasing kind can be achieved by nothing more than the addition of loudspeakers to existing hi-fi stereo systems.

Some existing records have pronounced front-and-rear information, and in typical examples the 'extra dimension' emerges as natural reflections—an essential part of the listening experience and basic to quadraphonics—or a miscellany of sounds that make for greater realism if reproduced behind the listener. The simplest way to extract the otherwise masked ambient information is to connect a rear speaker across the existing system, as illustrated (subject to technical safeguards and, where necessary, checking with amplifier manufacturers the acceptability of extra loading on the output stages). Out-of-phase components can be reproduced, all other components becoming part of the ambient information reproduced by the front stereo pair. In a more elaborate arrangement an extra speaker is at the front to reproduce 'sum' information and another at the rear for 'difference' signals. The stereo pair become left and right reproducers.

Thus the introduction of extra 'surround' information depends on the simulation of additional channels by the manipulation of sum and difference signals during recording. The information may in fact be there by accident, or there may be deliberate attempts to get more out of twin-channel stereo—as has been convincingly described by Dynaco, who have promoted this surround-sound idea with some success.

In the UK the first commercial record to present this feature for demonstration purposes is *This is Stereo** It is a complete hi-fi stereo demonstration including music, sound effects, narration and setting-up tests for ordinary stereo and surround sound. It offers complete compatibility, so that users who do not wish to try surround effects can play the disc in the usual way for purposes of entertainment and instruction.

*Available by post price £1.95 plus 15p postage and packing from EXP Technical Series, 62-4 Silver Street, Reading, Berks. (Trade inquiries to distributors, Howland-West Ltd.)

8 THE STEREO FUTURE

WE HAVE already looked at the subject which, to most people, is still around the corner. In view of the time, effort and money being expended on quadraphonic systems and recordings we can expect that this stereo-plus sound will be strongly promoted by the organisations concerned and taken up by some proportion of those who appreciate this approach to realistic music reproduction in the home. The attractions of competing systems will become better understood, and the new equipment will be installed by those with room to spare—and budgets to match, we might add, thinking of the cost of four channels of hi-fi standard.

In the long run we are likely to see considerable advances in home entertainment, and it is not difficult to visualise audio/video installations of great flexibility incorporating large colour screens (3D or in-the-round, eventually) associated with multi-channel sound as well as full video and audio recording facilities. No doubt the sonic presentation—concert-hall, recital room, jazz club—will be finely judged and readily controlled. Several vision-plus-sound recording systems—cassettes and discs—have been devised and it is to be hoped that we shall finish up with reasonably small and economical packages that are easy to use yet sacrifice nothing of the audio quality that has been won during the development of stereo.

As always, details will matter a great deal. Even in the short term this will be proved true as the use of new electronic devices—integrated circuits, for instance—is seen to influence performance and convenience. The value of special noise-reduction systems has been demonstrated and the emphasis on this aspect of performance is hardly likely to diminish as recording goes from strength to strength. We can expect tailored noise-reduction to feature in more tape machines and also in receivers, possibly to the stage where it is regarded as standard practice rather than a desirable addition.

Although it cannot be taken for granted that cassettes of tape as we now know them will always be regarded as a sensible way of presenting two or more channels of recording, it is probable on present evidence that these packages will gain a stronger position—an advance that rests even more on the development of machines of greater refinement and dependability than on the development of tape materials.

Again on present evidence, with the LP disc holding its own very successfully, we can expect that pickup development will receive a boost. Further reduction of pickup tracking weight below a gram is not the first priority, perhaps, but improved tracking on difficult modulations coupled with greater delicacy of reproduction and wide ranging resonance-free output—and all at moderate prices—will be welcome. There is scope for greater consistency in cartridge production; and while at present there are few models that have all the most desirable attributes, it must surely be the aim to produce thoroughly musical and dependable devices in large quantities at lower cost. With all the important matters under control we might find it interesting to explore some byways that at present are best left to the fanatic: radial tracking devices are representative.

Loudspeaker development is always slow and steady, tending to reflect traditional ideas and an acceptance of new methods and materials that is very gradual—almost grudging. Only the most optimistic enthusiast will expect this branch of the art to forge ahead as surely as others. However, there is

likely to be some influence on shapes and sizes, and even operating principles, if acceptance of four-channel sound is at all general. There is no sign that unusual principles—electrostatic or otherwise—will be exploited very rapidly, but one day the moving-coil unit in a cabinet may at last appear outmoded. Meanwhile, though we shall not expect a dozen speakers at the same price to sound uniformly good, we can express the hope that more will be done with existing ways and means to make better loudspeakers.

