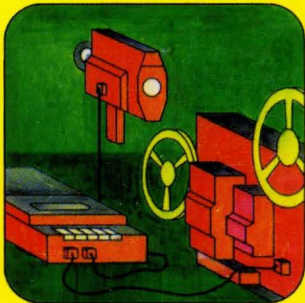
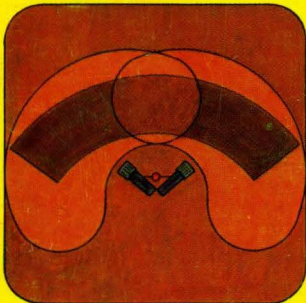
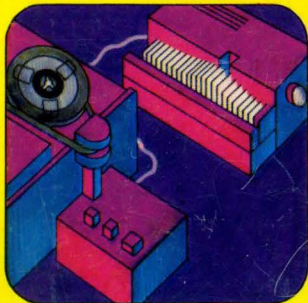
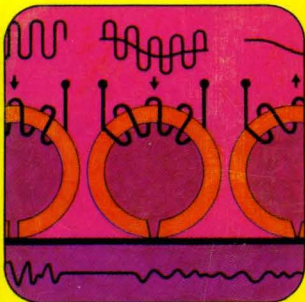


Tape Questions— Tape Answers

compiled
and answered by
Heinz Ritter



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1971

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Contents

1. Selecting the right Tape	11
2. Compact Cassettes or Spool Tape Recorders?	22
3. Selecting the Appropriate Compact Cassette Equipment	29
4. Selecting the Right Spool Tape Recorder	40
5. Which Trick Equipment for what Purpose?	57
6. Which Sound Mixing for what Purpose?	61
7. Which Microphone for what Purpose?	65
8. Recording with Microphones	74
9. How to Record Direct	78
10. Editing and Splicing of Magnetic Tape	83
11. Endless Tape Loops	88
12. How is a Tape Library arranged?	92
13. Tape and Recorder Maintenance	97
14. Exchange of Recorded Tapes	101
15. Exchange of Recorded Cassettes	103
16. How is Sound Added to Slides?	105
17. How to Add Sound to 8-mm Films	112
18. Diagrams	125

Chapter Reference

1. Selecting the Right Tape	11	3. Selecting the Appropriate Compact Cassette Equipment	29
1.1 Length of Tape – Playing Time – Speed of Tape	11	3.1 Construction of the Blank Compact Cassette	29
1.2 What Playing Time corresponds to the various Tape Lengths?	12	3.2 Construction of the Recorded Compact Cassette	29
1.3 What Types of Tape are available?	12	3.3 Operation of a Compact Cassette Recorder	30
1.4 Which Type of Tape for which Tape Recorder?	14	3.4 Track Pattern of Compact Cassettes	30
1.5 What are the Advantages of LH Tapes?	15	3.5 The Specification of Compact Cassettes	31
1.6 Which Spool holds which Tape Length?	17	3.6 Protection of Cassettes from Inadvertent Erasure	31
1.7 What are the Types of Packing for modern domestic Tapes?	18	3.7 The Types of Compact Cassette Machines	31
1.8 What Compact Cassettes are available?	19	3.7.1 The Compact Cassette Player	31
1.9 What are the Advantages of BASF Compact Cassettes?	20	3.7.1.1 The Cassettophone	31
		3.7.1.2 Domestic Cassette Players	32
2. Compact Cassettes or Spool Tape Recorders?	22	3.7.1.3 Stereo Cassette Changers	32
2.1 How much can be spent on a Tape Recorder?	22	3.7.1.4 The Radio Cassette Player	33
2.2 Cassette or Spool Tape Recorders?	23	3.7.1.5 The Car Cassette Player	33
2.3 Domestic Tape Recorder or HiFi Tape Recorder?	24	3.7.1.6 The Discassette	34
2.3.1 Frequency Response	24	3.7.2 The Cassette Recorder	34
2.3.2 Signal-to-Noise Ratio and Distortion Factor	24	3.7.2.1 Portable Compact Cassette Recorder	35
2.3.3 Cross Talk	26	3.7.2.2 The Car Recorder	36
2.3.4 Speed Variations	26	3.7.2.3 The Home Cassette Recorder	36
2.3.5 Speed Fluctuations	26	3.7.2.4 The Stereo Cassette Recorder	37
2.3.6 Conclusions	26	3.7.2.5 The Radio Recorder	37
2.4 Mono or Stereo?	27	3.7.2.6 The Car Radio Recorder	38
		3.7.2.7 The Casseiver	38

3.7.2.8	Cassette Recorder/Changer	38	4.7.6	The Headphone Output	55
3.7.3	The Cassette Radio	39	4.7.7	Remote Operation Socket	55
			4.7.8	The Projector Socket	56
4.	Selecting the Right Spool Tape Recorder	40	5.	Which Trick Equipment for what Purpose?	57
4.1	How does a Spool Tape Recorder work?	40	5.1	The Trick Button	57
4.1.1	The Tape Transport	40	5.2	Playback — Duoplay — Synchroplay	57
4.1.2	The Counter (Tape Programme Indicator)	42	5.3	Multiplay	58
4.1.3	The Input Selector Switch	42	5.4	Tape Speed Effects	59
4.1.4	The Track Selector Switch	42	5.5	Reverberation and Echo	59
4.1.5	Recording Level Indication and Recording Level Control	44	6.	Which Sound Mixing for what Purpose?	61
4.1.6	Automatic Recording Level Adjustment	45	6.1	Acoustic Mixing	61
4.2	The Track Pattern	46	6.2	Magnetic Mixing	61
4.2.1	Half-track Recording	46	6.3	Parallel Track Mixing	61
4.2.2	Quarter-track Recording	47	6.4	Electronic Mixing	62
4.3	Half-track or Quarter-track Operation?	47	6.4.1	Mixable Inputs	62
4.4	Which Tape Speed for which Purpose?	48	6.4.2	Active or Passive Mixer Unit?	62
4.5	Maximum Spool Size?	50	6.4.3	Directional Mixing	63
4.6	What Head Equipment?	51	7.	Which Microphone for what Purpose?	65
4.6.1	Advantages of Triple Head Machines	52	7.1	Microphone Systems	65
4.6.2	Quarter-track / Half-track Head Equipment	52	7.1.1	Carbon Microphones	65
4.7	Which Socket for which Purpose?	53	7.1.2	Crystal Microphones	65
4.7.1	Standard Radio Socket / Standard Diode Socket	54	7.1.3	Capacitor Microphones	65
4.7.2	The Radio/Phono Socket	54	7.1.4	Dynamic Microphones	66
4.7.3	The Phono Socket	54	7.1.4.1	The Moving Coil Microphone	66
4.7.4	The Microphone Socket	55	7.1.4.2	The Ribbon Microphone	67
4.7.5	Standard Loudspeaker Sockets	55	7.2	Directivity	68
			7.2.1	Microphones with Uni-directional Characteristic	68

7.2.2	Microphones with Bidirectional Characteristic	69	9.2.3	Tape Recorders with Standard Radio Socket	80
7.2.3	Microphones with Omnidirectional Characteristic	69	9.3	Connecting one Tape Recorder to Another	80
7.3	Electrical Matching	69	9.3.1	Copying Machine with Pick-up Socket	81
7.3.1	Connections and Matching for 3-pin Microphone Inputs	70	9.3.2	Copying Machine with Radio/Pick-up Socket	81
7.3.1.1	Low Impedance Microphones	70	9.3.3	Copying Machine with Standard Radio Socket	81
7.3.1.2	High Impedance Microphones	71	9.4	Copying at Multiplied Tape Speed	81
7.3.1.3	High/Low Impedance Microphones	71	10.	Editing and Splicing of Magnetic Tape	83
7.3.1.4	Medium Impedance Microphones	72	10.1	Cutting and Splicing	83
7.3.1.5	Universal Microphones (High/Low/Medium Impedance)	72	10.2	Editing Accessories	84
8.	Recording with Microphones	74	10.2.1	Anti-magnetic Scissors	84
8.1	Correct Microphone Location	74	10.2.2	The Hobby Box	84
8.2	Microphone Location for Stereo Recordings	74	10.2.3	The Splicing Block	84
8.2.1	The AB Method	74	10.3	Editing and Tape Montage	85
8.2.2	The XY Method	75	11.	Endless Tape Loops	88
8.2.3	Head Reference Stereophonics	75	11.1	Endless Tape Cassettes for Spool Tape Recorders	88
8.3	Microphone Recording	75	11.2	Endless Cartridges for Special Machines (Lear-Jet, Fidelipac)	89
8.3.1	Trial Recording Level	75	12.	How is a Tape Library Arranged?	92
8.3.2	Elimination of Background Noise	76	12.1	Storage Conditions for BASF Tapes	92
9.	How to Record Direct	78	12.1.1	Air Humidity	92
9.1	Connecting a Radio to a Tape Recorder	78	12.1.2	Storage Temperature	92
9.2	Connecting a Record Player to a Tape Recorder	79	12.1.3	Magnetic Stability	92
9.2.1	Tape Recorders with Phono Socket	79	12.1.4	Print Through	92
9.2.2	Tape Recorders with Radio/Phono Socket	79	12.1.5	Stray Magnetic Fields	93

12.1.6	Storage in Confined Space	93	15.	Exchange of Recorded Cassettes	103
12.2	Library Storage System	93			
12.2.1	Numerical Sequence	94	16.	How is Sound Added to Slides?	105
12.2.2	Numerical Sequence of Spools	94	16.1	The Pictures	105
12.2.3	Chronological Sequence	94	16.2	The Sound	105
12.2.4	Order by Category	94	16.3	Preparing a Script	106
12.2.5	The Tape Index	94	16.4	Slide Control	107
12.2.6	Tape Inscription	96	16.4.1	Manual Projector	107
13.	Tape and Recorder Maintenance	97	16.4.2	Semi-Automatic Projector	107
13.1	Cleaning the Tape	97	16.4.3	Automatic Projector	107
13.2	Cleaning the Tape Recorder	97	16.4.4	Fully Automatic Projector	107
13.3	Demagnetization	97	16.5	Automatic Slide Control— External and Internal Systems	108
13.4	Alignment of Magnetic Heads by BASF Alignment Tape	98	16.5.1	The External System	108
13.4.1	The BASF Alignment Tape	99	16.5.2	Recording the Pulses	109
13.4.2	Azimuth Alignment of the Head Gap	99	16.5.3	The Internal System	109
13.4.3	Adjustment of Height with Quarter-track Playback and Combination Heads	100	16.5.4	Table of Slide Control Units	109
14.	Exchange of Recorded Tapes	101	16.5.5	Exact Synchronism between Slides and Sound	110
14.1	Tape Speed	101	17.	How to Add Sound to 8-mm Films	112
14.2	Track Pattern	101	17.1	8-mm Film Formats	112
14.2.1	Exchange between Quarter- track and Half-track Machines with Mono Recording	102	17.2	Which Film Format should be chosen?	113
14.2.2	Tape Exchange between Quarter-track and Half-track Machines with Stereo Recording	102	17.2.1	The Double-8 System	113
14.3	Maximum Spool Size	102	17.2.2	The Super-8 System	113
14.4	Head Alignment	102	17.2.3	The Single-8 System	113
			17.3	Synchronizing Systems	114
			17.4	The Film Sound Stripe System	114
			17.5	The Double Tape System	116

17.6	Film Sound Tracks with Spool Tape Recorders	116	17.7.2	Electrical Synchronization with separate Recorder	120
17.6.1	Mechanical Sound Coupling	117	17.8	Adding Sound	122
17.6.2	Electrical Synchronization	117	17.8.1	The Script	122
17.6.3	Standard Synchronization	118	17.8.2	The Guide Text Method	122
17.7	The Synchronization System with Compact Cassette Recorders	119	17.8.3	The Sound Track	123
17.7.1	Mechanical Synchronization System with Recorder attached	119	17.9	Summary: Adding Sound to Film	123
			18.	Diagrams	125



1. Selecting the Right Tape

1.1 Length of Tape — Playing Time — Speed of Tape

For both recording and playback the tape is carried past the magnetic heads at a constant speed. A high tape speed means a greater length of tape and a low tape speed a shorter length of tape is used for a given playing time.

Almost all tape recorders using conventional tape spools work at tape speeds of 19 cm/s ($7\frac{1}{2}$ ips), 9.5 cm/s ($3\frac{3}{4}$ ips) and 4.75 cm/s ($1\frac{7}{8}$ ips) (cm/s = centimeters per second. ips = inches per second)

Thus, $3\frac{3}{4}$ in. of tape is being moved past the magnetic heads per second at a tape speed of $3\frac{3}{4}$ ips which for one minute of running equals $18\frac{3}{4}$ ft. In view of the permissible maximum tolerance for actual tape speeds of $\pm 2\%$ laid down by the German standard specification DIN 45511 and the British standard specification B.S. 1568

for domestic tape machines, tape playing times are stated in terms of a rounded up tape speed, e.g. 10 cm/s instead of 9.5 cm/s. This means that the playing times stated on the tape boxes would still be achieved even if the speed of the tape deck was at the upper limit of the tolerance i.e. at 9.7 cm/s or approximately 3.8 ips instead of 9.53 cm/s or 3.75 ips.

The actual tape speed of a tape deck can easily be measured using a tape of known length (see paragraph 14.1).

At a tape speed of 10 cm/s for a nominal value of 9.5 cm/s (the exact equivalent of 9.53 cm/s for $3\frac{3}{4}$ ips is rarely used in practice), the tape used per minute of playing time is 6 metres per track.

For the nominal speed of 9.5 cm/s the tape length and playing time can easily be estimated by the following approximate rules:

Required	Rule	Example
Tape length in metres	Minutes x 6 m/min	60 min x 6 m/min = 360 m (approx 1200 ft)
Playing Time per track	Length in metres $\div 6$ m/min	360 m \div 6 m/min = 60 min

This rule can be applied to the other tape speeds, if the calculation of playing time is based upon the length of tape, in each case, in metres per minute. This is for

19	cm/s	=	12	m/min
9.5	cm/s	=	6	m/min
4.75	cm/s	=	3	m/min
2.4	cm/s	=	1.5	m/min

(Note — 1 inch = 2.54 cm. 12 inches = 30.48 cm. 1 metre = 3.28 feet)

1.2 What Playing Time corresponds to the various Tape Lengths?

The playing time is always specified per track for a given tape speed so the

playing time therefore, depends on the tape length. Table 1 shows the playing time per track for all lengths of domestic tapes at the various speeds: —

Table 1
Playing Times per Track of Domestic Recording
Tapes in terms of tape length and tape speed.

Playing Time in Minutes per Track

Tape Length		Tape Speed			
m	ft	19 cm/s 7½ ips	9.5 cm/s 3¾ ips	4.75 cm/s 1⅞ ips	2.4 cm/s 15/16 ips
65	210	5.5	11	22	45
90	300	7.5	15	30	60
135	450	11	22	45	90
180	600	15	30	60	120
270	900	22	45	90	180
360	1200	30	60	120	240
540	1800	45	90	180	360
730	2400	60	120	240	480
1000	3280	85	170	340	680
1080	3600	90	180	360	720
1280	4200	107.5	215	430	860

The total playing time of a tape depends on the number of tracks recorded on that tape. For example, if the playing time per track at 9.5 cm/s (3¾ ips) for 360 m (1200 ft) length is 1 hour, four tracks recorded on the tape one after the other, give a total playing time of 4 x 1 hour = 4 hours for mono reproduction and 2 x 1 hour for stereo reproduction, as this requires one pair of tracks per run. With two half-tracks in mono recording, the 360 m would thus give a playing time of 2 x 1 hour = 2 hours, and with two half-tracks in stereo recording 1 hour. (See also paragraph 4.2 on Track Pattern.)

