5/-

PRACTICAL TAPE RECORDING HANDBOOK

No 1

By

CLEMENT BROWN

Information and Operational Notes

Etc.

BERNARDS RADIO MANUALS

147

Practical Tape Recording Manual

BY
CLEMENT BROWN

BERNARDS (PUBLISHERS) LTD.
THE GRAMPIANS
WESTERN GATE
LONDON, W.6.

General Editor
CLIVE M. SINCLAIR

First Published November, 1958

Printed by V. Cooper & Partners Ltd., Flitcroft Street, W.C.2,
for Bernards (Publishers) Ltd., The Grampians, Western Gate,
London, W.6.

CONTENTS

PREFACE 5

CHAPTER 1. THE TAPE AND THE RECORDER 7

CHAPTER 2. SOUND AND ACOUSTICS 14

CHAPTER 3. MICROPHONES 19

CHAPTER 4. RECORDING WITH THE MICROPHONE 23

CHAPTER 5. RECORDING FROM OTHER SOURCES 27

CHAPTER 6. EDITING AND SOUND EFFECTS 28

CHAPTER 7. OTHER APPLICATIONS 33

CHAPTER 8. MAINTENANCE AND FAULTS 39

TECHNICAL DETAILS OF COMMERCIAL TAPE RECORDERS

TABLE OF ILLUSTRATIONS

Fig.		*Page*
1	RECORDING TIMES FOR TAPES	8
2	THE TAPE	9
3	TYPICAL PROPERTIES OF LONG PLAY TAPE	10
4	RECORD (OR PLAYBACK) HEAD	11
5	RESPONSE BEFORE CORRECTION	12
6	STANDARD PLAYBACK CURVE	13
7	LAYOUT OF TAPE DECK	15
8	UNDERSIDE VIEW OF TYPICAL TAPE DECK	16
9	RANGE OF FUNDAMENTAL AND HARMONIC FREQUENCIES	17
10	RELATION BETWEEN DECIBELS AND POWER RATIOS	18
11	TYPICAL LOUDNESS LEVELS	18
12	ROUTE TAKEN BY SOUND	19
13	CRYSTAL MICROPHONE	20
14	MOVING-COIL MICROPHONE	20
14a	LONG WIRE CONNECTION FOR MICROPHONE	20
15	RIBBON MICROPHONE	20
16	POLAR DIAGRAMS OF MICROPHONES	21
17	UPRIGHT PIANO PICK-UP	22
18	GRAND PIANO PICK-UP	24
19	RECORDING A SMALL GROUP AND A VOCALIST	26
20	USING A PAROBOLIC REFLECTOR	29
21	SPLICING TAPE	30
22	DISTANCE BETWEEN HEAD GAP AND COVER	31
23	USING ONE ECHO CHAMBER	32
24	USING AN INDUCTION LOOP	36
000	POSITIONING OF SPEAKERS FOR STEREOPHONY	38
XXX	POSITIONING OF SPEAKERS FOR STEREOPHONY	40

PREFACE

It is not difficult to use a tape recorder, but to use one well requires a good working knowledge of a large number of factors ranging from acoustics to the art of editing.

This book is unique in its coverage of absolutely every skill required in making first class tape recordings and maintaining a tape recorder in its proper condition. No one is better qualified to write such a book than Clement Brown the author. His long experience as chief tape recorder engineer and designer for one of the largest firms, coupled with his beautifully concise and accurate style of writing make him the ideal authority on this most interesting of subjects.

CLIVE SINCLAIR,

General Editor.

CHAPTER 1

THE TAPE AND THE RECORDER

Magnetic recording tape consists of a finely ground ferrous oxide, mixed in manufacture with a liquid binder and applied thinly and smoothly to a base of plastics material.

P.V.C. (Polyvinylchloride) is the most widely used base material; it has good mechanical properties and the well-known brands resist stretching and wrinkling. They are not likely to snap even when mishandled. Freedom from curl is also important as this affects the smooth and consistent winding of the tape on to the spool.

Cellulose acetate is sometimes used: it is reliable in equable climates but does not maintain adequate mechanical properties over a wide range of temperatures and humidities. Polyester based tape (known as Mylar in the U.S.A.) has much to commend it in the thinner, long play version, where mechanical consistency and freedom from curl are very important.

Standard tape is about .002 in. thick and long play about .0014 in. Some brands of tape are thinner than others, of course, but in general, long play tape increases the capacity of a given size of spool by 50 per cent. The extra length thus accommodated accounts for the higher cost. A table of recording times is given in Fig. 1. This is based on several popular spool sizes and gives approximate times for full track recording. The more common method with domestic recorders is to record on two tracks on the tape with an unused portion .03 in. wide between them. The times for half-track or "twin track" recording are thus double those shown in Fig. 1.

The internationally used "recording sense" is as follows. With the tape inserted in the recorder and viewing it on its glossy, non-magnetic side, the top track is recorded with the tape travelling from left to right (see Fig. 2). When the top track has been recorded or played back, the other is used by interchanging the two spools and turning them over. In some of the more expensive recorders, the tape is reversed automatically, and in other cases by push button.

Typical properties of magnetic tape are shown in Fig. 3. The printing effect concerns the transfer of the recorded signal between adjacent turns of tape on a normally wound reel. The uniformity of output throughout a reel is an important matter and is a reflection of the consistency of the magnetic coating on the tape. Signal to noise ratio has a very direct bearing on the quality of the recording and the noise levels indicated are typical of good brands of tape.

Frequency response depends on tape speed, the properties of the magnetic head (e.g. gap width) and the excellence of the electronic circuitry of the recorder. In general, the frequency response improves with higher tape speed and many enthusiasts interested in high fidelity work use machines with a top speed of 15 i.p.s. This, incidentally, is the speed most often used by recording companies for the tapes from which the masters for commercial disc records are prepared.

This high speed is hardly economical for the layman, however, and it is fortunate that improvements in tape recorder heads and circuits have enabled high fidelity results to be achieved at the 7½ i.p.s. speed. It is as well to remember that small variation in frequency response over a given range is just as important as the actual width of response; there are now several machines which can boast a response of 40-16,000 c/s plus or minus 3dB at the 7½ i.p.s. speed. Every worthwhile medium-price recorder is equipped with this speed and the layman new to tape recording should be reminded that the recorded tapes issued by E.M.I. under the H.M.V. and Columbia trademarks are intended for playback at 7½ i.p.s.

There is little doubt that we can look forward to further improvements in both recorders and tape, enabling a high standard to be achieved at the next lowest speed—namely 3¾ i.p.s. The saving in tape will make this already economical activity more attractive than ever.

Recordings in storage have a practically unlimited life. Care should be taken, however, to avoid exposure to extremes of temperature, damp, electric wiring and other magnetic fields. Tapes should be re-spooled every few months to avoid print-through.

	SPOOL SIZE.	APPROX. LENGTH.	RECORDING TIME (MIN)			
			$1\frac{7}{8}$ i.p.s.	$3\frac{3}{4}$ i.p.s.	$7\frac{1}{2}$ i.p.s.	15. i.p.s.
STANDARD.	3"	200′	21	10	5	$2\frac{1}{2}$
	4"	300′	30	15	8	4
	5"	600′	60	30	15	8
	7"	1,200′	120	60	30	15
LONG PLAY.	3"	300′	32	15	8	4
	4"	450′	45	23	12	6
	5"	900′	90	45	23	12
	7"	1,800′	180	90	45	23

Fig. 1

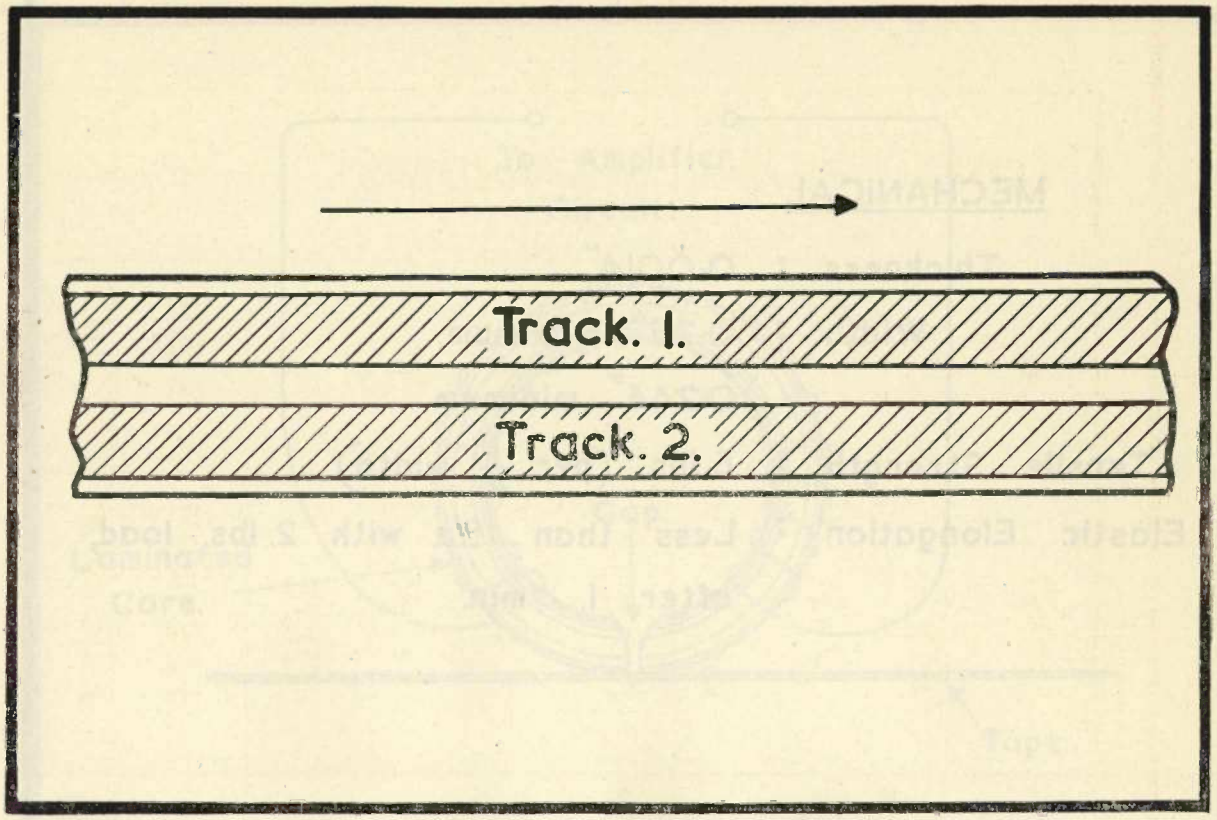


Fig. 2. Viewing the tape from its glossy side, the top track is recorded with the tape moving from left to right.

The Heads

Recording tape consists of countless millions of magnetic particles contained in a thin film on the surface of a plastic base. The magnetic pattern or orientation of the particles depends on the variation of the magnetic field across a thin gap in the head (see Fig. 4). In domestic type machines, the same head is often used for both recording and playback in order to keep costs within bounds; with really good design this can be a justifiable economy. See Fig. 7.

Professional recorders, and some non-professional ones, have separate heads and the two can be designed for optimum performance. Furthermore, the playback head can be used to monitor the tape while recording is in progress: the two heads are close together on the tape deck and any passage on the tape is thus monitored a fraction of a second after it has actually been recorded.

As already indicated, the extent of the response at high frequencies depends partly on the width of the gap in the heads. The gap should be smaller than one quarter of a wavelength of the highest frequency to be adequately reproduced. Gap widths of 0.0002 in. or less are commonly encountered. The actual shape of the response curve around this critical region will depend on a number of factors and a smooth curve will indicate not only good head design but efficient recording and playback amplifier circuits.

The addition of a high frequency signal to the actual recording signal has a beneficial influence on the orientation of the magnetic particles on the tape. Noise level and distortion are affected by this application of a " bias " signal, as it is called. The bias is produced by an oscillator circuit at about 50 kc/s or higher.

MECHANICAL

Thickness	:	0·0014″
Width	:	0·25″ maximum.
		0·246″ minimum.
Tensile Strength	:	6. lbs. (per $\frac{1}{4}$″ width.)
Elastic Elongation	:	Less than 1%. with 2. lbs. load, after 1. min.

MAGNETIC

Coercivity	:	250. Oersteds.
Uniformity	:	$\pm \frac{1}{2}$ dB. within reels.
Printing Effect	:	At least 55. dB. below recording level giving 2%. total harmonics.
Modulation noise	:	At least 55. dB. below recording level.
Basic noise	:	After proper erasure, at least 65. dB. below recording level.

Fig. 3. Typical properties of long-play tape.

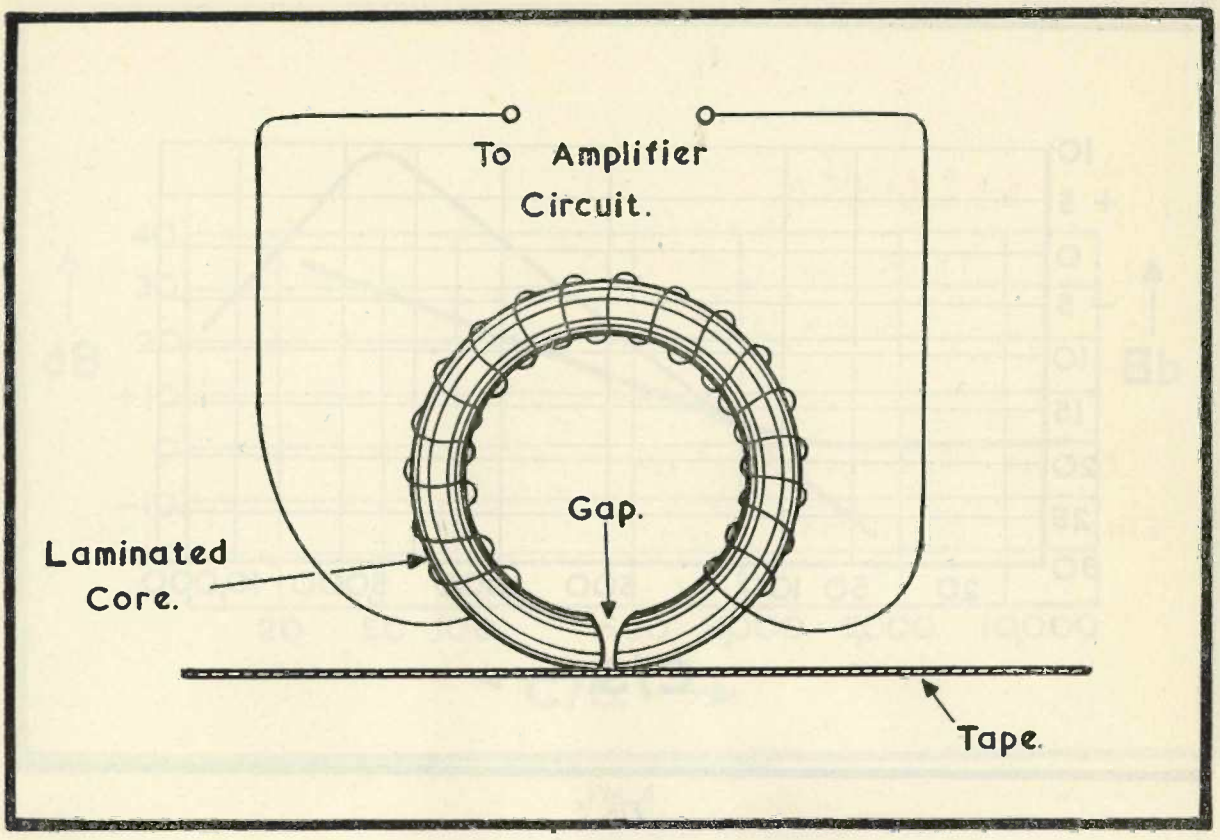


Fig. 4. Record (or playback) head.

A high frequency signal is also applied to the other head on the tape deck—that is, the erase head. The usual arrangement is for this head to erase any signal present as the tape passes on its way to the recording head.

A tape already bearing some unwanted programme can thus be recorded again and the old programme will be automatically erased just before the new one takes its place.

The gap in the record and playback heads should be at right-angles to the direction of the tape motion; if this is not so there will be a serious loss of high frequency response. An adjustment, known as the " azimuth adjustment ", is therefore provided for the heads and, in factory testing, the heads are adjusted for maximum output when a test tape bearing a high-frequency note is being played. This test can be repeated at a later date by the user if he suspects a loss in the high notes.

There are, however, other causes of high-frequency loss and these will be referred to later.

Recording and Playback Characteristic

The frequency characteristic of the tape is far from linear. From middle frequencies (around 4,000 c/s) downwards there is a 6dB per octave fall and above 4,000 c/s there is an even greater attenuation caused by losses in both circuits and tape, increasing with rise in frequency (see Fig. 5).