There is no intrinsic merit in a matched plug-in-and-play stereo system—other than the obvious advantage of convenience for the non-technical user who wishes to avoid the task of choosing the various components. A planned system package may or may not be the equal of an installation that has been chosen and put together piece by piece. However, it is a fact that many people are as anxious to avoid details as they are to enjoy hi-fi sound, and it is inevitable that complete systems, recently increased in variety, will become more common.

9 MAGNETIC CARTRIDGES

THIS BRIEF survey places the emphasis on the more recently introduced magnetic cartridges which, with a few exceptions, are of advanced type and suited to relatively costly systems of high fidelity calibre. Cartridges in this class depend on electro-magnetic principles as follows: moving-magnet, moving-armature and moving-coil (both these have fixed magnets) and 'induced magnet', the latter being an armature cartridge in which the fixed magnet is adjacent to the stylus-bar or cantilever. Shure and several Japanese makers yield examples of moving-magnet cartridges: so do Elac, who invented this particular type. Moving-armature cartridges include the Decca ffss and the Ortofon M15 series (some pickups in this category are called 'variable reluctance'). Goldring 800 and ADC series exemplify the induced-magnet approach, while examples of moving-coil cartridges presently available are Ortofon SL15 series, Micro Seiki and Sony VC8E.

Many cartridges are excluded from this survey, of course, and this is simply because they are well established designs, introduced some time ago. This applies to various popular models of Decca, Elac, Goldring, Ortofon, Shure, Sony and others. In view of the demand for information on low-budget systems we should note that cheap magnetic cartridges include: Goldring 800H and 850, Orbit NM22, Stanton 500A, NeatV70 models, AD and Audio Technica, B&O SP14, Empire 80EE and Elac 244-17 (this one from Unilet Products only).

ADC

Top quality cartridges ADC25, ADC26, ADC27 and ADC10/E remain unchanged, although prices have been reduced. Replacement stylus prices have also been reduced. The 'X' range of cartridges has been introduced and examples are listed below. Importer: Hisonic Ltd, Eccleston Road, Maidstone, Kent.

ADC25. Induced magnet type, supplied with three styli.
Output: 4mV at 5.5cm/sec.
Tracking weight: 0.5-1.25gm.
Frequency response: 10-24,000Hz ±2dB.
Separation: 30dB, 50-15,000Hz.
Compliance: 50×10^{-6} cm/dyne.
IM distortion: less than 0.5%, 400 and 4,000Hz at 14.3cm/sec.
Vertical tracking angle: 15°.
Load impedance: 47k.
Styli supplied: 0.0007 × 0.0003in. elliptical, 0.0009 × 0.0003in. elliptical, 0.0006in. spherical.

ADC26. As above, but supplied with one stylus only, 0.0007 × 0.0003in. elliptical.

ADC27. Induced magnet.
Output: 4mV at 5.5cm/sec.
Tracking weight: 0.5-1.5gm.
Frequency response: 10-22,000Hz ±2dB.
Separation: 30dB, 50-15,000Hz.
Compliance: 40×10^{-6}cm/dyne.
Stylus: 0.0007 × 0.0003in. elliptical.
Vertical tracking angle: 15°.
Load impedance: 47k.

ADC550XE. Induced magnet.
Output: 5mV at 5.5cm/sec.
Tracking weight: 0.75-2gm.
Frequency response: 10-20,000Hz ±2dB.
Separation: 20dB, 50-12,000Hz.
Compliance: 35×10^{-6}cm/dyne.
Vertical tracking angle: 15°.
Stylus: 0.0007 × 0.0003in. elliptical.

ADC660XE. Induced magnet.
Output: 5mV at 5.5cm/sec.
Tracking weight: 0.75-2gm.
Frequency response: 10-20,000Hz ±2dB.
Separation: 20dB, 50-12,000Hz.
Compliance: 30×10^{-6}cm/dyne.
Vertical tracking angle. 15°.
Stylus: 0.0007 × 0.0003in. elliptical.