1.3 What Types of Tape are available?

Recording tapes are coated with a magnetizable layer. The magnetic coating is applied to a plastic foil. The total thickness of the tape is the sum of the thickness of the backing foil and the coating (see Fig. 1).

The label of the tape indicates the total thickness. In 1934 BASF manufactured the first recording tape in the world, and in 1950 the first domestic tapes. In 1954 they manufactured a tape which had only 2/3 of the thickness of the previously supplied domestic recording tapes and which was therefore, for the same size of spool, 50% longer thus providing 50% more playing time. This was

called, in analogy to long playing records, a "Long Play tape". All other type designations of tape are also referred to the standard tape. A double play tape is twice as long, and a triple play tape three times as long as a standard tape of the same spool size, and they provide correspondingly longer playing times. In the table of Fig. 2 tape lengths and playing times are compared for a given size of spool, No. 13, which is 5 inches in diameter.

BASF supply standard tape in the studio range, long play, double play and triple play tapes on double flanged spools for domestic tape recorders with spool operation, and triple play tape (C 60), quadruple play tape (C 90) and sextuple play tape (C 120) for Compact Cassette Machines (see paragraph 1.8).

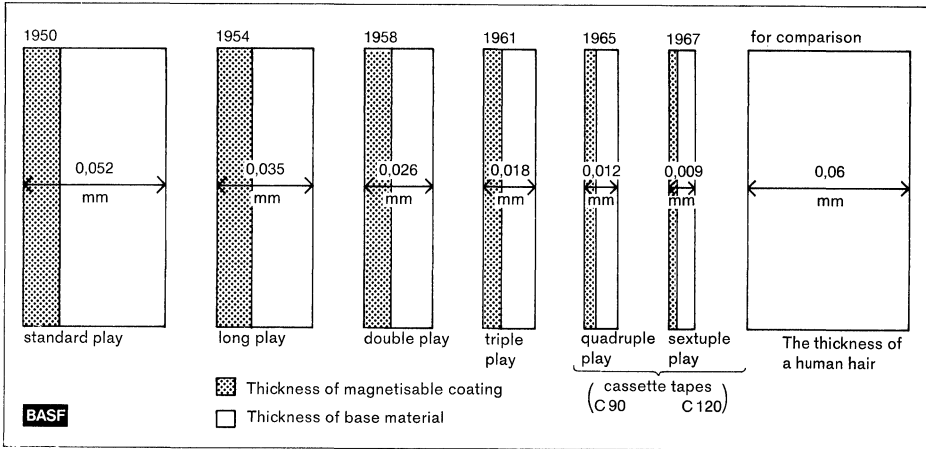


Fig. 1. Total Thickness of Recording Tape. The total thickness of recording tape is the sum of the thickness of the base material and the coating.

types of BASF tape

type	colour code	spool 13 cm (5")	playing time per track at a speed of 9.5 cm/s in mins.	tape length and playing time using standard play as the basis
standard play	red	180 m (600 ft)	30	single
long play	green	270 m (900 ft)	45	one and a half times
double play	blue	360 m (1200 ft)	60	double
triple play	grey	540 m (1800 ft)	90	triple

Fig. 2. Tape type denominations refer to the standard tape. For a given size of spool the tape length and playing time of a long play tape is one and a half times, of a double play tape twice and of a triple play tape three times that of a standard tape.

1.4 Which Type of Tape for which Tape Recorder?

BASF uses codes for its tape types

SP 52 means Standard Play

LP 35 means Long Play

DP 26 means Double Play

TP 18 means Triple Play

LP 35, DP 26 and TP 18 can be supplied as normal domestic or as LH tapes.

In principle all the above types of tape can be used on a domestic recorder. However, if a particular instrument is

to be matched by the most suitable tape, the following points should be noted :—

Type of Tape

Recommended for

Standard Tape SP 52

Studio recorders. Available in a variety of widths and sizes. For details see the BASF Studio Range.

Long Play Tape LP 35

Any domestic recorder up to a maximum spool size of 26.5 cm (10½ in) as universal tape, particularly suitable for high mechanical stresses such as occur on older recorders, recorders with triple motors or for adding sound to slides and 8-mm film.

Long Play Tape LP 35 LH Hi-Fi

For the same purpose as LP 35, but in addition with LH effect. See paragraph 1.5 on the advantages of LH Tape.

Double Play Tape DP 26

Domestic tape recorders of up to 22 cm (8¾ in) spool size, particularly suitable for recorders with combined record/playback heads since, due to its high flexibility it offers optimum tape-to-head contact. With combined heads this is particularly important, in order to avoid loss of high audio frequencies and to reduce possible volume fluctuations (so-called drop-outs) both during recording and playback.

Double Play Tape DP 26
LH HiFi

For the same purpose as DP 26, but in addition with LH effect. See paragraph 1.5 on the advantages of LH tape.

Triple Play Tape TP 18

Domestic tape recorders of up to 18 cm (7 in) spool size, particularly suitable for recorders with small spool diameters, such as battery powered recorders. For a given spool size TP 18 offers about 50 % more playing time than DP 26.

Triple Play Tape TP 18
LH HiFi

For the same purpose as TP 18 but in addition with LH effect. See paragraph 1.5 on the advantages of LH tape.

1.5 What are the Advantages of LH Tapes?

On all HiFi tape recorders, even normal BASF recording tapes will give high fidelity performance. With the new LH HiFi tape, the minimum requirements of this specification are considerably exceeded. Thus, with a tape speed of 9.5 cm/s ($3\frac{3}{4}$ ips) and half-track recording on LH tapes, the signal to noise ratio is much greater than that required by the German HiFi standard DIN 45500.

This is a decisive advantage, for the signal to noise ratio is a measure of the volume range provided by the recorder and contributes essentially to the quality of reproduction.

This technological advance was achieved by the use of an especially low noise iron oxide coating and by new

manufacturing methods which increase the magnetic density and hence the output. (See also Fig. 3).

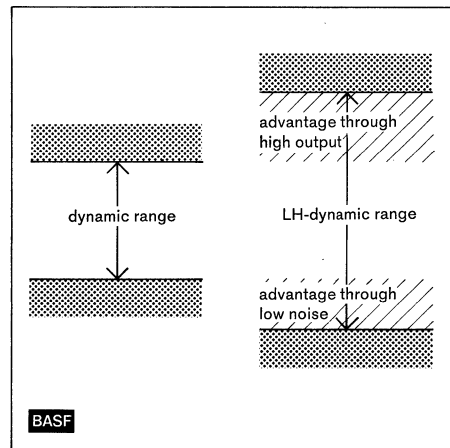


Fig. 3. Compared with normal tape the BASF LH Tape extends the signal-to-noise ratio (dynamic range) by the high output and low noise effect.

Compared with normal tapes, LH tapes offer advantages on all domestic and

semi-professional tape recorders, as set out below:—

LH Tape instead of Normal Tape offers on:—

Quarter-track recorders

the same low noise level as previous recordings with normal tape using half-track methods. In addition a considerable increase in output before the maximum distortion factor of 5%, permissible under Standard Specifications, is reached.

Half-track recorders

a gain of signal-to-noise ratio for a given tape speed more than doubles the volume range — from pianissimo to fortissimo — of the sound recording obtainable from the machine e.g. from 1:500 to 1:1000 (or 54 to 60 dB).

Tape Recorders with a tape speed of 9.5 cm/s ($3\frac{3}{4}$ ips)

a signal to noise ratio better than that formerly obtainable with normal tape at 19 cm/s ($7\frac{1}{2}$ ips).

HiFi tape recorders

a guarantee that full use is made of the possibilities of the tape recorder.

Tape recorders of latest design made to a specification according to DIN Standards

a signal-to-noise ratio corresponding to that stated for the instrument in the specification and a VU meter operating with optimum readings, since the instrument is adjusted for LH tape (see paragraph 4.1.5).

All German standard DIN reference tapes in classes 19 H (Home sound) 9 and 4.75 ($7\frac{1}{2}$, $3\frac{3}{4}$ and $1\frac{3}{8}$) have since June 1969, following a decision by the relevant technical standards committee, BASF double play tape DP 26 LH batch C 264 Z as a blank portion. This blank portion of the DIN reference (calibration) tape is used, inter alia, for the adjustment of the playback head and of the recording channel of domestic tape recorders.

1.6 Which Spool holds which Tape Length?

The spools have, inter alia, standard-

ized outside and hub diameters. There are specified tape lengths and spool diameters for the various types of tape.

Table 2

Tape Lengths of the various Types of Tape for the most Common Spool Sizes

Tape Length		For Domestic Recorders					For Home Studio Recorders				
		Spool Diameter (in cm and inches)									
m	ft	8 3"	9 3 1/4"	10 4"	11 4 1/4"	13 5"	15 5 3/4"	18 7"	22 8 3/4"	25 10"	26.5 10 1/2"
65	210	LP									
90	300	DP									
135	450	TP		LP							
180	600	TP		DP	LP						
270	900	TP		DP	LP						
360	1200	TP			DP	LP					
540	1800	TP				DP	LP				
730	2400	TP					DP	LP			
1000	3280	TP							DP	LP	
1080	3600	TP									
1280	4200	LP									

LP = Long Play, DP = Double Play, TP = Triple Play

Table 3 shows for various types of tape and spool diameters the lengths which are at present on the market.

Based on the same size of spool this table also shows, in addition to the relation already given in Fig. 2 for the spool of 13 cm (5 in) diameter and for the other spool sizes, the various lengths of tape and hence the lengths of playing time by comparison with the standard tape:

Table 3
Spool Diameters — Tape Lengths — Tape Types

Spool Diameter		Tape Lengths							
		Standard Tape		Long Play Tape		Double Play Tape		Triple Play Tape	
cm	in	m	ft	m	ft	m	ft	m	ft
8	3			65	210	90	300	135	450
9	3½							180	600
10	4			135	450	180	600	270	900
11	4¼			180	600	270	900	360	1200
13	5	180	600	270	900	360	1200	540	1800
15	5¾	270	900	360	1200	540	1800	730	2400
18	7	360	1200	540	1800	730	2400	1080	3600
22	8¾	540	1800	730	2400	1000	3280		
25	10	730	2400	1000	3280				
26.5	10½			1280	4200				

The most common spool sizes are 13 cm (5 in), 15 cm (5¾ in) and 18 cm (7 in) diameter, since the majority of spool tape recorders can take at least one of these sizes.

High quality tape recorders built for spool sizes below 13 cm (5 in) diameter are very rare, and tape recorders with a maximum spool size above 18 cm (7 in) are home studio sets which are of interest only to a very limited range of listeners, mainly advanced amateurs.

1.7 What are the Types of Packing for modern domestic Tapes?

The following types of packing are used for the various spool sizes and tape types: —

Round Pack

Long play tape, double play tape and triple play tape on spool sizes from 8 to 18 cm (3 in to 7 in) are supplied in the round pack. This handy and inexpensive pack is sufficient for dust-proof storage of the tapes.

The Plastic Swivel Box

Elegant and attractively styled plastic swivel boxes in grey for individual spools are available for the spool sizes from 8 to 18 cm (3 to 7 in).

The Library Box

In addition to the plastic swivel box for single spools, BASF offer a library box with three swivel compartments. This is available for the spool sizes of 13, 15 and 18 cm (5, 5³/₄ and 7 in).

The Slide-in Box

Robust slide-in boxes made of cardboard, with leatherette frame and a plastic hub mount are available in the home studio range. They comprise the spool sizes 22, 25 and 26.5 cm (8³/₄, 10 and 10¹/₂ in). These slide-in boxes are also supplied without tape.

The Cardboard Swivel Box

The demand for cardboard swivel boxes has dropped since the intro-

duction of the plastic box for one spool. BASF have deleted this type of packing from their domestic tape range.

1.8 What Compact Cassettes are available?

The total playing times — for two runs — of unrecorded compact cassettes can be seen from the type designation.

One C 60 cassette has a total playing time of $2 \times 30 = 60$ minutes. This can be calculated from the tape length — in the case of the C 60 cassettes 90 m (300 ft) of triple play tape — and the tape speed (all compact cassette recorders run at a tape speed of 4.75 cm/s (1⁷/₈ ips).

Table 4 shows the tape length, the tape type and the playing time for all compact cassettes.

Table 4
Playing Time of Compact Cassettes with Tape Length

Designation	Tape Width		Tape Length		Type of Tape	Playing Time
	mm	in	mm	ft (approx)		
C 60	3.81	0.15	90	300	Triple Play	$2 \times 30 = 60$ min
C 90	3.81	0.15	135	450	Quadruple Play	$2 \times 45 = 90$ min
C 120	3.81	0.15	172	560	Sextuple Play	$2 \times 60 = 120$ min

Compact Cassette recorders run at a tape speed of 4.75 cm/s = 1⁷/₈ ips.

1.9 What are the Advantages of BASF Compact Cassettes?

The following comments may be of interest:

The Sound Quality —

Considering the large number of compact cassettes offered, it is difficult for the buyer to appreciate the advantages and disadvantages of the available makes of cassettes.

of a recording on a compact cassette depends on the quality of the tape used for it. BASF indicate by the use of the term LH that BASF compact cassettes are suitable for highest quality recording and reproduction with a particularly good dynamic range.

Library Storage —

of a compact cassette is easier and more convenient if the package is specially designed and equipped for it. The plastic swivel box KK 8 is built as a library container. The lower pivot of the swivel portion along the narrow edge allows the cassette to be taken from the library without taking the container from the shelf. Index cards and sticky labels for the swivel boxes are easy to write on, and are supplied with the equipment. The tape index, which can be obtained free of charge in specialists shops or from BASF direct, keep the cassette or tape library properly documented.

Despatch by mail —

is no longer a problem with the practically unbreakable BASF plastic swivel box KK 8, since it is specially designed for that purpose. The attached self-adhesive address label*) is even large enough to accommodate a forwarding address. The closing flap which can be easily opened but which is otherwise quite secure, allows the box to be sent abroad at a reduced postage rate which applies if the packet can be opened. The weight of the box ready for posting is less than 4 oz. (100 grs).

*) Spare labels can be obtained free of charge direct from BASF.

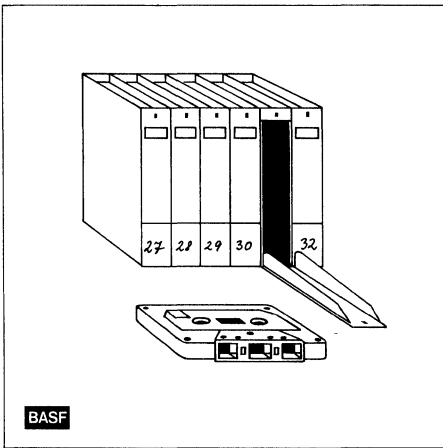


Fig. 4. The BASF plastic swivel box KK 8 is designed as a library cassette. The lower pivot of the swivel portion along the narrow edge allows the cassette to be taken from the library without taking the container from the shelf.

The plastic swivel box KK 8 is supplied with compact cassettes C 60, C 90 and C 120 and with spools of 8 cm (3 in) diameter containing either 210 ft of long play tape, 300 ft of double play

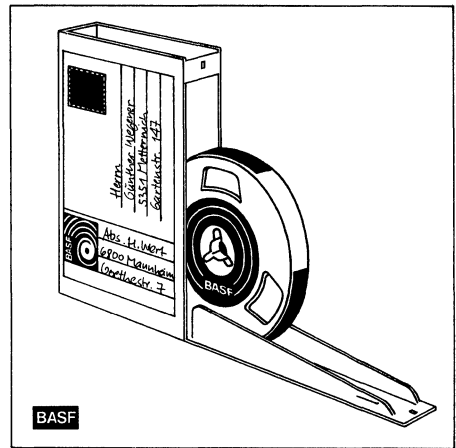


Fig. 5. The plastic swivel box KK 8 is a mailing box with an easily opened closing flap which allows it to be sent to addresses on the continent at a reduced postage rate.

tape or 450 ft of triple play tape respectively. See also paragraph 14.3 about exchange of tapes and Chapter 12 about Library Arrangement.