The high frequency losses are compensated in the recording amplifier while the low frequency compensation is applied in the playback circuits. This is in accordance with the recommendations of the C.C.I.R. (Comité Consultatif International des Radio-communications) and the same standard is adopted by the British Standards Institution. (See Fig. 6).

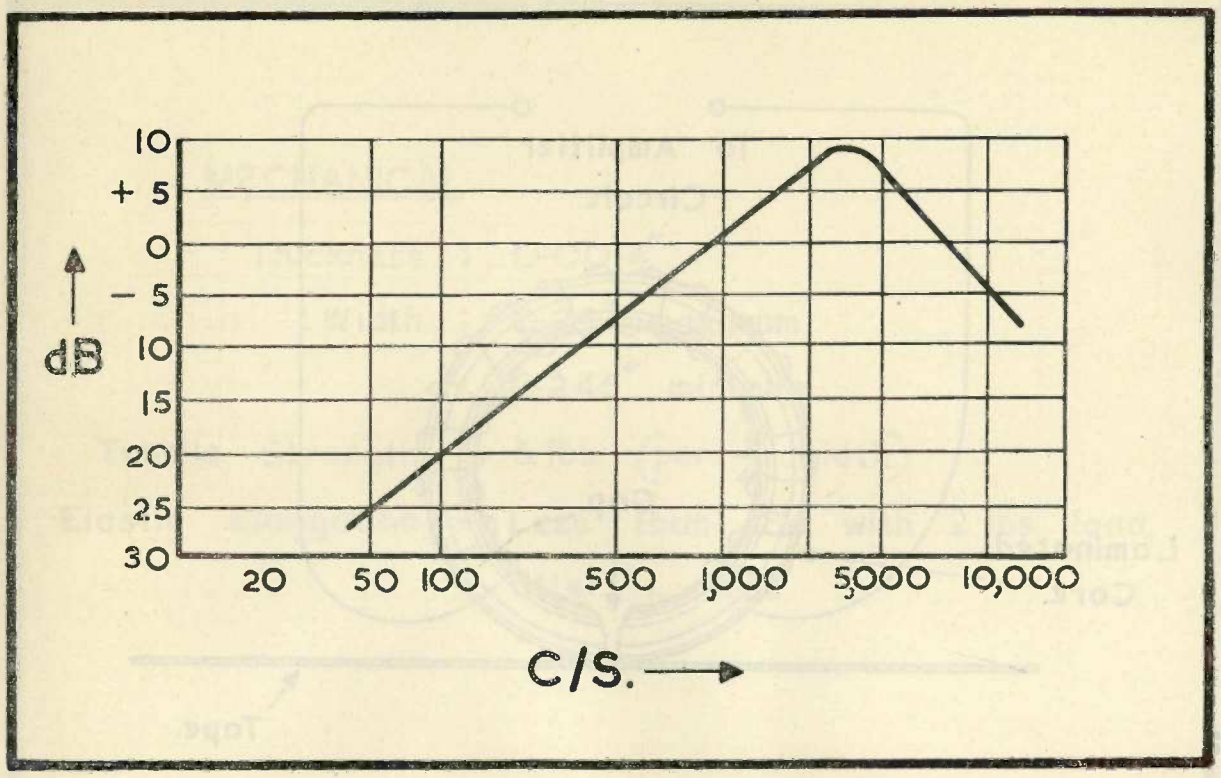


Fig. 5

Mechanical Considerations

Variations in pitch of music corresponding to speed fluctuations (" wow and flutter ") exceeding 0.3 per cent. are usually perceptible to the listener. The lower this percentage fluctuation, the better.

In tape recorders, this effect is minimised by driving the tape with a capstan wheel or spindle coupled to a heavy flywheel. The tape is pressed against the capstan by a rubber wheel. The tape speed is therefore independent of the two spools; these are associated with the mechanism for winding and rewinding the tape and they are arranged so as to maintain the proper tension for neat spooling. The braking mechanism is also applied to the spool drive.

Friction pads press the tape against the heads. This contributes to correct tape tension and also ensures that the magnetic contact between tape and head is adequate.

Tape recorders may have one, two or three motors. It can be said that one method is as good as another where domestic and semi-professional machines are concerned. Several motors will mean that the mechanics of the tape deck are simple. The mechanical complexity necessitated by one motor is quite acceptable if good design results in simple and positive action of the various control knobs and push buttons.

Playback Amplifiers

In recorders intended only for portable use, equal attention will have been given to all stages in the circuit, including the output stage and loudspeaker system. Many enthusiasts will wish to make use of high fidelity equipment for playback and the better portable machines give good results in such applications.

Where portability is not required, a different approach can be made and a tape deck with its recording and playback preamplifier can be incorporated in a Hi-Fi installation as a permanent feature. This important matter will be discussed in a later chapter.

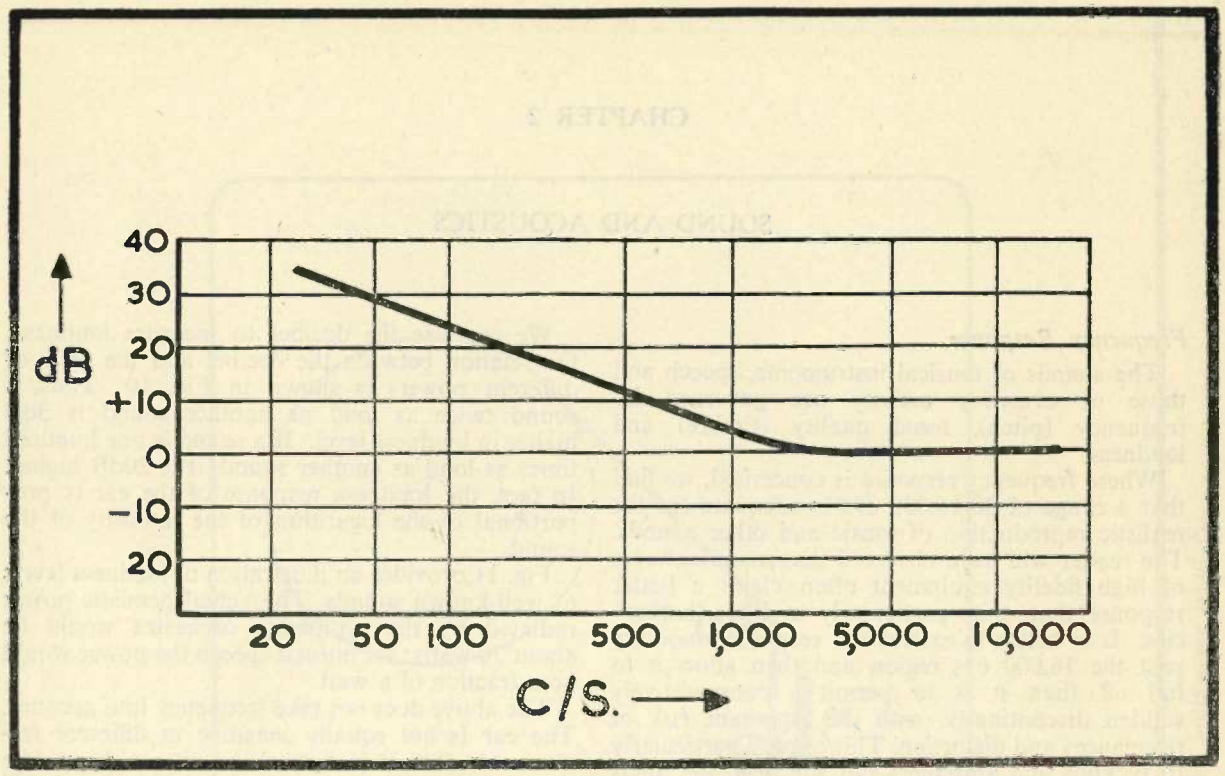


Fig. 6

CHAPTER 2

SOUND AND ACOUSTICS

Frequency Response

The sounds of musical instruments, speech and those of everyday activity are governed by frequency (pitch), tonal quality (timbre) and loudness.

Where frequency response is concerned, we find that a range of 30-16,000 c/s is adequate for the realistic reproduction of music and other sounds. The reader will have observed that manufacturers of high fidelity equipment often claim a better response than this, particularly at high frequencies. It is better to extend the response smoothly past the 16,000 c/s region and then allow it to fall off than it is to permit a comparatively sudden discontinuity, with the attendant risk of resonances and distortion. This applies particularly to pickups and amplifiers but the principle holds good for tape equipment of the highest class. In all cases, smoothness of response is as important as range.

The frequency range quoted embraces both the fundamental frequencies and the accompanying harmonics (or overtones) which we wish to record and reproduce. We identify any musical instrument largely by the harmonic make-up of its sound; in some cases the harmonics produce most of the instrument's output and in others most of the acoustic energy is in the fundamental frequencies.

Fig. 9 shows the range of fundamentals and harmonics for various sounds. The correct tone quality or " timbre " depends, then, on correct recording and reproduction of the audible frequency range.

Loudness

We can represent degrees of loudness by comparing different sounds with a reference point. This " zero level " is the point where sound ceases to affect the ear and is thus no longer perceptible. The Threshold of Audibility is the term usually employed. At the other extreme, the Threshold of Feeling is the point at which the ear experiences a tingling sensation and, above this, there is the Threshold of Pain, where permanent damage to the ears is threatened.

We can use the decibel to measure loudness; the relation between the decibel and the ratio of different powers is shown in Fig. 10. Thus, a sound twice as loud as another sound is 3dB higher in loudness level. If a sound is one hundred times as loud as another sound, it is 20dB higher. In fact, the loudness response of the ear is proportional to the logarithm of the intensity of the sound.

Fig. 11 provides an illustration of loudness levels of well-known sounds. The actual acoustic power radiated by the symphony orchestra would be about 70 watts; for normal speech the power would be a fraction of a watt.

The above does not take frequency into account. The ear is not equally sensitive at different frequencies—it is, in fact, most sensitive in the middle range, decreasing in sensitivity in the bass and treble. This has led to the use of a further unit, the Phon; similar to the decibel, but taking ear sensitivity into account.

Acoustics

Sound produced in an enclosed space has characteristics which are of great importance to the person contemplating the recording and reproduction of it.

In the first place, reverberation occurs to some degree in all rooms and halls due to reflection of sound waves by walls, ceiling and so on. Then some of the sound is absorbed in the walls and furnishings; the extent of the absorption depends on certain physical properties of the materials. Yet another part of the sound energy passes through the wall, emerging on the other side much attenuated, but this particular aspect of acoustics will not concern us here.

Reverberation can be illustrated in its simplest form as shown in Fig. 12. Sound travels directly from source to listener and also indirectly, as indicated. The indirect path is obviously much longer than the direct one and the sound reaches the listener a fraction of a second later. In very large buildings with hard reflecting surfaces, the delay may be much more than a fraction of a second—the layman often uses the term " echo " when he hears a much delayed reflected sound.

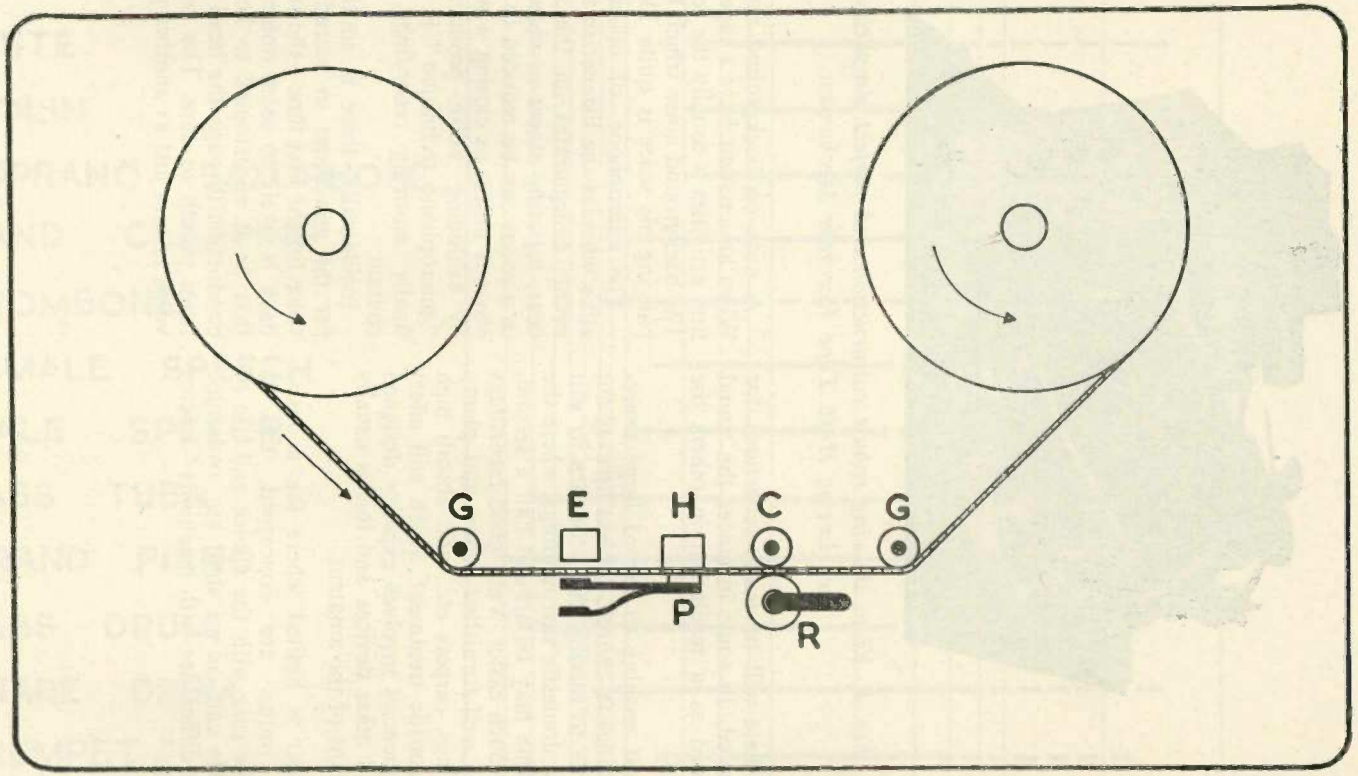


Fig. 7. Simplified layout of deck with erase head E.

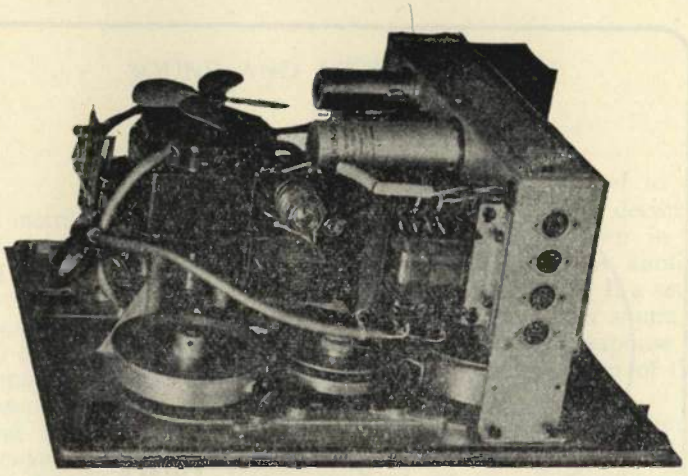


Fig. 8. View showing robust construction and perfect simplicity of the Harting HM6 Tape Recorder Mechanism.

In practice, there will be many reflections for each sound created. In some instances the sound will be reinforced as a result but in others the opposite applies.

The enthusiast wishing to record large reverberant surroundings (a church, for example) is not likely to be able to modify the acoustics to suit his purposes. In domestic surroundings, where the reverberation time may be around half a second, the position is much easier. Very good recordings can be made in well furnished rooms and plenty of soft furnishings, carpets etc., will absorb high frequencies. Acoustic treatment which will affect the lowest frequencies involves expertly designed diaphragms and other devices and this is usually beyond the means of the amateur.

If the amateur is limited where the acoustic properties of rooms are concerned, this is certainly not the case with the choice and use of microphones. He can, as we shall see, overcome many apparent difficulties with ingenious " microphone technique ".

A note on background noise is relevant here. When an amateur buys a tape recorder, one of his first activities is usually the recording of his voice. The background noise which he then hears accompanying his voice is quite likely to surprise him.

The microphone, of course, treats all sounds alike whereas the listener in the normal course of events concentrates on the sounds he wants to hear, rejecting others as required. The noise level in a room can be reduced to a minimum by such obvious means as closing windows and doors and by excluding noise - producing objects. Correct " microphone technique " is again the means of finally ensuring recordings with a low noise content.

Incidentally, there is another surprise in store for the newcomer to recording who records his voice for the first time—the sound he hears played back is likely to seem unfamiliar. The reason is that he is accustomed to hear himself speak by conduction through the head as well as by a path from mouth to ears. The recording presents his voice to him just as another person would hear it.