ADC990XE. Induced magnet.
Output: 5mV at 5.5cm/sec.
Tracking weight: 1-2gm.
Frequency response: 10-20,000Hz ±3dB.
Separation: 20dB, 50-10,000Hz.
Compliance: 25×10^{-6}cm/dyne.
Vertical tracking angle: 15°.
Stylus: 0.0007 × 0.0003in. ellictidal.

ADC220XE. Induced magnet.
Output: 6mV at 5.5cm/sec.
Tracking weight: 1-2.5gm.
Frequency response: 10-18,000Hz ±3dB.
Separation: 20dB, 50-10,000Hz.
Compliance: 20×10^{-6}cm/dyne.
Stylus: 0.0007 × 0.0003in. elliptical.
Alternative version with spherical tip available.

AUDIO TECHNICA

Most recent additions to this range are the VM3 and VM8, both at the lower end of the price scale. Special feature is the V-magnet arrangement.

VM3. Moving-magnet.
Output: 4mV at 5cm/sec.
Channel balance: ±0.5dB at 1,000Hz.
Frequency response: 20-25,000Hz ±2dB.
Separation: 20dB at 1,000Hz.
Impedance: 4,800 ohms at 1kHz.
Load: 50k.
Compliance: 26 ± 10^{-6}cm/dyne.
Tracking weight: 1-2.5gm.
Weight: 6.5gm.

VM8. Moving-magnet. Specification as VM3, except for the following.
Frequency response: 20-22,000Hz ±2dB.
Compliance: 10×10^{-6}cm/dyne.
Tracking weight: 3-5gm.

AT-55. Induced-magnet.
Output: 4mV at 5cm/sec.
Tracking weight: 2.5gm ±0.5gm.
Frequency response: 20-22,000Hz ±2dB.
Compliance: 22 c. u.
Stylus: 0.0005in. or 0.0007in.
Distributor: Shriro (UK) Ltd, 42 Russell Square, London WC1.

BANG & OLUFSEN

There are three additions, two at the upper end of the B&O price range and one cheaper model.

SP10 and SP12. Moving-armature.
Output: 1mV per cm/sec. (5mV nominal).
Frequency response: 15-25,000Hz ±3dB.
Separation: 25dB st 1kHz.
Compliance: 25 ± 10^{-6}cm/dyne.
Tracking weight: 1gm. (2gm. max.).
Weight: 8.5gm.
Load: 47k.
Vertical tracking angle: 15°.
Stylus: SP10, 0.0006in. spherical.
SP12, 0.0007±0.0002in. elliptical.
B&O also make these pickups in head form to suit B&O arms.
UK distributors: Bang & Olufsen UK Ltd, Eastbrook Road, Gloucester.

SP14
Output: 5mV nominal.
Frequency response: 20-16,000Hz ±2.5 dB.
Separation: 20dB at 1kHz.
Compliance: 15×10^{-6}cm/dyne.
Tracking weight: 1.5-2.5gm.
Load: 47k.
Stylus: 15-micron spherical.

EMPIRE

The UK agency for these American-made cartridges recently passed to Rank Audio Products. For this reason and because some new models have appeared, we include examples from the range. Probably best described as variable reluctance devices, the cartridges have a complex magnetic circuit.

1000ZE/X. Output: 5mV nominal.
Frequency response: 20-20,000Hz ±1dB.
Separation: 35dB at 1kHz.
Compliance: 35×10^{-6}cm/dyne.
Tracking weight: 0.5-1.5gm.
Load: 47k.
Stylus: 0.0002×0.0007in. elliptical.

999VE/X. Output: 5mV nominal.
Frequency response: 6-35,000Hz.
Separation: 35dB at 1kHz.
Compliance: 30×10^{-6}cm/dyne.
Tracking weight: 0.5-1.5gm.
Load: 47k.
Stylus: 0.0002×0.0007in. elliptical.

888VE/X. Output: 5mV nominal.
Frequency response: 6-32,000Hz.
Separation: 35dB at 1kHz.
Compliance: 30×10^{-6}cm/dyne.
Tracking weight: 0.5-1.5gm.
Load: 47k.
Stylus: 0.0002×0.0007in. elliptical.