2. Compact Cassettes or Spool Tape Recorders?

2.1 How much can be spent on a Tape Recorder?

In many cases the amount of money available decides the choice of the type or kind of recorder. Since prices differ regionally and nationally, an index scale might help to compare prices. Take, as a basic index of 100, the cheapest tape recorder, i.e., for example a cassette player or a Japanese toy recorder. Thus, if an index of 200 is given against a particular type of recorder it means that this is

about twice as expensive as the cheapest available. If a more precise comparison is required a new index scale can be based on the prices of different makes and types of tape recorders available locally. Manufacturers and dealers will always supply leaflets and prices on request.

The types of recorders are explained in Chapter 3 on Cassette recorders and Chapter 4 on Spool Type recorders.

Index	Type of Recorder	Spool	Compact Cassette
100	Toy tape recorder, cassette player	x	x
150—250	Battery-operated cassette recorder		x
	Simple spool type recorder	x	
250—350	Cassette recorder with power pack		x
	Battery-operator radio recorder		x
	Half-track tape recorder (mono) mains powered	x	
	Quarter-track tape recorder (mono) mains powered	x	
350—500	Combination mains and battery operated recorder		x
	Quarter-track stereo recorder, mains powered, with duoplay	x	
500—1000	Quarter-track HiFi stereo recorder with duo and multi-play (mains powered)	x	
	Battery operated portable for half or quarter-track with several tape speeds and a maximum tape spool diameter of 13 cm (5 in.)	x	
	Mains powered stereo recorders with 2 separate loudspeakers		x

Index	Type of Recorder	Spool	Compact Cassette
1500—2500	Half-track or quarter-track HiFi stereo recorder with triple head arrangement and for a maximum spool size of 26.5 cm (so-called home studio machines) with duo-play multi-play, reverberation and echo, direct and off tape monitoring, with or without built-in power amplifiers and loudspeakers.	x	

2.2 Cassette or Spool Tape Recorders?

Much depends on the use to which the tape recorder is to be put. Many tape recording enthusiasts use a cassette recorder in addition to a spool tape recorder whilst others having found that the facilities of a cassette machine are too limited, have invested in one of the more versatile spool recorders. The combination of the two does however, offer some useful possibilities.

Of course not everybody wishes or is able to buy a spool tape recorder in addition to a mains or battery powered cassette recorder or even a cassette tape player for use in the car. It is however, worth keeping in mind that a spool tape recorder could be used for copying favourite selections of music onto a compact cassette for use in a car cassette player which is incidentally a good alternative to a car radio. A battery operated portable cassette recorder is of course useful for recording outdoors where a mains machine could not be used.

The decision as to whether to buy a cassette recorder or a spool tape recorder, or both, should really be based on the kind of recording one may wish to do.

The following are the most important advantages and disadvantages of both types of recorder: —

Compact Cassette Set

Advantages:

They are easy to operate since it is not necessary to thread the tape or select the track and tape speed. In some cassette recorders even the recording level adjusts itself automatically. They are in most cases smaller than spool tape recorders and weigh less, and are therefore particularly suitable for battery operation. Some are designed to fit cars for playing pre-recorded music tapes or for recording and most can be combined with a radio receiver for recording music programmes etc.

Disadvantages:

Since the tape speed 4.75 cm/s ($1\frac{7}{8}$ ips) and track width are fixed, these two factors cannot be varied in order to improve quality. Access to the magnetic tape is difficult in the cassette and editing of the tape recording, e.g., by cutting out mistakes or unwanted passages was previously a difficult matter. Special cassette tape editing kits have however, recently become available and can be used quite successfully. The playing time is limited to a maximum of 1 hour per run in the case of the C 120 Cassette.

Spool Tape Recorders

Advantages:

Playing time per magnetic tape depending on the length of the tape, tape speed and track pattern from less than

1 minute up to 48 hours. For example, long speeches at a tape speed of 2.4 cm/s (15/16th ips) quarter-track recording with TP 18 1080 m (3600 ft). Better sound quality by choice of track width. For example half-track and recording at a tape speed of 19 cm/s (7½ ips) and with separate record and replay heads. i.e. triple head arrangement. Improvement of the presentation of the sound recording by editing or the introduction of special effects by dubbing (copying from another tape). Possibilities of trick recording by superimposing and track-to-track recording as described in Chapter 5.

Disadvantages:

Mostly of larger dimensions and therefore, not very portable and it is not always possible to incorporate a mains operated spool recorder into a radio for example. The magnetic tape has to be threaded onto the take-up spool and the operation of the recorder will generally be a little more complex than that of a cassette machine.

2.3 Domestic Tape Recorder or HiFi Tape Recorder?

The differences between domestic tape recorders and HiFi tape recorders are clearly laid down in the German Standard Specification (DIN). DIN 45511 contains inter alia the minimum requirements for domestic tape recorders of the various speed classes such as 19 Domestic (in contrast to 19 Studio) of 9.5, 4.75 and 2.4 cm/s (3¾, 17⁄8 and 15⁄16 ips). In DIN 45500 the special requirements for HiFi tape recorders are laid down.

For the principal technical specifications according to DIN 45511 (domestic tape recorders) and DIN 45500 (HiFi tape recorders) see the table.

Since DIN 45500 only lays down the minimum requirements for electro-acoustical equipment in order to define the concept of high fidelity, i.e., maxi-

imum reproduction fidelity, the manufacturers of such equipment endeavour to offer sets which will at least in some respects far surpass these minimum requirements.

The following are the most important distinguishing features of domestic tape recorders and HiFi tape recorders: —

2.3.1 Frequency Response

The minimum requirements of DIN 45500 and — for a tape speed of 19 cm/s (7½ ips) — of DIN 45511, are the same. The minimum frequency range required for HiFi recordings of 40 to 12,500 Hz is to-day achieved, with the tolerance permissible for the frequency response, in most tape recorders operating at a tape speed of 19 or 9.5 cm/s (7½ or 3¾ ips). However, for first class recordings a frequency range of approximately 30 to 16,000 Hz is really necessary.

2.3.2 Signal-to-Noise Ratio and Distortion Factor

The signal-to-noise ratio (dynamic range) or more precisely the static noise voltage range, of domestic tape recorders and HiFi tape recorders is the logarithmic ratio (expressed in decibels) of the reproduction voltage for full level recording to the noise voltage of the tape when only the erase current and the magnetic bias have been recorded on it. Full level recording means that the maximum distortion factor K_3 of 5% is reached. Thus the maximum permissible distortion factor of 5% is the same for HiFi tape recorders and domestic tape recorders.

However, the minimum signal-to-noise ratio required is 45 dB for domestic tape recorders and 50 dB for HiFi tape recorders.

If BASF LH HiFi tapes are used, these values can be achieved on most spool type tape recorders (see also paragraph 4.1.5 on Recording Level).

Minimum requirements for cross talk attenuation are higher for HiFi tape recorders than for domestic tape recorders, as follows:

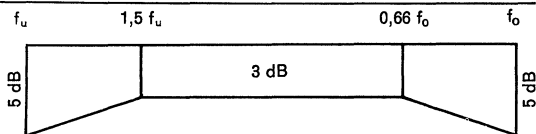
	Domestic Tape Recorders to DIN 45511	HiFi Tape Recorders to DIN 45500
mono	50 dB	60 dB
stereo	20 dB	25 dB

Table 5

The most important standard specifications of domestic and HiFi recorders are DIN 45511 and 45500. Shown in the table are some of the minimum standards laid down in the two specifications. Copies can be obtained from the publishers – Beuth-Vertrieb GmbH, Berlin 30.

Properties	Minimum Requirements for Domestic Tape Recorders according to DIN 45511				Special additional Requirements for hifi tape recorders according to DIN 45500
Variation of average speed measured for 30 sec not exceeding	19 H	9.5	4.75	2.4	
	± 2 %	± 2 %	± 2 %	± 2 %	± 1 %
Short Peak Speed Fluctuations (wow and flutter) not exceeding		± 0.2 %	± 0.3 %	± 0.6 %	± 1 %
					± 0.2 %
Frequency Range $f_u - f_o$ *)	f_u Hz f_o Hz	40 12500	63 10000	80 6300	40 12500
The full recording level at 333 Hz is reached with a cubic distortion factor of			5 %		5 %
Static noise voltage range referred to the full level recording of the set, minimum			45 dB		50 dB
Cross talk attenuation at 1000 Hz for twin track recording in opposite directions, minimum			50 dB		60 dB
for Stereo recording, minimum			20 dB		25 dB

*) The frequency range is described by the following tolerance limits within which the graph must lie. f_u is the lower and f_o the upper limiting frequency. (From DIN 45511)



2.3.3 Cross Talk

Cross talk means that in the case of multiple track recording, one track is listened to and the other track although it is not being listened to, can be heard. Since this is particularly annoying if in the case of monophonic recording one programme (e.g. Jazz) can be heard coming through the other programme (e.g. violin concerto) from a parallel track. Readers will notice from table 5 that the standard is far more stringent for mono than for stereo operation. This is because for stereo the parallel tracks carry the same programme. Therefore if the left hand channel is being reproduced in the background of the right channel this would not be noticeable, but would be very annoying in mono.

2.3.4 Speed Variations

In the permissible tolerance between actual and specified speed, the minimum requirement for HiFi tape recorders is again higher than for domestic tape recorders. This is important for the exchange of recorded tapes between HiFi enthusiasts. A tape recording produced at correct tape speed and played back on a tape recorder running at slower than correct speed results in a lower pitch. Similarly tape recorded on a machine running at below correct speed and played

back on another recorder working at correct speed results in a higher pitch. For domestic tape recorders the permissible tolerance is $\pm 2\%$ and for HiFi tape recorders only $\pm 1\%$.

2.3.5 Speed Fluctuations

Since short term speed fluctuations cause pitch fluctuations (wow and flutter) which considerably affect the quality of reproduction, a tolerance of not more than $\pm 0.2\%$ is permitted for HiFi tape recorders. This tolerance is independent of the nominal tape speed and applies to domestic tape recorders for the highest tape speed of 19 cm/s ($7\frac{1}{2}$ ips). For 9.5 cm/s ($3\frac{3}{4}$ ips) the tolerance is $\pm 0.3\%$ and for 4.75 cm/s ($1\frac{7}{8}$ ips) $\pm 0.6\%$.

2.3.6 Conclusions

The highest quality of recording and reproduction is achieved on domestic tape recorders with a tape speed of 19 cm/s ($7\frac{1}{2}$ ips). At that tape speed most domestic tape machines are in effect HiFi recorders according to DIN 45500.

Thus, if highest sound quality is desired, a HiFi tape recorder is necessary. This is particularly recommended, if the user already possesses other HiFi equipment or intends to buy such equipment later.

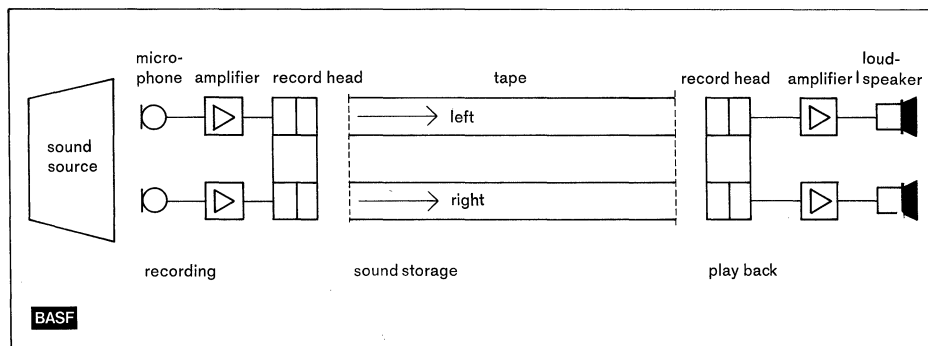


Fig. 6. Schematic representation of stereophonic recording and playback by means of a tape recorder.

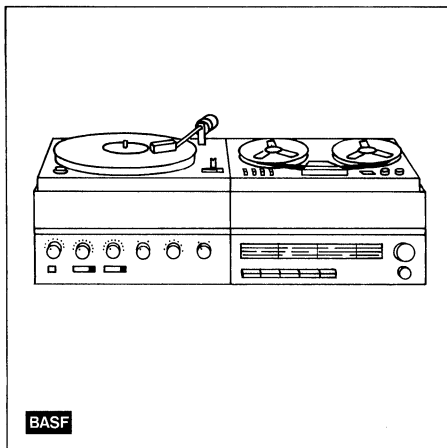


Fig. 7. Stereo control equipment comprising record player, tape recorder, radio tuner and amplifier.

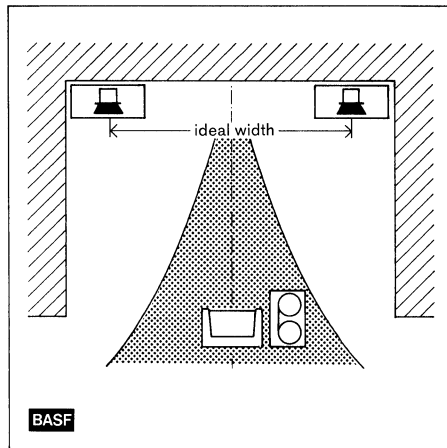


Fig. 8. The area in which a stereo recording can be heard to best advantage is shown in the dotted area.

2.4 Mono or Stereo?

Before answering this question we must consider the general requirements for stereo operation (recording and reproduction) and the various kinds of equipment necessary.

If the reproduction of pre-recorded stereo tapes only is intended, a quarter-track mono machine could be chosen and by incorporating or externally attaching a second amplifier and loudspeaker the machine would be suitably equipped.

The loudspeaker in the tape recorder and the extra speaker for the second channel are spaced apart to provide the proper spatial effect for good stereo reproduction. Such an arrangement is something of a compromise however, and the best solution is to purchase a

proper stereo tape recorder or a tape record/replay unit and couple it to a HiFi system.

Pre-recorded stereo music tapes are now readily available in most countries.

Anyone wishing to make stereo recordings will find a wide choice of stereo tape recorders or tape record/replay units in the middle and upper price brackets. Note that a tape record/replay unit requires an external stereo HiFi amplifier and loudspeakers for replay. Care should be taken however, to ensure that the quality of reproduction of the tape recorder is compatible with that of the other units in the stereo installation that have already been purchased or are likely to be bought at a future date.

Owners of a radio tuner or a good quality radio receiver, a HiFi amplifier or a combined radio tuner and HiFi amplifier with high quality loudspeakers

respectively should preferably select a first class stereo tape record/replay unit.

Basically the same quality of reproduction can be achieved with a mono tape recorder as with a stereo tape recorder since high fidelity reproduc-

tion is not confined to stereo equipment.

For both mono and stereo systems optimum results will be achieved if good equipment and suitable high performance loudspeaker enclosures are used for playback.

3. Selecting the Appropriate Compact Cassette Equipment

The number of different makes and designs of compact cassette recorders is steadily increasing, and a large variety of types and models are available on the market.

The purpose of this chapter is to provide a summary of the various types of compact cassette equipment in order to assist in the selection of the right one. We shall first discuss the construction of the compact cassette recorder and those features which are common to all types. In a more detailed description of the various types only their differences need to be emphasised.

3.1 Construction of the Blank Compact Cassette

Fig. 9 shows diagrammatically the inside of a compact cassette. In its original packing the tape is wound on the left-hand supply reel (2) — visible through the inspection window (15) — with its magnetic coating facing outwards, and attached to the right-hand take-up hub. (12) It runs along the guide pins (3 and 11) and the rollers (4 and 10) which guide the tape and control its height.