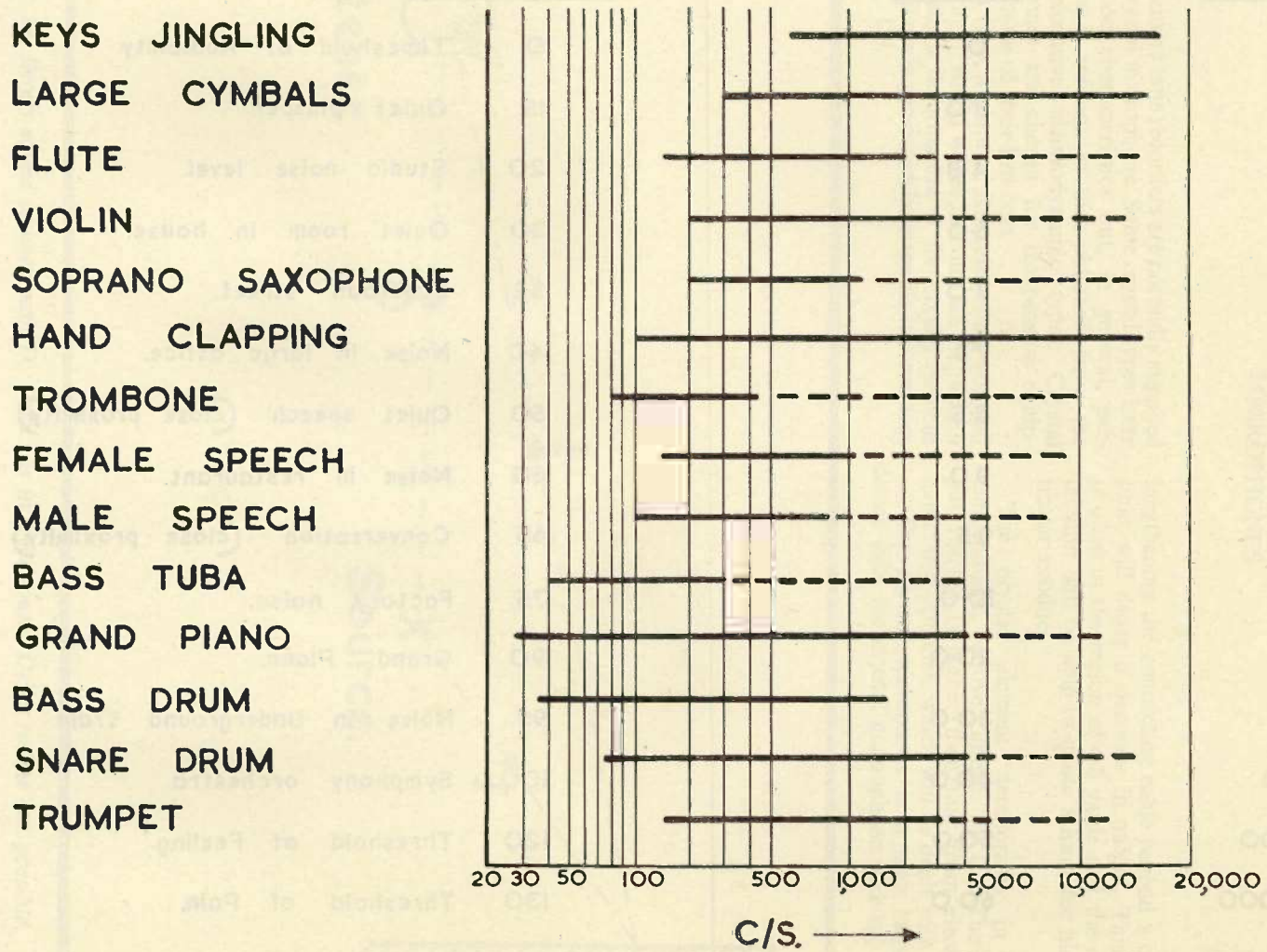


Fig. 9. Solid lines show range of fundamental frequencies. Broken lines show harmonics.

POWER RATIO	DECIBELS
1	0
2	3·0
3	4·8
4	6·0
5	7·0
6	7·8
7	8·5
8	9·0
9	9·5
10	10·0
100	20·0
1,000	30·0
10,000	40·0
100,000	50·0
1,000,000	60·0

Fig. 10. Shows relation between decibels and power ratios.

LEVEL IN dB.	
0	Threshold of Audibility.
15	Quiet whisper.
20	Studio noise level.
30	Quiet room in house.
32	Suburban street.
40	Noise in large office.
50	Quiet speech (close proximity.)
60	Noise in restaurant.
65	Conversation (close proximity.)
75	Factory noise.
90	Grand Piano.
95	Noise in Underground Train.
100	Symphony orchestra.
120	Threshold of Feeling.
130	Threshold of Pain.

Fig. 11. Shows typical loudness levels.

CHAPTER 3

MICROPHONES

Crystal

Inexpensive tape recorders are normally supplied with a crystal microphone. Some crystal types have quite good characteristics but, in general, performance is inferior to that obtained from the more expensive electrodynamic types. Crystal microphones are chosen for inexpensive equipment because of their low cost.

In this type, a plate of Rochelle salt is coupled to diaphragm; sound waves meeting the diaphragm cause a slight deformation of the crystal element and a voltage is generated between its two surfaces (see Fig. 13).

lengthening the connecting cable beyond a certain limit will cause a decrease in output. This limit is often in the region of 4-8 yards and the manufacturer will be able to quote a limit for his particular product.

The crystal element deteriorates in high temperatures, above about 50°C. The output voltage is higher than that from electrodynamic microphones, which will be dealt with next.

The crystal microphone is a high impedance device (like the crystal gramophone pick-up) and

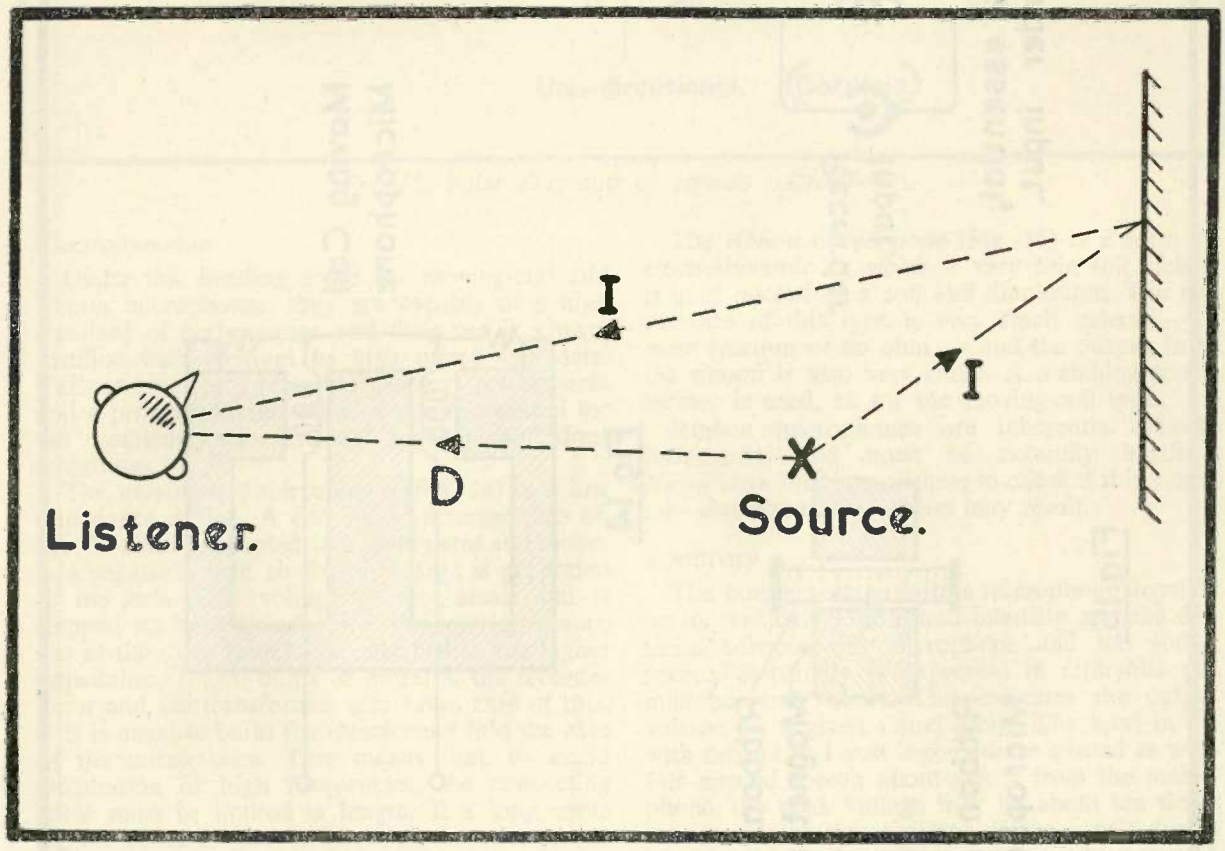
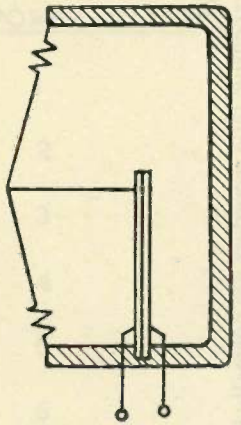
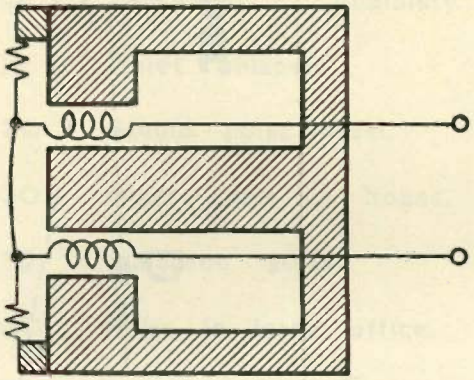


Fig. 12. Direct sound follows path D. Path I is indirect route. Other routes are possible.



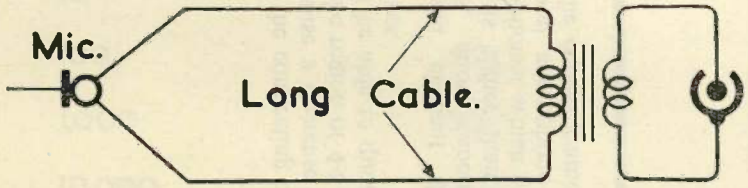
Crystal Microphone.

Fig. 13.



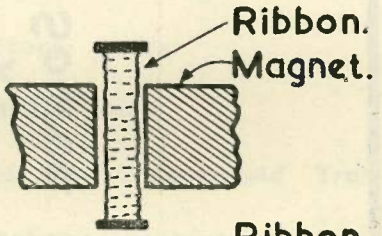
Moving Coil Microphone.

Fig. 14.



If very long connecting cable is essential, mount transformer at the recorder input.

Fig. 14. A.



Ribbon Microphone.

Fig. 15.

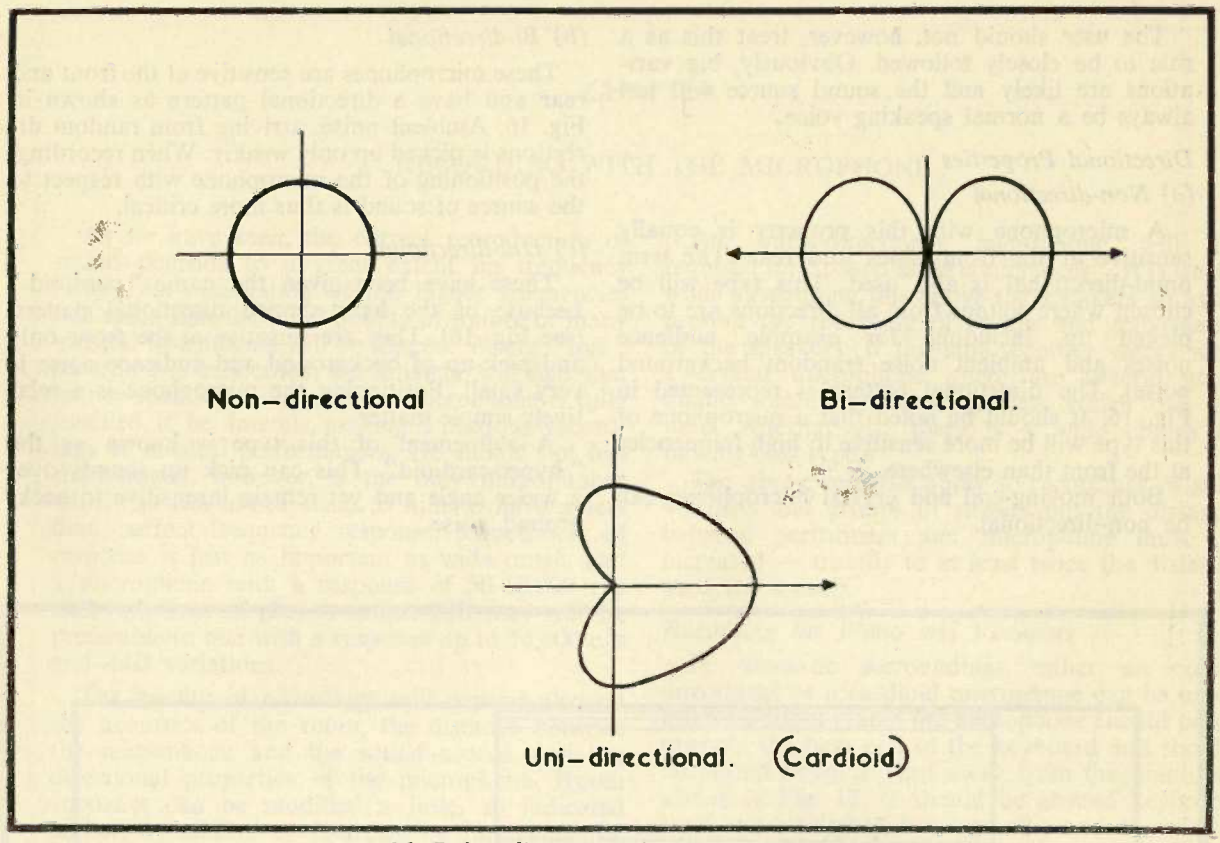


Fig. 16. Polar diagrams of various microphones.

Electrodynamic

Under this heading come the moving-coil and ribbon microphones; they are capable of a high standard of performance and their use is always justified with medium to high priced recorders. Various types of directional property are possible and a proper understanding of this is essential for the amateur who intends making ambitious recordings.

The *moving-coil* microphone (Fig. 14) is a low impedance device. A coil with an impedance of, say, 50 ohms is coupled to a diaphragm and moves in a magnetic field so that a voltage is generated in the coil. This voltage is very small and is stepped up by a transformer; the low impedance has at the same time to be matched to the higher impedance (10,000 ohms or more) at the recorder input and the transformer also takes care of this.

It is usual to build the transformer into the case of the microphone. This means that, to avoid attenuation of high frequencies, the connecting cable must be limited in length. If a long cable (above about 25 feet) is essential, the microphone must be used at low impedance and the transformer connected at the recorder input (see Fig. 14A).

The *ribbon* microphone (Fig. 15) is a form of electrodynamic in which a very thin foil ribbon is used instead of a coil and diaphragm. The impedance of this type is very small indeed — a mere fraction of an ohm — and the output from the ribbon is also very small. A matching transformer is used, as for the moving-coil type.

Ribbon microphones are inherently delicate instruments and must be carefully handled. *Never* blow into one of these to check if it is working—damage to the ribbon may result.

Sensitivity

The output voltage from a microphone depends on its sensitivity, the sound intensity and the distance between the microphone and the sound source. Sensitivity is expressed in millivolts per microbar (mV/ubar). This indicates the output voltage for a given sound input. The level in dB with respect to 1 volt is sometimes quoted as well. For normal speech about a foot from the microphone, the peak voltage may be about ten times the sensitivity figure. Thus, if the sensitivity is given as 3mV/ubar, the output may be as much as 30mV. peak.

The user should not, however, treat this as a rule to be closely followed. Obviously, big variations are likely and the sound source will not always be a normal speaking voice.

Directional Properties

(a) Non-directional

A microphone with this property is equally sensitive at the front, sides and rear. The term omni-directional is also used. This type will be chosen where sounds from all directions are to be picked up, including, for example, audience noises and ambient noise (random background noise). The directional pattern is represented in Fig. 16. It should be noted that a microphone of this type will be more sensitive to high frequencies at the front than elsewhere.

Both moving-coil and crystal microphones can be non-directional.

(b) Bi-directional

These microphones are sensitive at the front and rear and have a directional pattern as shown in Fig. 16. Ambient noise, arriving from random directions is picked up only weakly. When recording, the positioning of the microphone with respect to the source of sound is thus more critical.