888TE. Output: 6mV nominal.
Frequency response: 6-32,000Hz.
Separation: 32dB at 1kHz.
Compliance: 30×10^{-6}cm/dyne.
Tracking weight: 0.5-1.5gm.
Load: 47k.
Stylus: 0.0002×0.0007in. elliptical.

80EE. Output: 8mV nominal.
Frequency response: 12-25,000Hz.
Separation: 30dB at 1kHz.
Compliance: 20×10^{-6}cm/dyne.
Tracking weight: 1-4gm.
Load: 47k.
Stylus: 0.0004×0.0009in. elliptical.
UK distributors: Rank Audio Products, P.O. Box 70, Great West Road, Brentford, Middlesex.

GOLDRING

This British manufacturer's 800 series is very well known. To it has been added an economy-class cartridge, the 850. Stylus not interchangeable with 800 series.

850. Induced magnet.
Output: 8mV nominal.
Frequency response: 20-18,000Hz.
Separation: 20dB at 1kHz.
Tracking weight: 2-3.5gm.
Weight: 7gm.
Load: 47-100k.
Stylus: 0.0007in. spherical.
Manufacturer: Goldring Mfg. Co. (GB) Ltd, 10 Bayford Street, London E8.

MICRO SEIKI

A range of cartridges and other disc equipment is now imported.

MC4100/E. Moving-coil.
Frequency response: 5-40,000Hz.
Separation: 33dB at 1kHz.
Compliance: 25×10^{-6}cm/dyne.
Tracking weight: 1.5gm.
Spherical tip version, lower price. This Cartridge is for use with MTA41 preamplifier or a suitable transformer.

VF3100E Mk. 2. Variable reluctance.
Frequency response: 20-20,000Hz.
Tracking weight: 1-2.5gm.

M2100E.
Frequency range: 20-20,000Hz.
Separation: 30dB at 1kHz.
Tracking weight: 0.5-1.5gm.
Stylus: 0.0003×0.0008in. elliptical.
Spherical tip version, lower price.
Distributors: B. H. Morris & Co. (Radio) Ltd, 84 Nelson Street, London E1.

ORTOFON

This Danish manufacturer is of course well known for moving-coil pickups. However, the latest models are in the M15 series, a most successful design of the armature or variable reluctance type (fixed coils). There are four interchangeable stylus assemblies and a common cartridge body.

M15. Tracking angle: 15°.
Effective tip mass: 0.4mg.
Tracking weight: 0.75gm. min., 1.5gm. recommended.
Stylus: 18×8 micron elliptical or 15 micron spherical.

MF15. As above, but tracking weight 1gm. min., 2gm. recommended.

M15 and MF15. Common specification points are as follows.
Output: 0.9mV per cm/sec., 1kHz.
Frequency response: 20-20,000Hz ±2dB.
Separation: 30dB at 1kHz.
UK distributors: Metrosound (Sales) Ltd, Catersfield Road, Waltham Abbey, Essex.

PHILIPS

This manufacturer offers several magnetic cartridges, the most advanced of which is the 412 Super M.

412. Moving-magnet.
Output: 1.4mV per cm/sec. nominal.
Dynamic mass: less than 0.75mg.
Separation: 30dB at 1kHz.
IM distortion: less than 0.5%.
Compliance: 25mm/N dynamic (lateral)
Tracking weight: 0.75-1.5gm.
Vertical tracking angle 15°.
Load: 47k.
Stylus: 7×18 micron elliptical.
Manufacturer: Philips Electrical Ltd, Century House, Shaftesbury Avenue, London WC2.

PICKERING

From a wide range we choose a few of the most recently introduced models.

XV15/750E. Output: 4.4mV nominal.
Separation: 35dB at 1kHz.
Tracking weight: 0.5-1gm.
Frequency response: 10-25,000Hz.
Stylus: 0.0002×0.0009in. elliptical.

XV15/400E. Output: 5.5mV nominal.
Separation: 35dB at 1kHz.
Tracking weight: 0.75-1.5gm.
Frequency response: 10-25,000Hz.
Stylus: 0.0003 × 0.0009in. elliptical.

XV15/140E. Output: 8mV nominal.
Separation: 35dB at 1kHz.
Tracking weight: 3-5gm.
Frequency response: 10-20,000Hz.
Stylus: 0.0004 × 0.0009in. elliptical.