The side plates on either side of the reel (not shown) ensure the correct winding of the tape. The cassette is provided with a baffle (13) which protects the magnetic head from stray magnetic fields, and a pressure spring (5) with a small felt pad to ensure good tape-to-head contact. The rear face of the cassette carries two lugs (not shown) to actuate the recording button.

The tape length, and hence the playing time, depends on the tape used in the compact cassette (see paragraph 1.8).

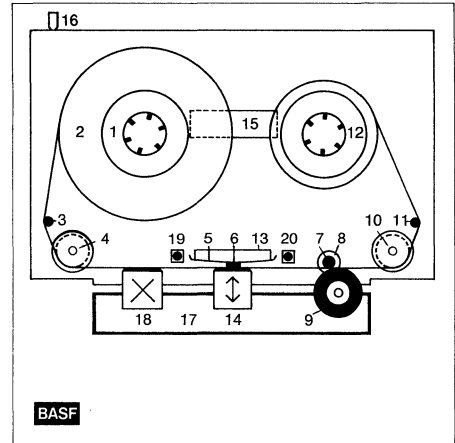


Fig. 9. Diagrammatic view of the tape path and the mechanical structure of the compact cassette. 1 Gearing of the left-hand supply reel, 2 Left-hand supply reel, 3 Guide pin, 4 Guide roller, 5 Pressure spring, 6 Felt pad, 7 Capstan, 8 Aperture, 9 Rubber pressure roller, 10 Guide roller, 11 Guide pin, 12 Gearing of the right-hand take-up hub, 13 Baffle, 14 Recording and playback head, 15 Inspection window, 16 Recording stop, 17 Shift plate, 18 Erase head, 19 Guide pin, 20 Guide pin.

3.2 Construction of the Recorded Compact Cassette

Basically this is the same as a blank cassette, except that the cassette does not carry the two lugs at the back. This brings the recording stop (16) into action and prevents erasure.

3.3 Operation of a Compact Cassette Recorder

When a compact cassette is inserted into the recorder, the winding spindle of the recorder engages with the gearing of the winding hubs (1 and 12). The capstan (7) extends into its aperture (8) and the two metallic guide pins (19 and 20) into the recesses provided for this purpose in the cassette.

These pins determine the horizontal and vertical location of the cassette in the recorder which is important for accurate location of the track.

When the start button on the recorder is actuated, the shift plate (17) of the recorder moves forward. This causes the pressure roller (9) to press against the capstan thereby moving the tape along. The combined recording and playback head (14) and the erase head (18) are pressed against the coated side of the magnetic tape.

Playback or — if the recording button is also actuated — recording can commence.

The stop button allows the shift plate to return to its original position. During fast wind and rewind, the shift plate (17) remains in its original position so that the heads are not in contact with the tape.

As soon as the first run has been completed, the cassette is taken out. Depending on the type of set, a button may have to be actuated to open the cassette compartment which enables the cassette to be removed. This completes the recording of the first track. The cassette is now turned round so that the second track is at the top and visible through the inspection window, and the full reel situated on the left hand side. When the cassette is turned round, the capstan (7) is passed through the opening similar to (8) shown in the

diagram, but not numbered, and which has not so far been used. The rubber pressure roller is passed through the aperture previously occupied by the erase head whilst the latter passes through the aperture, used during the previous recording, for the pressure roller. The apertures and recesses of the compact cassette are so located that by simply turning the cassette over both the upper and the lower parts of the tape can be used for recording.

3.4 Track Pattern of Compact Cassettes

This is made clearer by the diagram showing the track arrangement (Fig. 10). The magnetic head system is always in contact with the lower part of the tape at a height of 1.5 mm. For a mono recording track one is recorded first, and the cassette is then turned over. Thus the upper half of the tape will now be located at the bottom. Track no. 2 can now be used for recording. In that case an unused zone 0.8 mm wide remains between the tracks. The principle is the same for half-track recording on a tape 6.3 mm ($1/4$ in) wide.

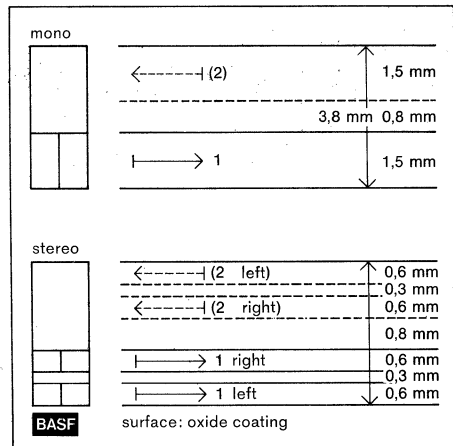


Fig. 10. Track pattern of Compact Cassettes.

For stereo, the 1.5 mm tracks are subdivided into two tracks each of 0.6 mm width which provide the left hand and the right hand stereo channels respectively with a neutral zone of 0.3 mm width between them.

Compared with the track pattern of spool tape recorders, which is dealt with in paragraph 4.2, the track division of compact cassette machines possesses one decisive advantage; it is fully compatible. Thus, stereo recordings can be played without difficulty on mono recorders, and mono recordings — without stereo effect, of course — on stereo recorders.

3.5 The Specification of Compact Cassettes

Compact cassettes are labelled in accordance with their total playing time (see paragraph 1.8). The tape speed of all compact cassettes is 4.75 cm/s (17 $\frac{1}{8}$ ips). The available frequency range of LH cassette tapes is on average approximately 40 to 12,000 Hz and the signal-to-noise ratio 48 to 50 dB.

3.6 Protection of Cassettes from Inadvertent Erasure

At the rear of the cassette there are two lugs which allow the recording button to be actuated. When the right-hand lug is broken off, the recording button can no longer be actuated for the track then in front of the head.

3.7 The Types of Compact Cassette Machines

The following are the most important types of compact cassette machines, with notes on their use.

3.7.1 The Compact Cassette Player

The compact cassette player is for reproduction only just like a record player. The number of titles available on music cassettes — i.e. recorded compact cassettes — is continually increasing and the selection available includes not only music but also complete language courses. Compact cassette players are of interest for those who either do not wish to record or who have an additional cassette recorder which they can use to compile their own programmes of recorded cassettes.

There are various types of Compact Cassette Players.

3.7.1.1 The Cassettophone

Probably derived from the term “electrophone”, which is a record player with built-in power amplifier and loudspeaker, the word “cassettophone” was chosen for a cassette player also having a built-in power amplifier and loudspeaker. These sets are mostly built for battery operation. As an accessory an external mains power pack can be supplied.

They are very easy to operate (see Fig. 11) the control buttons being mostly limited to “start”, “stop” and “fast wind”. In addition there is a volume control. Since these sets are not designed for connection to an external amplifier — e.g. if there is no suitable output socket — the quality of reproduction is limited to that of the built-in loudspeaker. The advantage of these sets, compared with a record player is that in the first place, they can be played anywhere like a portable radio. Compact cassettes are easier to carry and less likely to suffer damage than records, even when the playing time of both is equal.

Care must be taken however, as in the case of a record player and disc records, not to expose a cassettophone or compact cassettes to the direct rays of the sun, since both are made of thermoplastic materials, which warp when hot and suffer other damage.

3.7.1.2 Domestic Cassette Players

Domestic cassette players have not achieved great popularity so far. They

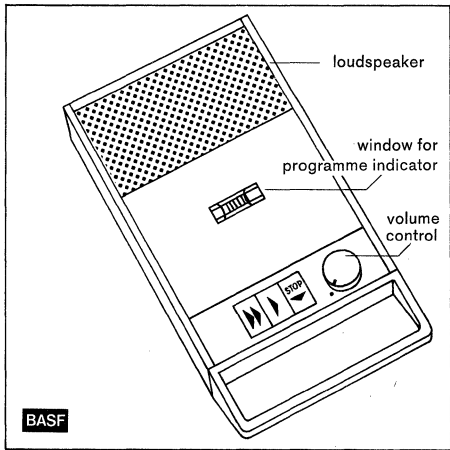


Fig. 11. Battery operated compact cassette player, also called a Cassettophone.

are normally mains operated and designed for playing pre-recorded compact cassettes and have no power amplifier or loudspeaker. This type of cassette player is connected to an external amplifier like a turntable. The reproduction quality will therefore, be better than that from a battery operated cassettophone.

3.7.1.3 Stereo Cassette Changers

A domestic cassette player which can automatically play a number of recorded cassettes one after the other is called a stereo cassette changer, the construction of which is shown in Fig. 12. The instrument can be used for playing one or more cassettes. For automatic changing the requisite number of cassettes are inserted into the cassette well. For playing single cassettes, the cassette well is taken off and closed by a dust cover.

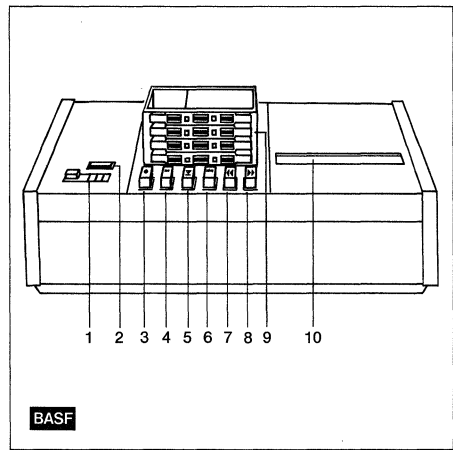


Fig. 12. Stereo Cassette Changer. 1 Indicator Lamp, 2 Counter and Reset, 3 Mains Switch, 4 Start/Reject Button, 5 Pause Button, 6 Stop Button, 7 Return Button, 8 Forward Button, 9 Cassette Well, 10 Cassette Ejection.

When the player has been switched on, an indicator lamp lights up. The reproducing amplifier which is also connected to the mains voltage supply must also be in use and the volume, tone and balance controls adjusted accordingly.

The following control buttons are provided on the stereo cassette changer: —

Button	Function
Start/Reject (4)	starts the tape or changes the cassette, prematurely and automatically selects and starts the next one.
Pause (5)	interrupts the programme without changing the cassette. When the button is pressed again, the programme continues.
Stop (6)	stops playback and changes the cassette. Eventually the set may then be switched off.
Fast Forward (8) Fast Rewind (7)	rewinds the tape as long as the button, which does not engage, remains depressed. Depending on the design of the set it may be also necessary to depress the Start/Reject button.

Cassettes which have been played are caught by the cassette receiving compartment which has in most cases only a limited capacity and stops the drive when it is full. The used cassettes must be removed before the changer is re-loaded and started again. When the changer is switched on, it is incidentally advisable to empty the receiving compartment before the cassette well is filled, should the capacity of both compartments be the same. The set will then be in operation until all cassettes in the well have been played. Thus, a supply of 6 compact cassettes C 120 would give 6 hours playing time plus another 6 hours after all cassettes have been turned round (track 2) and placed back in the changer.

A stereo cassette changer is very suitable for music lovers who, in addition to a record collection can also build up a good library of recorded compact cassettes which incidentally are also known as Musicassettes. A good amplifier used with a cassette

player also helps to achieve a high quality of reproduction.

3.7.1.4 The Radio Cassette Player

The radio player is not very popular. It is basically a compact cassette player built into a radio set. It is offered as a portable radio set with built-in power amplifier with or without a speaker or as a mains-powered radio set with or without amplifier and loud-speaker. To play compact cassettes, a suitably inscribed key on the radio set must be depressed. The cassette drive has the usual controls for start, stop and rewind. A radio player does not allow the recording of one's own programmes. A radio recorder, on the other hand, has both recording and playback facilities and is therefore more versatile in use.

3.7.1.5 The Car Cassette Player

These are already being fitted in various makes of car as a normal acces-

sory. One can also be fitted to any car as an additional extra. These compact cassette players are designed for operation in cars only and various types are available. As a car radio player (see Fig. 13) they are integrated with a car radio. However, such sets are not equipped for all wave-bands since extra space is required to accommodate the operating controls and cassette drive.

Car cassette players without an output stage and loudspeaker for reproduction are played through the car radio. Some modern car radios have facilities for connecting cassette players of this kind.

Car cassette players (available as mono and stereo versions) with a built-in output stage and speakers which can be separately connected, are advisable for those who do not wish to fit a car radio but would nevertheless like to have music in the car.

The cassette magazine of car players is usually designed for the cassette to be inserted lengthwise (see Fig. 14). For this purpose the cassette is held at the side of the full reel (visible through the inspection window) so that the open side points to the right when it is inserted into the cassette slot. The fittings are so arranged that the winding pins do not engage with the plastic hubs of the cassette until the cassette has been fully inserted.

3.7.1.6 The Discassette

The Discassette, still regarded as a novelty and not yet available everywhere, plays cassettes and certain sizes of discs.

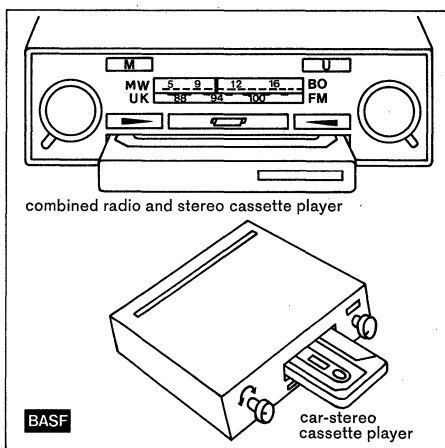


Fig. 13. Car stereo radio players are stereo compact cassette players fitted to the car radio.

Fig. 14. Car stereo players are supplied minus output stage and loudspeaker for the reproduction of recorded cassettes through the car radio or with output stage and separately connected loudspeaker. In most cases the cassette magazine is so arranged that the cassette is inserted lengthwise.

3.7.2 The Cassette Recorder

In contrast to the player, which only allows playback of pre-recorded cassettes, the recorder offers facilities for recording and replay as well. It is therefore more popular than the player. In addition to the normal stop and start controls used for the cassette player, the more expensive models include pause, fast wind, fast rewind, and other controls as follows.

A recording key or lock must be actuated in addition to the start button in order to set the instrument to the record position. In more expensive models, a pause key is also provided which will, for example, allow the

recording level control to be adjusted whilst the tape is held stationary.

Cassette recorders have either automatic or manual recording level control or both. A recorder with both forms of control can usually be switched to one or the other (see also paragraphs 4.1.5 / 4.1.6 on Level Control).

Monitoring during recording is possible, depending on the design of the machine, either by headphones or the built-in loudspeaker and in some cases by an externally connected speaker.

Sound sources chosen are, for example, microphone, radio, record player or a second tape recorder, provided corresponding inputs exist.

There are many different types of cassette recorders and we will now discuss these.

3.7.2.1 Portable Compact Cassette Recorder

The first compact cassette recorder was battery powered, and this type of portable machine is still the most popular; many different models are available (see Fig. 15).

The choice is therefore difficult and the following explanations are intended to provide pointers for selection.

The choice of equipment depends on the purpose for which it is to be used. Bought for general use, its

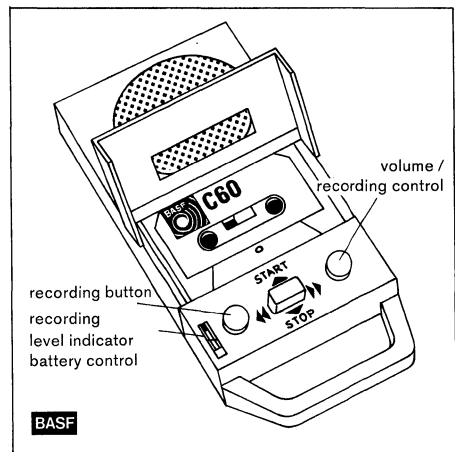


Fig. 15. The portable Compact Cassette Recorder is a battery powered combined recording and playback instrument.

choice is governed by aspects which are different from those required for a recorder that will be used for a specific purpose. For example, if it is to be used mainly out of doors the dimensions and weight are of some importance. The smallest dimensions are about $4 \times 1\frac{1}{2} \times 5\frac{1}{2}$ in, the largest about $6 \times 2\frac{3}{4} \times 10$ in. The range of weights is about 1 to $4\frac{1}{2}$ lbs.