(c) Uni-directional

These have been given the name " cardioid " because of the heart-shaped directional pattern (see Fig. 16). They are sensitive at the front only and pick-up of background and audience noise is very small. Positioning the microphone is a relatively simple matter.

A refinement of this type is known as the " hyper-cardioid". This can pick up sounds over a wider angle and yet remain insensitive to background noise.

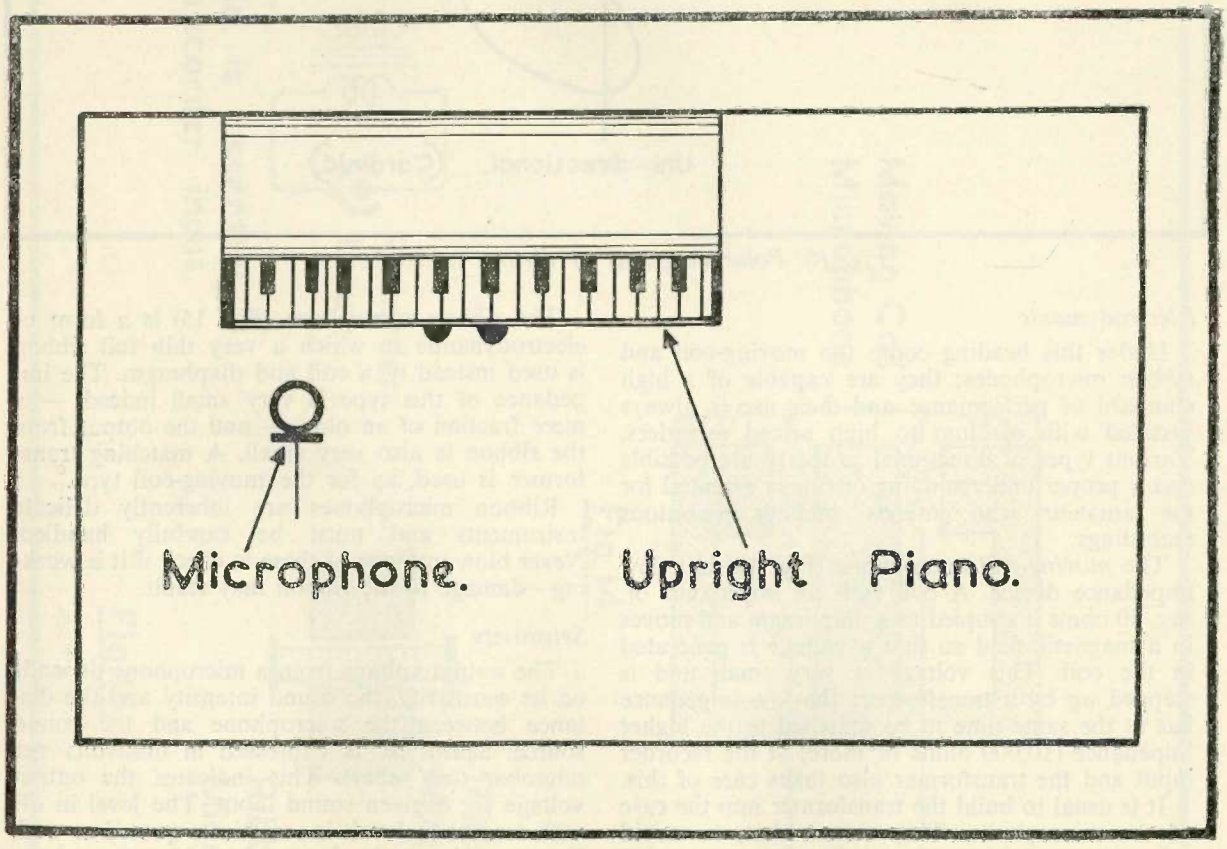


Fig. 17.

CHAPTER 4

RECORDING WITH THE MICROPHONE

As we have seen, the correct reproduction of sound depends to a great extent on frequency range. An attenuation of the higher frequencies will mean that the tonal quality of timbre of many musical instruments will be altered. Where "live" recording is concerned, the amateur will find that money spent on a high quality microphone is fully justified if he intends making ambitious recordings of musical performances. He should not feel discouraged, however, if the only microphones which he can afford seem to him to have a less than perfect frequency response. Smoothness of response is just as important as wide range, and a microphone with a response of 50-10,000 c/s and variations of plus or minus 2dB may well be preferable to one with a response up to 14,000 c/s and 4dB variations.

The quality of recordings will depend also on the acoustics of the room, the distance between the microphone and the sound source, and the directional properties of the microphone. Room acoustics can be modified a little, as indicated earlier, by adding or re-arranging furnishings or other materials which absorb the higher frequencies and hence change the amount of reflected sound. The other two factors bring the need for experiment and a number of practical examples will serve to show which way to approach the problem.

Recording the Voice

It must be borne in mind from the start that the proportion of direct to indirect sound is determined largely by the distance between the speaker and his microphone. In a normal room, a distance of a foot or so will ensure maximum intelligibility. An inexpensive crystal or moving-coil microphone will be adequate for most occasions.

In spacious surroundings where reverberation is encountered, the speaker should be very close to the microphone and should not raise his voice too much. If there are background sounds, the microphone position will depend on whether these sounds are to be picked up or not. In really difficult cases, much unwanted noise can be excluded if a cardioid microphone is used. If it is required to reduce the high frequency content of the recorded voice, the speaker should not face the microphone squarely but should be at a small angle off its axis.

An omni-directional microphone will be required for "round table conferences". It is worth while suspending this above the speakers so as to prevent the recording of bumps and movements of the speakers. If the tape recorder works with a crystal microphone, there are several good quality omni-directional models which can be used. Alternatively, there is a wide choice of moving-coil types.

The above remarks apply to recordings of solo vocalists and groups of singers but the distance between performers and microphone must be increased — usually to at least twice the distance used for speech.

Recording the Piano and Vocalists

In domestic surroundings, either an omni-directional or a cardioid microphone can be used. For an upright piano, the microphone should point towards the bass end of the keyboard and should be placed about a yard away from the piano, as shown in Fig. 17. It should be around keyboard level or a bit higher. For a grand piano, the microphone should be at least two yards away as shown in Fig. 18, and above keyboard level.

The enthusiast will find that some experiment is needed to produce an agreeable balance between bass and treble and, if a more reverberant type of recording is wanted, the distances just quoted should be increased considerably.

If a vocalist wishes to accompany himself on the piano, the microphone should be suspended above the piano about a foot from the singer's face. If several vocalists are to be given piano accompaniment, the microphone should be positioned as in Fig. 18 with the singers placed between it and the piano.

Other Instruments

Solo performers on string, brass and woodwind instruments should, in general, place themselves on the axis of the microphone and the loudest ones should be furthest from it. During particularly loud passages, brass players should turn their instruments away from the microphone. The guitar should be about a yard from the microphone. Other stringed instruments are positioned similarly. Percussion instruments may be in almost any position and should be several yards from the microphone.

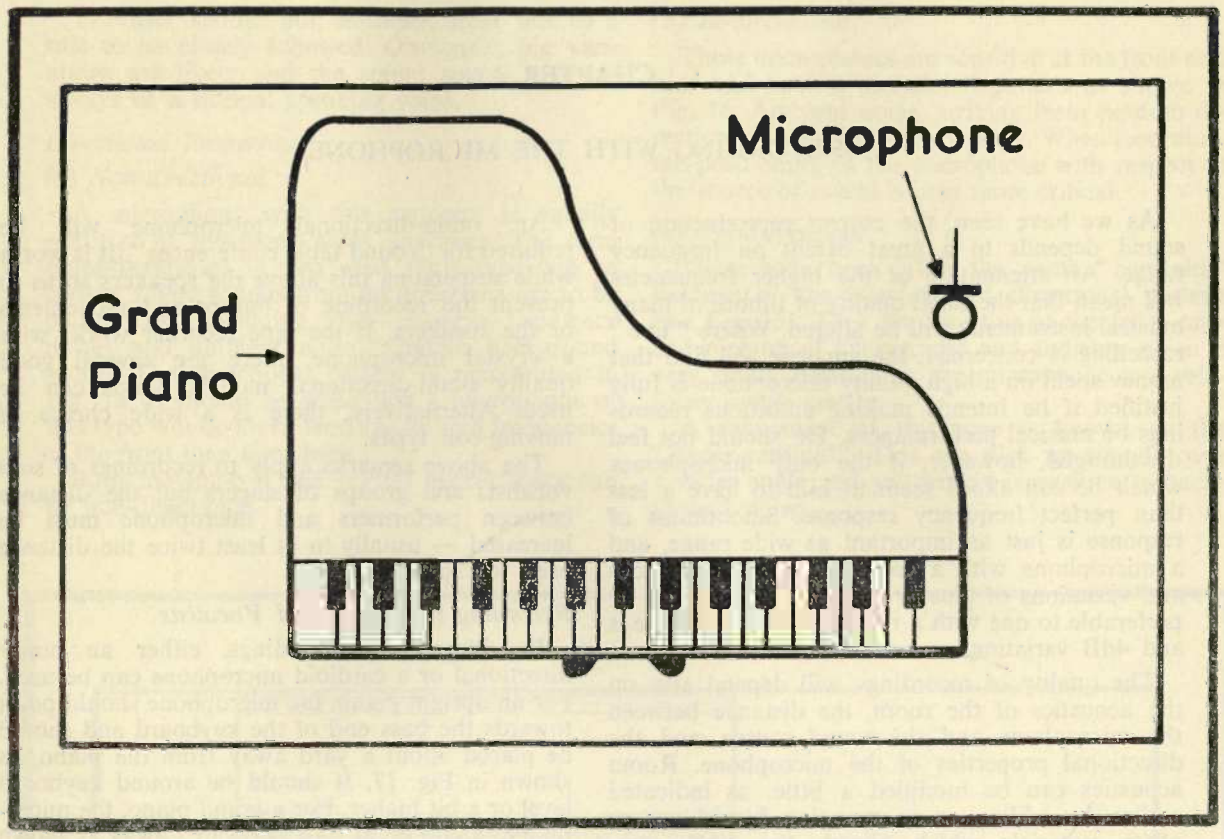


Fig. 18. Using a microphone in conjunction with a grand piano.

An omni-directional microphone will be satisfactory in the above cases but the marked directional characteristics of a cardioid microphone will be of great value if there is background noise. If an audience is present, they should of course be placed behind the microphone.

Choral and Orchestral

In some cases a satisfactory recording can be made by suspending an omni-directional microphone over the performers or by grouping them each side of a bi-directional microphone. Performances will often be in halls and, if the acoustics are unfavourable and reverberant, a uni-directional (cardioid) type will be needed.

With large numbers of performers, or where a singer or other soloist is included, more than one microphone is necessary (Fig. 19). Dance and jazz ensembles benefit from a "close-up" type of recording where the amateur is concerned and the performers can be split into groups, each with a cardioid microphone positioned such that it will pick up only the instruments concerned. As mentioned before, the loudest instruments must be the furthest from the microphone and some experiment is necessary to achieve the right balance between the groups.

The use of several microphones brings the need for mixing and separately controlling the output from each. Several manufacturers now market mixers having three, four or more inputs, each input having its own control. A further control is usual to adjust the mixed output fed to the recorder. Two similar moving-coil microphones can often be connected in parallel but this is of use only where the matter of balance is not particularly important.

Recording a large choral group should not prove difficult with a single cardioid microphone directed towards the singers from three yards distance or more and stood or suspended a little above head level. If a trial recording indicates that certain singers sound too prominent, they should be moved further from the axis of the microphone.

Other Recordings

In large conferences where contributions from many people are to be recorded, a considerable number of microphones may be necessary. Their output should be mixed together. Omni-directional microphones are suitable. It should be remembered that, where a public address system is in use, it is possible to produce a perfectly good recording with the minimum of effort by connecting in the recorder's radio/pick-up input at the public address amplifier.

Recording of church services is becoming an increasingly popular activity. Many churches are, of course, highly reverberant but since this is part of the " atmosphere " to be recorded, no special precautions are necessary where the musical parts of the service are concerned. For this, a good quality omni-directional microphone should be suspended over the nave, in a central position and three yards or so above the congregation.

Where the sermon or other speech is concerned, more care is necessary to achieve maximum intelligibility and a cardioid or hyper-cardioid microphone should be installed on the pulpit.

In a theatre, two or more cardioid microphones in the footlights will ensure good pick-up of the actors with minimum sound of the audience. Proceedings in a corner of the stage or off-stage sounds, can be caught by an omni-directional type. A bi-directional microphone is very useful indeed for recording plays in the home. The actor's voice will be picked up more faintly as he moves into the " dead " area at the sides of the microphone (see Fig. 16) and he can then give the impression of leaving the stage.

Outdoor Work

An outdoor interview can be conducted with an inexpensive crystal or moving-coil microphone with omni-directional properties. It can be held in one position while several people speak and at sufficient distance to allow a little background noise to be recorded.

The method is very different when there is a high level of noise. A cardioid or hyper-cardioid is then necessary and the interviewer will have to place himself carefully in relation to the speakers so that the source of noise is, as far as possible, behind the microphone.

The directional properties of a cardioid microphone are of great help in the majority of outdoor recordings. A cardioid with a really good frequency response is ideal for bird-song and other country-side sounds. Keen enthusiasts intent on picking up faint sounds with the exclusion of ambient noise will find that a parabolic reflector used with the microphone increases enormously the signal to noise ratio (Fig. 20). The microphone is fixed facing the reflector and at its focal point, and the whole assembly is " beamed " at the sound source.

The biggest drawback in outdoor work is, of course, the absence of a mains supply. There are very few recorders for battery operation which are at the same time suitable for a wide variety of recordings and the most reliable method is to feed a mains portable from a battery via a DC/AC converter. Converters incorporating vibrators, as well as those working electronically, are available from several manufacturers and most radio component dealers can give advice. An array of equipment including a recorder, converter and a large L.T. battery is far from portable but enthusiasts with a car or van will find that the excellent " effects " tapes which can be made amply reward the trouble taken.

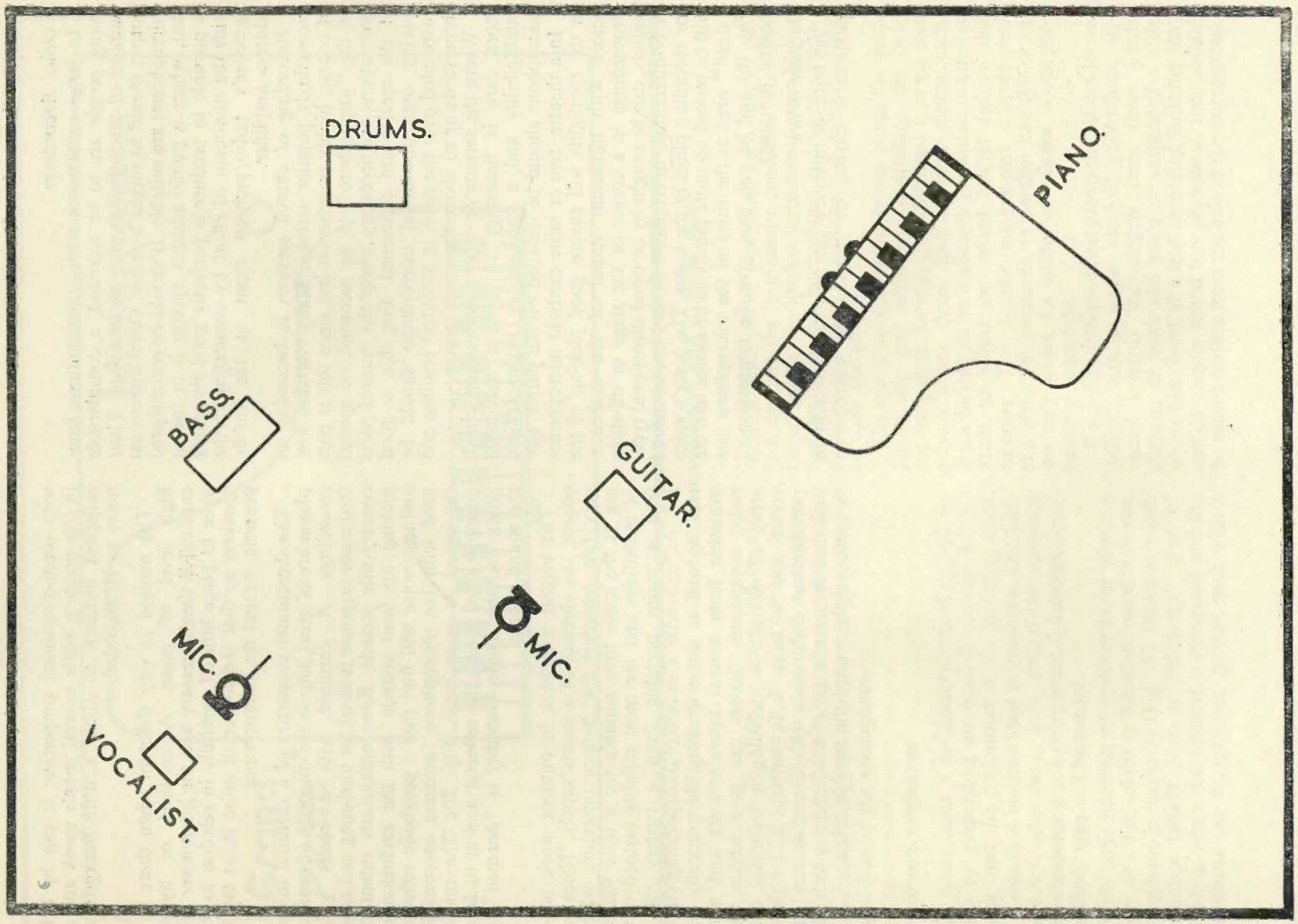


Fig. 19. Using two unidirectional microphones to record a small group and a vocalist.