XV15/350. Output: 6mV nominal.
Separation: 35dB at 1kHz.
Tracking weight: 1-3gm.
Frequency response: 10-25,000Hz.
Stylus: 0.0007in. spherical.

XV15/150. Output: 8mV nominal.
Separation: 35dB at 1kHz.
Tracking weight: 2-5gm.
Frequency response: 10-25,000Hz.
Stylus: 0.0007in. spherical.
UK distributors: Highgate Acoustics, 184 Gt. Portland Street, London W1.

SHURE

This company's top-of-the-range cartridge has recently been upgraded, and as before the emphasis is on 'trackability'. The same emphasis is applied to other cartridges in the range but these are longer established models and do not feature in this survey.

Shure V15/II improved. Moving-magnet.
Frequency response: 20-25,000Hz.
Output: 3.5mV nominal.
Balance: within 2dB.
Separation: more than 25dB at 1kHz and at least 17dB from 500Hs to 10kHz.
Tracking weight: 0.75-1.5gm.
Typical tracking at 1gm :400Hz, 28cm/sec; 1kHz, 35cm/sec; 10kHz, 22cm/sec.
Load: 47k.
Weight: 6.8gm.
Stylus: 0.0007 × 0.0002in elliptical.
Distributors: Shure Electronics Ltd, 84 Blackfriars Road, London SE1.

Features of modern stereo cartridges are improved tracking ability at low tracking weight, lower tip mass and improved control of mechnical impedance, reduced distortion and—last and perhaps least—smoother response. Benefits to the user are, particularly, improved fidelity (a more honest, analytical effect with greater detail and delicacy) with secure tracking of awkward high-level recording at tracking weights down in the 1 gm. region—assuming the pickup arm allows all this to be realised.

Although we can always find a few discs that simply cannot be played to perfection by any good pickup, the best, most advanced examples of the science and art of cartridge manufacture give superb results on most material. At least part of their capability is reflected in specifications, although the purchaser should be warned that claimed figures for effective tip mass are notoriously unreliable (measurement is difficult) and that compliance figures—generally high in expensive cartridges—are about the least useful of guides when it comes to choosing the product.

A diamond stylus tip is standard in a hi-fi cartridge, and we do not know of any exceptions among recently introduced models. (A sapphire or any other practical material would be useless on account of very limited life, and even a diamond is not forever.) The elliptical (bi-radial) tip is very common in the best cartridges but adds to the price; it has a happier relationship with the groove than does the conventional spherical tip and gives better definition on most records. There is some debate about dimensions, but we think the minor-major radius dimensions of 0.0002 × 0.0007in. are about right for the low pressures (1 gm. or so) at which cartridges of advanced type are used. Some cartridges intended for appreciably higher tracking weight have an increased minor-axis radius, such as 0.0004in., and this is necessary to reduce wear. However, we doubt whether an elliptical tip of this size is of much benefit in practice.

Magnetic cartridges are commonly presented in 'families' in which spherical and elliptical tips may be offered as alternatives. the latter being largely responsible for higher cost. Generally the cartridge body is common to several models and the stylus assemblies are intechangeable. It follows that the user can start with the conventional stylus and upgrade to elliptical when the time comes for stylus replacement.

Further, in most cartridges the stylus assembly—cantilever, tip, armature, compliant hinge, all in a plastic holder—is the only 'working' part, subject to wear or deterioration, so that replacing the stylus effectively renews the cartridge.

10 QUESTIONS AND ANSWERS

? Which parts of the system influence the stereo most strongly, and is it possible to economise on one part to the advantage of another? As a keen record collector should I concentrate on the player and save something on the speakers?

If you mean the stereo definition—the realistic effect due to superior reproduction of the stereo that is in the recording or broadcast—then the answer is that the transducers are most important. The electronics are less vital in this respect, although it is obvious that the amplifier has a big influence on sound quality. A pickup helping to produce a consistent, stable stereo image makes an important contribution; and high-grade loudspeakers with a favourable dispersion pattern and generally good analysis of their inputs will likewise influence the accuracy of the stereo.

If best results are required it is unwise to unbalance the quality through making economies. Although sharp, detailed stereo is desirable, so are hi-fi attributes such as adequate power handling, low distortion, negligible noise level, accurate pickup tracking and so on. And the best possible pickup should be used in the interest of record life, quite apart from anything else.