The power supply is also a deciding factor. It is true that battery sets with an external power pack are lighter than sets which incorporate a power pack, but operation from batteries is much more expensive per hour than when using a mains powered recorder. Battery operation does of course make the recorder completely portable.

If the recorder or player is to be used in a car, it is necessary to find out before purchase, whether suitable fittings for mounting and connection to the car

battery are available. Such fittings are permanently installed in the car and provision is made for automatic connection of the recorder to the car battery.

If the recorder is to be used only occasionally in a car, a special connector flex is adequate for 6v car batteries. This requires a socket which in most cases can be fitted to the dashboard and which carries the 6v supply to the input socket of the recorder. In the case of 12v batteries, an adapter or a special cable containing an adapter may have to be used. If a recorder is to be fitted into a car permanently, it may be necessary to obtain precise information on the procedure before the set is purchased. Some cables can incidentally be extended, so that the recorder can be operated outside the car.

Most battery operated cassette recorders have a remote start/stop control system that can be controlled from a switch on the microphone. Hence in the recording position, the tape can be stopped and re-started by the microphone switch without releasing the record button.

It is also an advantage if the recorder has an end of tape switch, which automatically switches off the motor when a track comes to an end. This prevents possible damage to the tape in the cassette.

If a machine is to be used only occasionally out of doors it is not important for it to be particularly small or light. What matters more is that it has the best possible recording and reproduction quality, particularly if used with an external amplifier and speaker.

The various input sockets should cater for microphone, radio, and if required, the connection of a second tape recorder or a record player. In addition a headphone output and/or an external loudspeaker output are worth having for direct listening or for monitoring purposes. Since the output power of such recorders is mostly limited, even when they are mains operated, their reproducing quality is best if they are played through an external amplifier or a radio which has provision for connection to a tape recorder.

As regards the frequency range and the signal to noise ratio, the quality which can be achieved was discussed in paragraph 3.5. A comparison of the specifications of those sets which have been selected for further consideration will show which provides the better facilities and reproduction quality etc.

3.7.2.2. The Car Recorder

Car recorders are intended to be permanently fitted to a car. Basically they are governed by the statements made in subparagraph 3.7.1.5. for car players. They allow recording in the car by connection with the car radio or by plugging in a microphone.

3.7.2.3 The Home Cassette Recorder

The mains-powered home cassette recorder came on the market much later than the portable model and the choice is still limited. Most home cassette recorders have an automatic recording level control which can be disconnected. In contrast to comparable spool

tape recorders they are not always provided with separate connecting sockets for microphone, record player and radio which may necessitate an alternative method of connection if these signal sources are to be used. Home cassette recorders of the mono variety are recommended for those who wish to record at home from radio, records or a microphone or to play pre-recorded music cassettes.

3.7.2.4 The Stereo Cassette Recorder

This set is also mains powered and has in most cases, in contrast to the mono home recorder, separate connecting sockets for microphone and radio etc. In addition to the usual control buttons for the tape run and controls for recording and playback it also has a balance control which can be turned to the left or right so that the ratio of the volume of the sound from the two loudspeakers (connected externally) can be changed in accordance with the acoustics of the room to achieve the best stereo effect.

Listeners who already possess a stereo reproduction system (HiFi equipment) or who intend to buy one should buy a stereo cassette recorder unless of course they prefer to use a spool tape recorder (see Fig. 16).

3.7.2.5 The Radio Recorder

The radio recorder has achieved some popularity in European countries (see Fig. 17). It is a radio set with built-in compact cassette recorder. Other names for the same type of apparatus are "Combiphone" or VHF-FM Recorder (FM is frequency modulation and VHF is very high frequencies). There are also recorders for AM (amplitude modulation), i.e. long or medium waves.

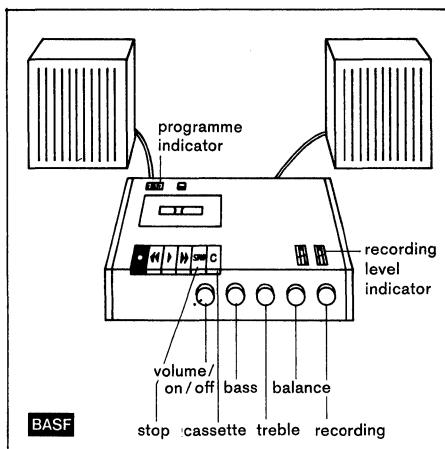


Fig. 16. The Stereo Cassette Recorder is a mains powered combined stereo recording and playback machine with built-in power amplifiers and two speakers which can be connected separately.

Some cover both FM and AM broadcasts on their respective wavebands.

Since in this case there are two different types of set accommodated in one housing, it is necessary when choosing

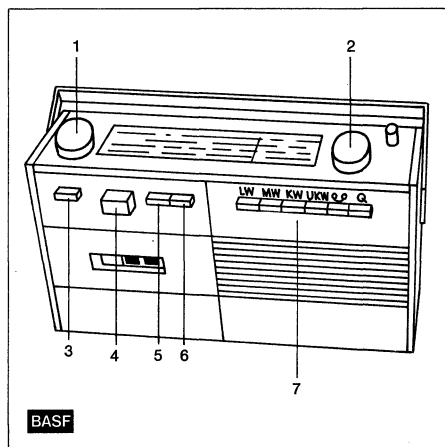


Fig. 17. The Radio Recorder is a portable radio (most are battery powered) with built-in compact cassette recorder. 1 Volume, 2 Tuning, 3 Microphone Key, 4 Operating Switch for Cassette Drive, 5 Recording Key, 6 Cassette Slot, 7 Wave Range and Input Preselector Keys (LW, MW, SW, VHF).

a radio recorder to compare various types and particularly the facilities of both the radio and recorder sections.

Since almost all radio recorders are also designed for battery operation, all the comments made for portables apply as well (see paragraph 3.7.2.1).

As regards the radio section the decision as to whether to have VHF only or MW and LW bands or all three, is one of personal preference.

If the instrument is to be mainly used in a stationary role and only occasionally operated by batteries, the specification relating to the recording quality should be studied and it should be noted which sets have separate connecting sockets for the recorded inputs (e.g., microphone, record player). Where only a single input socket is provided it can only connect one signal source at a time. Here again it may be necessary to compromise. A set intended for home use may not be ideal for use in a car. If it has special fittings for a car and has been specially designed for car operation, it will probably have no separate inputs for two or more signal sources and no built-in power supply.

3.7.2.6 The Car Radio Recorder

Here a cassette recorder is incorporated in the car radio (mostly for mono only). When a suitable key is actuated, recordings are made directly from the car radio.

3.7.2.7 The Casseiver (Radio Cassette Recorder)

This term, which may be American, denotes a cassette receiver, i.e., a radio receiver with a built-in cassette recorder. In a wider sense it means a mains-powered radio set (with or with-

out power amplifier) incorporating a cassette recorder (see Fig. 18). Such sets generally have no loudspeaker (inexpensive types are commercial radio sets with loudspeakers which are then not referred to as casseivers).

It may be possible in future to buy a HiFi system incorporating a radio section (tuner) with or without cassette recorder and/or a combined tuner/amplifier (radio section with power amplifier) also with or without cassette recorder.

3.7.2.8 Cassette Recorder/Changer

A cassette recorder/changer is a cassette machine which in principle operates like the stereo cassette/changer described in paragraph 3.7.1.3 but which is also suitable for tape recording. It can be both a mono or a stereo machine.

In addition to the controls as shown for the stereo cassette changer in diagram 12 on page 32, the cassette recorder/changer is equipped with the necessary facilities for use as a

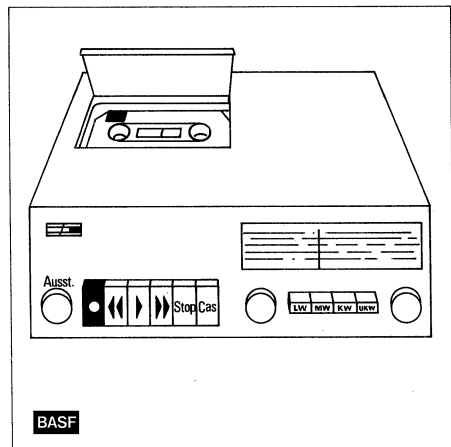


Fig. 18. A Casseiver is a mains-powered radio set incorporating a cassette recorder.

recorder, i.e., it has one or more input sockets, a recording button and connector.

Such machines are normally operated individually for recording. On playback they automatically change the cassette, if the cassette shaft is filled.

If a so-called cassette turner is mounted inside the cassette shaft as shown in diagram 12, a certain number of compact cassettes (e.g., 4–6 units) can be played back non-stop. The cassette turner, as the name indicates, turns the recorded compact cassettes over so that after side 1 has been played side 2 will be played. This applies whether the recording is mono or stereo.

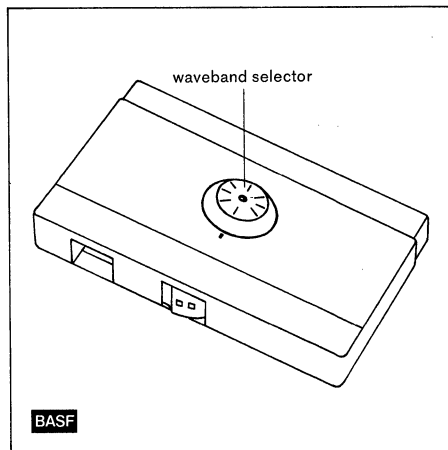


Fig. 19. A Cassette Radio or the FM Tuner Cassette (for VHF) or an AM Tuner Cassette respectively (for MW) can be inserted into a cassette tape recorder instead of the tape cassette itself, i.e., a compact cassette tape recorder can be converted into a radio receiver.

3.7.3 The Cassette Radio

Complete radio tuners are also available as cassettes which are inserted in a tape cassette recorder in place of the tape cassette itself. These are available as FM tuner cassettes (for VHF) or AM tuner cassettes for MW.

They have a single fixed tuned station selector and may be of interest to those, who, whilst travelling for instance, require the use of a very small combination cassette recorder and radio instead of a portable radio set (see Fig. 19).

4. Selecting the Right Spool Tape Recorder

The first domestic tape recorders appeared on the market in the early 1950's. During the 20 years of domestic tape recorder development hundreds of differently designed models have been manufactured.

In Germany alone more than 60 different models are manufactured for home and domestic studio use.

Since spool tape recorders, in contrast to compact cassette machines, have different track patterns, recording head arrangements, tape speeds and trick recording facilities etc., it is necessary, when choosing a spool tape recorder, to consider which of these functions or facilities may be required. Some understanding of the function of a spool tape recorder is therefore necessary and may help considerably in making the right choice.

4.1 How does a Spool Tape Recorder work?

4.1.1 The Tape Transport

With a spool of magnetic tape loaded and with the tape threaded across the recording/replay heads, the start button of the recorder can be depressed. The tape then unwinds from the left hand supply spool and is carried at a constant speed, across the magnetic heads and is then wound on to the right hand take-up spool. For recording, the record button and possibly a recording interlock button, must be depressed in addition to the start button. The tape transport must function to exact requirements for recording and playback. Likewise, any speed fluctuations (wow and flutter) may not be greater than the minimum requirements of the German Standard specification DIN 45511

(Domestic) or DIN 45500 (HiFi) (see paragraph 2.3).

In toy tape recorders and some dictating machines, the tape is driven by the right-hand spool carrier. However, this does not provide a constant tape speed because the tape runs faster as it unwinds from left-hand supply spool. Hence in most tape recorders the tape is driven by a capstan and is held in contact with this, whilst in motion, by a rubber roller (see Fig. 20). In the "record" or "playback" position, the tape movement can be stopped by means of a key (sometimes called a pause control) which lifts the rubber pressure roller clear of the tape. This overcomes having to re-select the recording or playback controls which are not cancelled. The "stop" button, on the other hand, not only stops the tape, but also cancels the selected control, (see Fig. 21).

To enable a recording to be found quickly on the tape or to transfer the tape from one spool to the other, nearly

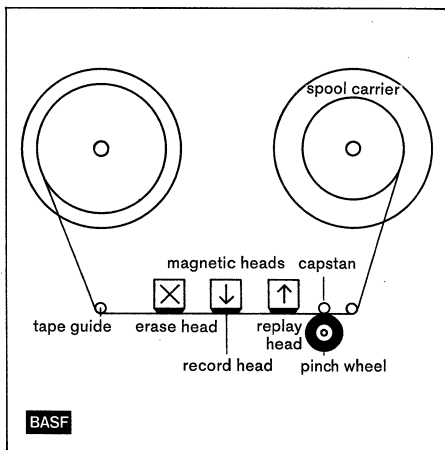


Fig. 20. On most Tape Recorders the tape is driven by means of a capstan against which the tape is pressed by a rubber roller (pinch wheel).

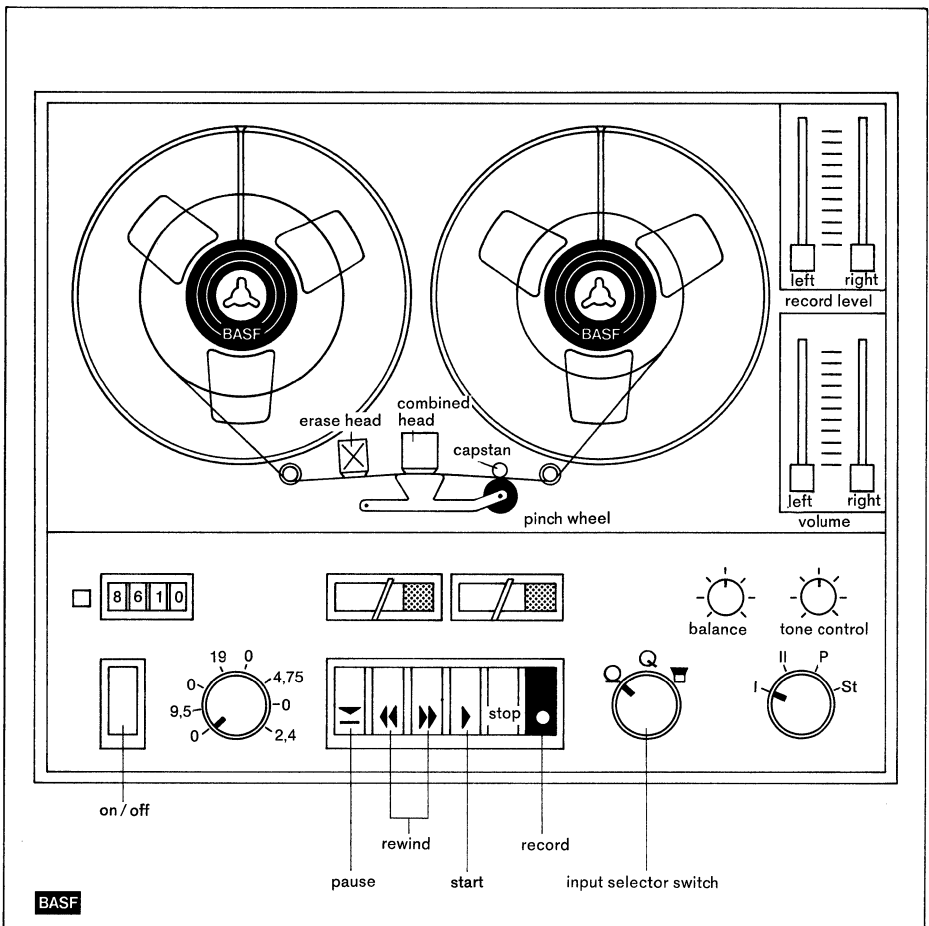
all spool tape recorders are provided with fast "forward" and "rewind" controls. When rewinding, the rubber pressure roller does not bear against the capstan and the tape is not in contact with the magnetic heads.

often have a triple motor drive system (one motor to drive the capstan and one for each spool carrier).