CHAPTER 5

RECORDING FROM OTHER SOURCES

Recording Radio Programmes

In the case of a few very simple recorders it may be necessary to hold the microphone in front of the radio receiver. This is never really satisfactory, however, and most recorders have an input (other than the microphone input) for radio recording. The extension loudspeaker sockets of a receiver should be connected to the recorder input by means of screened cable of the coaxial type. Some recorders are already provided with a connecting cable; failing this, most radio dealers can supply a length.

The receiver's output stage and the distortion which this sometimes introduces can be eliminated by arranging an output from the detector stage. A radio engineer can advise on the possibility of this for a particular receiver. A few receivers are provided with this facility. A radio tuner can also be used and this will be referred to later.

Putting Records on Tape

A gramophone pick-up may be connected by means of screened cable to the recorder's radio input or to any special input which may be provided. The input will normally be intended for a crystal pick-up: the manufacturer's instructions should be followed in this respect.

It is usual for the radio/pick-up input and the microphone input to have separate recording controls. Speech and music may thus be mixed quite easily. Headphones are useful for listening in or " monitoring " while recording is in progress.

COPYRIGHT

Recording of broadcast programmes and gramophone records is only permissible in so far as copyright is not thereby infringed.

It is well known that enthusiasts frequently carry out recording which infringes copyright but it is unlikely that proceedings will be taken against them if they restrict their activities to the immediate domestic circle. In case of doubt, and where more ambitious recording is intended, advice should be sought. The Mechanical Copyright Protection Society Limited, 29, Maddox Street, London, W.1, will be pleased to offer their comments.

Recording Telephone Calls

Several tape recorder manufacturers supply " telephone coils " or adaptors for recording two-way conversations. Direct connection to telephone lines and equipment is not permitted and the adaptor is therefore made to pick up the signal by magnetic induction.

The adaptor consists of a coil wound on a magnetic core. This is contained in a small housing and fitted with a suction disc for attachment to the body of the telephone instrument. The adaptor is provided with a length of screened cable and is plugged into one of the tape recorder's inputs.

Playback

A good quality extension loudspeaker will usually give better results than the recorder's own speaker system. It should be evident that the cabinet of a portable recorder cannot provide an adequate enclosure or baffle area for the speaker. An external speaker, on the other hand, can be properly housed in a neat cabinet or on a baffle. The speaker to be used should have roughly the same impedance as the one in the recorder but exact matching is not important.

Most recorders have an output socket intended for connection to amplifier or radio receivers for playback purposes. Playback via high fidelity equipment is dealt with in another chapter.

Note: Connection to radio and television receivers having AC/DC circuits should only be undertaken by those with a full knowledge of what is involved. A risk of electric shock exists and special precautions, including the use of an isolating transformer, must be taken. Consult a qualified radio engineer in such cases.

CHAPTER 6

EDITING AND SOUND EFFECTS

Editing

This concerns the removal of unwanted passages from a recording and the joining together of different sections to make a complete recording. For example, a radio programme can be recorded in its entirety, complete with announcements or audience sounds which may afterwards prove to be unwanted. These parts can then be cut from the tape and the wanted sections joined together.

A little practice in splicing tapes will produce noiseless joins which are as strong as the tape itself. The tools needed are simple and inexpensive: a razor blade or scissors (these must not be magnetised) and some of the special adhesive tape made for this job.

Referring to Fig. 21, place the two ends of tape together with a small overlap and cut through the centre of the overlap with the blade, producing a diagonal cut as shown. Next lay the two ends on a flat surface so that they are touching but not overlapping and ensure that the glossy side of the tape is uppermost. Now press a short length of the adhesive tape across the join as indicated and trim the edges with blade or scissors so that there is no stickiness at the edge of the finished splice. A sticky splice adheres to adjacent turns on a spool or to the capstan and may well cause wow and flutter. An alternative method of applying the adhesive tape is indicated in the illustration.

Splicing tools are available which make easy the accurate alignment of the tape. Another useful accessory is the coloured leader tape marketed by the manufacturers of magnetic tape; this can be spliced in so as to identify ends or intermediate sections of a recording.

The odd lengths of tape cut from recordings should be kept and spliced together when there are enough of them. It is best to keep different brands apart as they have slightly different magnetic characteristics and, as a consequence, noise levels.

Editing is simple with full-track recorders. Owners of twin-track machines should remember that the tape to be worked must be recorded on one track only. Alternatively, the second track should contain something which is no longer required.

When undertaking editing work, it is of great value to be able to find quickly the point at which the tape is to be cut, without having to mark the tape where it rests against the playback head. The following is a simple method of doing this (see Fig. 22).

Remove the cover which protects the heads. Measure very precisely the distance along the tape from the playback head gap (the middle of the head) to some point along the direction of travel. The point where the tape leaves the cover is convenient. Note this distance and make two marks corresponding to it — on the front edge of the recorder, for example. The precise point at which the tape is to be cut on future occasions can then be found easily by stopping the recorder at the appropriate instant and marking the tape where it leaves the cover. Measure back along the tape with the aid of the two marks which have been made and make the cut.

Incidentally, removing a single note of music or other short sound from the tape is easily accomplished without the need for splicing. In some machines, the offending section of tape can be held against the erase head for a moment and, in others, very quick operation of the controls will ensure that this section and no other is erased. The Wearite Defluxer, normally used for demagnetising heads, is ideal for erasing short lengths of unwanted programme.

This may be the moment to remind readers that a complete reel of tape can be erased on one of the devices now marketed for this purpose. The full spool is placed on the device, which subjects it to an alternating magnetic field. This saves the time taken in running the tape through the recorder for erasure. Newcomers to tape recording are reminded, however, that a recorder erases anything on a tape automatically when a new recording is made. The foregoing remarks are for those who wish to store a tape which must for some reason be free from any signal.

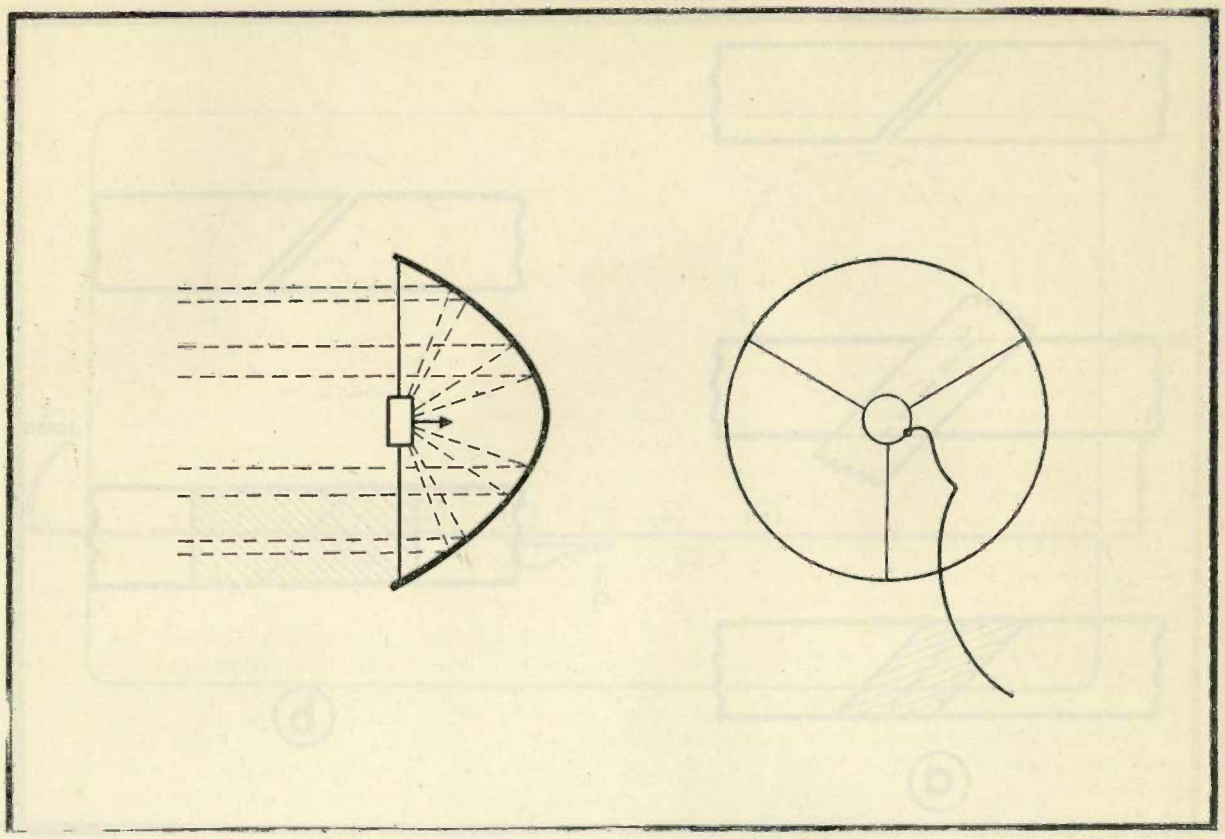


Fig. 20. Microphone suspended in centre of parabolic reflector to improve the signal to noise ratio.

Sound Effects

An obvious way of obtaining sound effects is to leave the recorder connected up to your radio receiver during broadcasts of plays and documentary programmes. The sound effects alone can be taken or they can be abstracted later if you record the whole programme. The appropriate effects can be spliced into a composite tape.

The sound effects sections are almost certain to have different acoustical characteristics to those of the main recording to be made subsequently. When different sections are spliced together, the joins will mark the transition from one frequency or reverberation characteristic to another and the result will sound far from convincing.

The first requirement is to obtain more of the various sound effects than will actually be needed; it is then necessary to blend them smoothly with the rest of the recording so that the transition will be easy on the ear.

Ideally, sounds from two or more sources would be mixed together in one process but this is not practicable where some of the material has been gathered from the radio, some from outdoor sources and some spoken into the microphone. What is needed is a means of adding a new sound over some other sound which has been recorded earlier.

A few recorders have a control which enables the effect of the erase head to be reduced. The existing recording is retained (at reduced level) and the new recording is made over the top of it. A tape of background sounds can be made at a convenient time and a commentary or music " superposed " on it at a later date.

In a recorder not provided with this facility, the " superposition " effect can be achieved by inserting a small piece of celluloid between the erase head and the tape. By doing this, the erase head is is allowed to reduce the level of the original recording but does not wipe it off completely. The new recording is added while the piece of celluloid is in position and the necessary fading in and out achieved by judicious use of the recording control.

Great care should be taken to avoid damage to the erase head and the celluloid should be quite smooth and a good fit over the head surface. No attempt should be made to disconnect the erase head; this can lead to damage and does not in any case produce the desired effect. The procedure just

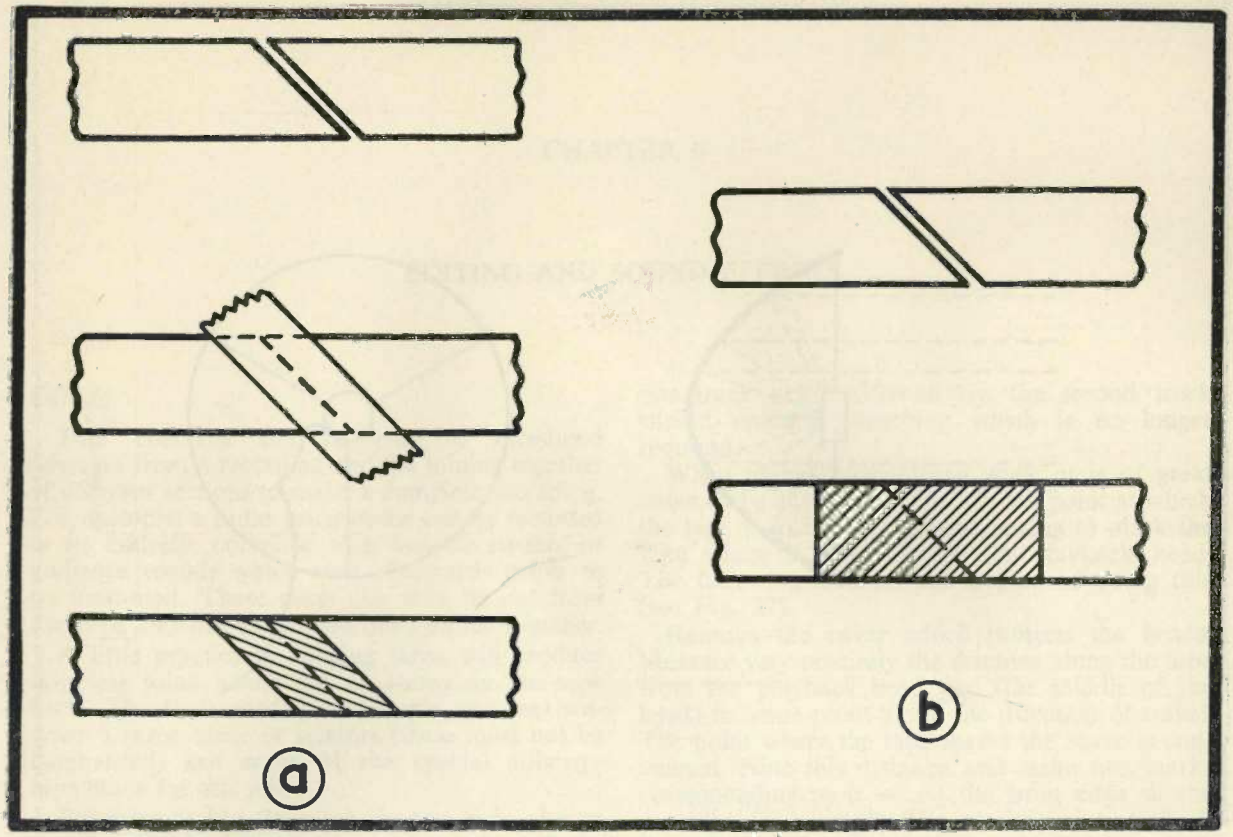


Fig. 21 (a). The two ends, cut diagonally, are butted together and covered with adhesive tape. (b) Alternative method.

described is very useful for such diversions as singing duets with yourself.

Many sound effects can be produced from quite ordinary materials and most homes are a veritable armoury of devices of potential value. Sounds of rivers, streams and waterfalls can be simulated by pouring water from one container into another. Varying the rate of flow gives different effects of splashing, gurgling and so on. If the sound is too well defined or seems obviously artificial, cover the microphone with a cloth.

Of the several ways of producing sounds of the sea, the most straightforward makes use of an inflated toy balloon containing a quantity of small but heavy particles such as lead shot. A little practice at manipulating the balloon will produce a convincing impression of waves breaking and receding from the shore. The recorder's control can be adjusted to heighten the effect.

Needless to say, many simple but useful effects such as thunder, rain and footsteps are easily obtained by placing the microphone in an open window at the appropriate time. Such sounds can be simulated, however.

Thunder is produced by jerky movements of the balloon mentioned just now. Alternatively, a sheet of metal or foil can be made to give the right effect. Rain is produced by pouring sugar along a trough of greaseproof paper. Footsteps on a path can be made by agitating some gravel with a piece of wood or by crunching the gravel in a cloth. The microphone should be very close.

The rustling and crackling sounds made by someone walking in a copse or woods are simulated by crumpling cellophane and paper. Snapping hard, dry pieces of wood near the microphone will complete the sound picture. A sheet of cellophane which has been energetically crumpled into a ball exhibits a tendency to expand a little to the accompaniment of a small but continuous crackling sound. This, when recorded and heard at a higher sound level, simulates a forest fire.