? Music cassettes seem to be improving in quality, no doubt due partly to the use of the Dolby system. Is this trend likely to continue?

Yes, some further improvement is to be expected due to the application of modern techniques including the Dolby noise-reduction system. Although many non-Dolby commercial music cassettes are released, there is a big list of Dolby-treated cassettes from Decca and some more from other sources—Pye, for instance. In the USA all Columbia cassettes are to be Dolby, and we can expect some RCA cassettes recorded with the aid of the same system. Enthusiasts can now make their own recordings on cassettes and spooled tape using the Dolby B system.

? How does one go about choosing speakers? The prospect is rather bewildering, although I know how much I want to spend—about £80 a pair.

As long as you are not expecting *Hi-Fi Sound* to choose them for you, a few comments can be offered. Speakers are so numerous it is not realistic to expect to hear more than a few possibles. It helps that you have fixed your budget, which will buy the bigger type of compact models. While narrowing the field, go to some extent on popularity and reputation and read the more objective of the published test reports. Get down to a short-list and hear these. If you find a retailer who will let you try models from the list at home, so much the better, but take time to reach a decision. Some speakers may make an initial impression yet be suited only to occasional use. If long-term serious listening is your aim, consider whether or not the sound is tiring to the ears.

USEFUL DATA

ABBREVIATIONS

AM	Amplitude modulation
FM	Frequency modulation
af	Audio frequency
hf	High frequency
VHF	Very high frequency
Hz	Hertz (cycles per second)
dB	Decibels
A	Amps
V	Volts
W	Watts
C	Capacitance (or capacitor)
L	Inductance (or inductor)
R	Resistance
rms	Root-mean-square
ips	Inches per second (tape speed)
rpm	Revolutions per minute
afc	Automatic frequency control
agc	Automatic gain control
rf	Radio frequency
vf	Video frequency
μ	micro (millionths), as in μV (microvolt) and μF (microfarad)
m	milli (thousandths), as in mV (millivolt) and mS (milliseconds)
k	kilo (thousands), as in kHz (kilo-Hertz)
M	Mega (millions), as in Megohms (Mohms)

EQUIVALENTS

Metric/British conversions:

1 metre	=39.37in.
1 centimetre	=0.394in.
1 micron (μ)	=0.39thou. (say, 0.00004in.)
1 litre	=0.035 cu. ft.
1gm.	=0.035oz.

British/Metric conversion:

1 yard	=0.91 metre
1 inch	=2.54cm.
1 thou.	=25.4μ
1 cu. ft.	=28.3 litres
1 lb.	=0.453kgm.
1 oz.	=28.35gm.

Metric equivalents of tape speeds:

15ips	7½ips	3¾ips	1⅞ips
38cm/sec	19cm/sec	9.5cm/sec	4.8cm/sec

Approx. equivalents of disc sizes:

12in.	10in.	7in.
30cm.	25cm.	17.5cm

Approx. equivalents of stylus tip radii (μ=micron):

0.001in.	0.0007in.	0.0005in.	0.0003in.
25μ	18μ	13μ	7μ

Decibel conversion

	Power Ratio		Voltage Ratio	
Decibels	*Gain*	*Loss*	*Gain*	*Loss*
1	1.259	.7943	1.122	.8913
2	1.585	6310	1.259	.7943
3	1.995	.5012	1.413	.7079
4	2.512	.3981	1.585	.6310
5	3.162	.3162	1.778	.5623
6	3.981	.2512	1.995	.5012
7	5.012	.1995	2.239	.4467
8	6.310	.1585	2.512	.3981
9	7,943	.1259	2.818	.3548
10	10.000	.1000	3.162	.3162
20	100.000	.0100	10.000	.1000
30	1,000.000	.0010	31.620	.0316
40	10,000.000	.0001	100.000	.0100

TEAC announces a current event: BiaTron

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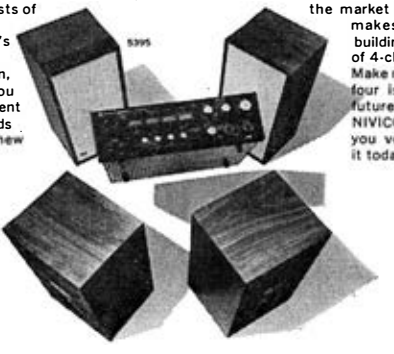

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