Most domestic tape recorders will accommodate tape spools up to 18 cm (7 in.) in diameter and usually have only one motor, which drives all the mechanism concerned with the tape transport. Semi-professional and studio recorders in particular will usually accommodate tape spools larger than 18 cm/s (7 in.) in diameter and

This means that for all spool sizes including those above 18 cm/s (7 in.) in diameter, faster winding times can be achieved which are usually necessary for studio recording. Many tape recorders have an automatically operated switch to stop the drive at the end of a tape. This is done by means of either an electrical or a photo-electric method. With the electrical method, two insulated contacts are provided in one of the tape guides so that when the

Fig. 21. Controls of a stereo Spool Tape Recorder.



metallic switch foil passes across them they are short circuited. This supplies current to an electro-mechanical mechanism which stops the tape drive. This applies whilst either recording or on playback or at the end of rewinding. With the photo-electric system, the tape itself is used to actuate a photo cell by allowing light to fall upon it at the end of the tape. The photo cell, in turn, operates a mechanism which stops the motor and tape drive.

4.1.2 The Counter (Tape Programme Indicator)

Counters with zero reset make it possible to find a given recording on the tape quickly. They are usually driven by one of the spool carriers and actually count the number of spool revolutions. The counter is not calibrated and only provides reference numbers. The figures shown by the counter depend on the diameter of the spool hub from which it is driven. At the beginning of the tape, before recording is started, the counter is set to zero. If several recordings are made on one tape and if the counter indication of each individual tape recording is noted on an index card, it is quite easy to find the recording later on. The BASF Tape Index can be obtained free of charge from specialist dealers or directly from BASF. (See also Chapter 12 on Library Arrangement).

4.1.3 The Input Selector Switch

Tape recorders with several input sockets may also have one or more input selector switches. Each input may also have its own volume control and provision may also be made for mixing the input signals whilst recording. Before a recording is started the chosen input for example microphone or radio, may have to be pre-selected. If an external

mixing unit is used this will normally be connected to the radio or line input socket of the tape recorder.

In some tape recorders the input socket circuitry is so arranged that when a connection is made to one input socket the other is automatically cut off. Normally all input sockets remain connected and the input selector switch is simply set for the required input. This is particularly useful for tape recorders which are permanently connected to a HiFi system.

4.1.4 The Track Selector Switch

With the exception of mono half-track recorders nearly all domestic tape recorders have track selector switches. Quarter-track machines, whether they are mono or stereo, and half-track stereo machines, have duplex head systems (see also paragraph 4.2 on Track Pattern). These recorders may have switch positions for the upper head block, the lower head block or both head blocks together.

It should be noted however, that the different tracks may not be selected uniformly. On quarter-track recorders the tracks may be numbered according to DIN 45511, viewed from top to bottom on the recorded tape: 1, 2, 3, 4. The edge tracks are associated with the upper head system. After the first run of the tape (track 1) the spool is turned over so that the lower half of the tape will be uppermost and when the upper head system is switched on, the second edge track (Track 4) will be recorded in the opposite direction. The inside tracks are labelled 2 and 3. Some quarter track machines have their track selection switch settings marked 1—4 and 2—3 and on some they may be numbered 1—2 and 3—4.

On machines with interchangeable head carriers the switch may be marked I and II where I represents the upper and II the lower head block. The same marking may also be used for half-track stereo as well as for quarter-track stereo recorders.

Also, when both head systems are in use simultaneously, as for example, duoplay or stereo operation, the switch

positions and marking is not uniform as the track selector may also be used as a switch for the amplifier, and for stereo and duoplay there may be different circuits in the amplifier.

For the same reason certain functions of a given head system may correspond to different switch positions. Here are some examples for the lettering used on track selection switches:

Lettering

Significance

1—4	Edge tracks (quarter-track system)
2—3	Inside tracks (quarter-track system)
1—2	Edge tracks (quarter-track system)
3—4	Inside tracks (quarter-track system)
I	Upper head system
II	Lower head system
S or Stereo	Stereo recording or playback respectively
D	Duoplay (see paragraph 5.2)
P	Parallel track (see paragraph 6.3)
Synchroplay I	Duoplay for the upper track
Synchroplay II	Duoplay for the lower track
Echo I	Echo or reverberation on upper track
Echo II	Echo or reverberation on lower track (see paragraph 5.5)
Multiplay I	Multiplay on upper track (see paragraph 5.3)
Multiplay II	Multiplay on lower track (see paragraph 5.3)
Diapilot Mono	Internal slide control monophonic
Diapilot stereo	Internal slide control stereophonic quarter-track (see also paragraph 16.5.3.)

In most cases the track selection switch can only be actuated if all tape transport buttons are disengaged or if the set is in the stop position.

4.1.5 Recording Level Indication and Recording Level Control

Whilst recording, the tape must not be magnetically overloaded (see Fig. 22) or else non-linear distortion which is measured as a distortion factor will occur. According to DIN 45511 and 45500 this must not amount to more than 5%. Hence tape recorders are provided with a VU meter (two for stereo) to indicate the recording level and with one or more controls to control the recording level.

If, during recording, the recording level control is not turned up sufficiently, the result will be 'under-recording' (see Fig. 23). The level on replay will then be too low and if the volume control is adjusted to bring up the sound level then the background noise will also be increased.

It may be stated in manufacturers leaflets or in operating instructions whether specifications are according to German DIN standards. If this is the case domestic tape recorders will be adjusted according to BASF tape. Until June, 1969, a BASF Doubleplay Tape LGS 26 would have been used and after June, 1969, a BASF Doubleplay type DP 26 LH, for the unrecorded section of the DIN reference tapes for domestic tape recorders (see also paragraph 1.5).

Since BASF supply almost all recorder manufacturers with DIN reference tapes, many tape recorders are adjusted to BASF tape even though their specification does not contain a direct reference to DIN standards. (Normally only applies to Germany.)

In practice this means that in the case of older tape recorders with the normal BASF tape and in the case of newer recorders with BASF LH tape the VU meter of the tape recorder is correctly calibrated. Tape recorder manu-

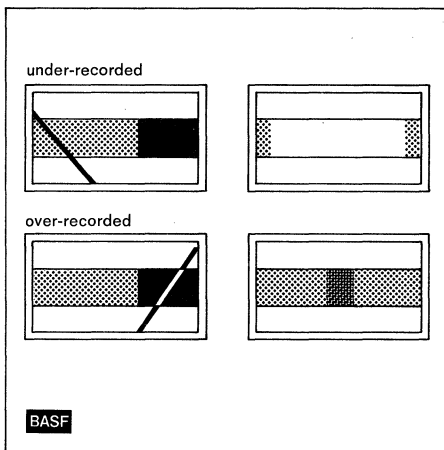


Fig. 22. The lower part of the diagram shows overloading. With a VU meter the pointer has moved far into the overload area. With a magic eye (right-hand diagram bottom) the two sectors overlap.

Fig. 23. The upper part of the diagram shows under-recording. With a VU meter the pointer should not, during the duration of a recording – except for pianissimo passages – be resting at the left-hand of the meter. With a magic eye – right-hand diagram top – the illuminated areas must not rest near the edges.

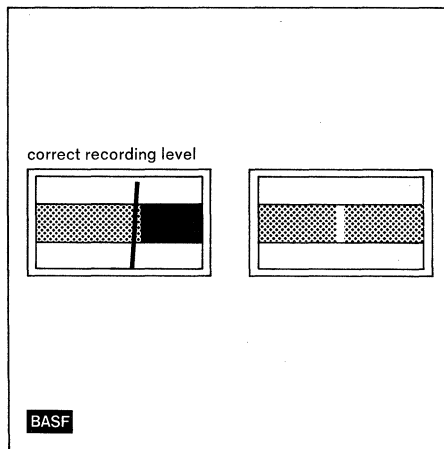


Fig. 24. The correct recording level for a tape recording is obtained if at the loudest passages the pointer does not indicate for a prolonged period the overload area, which is mostly marked in red. On a magic eye the recording level should be such that the two illuminated areas do not overlap.

facturers adjust the VU meters so that full level recording is reached (with a maximum distortion factor of 5%) when the pointer of the instrument reaches 0 dB or the lower limit of the red section (see Fig. 24). In the case of magic eye indicators full level is shown when the illuminated sections just touch.

If LH tapes are used on older tape recorders, a magic eye indicator may be allowed to overlap or the pointer of a VU meter to enter the red section, a little over 0 dB. The extent to which the tape may be overloaded before distortion becomes apparent must be determined by trial and error by varying the recording signal.

Stereo machines often have separate level indicators and controls for the right and left-hand channels (see Fig. 25). Some recorders also have separate controls for the various sound inputs. If the inputs can be mixed, these recorders incorporate a mixer unit.

4.1.6 Automatic Recording Level Adjustment

With manual recording level control it is necessary to check the recording level indicator whilst recording and if necessary, adjust the level accordingly. This is not necessary if an automatic recording level system is provided.

For automatic recording level, suitable circuits in the tape recorders ensure that the maximum recording level is not exceeded. This applies to both mono or stereo cassette and spool tape recorders.

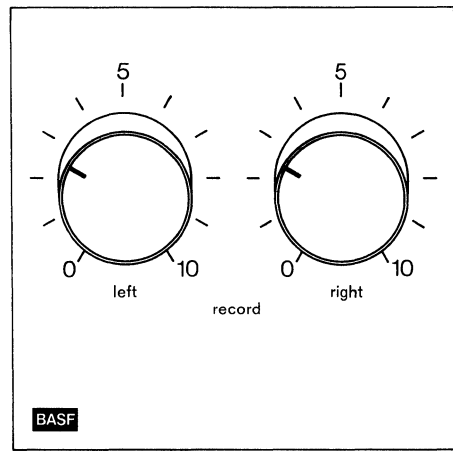


Fig. 25. Stereo tape recorders are normally provided with separate recording level controls for the left and right-hand channels. In that case the left-hand control is used for mono recordings to the international track pattern.

The requirement for automatic recording level control is the same as for manual level control, i.e., the level must be consistent with the dynamic range without under or over-recording. With stereo both channels must be correctly adjusted simultaneously.

With such machines the signal to be recorded passes through the amplifier stages incorporated in the tape recorder and under-recording is compensated for automatically. In such recorders the recording amplifier is so designed that the strength of the signal fed to the magnetic head is adjusted so that full recording level (with a maximum permissible distortion factor) is reached. Suitable circuits in the recording amplifier also ensure that strong signals likely to cause overloading are reduced to the required level within a few milli-seconds.

Because of the marked tendency of the automatic arrangement always to adjust the signal to the correct recording level it is unsuitable for fading effects.

If a tape recorder is therefore to be used with an external mixing unit, without foregoing the advantages of automatic adjustment, a recorder should be chosen on which the automatic adjustment can be switched off. With such sets either manual or automatic recording level control can be selected.

4.2 The Track Pattern

Almost all domestic tape recorders allow multiple track operation. Tapes in their original package have no track division. Nevertheless many buyers of tape ask: "Have you any quarter-track tapes?" In addition BASF tapes pass through an erasing run before they are packed so that any measurements made with actual recordings whilst the tape was being tested are erased. Hence a BASF tape in its original packing does not carry a recording.

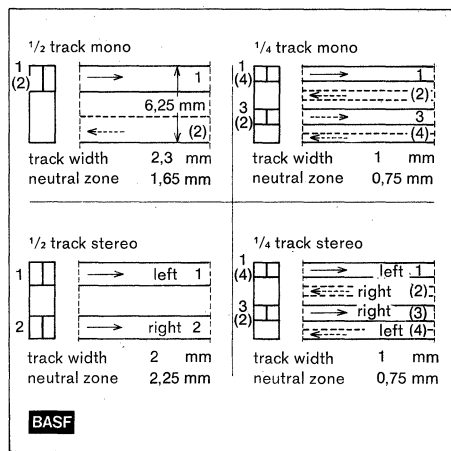


Fig. 26. Track pattern of half-track and quarter-track machines for mono and stereo operation. The arrangement of the magnetic heads is shown at the left of the tape. The tracks are numbered. Figures in brackets indicate as shown that the particular track does not pass the magnetic head. Dotted line tracks are not recorded or played back, respectively in the operation above.

Fig. 26 shows the track arrangement on domestic tape 6.3 mm ($1/4$ in) wide. On the left of these diagrams the outline of the relevant magnetic head is shown. The tape is represented graphically in the position for recording and play-back. This shows that the height of the track is the same as that of the head gap.

Only on studio tape recorders does the magnetic head scan the whole 6.3 mm width of the tape simultaneously (full-track recording). For half-track or quarter-track recording only a portion of the tape width is used.

4.2.1 Half-track Recording

If — as shown in Fig. 26 — a magnetic head was one block at a height of

about 2.3 mm, the upper half of the tape is recorded on after its first run in the recording position. Re-winding is now avoided if the right-hand spool, which is now full of tape is exchanged for the left-hand spool which is now empty. The full spool is turned over before it is placed on the spool carrier. On the second run of the tape the free or unused half is then recorded. There are, therefore, two mono recordings made in opposite directions on the two halves of the tape. This is called half-track recording, although it is not exactly half the width of the tape which is used. A so-called neutral zone is left in the tape which allows for the tolerances permitted in the passage of the tape, or the height of the magnetic head, ensuring that the recordings on the two tracks do not interfere with each other. With a half-track stereo machine the distance of the two head systems from one another is even greater and

produces a neutral zone about 2.25 mm wide in order to reduce cross talk (leakage of signals from track to track). (See also paragraph 2.3.3.)

With a half-track stereo machine it is usual to take the upper magnetic head system (fixed internationally for the left-hand stereo channel) for mono recording so that such recordings can be played back at the corresponding tape speed on any half-track mono set. In principle it would, however, be possible to employ the bottom head system for this (right-hand stereo channel). In the so-called German track pattern, which was used in Germany up to about 1953, the magnetic head system of mono half-track recorders was at the bottom, so that compared with the track pattern now used internationally, the recordings of the two mono recordings were in opposite directions. If such recordings are to be played back on modern tape recorders, the right-hand channel of a half-track stereo machine would have to be used. Thus, valuable recordings in the German track pattern can still be played and therefore, re-recorded, if necessary, on machines which have the international track pattern.

It will be seen from Fig. 26 that with half-track stereo recording two tracks are being recorded simultaneously in the same direction (see paragraph 2.4. on stereo). This is often called twin-track recording.

4.2.2 Quarter-track Recording

The term "quarter-track" analogous to "half-track" is in common use. Quarter-track recording is often called four-track recording.

On a stereo compact cassette recorder the duplex head system including the neutral zone is of the same head gap

height as a single-block mono head system. This is not so in the case of a quarter-track spool tape recorder (see Fig. 10 Compact Cassette Track Pattern).

The right-hand part of Fig. 26 shows that in the case of the quarter-track system the distance between the two heads is such that two neutral zones and track 2 can be accommodated between track 1 and 3. This arrangement of the heads enables a high degree of crosstalk attenuation to be achieved. A tape can therefore be used not only for the recording of two parallel pairs of tracks for stereo, but also for four separate mono tracks, one after the other. When the first quarter-track machines appeared about 1959 the economy of tape it offered was understandable. To-day a minute of tape playing time is very cheap. Many owners of quarter-track machines nowadays hardly ever make full use of the high storage capacity of quarter-track mono recording, for it is quite laborious to record for example the 24 hours of music that could be accommodated at $1\frac{7}{8}$ ips on a 7 in. spool using triple play tape and then carefully write all the titles on a library index card. At 3 minutes per title, this would work out at around 480 titles!