Adding Reverberation

We are at pains to avoid the muddled effect produced by reverberation in most recordings except, of course, where it adds to the sense of "atmosphere". Reverberation effects are often used in records of popular music; both echo-

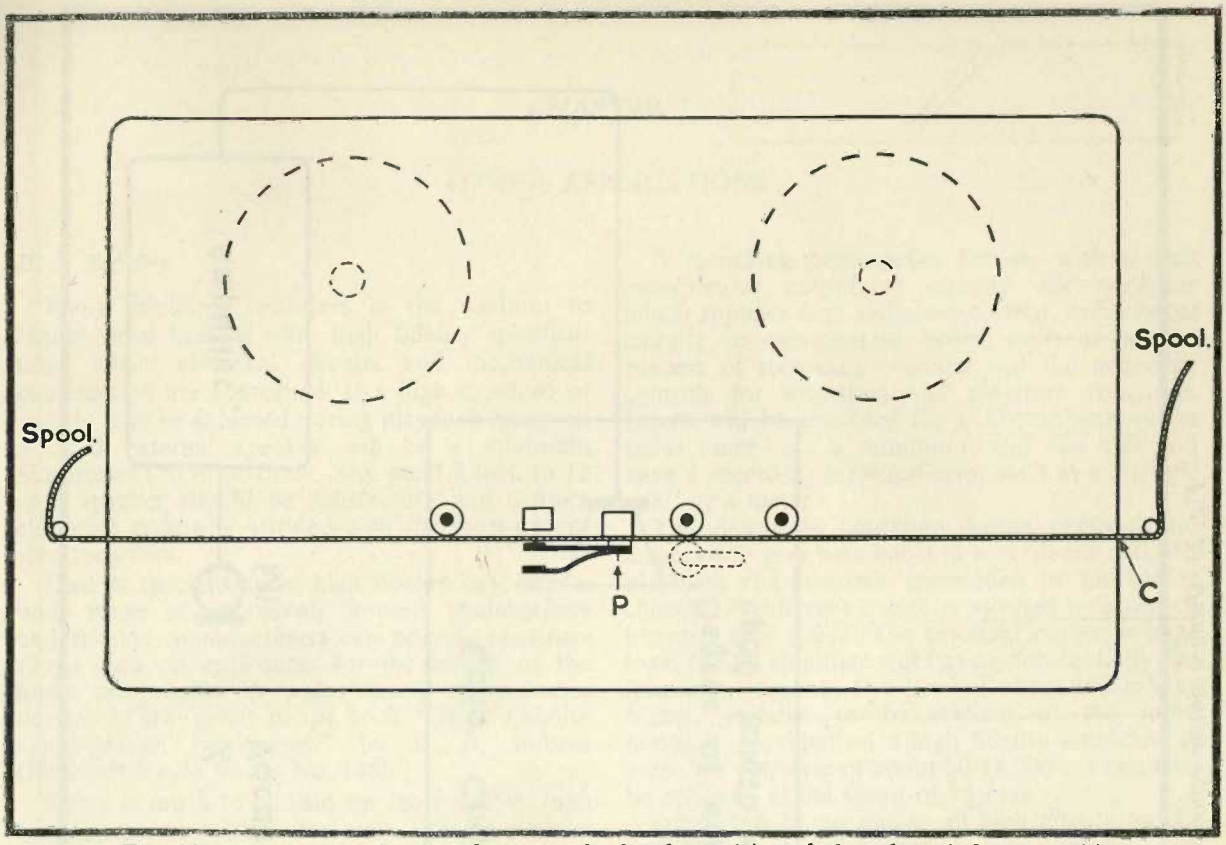


Fig. 22. Measure the distance between the head gap (p) and the edge of the cover (c).

chambers and electronically-produced reverberation are used in professional work.

An experimental echo-chamber can be devised by the amateur. A room with hard walls and devoid of soft furnishings is required: a bathroom has been used successfully. A microphone is placed at one end of the room and a loudspeaker at the other end. The loudspeaker is connected via an amplifier to the main " studio " microphone which the vocalist or instrumentalist is using and the " echo " microphone is connected to the tape recorder (see Fig. 23).

The amount of echo is controlled by moving the loudspeaker and echo microphone to different positions and by placing a screen between the two. The output of the studio microphone can be mixed with that of the echo microphone so that reverberant and normal characteristics are combined.

Other Effects

A number of composers have experimented in recent years with a form of composition known as " electronic music ". Sounds may be produced from normal musical instruments, created by electronic equipment or taken from other sources. Equipment used has included oscillators, noise generators and an electronic clavichord. Tape recording plays a leading part in this type of composition and many basic effects are obtained readily on professional tape recorders.

Amateurs can employ these methods to some extent. Few people will have an assortment of electronic equipment but recorders with more than one speed enable variations in pitch to be produced. One or more male voices can be recorded at one speed and played back at a higher speed and musical instruments can be played back at half-speed.

The effect can be tried of splicing in a section of tape in reverse. A sustained piano note or a stroke on a gong played backwards will illustrate the percussive nature of the sound, which will build up to a climax and cut off abruptly. The effect of reverberation adds considerably to the dramatic effect and an ingenious enthusiast can evolve a " study in sound " which may be considered on its own merits but not, of course, compared with conventional music.

The amateur intending to make an ambitious recording of this type should record with the aid of a comprehensive amplifier in order to make use of the tone controls, and the steep-cutting filter if provided.

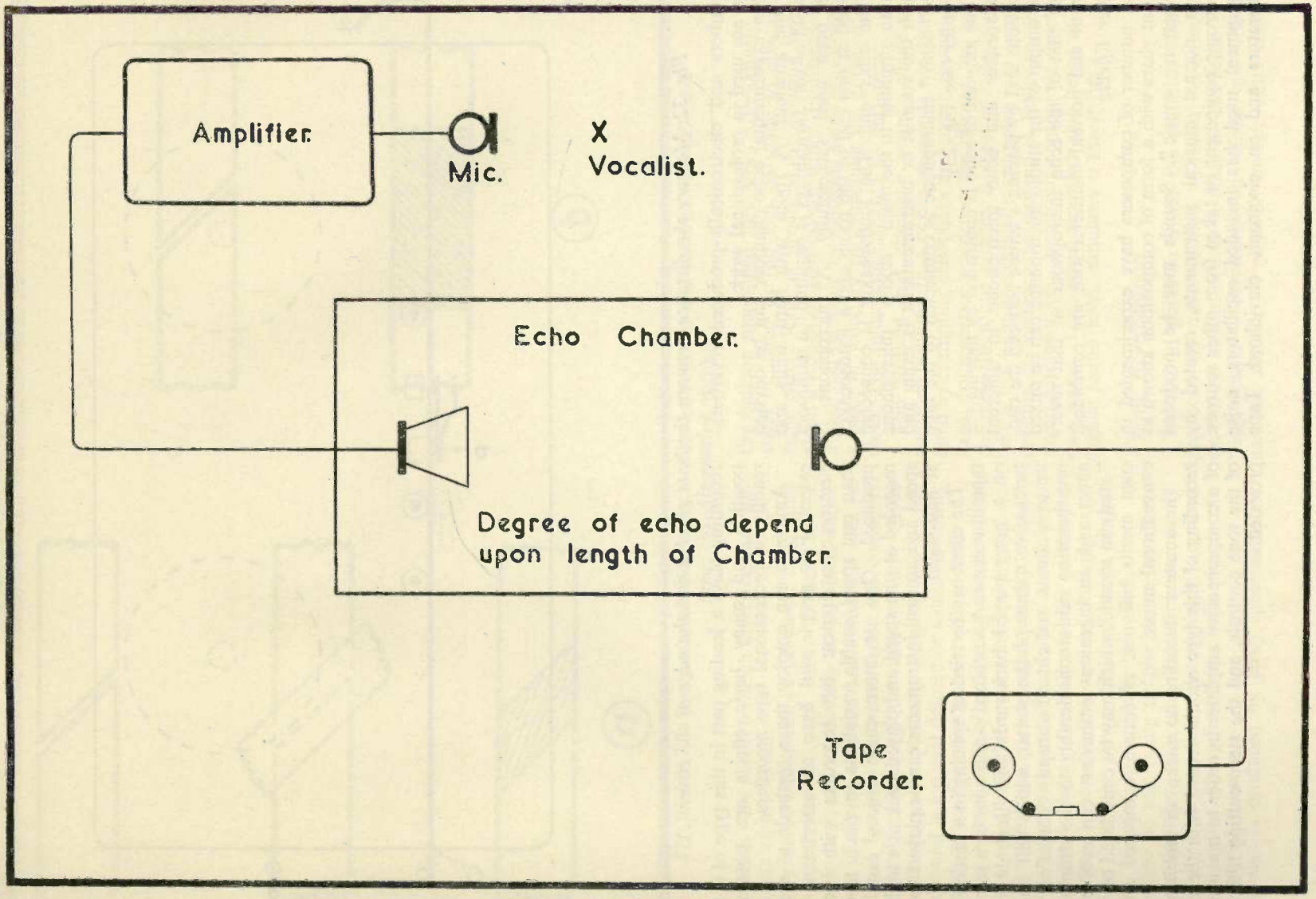


Fig. 23. Using a simple echo chamber to add to reverberation.

CHAPTER 7

OTHER APPLICATIONS

High Fidelity

Many complete recorders in the medium to higher price bracket offer high fidelity specifications where electrical circuits and mechanical construction are concerned. If a high standard of quality is to be achieved during playback however, a good external speaker will be a minimum requirement in most cases. Any good 8 inch to 12 inch speaker should be satisfactory and a more elaborate system is justified with the most expensive recorders.

Dealers specialising in high fidelity can offer a wide range of attractively housed loudspeakers and speaker manufacturers can provide constructional data on enclosures for the benefit of the home constructor. A wide variety of enclosure designs is also given in the book "High Fidelity Loudspeaker Enclosures" by B. B. Babani (Bernards Radio Books No. 146).

There is much to be said for the portable, high quality recorder when the user already owns a high fidelity installation. The recorder can be used for recording and playback in conjunction with the high fidelity amplifier and speaker system; at other times it can be taken further afield for the purpose of recording with the microphone. It is essential that a recorder to be used in this way has an output specially intended for hi-fi playback. This will preferably be a high impedance output taken from the playback amplifier circuits, by-passing the recorder's output stage and loudspeaker. Connection will be to a "tape" input on the hi-fi amplifier.

Where the facilities of a portable machine are not required, the tape deck and associated circuits can be built into a permanent high fidelity installation. The tape equipment will then offer the usual features of a complete recorder but the output stage and loudspeaker are dispensed with. This approach to tape recording is dealt with in the following sections.

Hi-Fi Recording and Playback

The tape deck is the mechanical part of a recorder. The tape heads are ready for connection to the circuits which will be associated with the deck and the other connection to be made is for the mains supply to the driving motors.

A recording preamplifier for use with a deck incorporates amplifying circuits, the oscillator which supplies bias and erase current, treble boost circuits to compensate losses inherent in the process of recording on tape and the necessary controls for recording and playback functions. Inputs will be provided for a microphone and a radio tuner—(as a minimum) and the unit will have a recording level indicator such as a "magic eye" or a meter.

The circuits in operation during playback are arranged to give bass boost in accordance with the playback characteristic mentioned in an earlier chapter. A different circuit is selected by a switch for each tape speed. The resultant output voltage from the preamplifier will have a substantially flat frequency response at a level of about 100 mV or higher, suitable to be applied to the input normally provided on a high fidelity amplifier. A corrected response of about 30-14,000 c/s can now be achieved at the speed of 7½ i.p.s.

Some, but by no means all high fidelity amplifiers have a special output for tape recording and this can be taken to the tape preamplifier. Recordings of all types can then be made via the hi-fi amplifier and full advantage can be taken of its tone controls and filters.

Performance requirements for a tape deck naturally include most of those which apply to a good portable machine. The amount of wow and flutter is likely to be a reflection of the standard of mechanical construction; it should not exceed 0.2 per cent. at 7½ i.p.s. A deck which is claimed to be of professional standard should offer 0.1 per cent. wow and flutter.

If the twin-track system of recording is used, automatic or push-button tape reversal at the end of track is very useful as the duration of a long musical work may easily exceed the recording time of one track. It should be remembered, however, that the facility of recording in either direction of tape travel involves the use of two sets of heads and, if the heads are good ones, the deck will be expensive.

The recording preamplifier may be fitted under the deck in some cases; it can also be obtained housed for shelf mounting or for mounting in a cabinet.

The problem of hum and other noise is always a very present one in tape recorders. Whatever the

type of machine, a very small signal voltage has to be amplified considerably and there are many points in the circuits, from the heads to the later stages, where hum can be introduced. There is particular need for care in portable machines, where the heads and wiring are necessarily close to a mains transformer and one or more motors.

The amateur can confidently expect a good medium priced recorder to have a hum level representing the best which can be achieved in the face of many difficulties. He should, however, keep firmly in mind the purpose for which the newly-acquired recorder is to be used.

If a wide-range external speaker is included in his plans, or the recorder is to be fed into a Hi-Fi outfit, the resulting extension in bass response will reveal whatever hum is present. The amateur should not rely, therefore, on what he hears issuing from the portable's built-in speaker, which will not reproduce the hum.

Where high frequency noise is concerned, much will depend on the linearity of the frequency response and the excellence of any tone control circuits. Treble boost, as already mentioned, is applied during recording. In the interests of noise level, boost should not be applied during playback. There is a certain amount of noise inherent in the tape. Noise introduced in recording amplifier and bias oscillator circuits is minimised by good design. An overall signal to noise ratio of −45 dB is very satisfactory; some recorders offer even better noise levels.

Playback Only

If only playback is intended, the head(s) can be connected to the high fidelity amplifier via a simple preamplifier circuit. This must raise the head output of a few millivolts to a level of about 100 mV and must correct for the recording characteristic. A few hi-fi amplifiers have inputs for direct connection of a playback head, thus eliminating external circuits altogether.

Programme Material

There are three main sources of programme material for the enthusiast seeking the highest possible quality.

First there is the tape recording by the enthusiast himself, using the microphone. If he has access to the activities of a group of musicians, or is a member of such a group, it is possible for him to build up a library of high fidelity material. A professional type microphone will be essential, or perhaps more than one, and success will depend on the positioning of these, as already pointed out.

Secondly there are the tape records of both serious and light music issued under the H.M.V. and Columbia trademarks. These are for reproduction at 7½ i.p.s. and are supplied on seven inch spools. They will give a very high standard of sound quality, frequently better than the long playing records of the same performance (which are prepared from the same original tapes). Both normal single-channel and stereophonic tapes are available.

The third main source of material is the B.B.C.'s high quality VHF/FM service. Assuming a good radio tuner and an adequate aerial, the results from the best of these broadcasts are excellent where background noise, dynamic range (quietest to loundest sounds) and frequency range are concerned.

Results where all three factors are concerned will not always approach the ideal. Many broadcasts are from recordings and a great number of commercial records, including 78 r.p.m. discs, are used on the air. Concerts originating in a hall or studio in a part of the country remote from the listener will be fed to his local transmitter by land lines which inevitably bring limitations on sound quality. The acoustical properties of the hall or studio also affect the quality.

Broadcasts originating locally, however, are often of impressive quality with a frequency range which, at best, is about 40-15,000 c/s. Listeners in the London area find that concerts from the B.B.C.'c Maida Vale studios provide the best of all broadcast material.

VHF/FM Radio Tuners

The enthusiast can make the best of high quality VHF broadcasts if he invests in a tuner. As the name implies, a tuner incorporates the radio frequency tuning circuits but it will also have some form of detector in order to produce an audio output. It is, in fact, a receiver minus the power output stage and loudspeaker.

Tuners are available for FM only and this type is the most economical proposition. The tuner may be manually tuned and have a dial (the tuning range is 88-100 Mc/s) or pre-tuned models with switched positions for Home, Light and Third are available. Tuners covering both FM and AM bands are available for the listener who considers medium and long wave reception essential.

The radio tuner, then, is designed to be part of an installation. Where a high fidelity system is in use, the tuner can often draw its HT and LT power from the main amplifier. Mains-powered tuners are made, however, for cases where the amplifier cannot supply power.

The combination of tuner and high fidelity amplifier is an ideal arrangement for the recording enthusiast. He can modify the signal if necessary by judicious use of the amplifier's tone controls and can then monitor the programme with

the installation's loudspeaker. The recording can afterwards be played back under the best possible conditions.

A mains-powered tuner is still useful for the amateur who does not own a separate amplifier. Its output can usually be fed straight into the recorder's radio input. This means that nothing will be heard of what is being recorded unless some provision is made for monitoring the signal. In some recorders this can be done with the internal speaker; in others, headphones can be used. Most people will have a radio set in the house (even if it is not a VHF model) and this can be used for monitoring in the absence of any other facility.

Tuning in by ear is far from reliable where FM is concerned and most tuners have some form of indicator. The simplest is the " magic eye " similar to that used as a recording level indicator in tape recorders.

Proper attention to the aerial is essential for good results. Although VHF/FM radio is far less susceptible to interference than AM, some noise—from motor car ignition, for example — may be experienced if only a length of wire is used.

FM dipoles cost very little and can be erected indoors, preferably in the loft, if the local signal strength is adequate (up to about 20 miles from the transmitter, as a rough guide).