The arrangement of the magnetic head systems for quarter-track recorders allows the tapes to be exchanged between quarter-track and half-track machines if certain conditions are fulfilled (see chapter 14 on the Exchange of Tapes).

4.3 Half-track or Quarter-track Operation?

The question of for or against one or the other method is a difficult one to answer.

Half-track mono machines are used for recording music and speech in cases where only one track is to be recorded at a time. This allows two recording tracks for a single spool of tape.

However, if two parallel tracks are to be recorded then quarter-track or half-track stereo machines are required.

Depending on the equipment available, the following operations are possible: —

1. Stereo playback for the playback of recorded stereo tapes.
2. Stereo recording and playback by so-called full stereo machines
3. Playback (Duoplay) of two related synchronous sound recordings on separate tracks (see paragraph 5.2)
4. Multi-playback (multiplay) of several related synchronous sound recordings by cross-recording (e.g. self trios, self-quartet) (see paragraph 5.3)
5. Parallel track mixing analogous to 3 and 4 for adding sound to slides and 8-mm film (see paragraph 6.3).

Quarter-track operation therefore, offers primarily inexpensive parallel track recording, and half-track operation, good tape-to-head contact and excellent dynamic range owing to the greater track width available.

What is the procedure if one already possesses a quarter-track machine or a whole library of quarter-track tapes and wants to change over to half-track recording?

In this case it is necessary to purchase a tape recorder with a magnetic head which permits the playback only of quarter-track tapes and the recording and playback of half-track tapes (see paragraph 4.6 on Magnetic Head Equipment).

4.4 Which Tape Speed for which Purpose

Domestic tape recorders operate at one or more of the following four tape speeds: 19, 9.5, 4.75, 2.4 cm/s ($7\frac{1}{2}$, $3\frac{3}{4}$, $1\frac{7}{8}$, $1\frac{5}{16}$ ips). Studio tape recorders operate mainly at 38 cm/s (15 ips), but also at 19 cm/s ($7\frac{1}{2}$ ips). Very early tape recorders operated at 76 cm/s (30 ips). Almost all spool tape recorders in the domestic recorder field have the 9.5 cm/s ($3\frac{3}{4}$ ips) speed. Simple recorders have only this speed. All other spool tape recorders have two, three or even four tape speeds.

In the case of recorders having two tape speeds there is often a choice between the next lower speed, i.e., 4.75 cm/s ($1\frac{7}{8}$ ips) or the next higher one, i.e., 19 cm/s ($7\frac{1}{2}$ ips) in addition to the standard 9.5 cm/s ($3\frac{3}{4}$ ips).

If tape consumption is to be particularly economical and the quality of sound of secondary importance, the middle speed range might be chosen, i.e., a tape recorder which runs at 9.5 and 4.75 cm/s ($3\frac{3}{4}$ and $1\frac{7}{8}$ ips.). If really high quality reproduction is desired, however, then tape speeds of 9.5 and 19 cm/s ($3\frac{3}{4}$ and $7\frac{1}{2}$ ips) are best, particularly since almost all domestic tape recorders, at least those of German make, will then also comply with the minimum requirements for HiFi ac-

ording to DIN 45500. In most cases these requirements will be surpassed (see paragraph 2.3 on HiFi machines).

Special types of domestic studio machines which include the 38 cm/s (15 ips) speed, can also be obtained. They are of interest to semi-profes-

Tape Speed

19 cm/s ($7\frac{1}{2}$ ips)

9.5 cm/s ($3\frac{3}{4}$ ips)

4.75 cm/s ($1\frac{7}{8}$ ips)

2.4 cm/s ($\frac{15}{16}$ ips)

sional users where it is necessary to have reproduction quality approaching that obtained in a recording studio. The four speeds used for domestic recorders are suitable for the following purposes: —

Purpose

All sound recordings of highest reproduction quality (HiFi) and tape recordings that are to be edited.

Universal speed for all tape recordings not requiring HiFi quality. Suitable for recordings of classical, light and dance music. Recordings for international tape exchange unless a different tape speed has been agreed between the correspondents.

Music for light entertainment and dance music not required to be of high quality. Recorded speech not to be used for semi-professional or teaching purposes.

Taped speeches at meetings etc., where particular distinctness is of less importance than content and when a very long playing time is required. Trick effects (e.g. echo with particularly long time delay).

4.5 Maximum Spool Size?

Domestic tape recorders are normally intended for operation with double flanged spools of a specified maximum size. The diameter varies from 5 to 26.5 cm (2 to 10½ in), depending on the type of machine employed. Starting from the maximum spool size a machine can hold, the maximum tape length per type of tape for the machine in question can be determined from the range of domestic recording tapes available. From this the playing time per track for a certain tape speed or the maximum playing time of the tape recorder can be ascertained.

This is calculated from the lowest tape speed possible, the number of tracks, the kind of recording — mono or stereo — the thinnest type of tape and the maximum spool diameter.

The maximum playing time with quarter-track mono machines at a tape speed of 2.4 cm/s ($1\frac{5}{16}$ ips) and using a maximum spool diameter of 18 cm (7 in) is 48 hours, if triple play tape is used an 18 cm (7 in) spool holds 1080 m (3600 feet of tape).

Although this corresponds to a playing time of 12 hours per track it is only likely to be used occasionally for recording long speeches at meetings etc. This playing time can however be achieved with some commercial tape recorders.

Assuming the same conditions, the same machine would offer a playing time per track of 1½ hours or six hours in all for HiFi recordings using a tape speed of 19 cm/s ($7\frac{1}{2}$ ips).

In many cases the various types of machine can be identified by reference to their maximum spool size. These are some indications: —

Max. Spool Size

5–9 cm (2–3½ in)

10–13 cm (4–5 in)

15 cm ($5\frac{3}{4}$ in)

Class of Machine

Most of these machines have a single tape speed of 4.75 cm/s ($1\frac{7}{8}$ ips) if they have a capstan drive, or a non-standard tape speed if the tape is driven from the right-hand spool (reel drive).

These are machines which in most cases work on several types of power supplies (single cell batteries, storage batteries and power packs), have one 9.5 cm/s ($3\frac{3}{4}$ ips) or several tape speeds, and are preferred by tape amateurs as battery powered recorders for outdoor use and reporting.

These are machines in the middle price group, usually with a single tape speed of 9.5 cm/s ($3\frac{3}{4}$ ips) alone or with the next lower speed of 4.75 cm/s ($1\frac{7}{8}$ ips) but rarely with 19 cm/s ($7\frac{1}{2}$ ips) because in that case the maximum playing time per track is only one hour even if triple play tape is used.

18 cm (7 in)

These are machines in the middle and upper price groups and HiFi machines. In addition to a tape speed of 9.5 cm/s ($3\frac{3}{4}$ ips) most of these machines have a tape speed of 19 cm/s ($7\frac{1}{2}$ ips), sometimes in addition to one or two other standard speeds.

22–26.5 cm ($8\frac{3}{4}$ – $10\frac{1}{2}$ in)

Home studio machines, which are predominantly fitted for 9.5 cm/s and 19 cm/s ($3\frac{3}{4}$ and $7\frac{1}{2}$ ips) or for 19 and 38 cm/s ($7\frac{1}{2}$ and 15 ips) and have a triple motor tape transport system for better rewinding of the large spools.

4.6 What Head Equipment

In contrast to compact cassette machines, where a distinction is made between players and recorders (see Chapter 3), spool tape machines are almost exclusively designed for recording. Thus, the tape machine must, for each track pattern (half-track or quarter-track), be equipped with magnetic heads permitting the functions of erasing, recording and playback (see Fig. 27).

In the “Recording” position the erase head acts automatically on the track passing it, so that any previous recording on that track does not affect the new recording. In order to prevent inadvertent erasing of a recorded tape during playback, most machines have, in addition to the ‘Start’ button, a ‘Record’ button. If a recording is to be erased without making a new one, the tape is allowed to run through in the “Record” position with the recording level control completely turned down.

Most domestic tape recorders have only one magnetic head for both

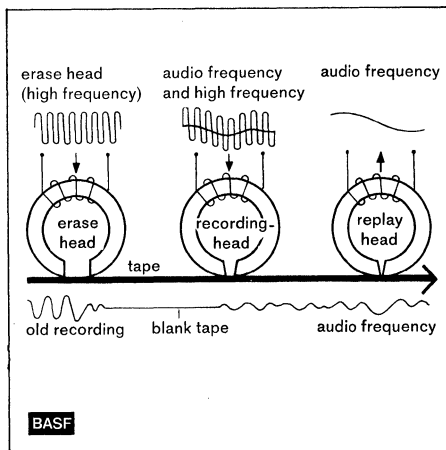


Fig. 27. The upper curves show the current in the head coils, the lower curves show what has been recorded on the tape after passing the various heads.

recording and playback, the so called combined head. Tape recorders in the upper price groups and almost all domestic studio machines, however, have separate recording and playback heads. Thus these machines are equipped with a so-called triple head arrangement (erase head, recording head, playback head).

Combined head sets are inexpensive, offer no problems as regards alignment of the magnetic heads (see paragraph 13.4) but are nevertheless suitable for achieving excellent recording and playback quality. Many HiFi recorders have combined heads, but in addition triple head machines have various advantages.

4.6.1 Advantages of Triple Head Machines

If, instead of a combined recording and playback head, a separate recording and playback head is used, it is possible to provide heads specially designed for these functions. Thus it is expected of a recording head that its gap is wider than that of a playback head so that its effect applies not only to the surface but to the whole thickness of the magnetic coating. A rough rule is that the width of the gap of the recording head should correspond approximately to the thickness of the coating of the tape used. BASF LH tapes have coatings $10\ \mu$ (0.01 mm) thick which is also the width of the gap of the recording head of various domestic tape recorders with triple head arrangement. Due to the greater width of its gap, and the more intensive magnetisation of the coating the use of a separate recording head means a higher dynamic range and more effective elimination of drop-outs (failure of sound e.g. due to separation of the tape from the head).

The ideal playback head, on the other hand, should possess a particularly narrow gap (special playback head about $2\ \mu$, combination head $3.5\text{--}4\ \mu$) to provide good reproduction of high frequencies even at high tape speeds.

Also, with a separate playback head it is possible to monitor the recording just made by the recording head (off-tape monitoring) whereas with a

combination head only direct monitoring is possible.

By switching during recording from direct to off-tape monitoring it is possible to check the quality of a recording with a triple head arrangement. With a combined head this is only possible after recording has been completed. Thus it is possible to ascertain with a triple head arrangement whether the high frequency oscillator providing the erase current and the magnetic bias has failed, as off tape monitoring would show the recording to be low level and distorted. With direct monitoring these facts would not be apparent until the tape is replayed.

In addition the voltage tapped off the playback head can be fed back to the recording head in order to achieve so-called echo and reverberation effects (see paragraph 5.5).

In short, the advantages of triple head arrangement are:—

- a) better sound quality by increased dynamic range and frequency response
- b) off tape monitoring
- c) Echo and Reverberation effects

4.6.2 Quarter-track/Half-track Head Equipment

To reproduce half-track recordings on quarter-track machines is quite simple. The reproduction of quarter-track recordings on half-track machines (see Chapter 14) requires a tape recorder which can be used for both quarter-track and half-track operation, i.e., a

tape recorder with a special magnetic head equipment is needed. There are various alternatives available:

a) A combined quarter-track and half-track machine whereby the additional quarter-track playback head permits the reproduction of quarter-track tapes.

In the case of half-track stereo machines with quarter-track re-play heads, quarter-track tapes can be reproduced in mono and stereo. The switch for quarter-track playback is usually mounted on the head support.

b) Double head equipment for half-track and quarter-track versions. Such machines have for example 2 erase heads and 2 combination heads one each for half-track and quarter-track operation. The switch for the track position is mounted on the tape deck and the track pattern permits both recording and playback for either half-track or quarter-track operation, or both.

c) Interchangeable Head Supports. On these recorders as also with studio machines, the magnetic heads are mounted on a head support board joined by plug connections to the tape recorder. The machine can then be supplied alternatively with a half-track or a quarter-track head block. The head block for the other track pattern can be obtained as an accessory and can, if required, be changed over by the owner of the recorder.

d) Additional Pulse Head
Various tape recorders are provided, as part of their original equipment, or as later accessories, with pulse heads for control of colour slide projection (see paragraph 16.5.3) and for adding sound to 8-mm film by the unit sound system (see paragraph 17.6.3).

e) Tape Run in both Directions
Usually the tape runs from the left-hand spool carrier to the right-hand one. After passing through it is turned over for the other track or channel or exchanged for another tape. An exception is the endless cartridge (see paragraph 11.1). Another exception is a tape recorder that switches automatically to a tape transport from the right-hand to the left-hand spool. To enable the tracks to be recorded and played back in either direction, two combined heads and two erase heads are required which are so arranged that recording and playback is possible from left to right—as is the international practice—and from right to left.

4.7 Which Socket for Which Purpose?

The tape recorder may be considered a link in an electro-acoustic chain beginning at the microphone and ending at the loudspeaker or headphones.

To enable domestic tape recorders to be used universally, the plugs and sockets required for connection, and the individual connecting terminals of these should be internationally standardised. This is unfortunately not the case. However, in Germany DIN standards have been laid down for plugs and sockets on tape recorders and HiFi equipment which are now being adopted by many other countries.

Connecting cables or patch cords also allow the use of plugs and sockets of other design, e.g., standard jack plugs and phono plugs etc. to be connected to plugs or sockets of the DIN type. Only connecting sockets in accordance with DIN will be dealt with here.

Before a tape recorder is purchased, information should be obtained about

the connecting sockets fitted, in case it is required to match them with plugs on leads belonging to other equipment.

Here the following applies: —

4.7.1 Standard Radio Socket/Standard Diode Socket

Modern tape recorders have a standard radio socket and modern radio sets a standard diode socket. On the latest sets these sockets have five holes (see Fig. 28), which in the case of mono only, the terminals are 1 (recording), 2 (earth) and 3 (playback). In the case of stereo the additional terminals are 4 (right-hand channel recording) and 5 (right-hand channel playback).

The standard radio socket of the tape recorder and the standard diode socket of the radio are connected by a sound cable which, depending on the connections, must have three or five pins (see paragraph 9.1 Connecting a radio to a tape recorder).

The purpose of the standard radio socket is

- a) to record radio broadcasts
- b) to reproduce recorded tapes via the radio.
- c) Dub from records or tapes by means of an intermediate coupling.

NOTE: 'Dubbing' means that the signals to be recorded are taken from disc records, radio or another tape recorder.

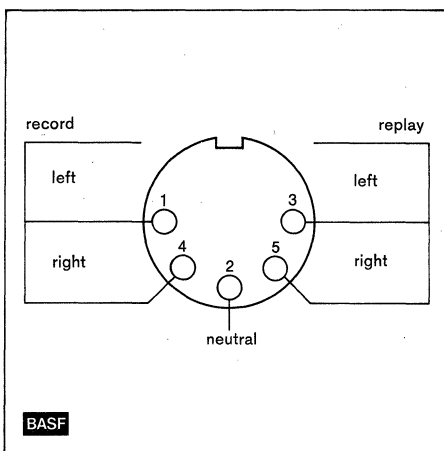


Fig. 28. The standard radio socket or standard diode socket respectively of stereo design. The same terminal connections apply to stereo sound cables.

4.7.2 The Radio/Phono Socket

As regards the terminal connections this is identical to the standard radio socket, but its terminals 1 and 3 and terminals 4 and 5 are connected in each case by a potential divider of 2 Megohms. It is therefore a combined standard radio and phono socket. When a record player is connected the audio voltage fed to terminals 3 and 5 is applied via the potential divider to the recording terminals 1 and 4.