Alternatively, a reasonably good substitute can be made from wire. Nation-wide VHF coverage should enable almost everyone to get good results on an efficient indoor aerial. If local reception is for some reason poor, an outdoor aerial should be used. Combined TV and VHF/FM aerials are available.

Stereophonic Sound

Conventional sound reproduction—"monaural" is the term used to distinguish it—has reached a very high performance standard. Enthusiasts now almost take for granted a frequency response corresponding to the entire audible range and distortion levels which cannot be detected by the ear.

It is, however, widely acknowledged that, in spite of the care and ingenuity exercised in the design and production of high fidelity equipment, something essential is missing from the reproduced sound. The listener, particularly if he attends concerts regularly, becomes aware that he does not experience the spaciousness of the concert performance; the orchestra is restricted to a small sound source and the sound intensity which could give some semblance of realism is difficult to listen to in comfort.

With recordings of opera and other stage performances, the movement of the actors, which could add so much to the listener's enjoyment, is confined to variations in loudness. The actors seem to move into and away fom the loudspeaker.

Some of these disadvantages have been countered by careful loudspeaker design aimed at producing a broader source of sound and some manufacturers have introduced reverberation, both natural and artificial, into their recordings in an attempt to give a more convincing representation of concert-hall spaciousness.

Even before these improvements in monaural reproduction became possible, however, laboratories in several countries including Great Britain were at work on stereophonic recording techniques. One of the first outstanding practical applications to come before the public was Walt Disney's film " Fantasia ", which was shown in the U.S.A. with stereophonic sound.

Several channels of sound are possible in the cinema but two channels are likely to be the economic limit in the home for a long time to come. Two-channel stereo nevertheless represents a great advance in sound reproduction. It provides us with a notable improvement in " spaciousness ", it enables us to localise solo performers or groups of players in an orchestra and spreads the apparent source of sound right across the room. The illusion of movement which is made possible will be greatly appreciated by the opera enthusiast.

The layman is reminded that stereophony is not " three-dimensional " — the many real attractions and advantages of stereo can be fully appreciated without the addition of the sadly mis-used 3-D label.

A microphone set-up is used in the studio which has, as it were, two separate " views " on the orchestra. The principle of two channels is carried on through the recording process and is continued in the reproduction with two amplifying circuits and two loudspeakers.

Magnetic tape was an essential part of early experiments and is, of course, used in the recording studio. Today, a high standard of stereophonic realism is achieved from tape records marketed under the HMV and COLUMBIA trademarks. These tapes are supplied on seven-inch spools for production at $7\frac{1}{2}$ i.p.s.

The stereo tape has two tracks which are picked up by a " stacked " playback head. This, in effect, comprises two heads, one above the other and assembled as one unit. If a tape deck is used, the two windings of the stacked head are each connected to a preamplifier which amplifies the signals and corrects them according to the CCIR characteristic mentioned earlier. The signals are then passed on through two power amplifier channels to the two speakers.

It is possible for the preamplifier to incorporate the circuits necessary for conventional monaural

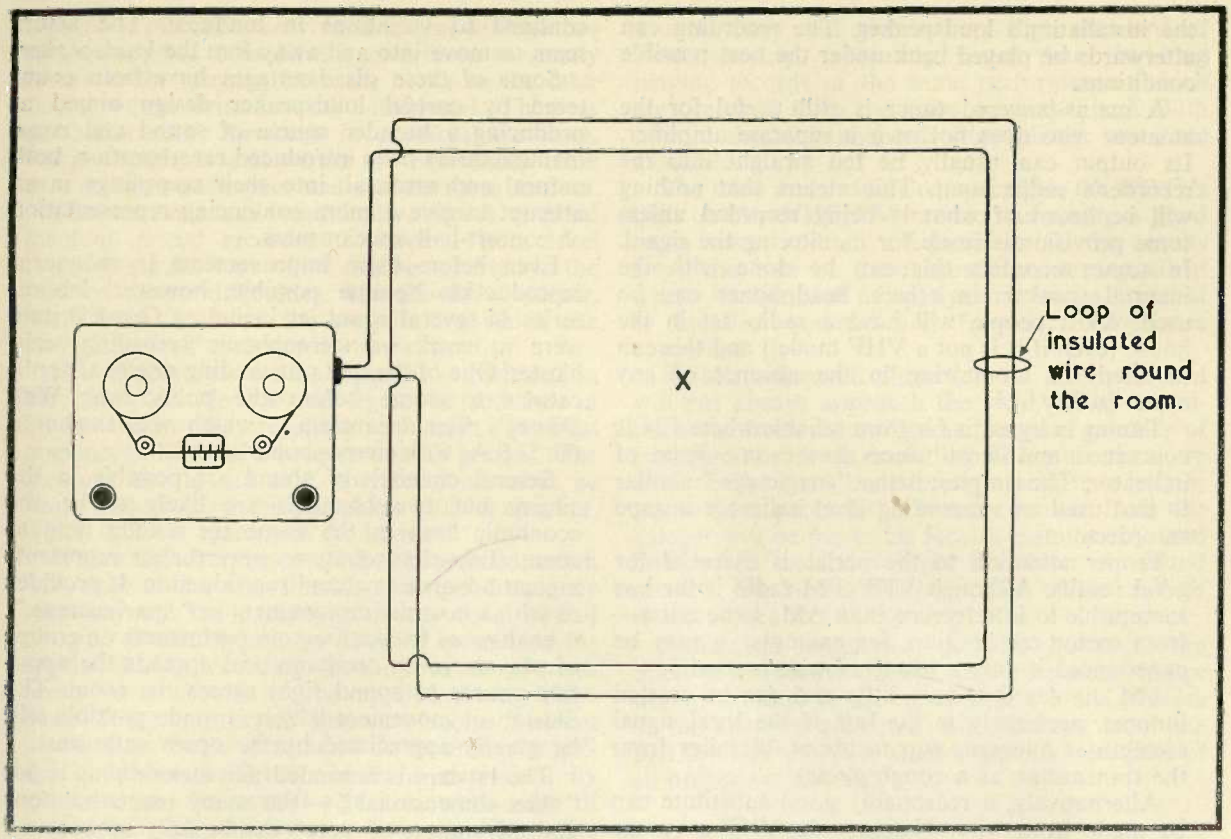


Fig. 24. A hearing aid (x) fitted with a listening coil may be used anywhere inside the loop. The loop comprises one or more turns of wire connected to the extension speaker sockets.

recording and playback. Stereophonic recording with microphones is theoretically possible if two good microphones are used but the difficulties surrounding balancing and domestic acoustic conditions make it unsuitable for the amateur.

Complete, portable recorders have been developed which incorporate facilities for stereo playback as well as full monaural facilities. The Tandberg "Master" is an example; this model offers a high fidelity specification and has built-in power amplifiers which await only the connection of two external speakers for stereo reproduction to be obtained.

It will be ideal if the two speakers are identical but this is not absolutely essential provided that their high frequency responses are very similar. They must be correctly sited in relation to the listener.

The arrangement shown in Fig. 000 can be used with many types of speaker; the best position for the listener is approximately at the apex of an equilateral triangle, shown in the sketch as having six feet sides. The triangle can be made bigger or smaller but the listener should maintain his position at or near the apex. The arrangement of Fig. XXX is particularly appropriate for omni-directional speakers, which do not beam the high frequencies at the listener. With this arrangement, the useful listening area is increased and a greater number of people can obtain a true stereo impression.

It is important to check that the speakers are in phase during stereo reproduction, i.e. that their cones move in and out together. If they are out of phase, the stereo illusion may well be lost.

For the Hard of Hearing

Deaf people can benefit to some extent from the advantages and pleasures of tape recording. Many recorders have an output suitable for connection to headphones; partially deaf people can use high impedance headphones connected to the appropriate socket and the higher quality moving-coil headphones, which are of low impedance, will often give good results from the extension speaker output. Deaf-aid earpieces can also be connected to some recorders but the manu-

facturers of both should be consulted to ascertain whether proper impedance matching is possible.

Some people use deaf-aids which have a built-in listening coil. With these, a signal can be picked up by magnetic induction and no wired connection is needed. A "loop" consisting of several turns of insulated wire is laid round the room and the ends are connected to the recorder's extension speaker sockets. Connection to a radio receiver is possible in the same way.

Experiment with the amount of wire in the loop will result in approximate matching to the output impedance of the recorder. A person using the appropriate type of deaf-aid inside the area contained by the loop will hear the programme as a result of the current induced in the listening coil. The arrangement allows great freedom of movement and the signal can usually be picked up just outside the loop as well as inside it.

A simple loop is sketched in Fig. 24. If the deaf person wishes to use a certain chair for listening, the loop need only be formed temporarily round the chair.

The warning given in Chapter 6 concerning AC/DC receivers and other equipment is once more emphasized. Any wiring or other items added to these receivers must be isolated from the mains electricity supply and a qualified radio engineer should be consulted.

"Spoken Letters"

The exchange of recorded tapes by post is becoming increasingly popular. To avoid disappointment due to the inability to reproduce a tape, the correspondent should use a spool and a recording speed which can be catered for on the majority of recorders.

Where the correspondent has no details of the recorder at the receiving end, a spool of five inch diameter or less should be used. A three inch spool is convenient for most "letters". The 3¾ i.p.s. speed is the best since nearly all recorders have this. The recording "sense" mentioned in Chapter 1 is widely used and no trouble is likely in this respect.

Some people will wish to send tapes to friends overseas. The risk that the recipient will have a non-standard machine is very small but it is wise to write first and obtain confirmation that the simple requirements mentioned above will be catered for. The fact that a recorder in another country may be on 60 c/s mains makes no difference: it will, of course, still be recording and playing back at the standard speed.

A tape recorder designed for our mains supplies cannot, on the other hand, be taken to a 60 c/s country without first being modified. This usually involves changing the recorder's motor pulley and the manufacturer should be consulted.

Miscellaneous

Apart from the many applications already described, there are hundreds more uses for the tape recorder. The following is a reminder of its wide scope.

In the Home

An "album" in sound can be built up. Children can be recorded at intervals of months or years, as required, in much the same way as snapshots are collected. It is, moreover, easier to take a recording of children's voices without their knowledge than it is to take their photographs. A recorded tape will last as long as a snapshot, if stored carefully.

The recorder is very useful at parties and celebrations: use the microphone to record guests and provide backgound music from a previously recorded tape.

A recorder is of great use, too, as an educational aid for children and as a source of instruction and entertainment for blind people and invalids.

The exchange of "spoken letters", mentioned earlier, is another attractive application.

In Education

The recorder will be found invaluable in preparing lessons, in examinations and for giving lessons to individual students, backward children and those kept at home by illness.

It can be used for repetitive parts of lessons and particularly in the exposition of correct pronunciation during language instruction. Imperfections in accent and enunciation can be pointed out—both in the student's own language and in foreign language lessons.

There is considerable scope for the tape recorder in music teaching. It offers a fair criticism of progress and both student and teacher can record difficult passages of music for comparison purposes.

Actors; Public Speakers

A recorder can assist rehearsals and can provide music and sound effects via a public address system. The public speaker can benefit considerably when preparing speeches and the recorder will be useful for recording meetings and assessing the reactions of audiences.

Medical Profession

Symptoms, prescriptions and other information can be recorded, as can important telephone calls. A record may be kept of hospital lectures and meetings. The tape recorder is invaluable in psycho-analysis.

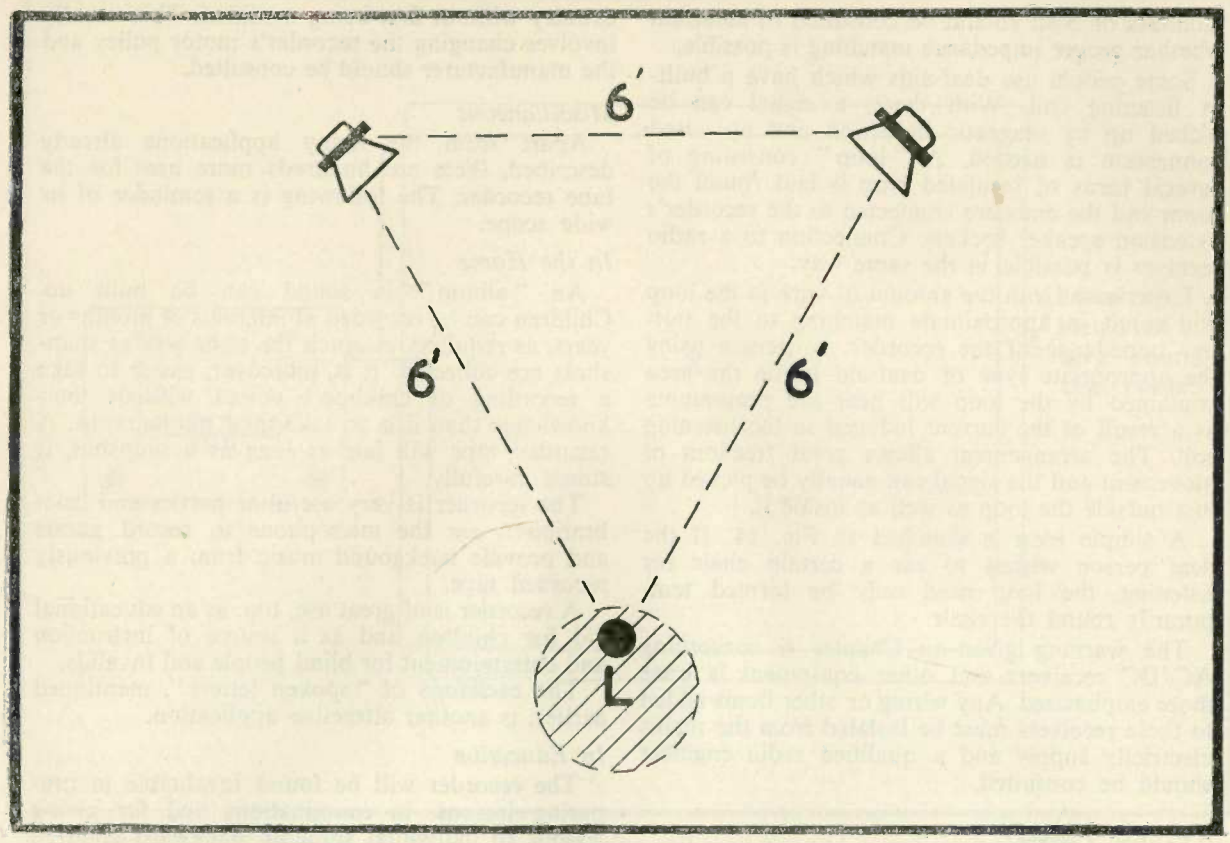


Fig. 000. This diagram shows the positioning of speakers for stereophony. An alternative method is shown in Fig. XXX.

Journalists; Salesmen; Advertising

An outstanding application is on - the - spot reporting and interviewing. The recorder can also be used for intermittent announcements, instructions, recording of discussions and sales training.

Religion

Preparing sermons; recording services for the sick; choir practice.

CHAPTER 8

MAINTENANCE AND FAULTS

Periodic maintenance is essential if the tape recorder is to keep its original standard of performance. A brief survey of faults is given; it is not, of course, fully comprehensive, but it gives an indication of some troubles which can occur when conditions depart from the ideal. It cannot be too strongly emphasized that, should the non-technical user find himself unable to cope with maintenance or a fault, the dealer familiar with tape recorders is there to give practical help.

The heads, pressure roller, capstan and surrounding parts of the tape deck should be cleaned occasionally with a suitable fluid on a soft cloth or a small brush. Suitable cleaning fluids are carbon tetrachloride (from chemists) or benzene. The brush should have proper bristles, not synthetic ones. Do not use cleaning fluids in a confined space, or you may suffer ill effects. Ensure that nothing abrasive touches the surfaces of the heads.

The exposed bearings may be lubricated with a little thin oil; the pressure roller particularly will benefit from this. It is important to prevent oil from reaching the surfaces of the roller, heads and capstan.

The frequency of such maintenance obviously depends on the amount of use. Cleaning every 100 hours is adopted by some people, but it is difficult to lay down any rules about this.

A pressure pad is often used to maintain tape-to-head contact. The pressure affects both tape tension (and speed) and audio performance. If pressure is too light, electrical performance may suffer; if it is too heavy, the tape speed may be slow and head wear will be accelerated. Poor tape contact can also cause low frequency noise.

High frequencies will also suffer if the heads need cleaning. If they are badly worn, however, replacement is the only solution.

Examination of a record or playback head a month or so after being put into service will show whether or not the tape contact is satisfactory. The polish on the head should appear even and symmetrical.

The following comment concerns head adjustments. In twin-track machines, the output from both tracks will be mixed if the head is set too low. The mounting screws must then be adjusted until only the top track is heard. The erase head also has adjusting screws and it should be set so that the top track is completely erased and the bottom track is not noticeably affected.

The "azimuth" adjustment concerns the setting of the record/playback head such that the gap is at right angles to the axis of the tape. To test this, a test tape recorded with a steady 8 kc/s tone at 7½ i.p.s. is suggested. Connect a suitable meter to the output of the recorder provided for Hi-Fi playback, or to the extension speaker socket if good top response is guaranteed at this point. Run the tape through and adjust the spring-loaded screws holding the head until maximum output is read on the meter.

The azimuth adjustment applies, of course, to full track machines as well, and to those having separate record and playback heads. The adjustment is first made by the manufacturer and this may well be good for the life of the recorder.

The frequency test tape marketed by E.M.I. is an excellent aid for both amateur and professional users.

Remember that a change in tape speed means a change in pitch of speech or music. Small

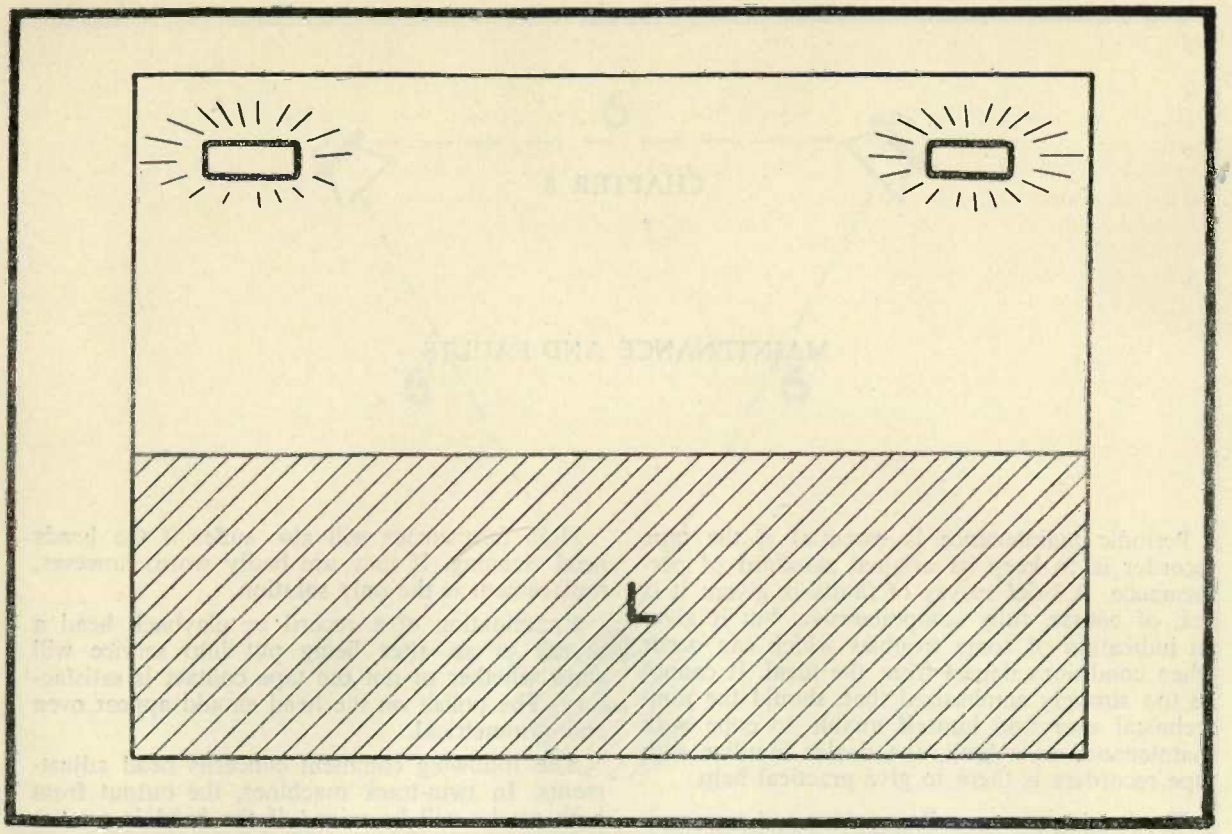


Fig. XXX. This diagram shows the area in which the stereophonic sound is effective using omni-directional speakers.

fluctuations ("wow" and "flutter") are most annoying in the reproduction of music. This effect can be due to damaged edges of idler wheels. Normally, these wheels are disengaged when the machine is switched off and are therefore less likely to become deformed. Beware of disconnecting the mains from the recorder while the controls are in the operating position: always switch to the "off" position on the recorder when the machine is finished with.

Wow and flutter can be due to moving parts rubbing intermittently: the clutch may need adjustment. Slip between capstan and pressure roller, or damage to these parts, will also produce fluctuations.

A large discrepancy in tape speed is as serious a matter as the more obvious fluctuations of wow and flutter. Tapes recorded on a machine in which a fault kept the speed below nominal will be reproduced at a higher speed when the fault is rectified. An occasional speed check is therefore a useful item of maintenance.

The simplest way to do this is to run a known length of tape (200 feet for example) through the recorder and time it carefully with the second hand of a watch. Mark the tape on the glossy side with small pieces of adhesive tape, one at each end of the test length.

If the measured speed is a *little* above or below the nominal, do not assume that a fault exists. A tolerance must be allowed, greater on domestic machines than on professional ones. For the above test, an accuracy of plus or minus five seconds in five minutes would be acceptable, assuming a portable recorder in the medium-price range. A much bigger discrepancy will indicate a fault.

Causes of slow speed include greasiness or deformation of the driving belt or pulley system and lack of lubrication in the capstan bearing.

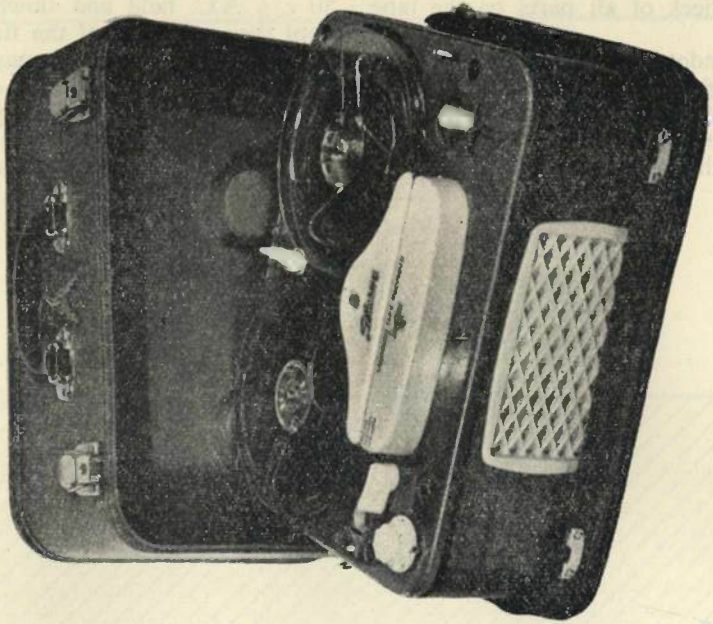
Modulation noise, a hissing or similar sound varying with the signal, may be due to poor and intermittent tape to head contact, possibly accompanied by irregularities in the driving mechanism. If the bias current is incorrect or poor tape is used

this may influence the matter, but the most rewarding line of investigation for the amateur is likely to be a thorough check of all parts on the tape deck.

This effect and, indeed, all background hiss, is made worse by slight magnetisation of the tape head. Be very careful that tools used for work on the tape deck are not magnetised. Check them by finding whether they will pick up a small piece of magnetic material such as a steel pin. Tools can be demagnetised by holding them in a strong 50 c/s A.C. field and slowly withdrawing them until they are clear of the field (this is a similar process to the high frequency demagnetisation of the tape by the erase head).

Heads can become slightly magnetised after a period of normal use. The Wearite Defluxer is a useful tool for demagnetising them.

The Harting Tape Recorder.



The Tandberg Tape Recorder.

On the following pages are given the technical specification of two of the world's leading tape recorders. These two have been chosen because of their quite remarkable performance as compared with others in the same, and even higher, price ranges.

The Tandberg is extremely interesting to the enthusiast because it is the only domestic 4 track stereo tape recorder built to professional standards, so far on the market, anywhere in the world.

The beauty of the Harting is its amazingly smooth frequency response. Even at 3¾ i.p.s. it surpasses the best performance of other models operating at much higher speeds.

TANDBERG 4 TRACK STEREO MODEL 5

TECHNICAL SPECIFICATION

Frequency Response

From 30-20k c/s at 7½ i.p.s.
From 30-12k c/s at 3¾ i.p.s.
From 30- 4k c/s at 1⅞ i.p.s.

Wow and Flutter.

Total wow and flutter better than 0.15 per cent. at 7½ i.p.s., 0.2 per cent. at 3¾ i.p.s., and 0.3 per cent. at 1⅞ i.p.s.

Amplifiers

Two matched amplifiers which never deviate from one another by more than 1db. Output 3½ watts (5 peak) is available from each.

Signal to Noise Ratio

55 dbs below recording level.

Motor

Precision capacity split-phase motor with multiple poles.

Drive

Indirect fly-wheel drive statically and dynamically balanced.

Playback Facilities

(a) Half track on four tracks.
(b) Full track on two tracks.
(c) Stereophonically on two separate tracks.

Reel Size

7 inch reels maximum.

Tape Playing Time

2 hours at 7½ i.p.s.
4 hours at 3¾ i.p.s.
8 hours at 1⅞ i.p.s.
with double tapes such as BASF these playing times are increased to 4, 8 and 16 hours respectively.

Recording Level Indication

By means of EM71 fluorescent beam indicator.

Recording Tape Measurement

A clock face indicator is provided.

Controls

1. Volume control for record and playback.
2. Operation selector switch.
3. Stereo or monaural switch.
4. Microphone socket.
5. Function selector.
6. On-Off switch with red pilot lamp.
7. Speed change switch
8. Monitor switch for connecting monitor speaker.

Heads

Record playback head with stacked in line 4 track stereo head. Head gap 0.00025 ins. Crosstalk between any pair of tracks is better than −60 db.

Inputs

Sockets for Microphone, Radio, Gram and other external signal source are provided.

Using Recorder as High Fidelity Amplifier

The Tandberg Stereo Master recorder may be used as a straight forward high fidelity amplifier for use at recitals, lectures, etc.

Speed Change

This may be effected during either record or playback without interruption.

Distortion

A recording level 10 db's below the saturation point results in less than 1 per cent. distortion of a 400 c/s signal on replay.

Speed Tolerance

Better than ± 1 per cent. for all speeds.

Stopping and Starting Speeds

Instantaneous.

Loudspeakers

A high fidelity loudspeaker is included with the recorder as a monitoring unit. However, to obtain the really remarkable results that are available with this machine, it is essential that two matched loudspeaker enclosures, such as the Technical Suppliers Ltd. (T.S.L.) Soundcorner should be used.

Size and Weight

11½ in. × 15 in. × 6¼ in. and 26 lbs. (11.8 kgs.).

Price

124 guineas.

The Tandberg Add-on Unit

Enables Tandberg Stereo recorders to be used for recording Stereophonically either from Stereo discs or from live sources.

Price

£17

HARTING HIGH FIDELITY TAPE RECORDER MODEL HM5M

TECHNICAL SPECIFICATION

Frequency Response

30 c/s to 20 kc/s within ± 1½ db at 7½ i.p.s.
30 c/s to 16 kc/s within ± 1½ db at 3¾ i.p.s.

Wow and Flutter

Total of wow and flutter better than .1 of 1 per cent.
Total wow better than .06 of 1 per cent.

Amplifier

Laboratory quality high fidelity amplifier designed to professional standards with 5 watt output (6 watt peak) at 5 ohms impedance.

Signal to Noise Ratio

Better than 52 db unweighted.

Speeds

3¾ and 7½ i.p.s.

Motor

Precision quadripolar shaded pole motor of extremely large size and robust construction with 100 per cent. power reserve.

Reel Size

7 inches maximum.

Tape Playing Time

1 hour at 7½ i.p.s. 2 hours at 3¾ i.p.s. with double tapes such as B.A.S.F. 2 hours at 7½ i.p.s. and 4 hours at 3¾ i.p.s.

Re-wind Time

2½ minutes.

Braking

Laboratory designed positive mechanical braking system with the most rapid stop mechanism on any recorder.

Automatic Stopping

Electronic micro-switch fitted.

Recording Level Indicator

Uses latest type EM84 fluorescent beam with broad and narrow indicator paths.

Recording Tape Measurement

Precision digital counter with extra bold numbering.

Monitoring

Monitoring switch enables recording to be controlled at any required level.

Controls

(a) Record press button.
(b) Right-hand fast re-wind press button.
(c) Left-hand fast re-wind press button.
(d) Playback press button.
(e) Large stop bar.
(f) Speed selector on ON/OFF control knob.
(g) Dual coaxial control combining internal loudspeaker on-off switch with volume control on recording. Volume and Tone control on playback.

Heads

Two heads are used. Record/Replay and Erase.

Sockets

(a) Microphone
(b) Radio
(c) Phono
(d) Remote control
(e) External speaker.

Tone Control

Full range tone control for base and treble.

Erase Safety Switch

Loudspeakers

One Lorenz 8½ in. × 6 in. in high fidelity special full range speaker, extra high flux, giant ALNI magnet.

Stopping and Starting Speeds

Instantaneous.

Tape Tension

Constant.

High Impedance Output

High impedance output (.5 volts into 10 kohms) is available for feeding external amplifiers.

Weight

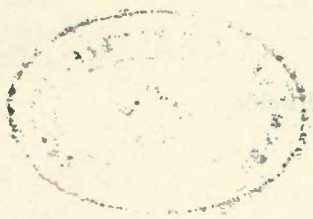
37½ lb. (17 Kg.).

Size 8

12¾ in. × 15½ in. × 8½ in. (10½ in. with closed lid).

Price

82 guineas.



BERNARDS RADIO BOOKS

No.		
35.	Dictionary of Mathematical Data	2/-
61.	Amateur Transmitter's Construction Manual	2/6
64.	Sound Equipment Manual	2/6
65.	Radio Designs Manual	2/6
66.	Communications Receivers' Manual	2/6
68.	Frequency Modulation Receivers' Manual	2/6
69.	Radio Inductance Manual	2/6
70.	Loudspeaker Manual	2/6
73.	Radio Test Equipment Manual	2/6
78.	Radio and Television Laboratory Manual	2/6
81.	Using Ex-Service Apparatus	2/6
83.	Radio Instruments and their Construction	2/6
86.	Midget Radio Construction	3/6
96.	Crystal Set Construction	1/-
97.	Practical Radio for Beginners, Book 1	3/-
99.	One Valve Receivers	1/6
100.	A Comprehensive Radio Valve Guide, Book 1	5/-
101.	Two Valve Receivers	1/6
102.	40 Circuits Using Germanium Diodes	3/-
103.	"Radiofolder" A The Master Colour Code Index for Radio and Television	1/6
104.	Three Valve Receivers	1/6
106.	Radio Circuits Handbook No. 4	2/6
107.	Four Valve Circuits	1/6
108.	Five Valve Circuits	2/6
110.	The Emperor: A Radio-gram for Home Constructor	3/6
112.	"Radiochart" Electronic Multimeter Construction	2/6
115.	Constructors' Handbook of Germanium Circuits	2/6
120.	Radio and Television Pocket Book	2/6
121.	A Comprehensive Radio Valve Guide, Book 2	5/-
122.	Wide Angle Conversion: For Home Constructed Televisors; Constructional Envelope	3/6
123.	"Radiofolder" F. The Beginners' Push-Pull Amplifier	1/6
125.	Listeners' Guide to Radio and Television Stations of the World	2/6
126.	The Boys' Book of Crystal Sets	2/6
127.	Wireless Amplifier Manual No. 3	3/6
128.	Practical Transistors and Transistor Circuits	3/6
129.	Universal Gram-Motor Speed Indicator	1/-
130.	Practical F.M. Circuits for the Home Constructor	5/-
131.	"Radiochart" Guide to Modern Valve Bases	2/6
132.	Reactance—Frequency Chart for Designers and Constructors	1/6
133.	Radio Controlled Models for Amateurs	5/-
134.	F.M. Tuner Construction	2/6
135.	All Dry Battery Portable Construction	2/6
137.	An A.M.-F.M. De-Luxe Receiver	3/6
138.	How to make T.V. and F.M. Aerials Bands 1, 2 and 3	2/6
139.	Practical Radio for Beginners, Book 2	3/6
140.	Television Servicing for Beginners. Book 1	4/6
141.	Radio Servicing for Amateurs	3/6
142.	Modern Television Circuits and Fault Finding Guide	4/6
143.	A Comprehensive Valve Guide, Book 3	5/-
144.	The New "At a Glance" Valve and Television Tube Equivalents	5/-
	Servicing the Modern Radio Receiver	1/6
	A Magnetic Tape Recorder	3/6
	The Electronic Photographic Speedlamp: How to Make it and how to Use it	3/6