Thus it has the same purpose as the standard radio socket, but when disc records etc. are being recorded it is not necessary to insert the coupling whose functions are taken care of by the two potential dividers (see paragraphs 9.2.2).

4.7.3 The Phono Socket

In contrast to the standard radio socket, which is a combined input and output

socket, the phono socket is only an input socket for a record player or a second tape recorder. The arrangement of the terminals is the same as those of the record player plug for mono and stereo (Fig. 29).

Where machines on which the radio socket and phono socket are separate, the plug connections from the radio and record player at one end and the tape recorder at the other end may be permanent.

4.7.4 Microphone Socket

For details concerning the switching of microphone sockets and microphone adaptation see paragraph 7.3.

4.7.5 Standard Loudspeaker Sockets

Standard loudspeaker sockets (see Fig. 30) may be in the form of sockets with two or three holes. They permit the connection of external speakers or headphones fitted with a standard speaker plug. In the case of two hole sockets the built-in loudspeaker of the tape recorder is switched off when the standard plug of the loudspeaker is inserted. The same applies to the three hole socket when the plug is in a certain position. If the latter is turned round the speaker of the tape recorder continues running. In inexpensive tape recorders the speaker amplifier may function as a high frequency oscillator during recording. This makes it impossible to monitor via the speaker. If monitoring is necessary, a separate headphone output can be used.

4.7.6 The Headphone Output

On many recorders the technical design of the circuits is such that for duoplay

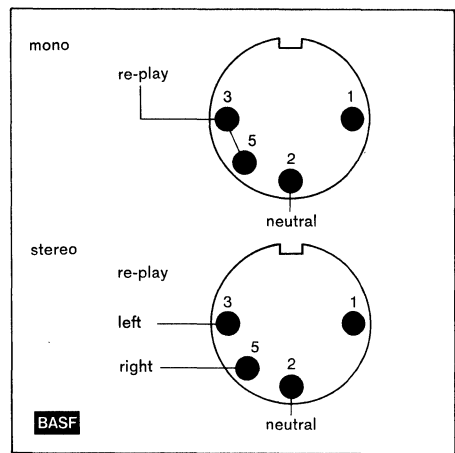


Fig. 29. Record Player Plug in Mono and Stereo Form.

and multiplex it is not possible to monitor the recording via the standard speaker sockets. This cannot be carried out via the built-in speaker because of acoustic feedback (howling and whistling). Such recorders have an output for headphones which are often supplied as accessories to the recorder. The monitoring volume may be either fixed or adjustable. (See chapter 5 on Trick Recording Equipment.)

4.7.7 Remote Operation Socket

With some tape recorders electrical remote operation is provided. Thus the tape run can be stopped and re-started in the Recording and Playback positions, by means of a remote operating cable on recorders which incorporate an electro-magnetically operated stop (pause) switch. Recorders on which all tape transport functions are controlled electrically and not mechanically are also equipped with remote operation facilities of which all tape drive functions (Start, Wind,

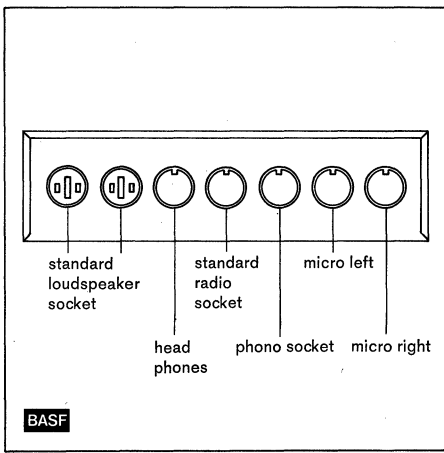


Fig. 30. Before the purchase of a tape recorder information should be sought about the connecting sockets.

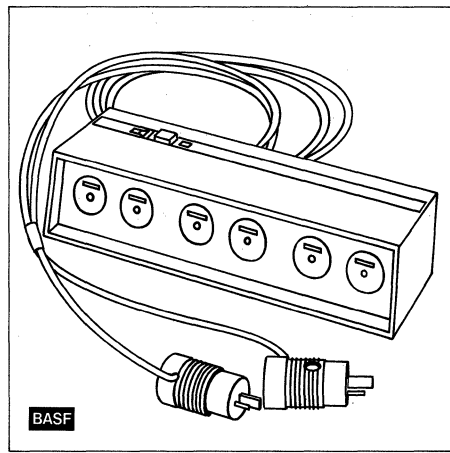


Fig. 31. A triple headphone distribution box connected to a stereo reproduction unit allows operation through loudspeakers if a slide switch is actuated, or—for example at a late hour—through up to three pairs of headphones without disconnecting the connecting cables and with the speaker(s) switched off.

Rewind, Stop) including “Recording” and mains switch can be actuated.

Other tape recorders can for example be fitted with an electronic acoustical switch, a so-called Akustomat, which starts the tape recorder when a noise of a certain pre-set level is maintained for a definite pre-set period (this is for example important when animal sounds are being recorded).

4.7.8 The Projector Socket

Tape recorders fitted with an impulse head (see paragraph 4.6) are provided with a cable connection to the slide projector or 8 mm film projector, which is inserted into a projector socket ensuring synchronization of picture and sound.

5. Which Trick Equipment for what Purpose?

The magnetic sound method offers many possibilities for trick recording. Below the most important ones are described with hints on how they can be put to use.

5.1 The Trick Button

The trick switch is used to make the erase head ineffective either mechanically (see Fig. 32)—by separating the tape from the head—or electrically (Fig. 33)—by switching off the erase current. If a recorder has no trick switch, the same effect can be produced by covering the erase head by a piece of cardboard or plastic (about 0.5 mm thick). Note: The trick switch may also be called a superimposing button or switch.

Since earlier recordings will now no longer be erased, multiple magnetization of one and the same track is possible, so that one or more recordings can be successively superimposed on the original one (see Fig. 34). As, however, the bias current of the recording head partly erases earlier recordings, only the last recording made by such a magnetic mixing process will exhibit the usual volume and sound ranges. This trick recording method does not therefore meet stringent requirements. It can only be used if the various sound recordings do not have to be perfectly synchronized.

5.2 Playback—Duoplay—Synchroplay

If, on the other hand, the sound components have to be mixed synchronous-

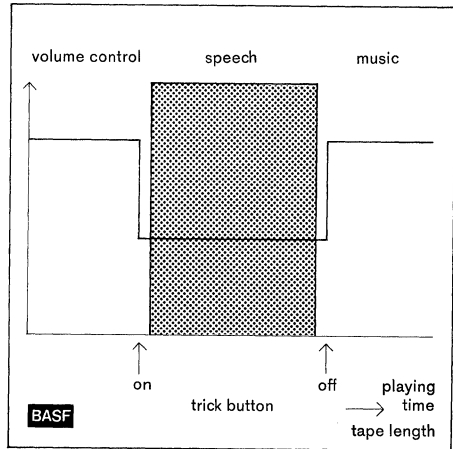
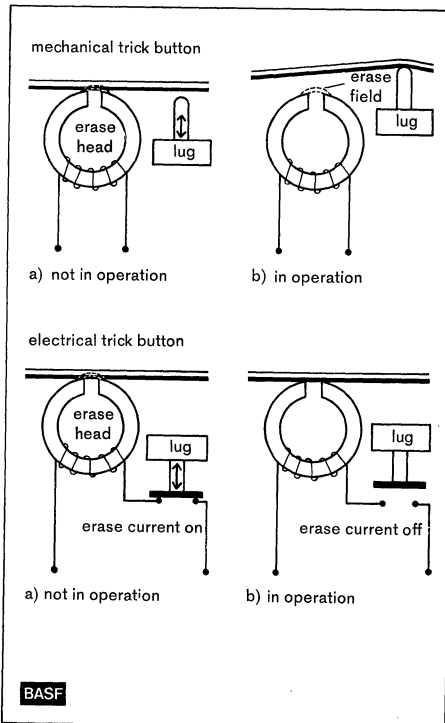


Fig. 34. The trick switch eliminates the erase current mechanically or electrically and thereby permits multiple magnetization.

Fig. 32. The mechanical trick switch (upper part of the diagram) interrupts the erase current by separating the tape from the erase head.

Fig. 33. The electrical trick switch (lower part of diagram) switches the erase current off.

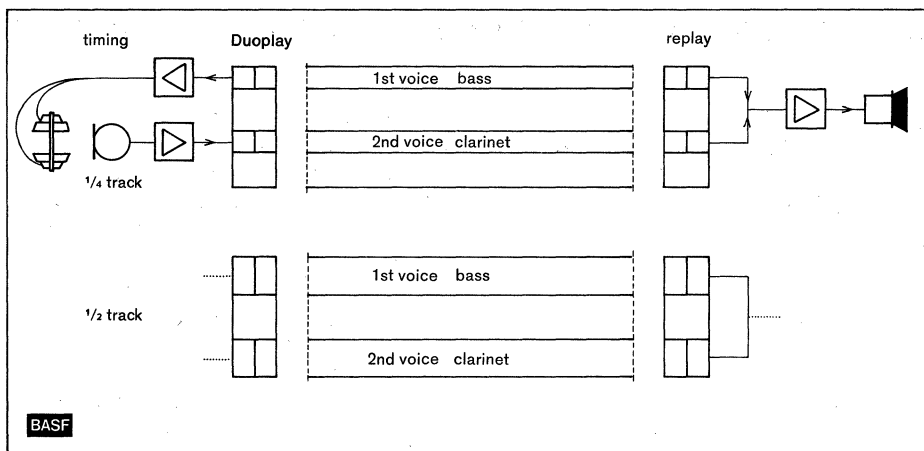


Fig. 35. Playback or Duoplay or Synchroplay. Playback recordings and parallel track mixing with domestic tape recorders call for (a) two parallel tracks, (b) the possibility of monitoring one track whilst the parallel one is being recorded, (c) provision for simultaneous playback of both tracks. Many quarter-track machines and half-track stereo units are equipped for double track replay.

ly, e.g., as in multiple music recording, the playback method must be used. The expressions “duoplay” and “synchroplay” denote the process of producing, for example, a self duet with the aid of a playback tape recorder by adding a second voice or musical part in strict musical time with a first voice or part.

A tape recorder designed for duoplay or synchroplay has two parallel tracks one of which can be listened to via headphones whilst the other one is being simultaneously recorded. When the playback recording is reproduced these two parallel tracks are replayed simultaneously (see Fig. 35).

As all quarter-track machines have a duplex head system they already fulfil one requirement for duoplay operation. On the more modern quarter-track machines the other two requirements are also met by recorders in the middle price group or can be provided by fitting suitable accessories (additional playback amplifier, special head-

phones). Amongst the half-track recorders on the other hand, only half-track stereo machines have a duplex head system. Half-track mono machines can therefore, not be used for duoplay in the manner described. The duoplay or synchroplay method also allows sounds to be mixed, e.g., for radio plays or for adding sound to colour slides. This is called parallel track mixing.

5.3 Multiplay

This involves multiple playback. Multiplay machines therefore not only permit self duets but also a self trio, self quartet etc. To put it simpler: tape recorders with multiplay facilities permit the amateur to supply not only his own second, but also his own third, fourth, fifth and more instrumental or vocal voices. As in the case of the playback method the first musical part is recorded by one of the two head systems and used as a measure of time. Here too this track must be capable of being monitored via headphones whilst the other one is being recorded.

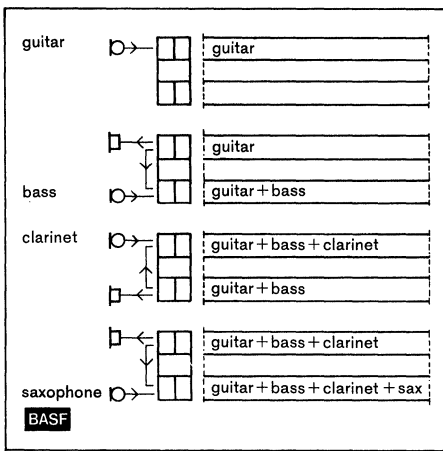


Fig. 36. Domestic tape recorders are suitable for multiplay recording if they have two parallel tracks and one track can be monitored via headphones whilst the other one is being recorded on and if in addition it is possible to record from one track to another by means of a built-in or external mixer unit.

As more than two voices are to be recorded and only two parallel tracks are available in one direction, the parallel track (see Fig. 36) and at the same time a further voice are added. To this end a built-in mixer unit or a multiplay control is required. With some types of machines a mixer unit is necessary.

5.4 Tape Speed Effects

When a recording is played back at the next higher tape speed the pitch is raised by one octave and the playback time reduced correspondingly. The opposite applies when the next lower tape speed is used for playback.

If the change by one octave upwards or downwards is too drastic for the intended effect, intermediate changes

of pitch are also possible. To this end a piece of rubber tube with as uniform a wall thickness as possible is put over the capstan. A thin-walled piece of tube will produce a less marked change in pitch and a thick-walled one a more pronounced change.

5.5 Reverberation and Echo

When sound waves are produced they are reflected from walls and partitions etc. thereby producing delay effects which can substantially change the acoustical effect of the original sound. If these sound reflections merge more or less closely with the original sound the result is called reverberation. If, however the reflected components reach the ear at different intervals in time the effect is that called an echo.

Most triple head machines are equipped for reverberation and echo effects (see Fig. 37). During the recording process part of the playback signal voltage is applied through a mixer unit control (and if necessary a reverberation filter) back to the recording head; the reverberation component being determined by adjusting the mixer unit accordingly. When the mixer unit control is cut out completely, the recording will be without reverberation, or "dry". The reverberation filter, which is also sold as an accessory in the form of an "echo line," reduces the feedback tendency which results when reverberation is produced via the tape when the reverberation volume is increased.

The time delay required for the echo or reverberation effect depends on the time taken by the tape to travel from the recording to the playback head. This delay depends in turn on the distance from the recording to the playback head (called x in the diagram) and on the tape speed. Since the distance x remains constant the echo or reverberation

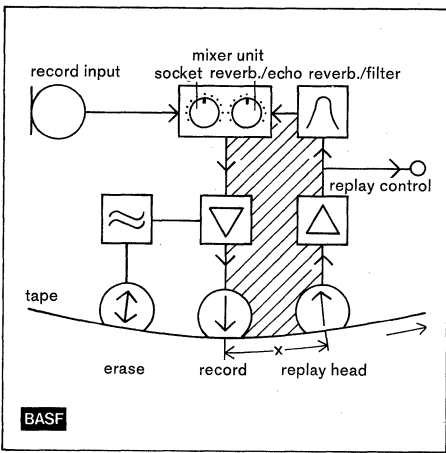


Fig. 37. Triple Head Machines are mostly equipped for reverberation and echo effects. During the recording process part of the playback voltage is fed back via a mixer unit (if necessary via a reverberation filter) to the recording head. The reverberation component is then determined by adjusting the mixer unit control accordingly.

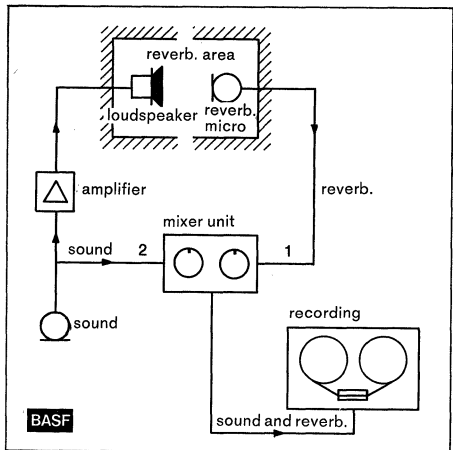


Fig. 38. A Reverberation Chamber—for example in the basement or the bathroom of a house—permits reverberation recordings to be made with any commercial tape recorder and mixer unit. The intensity of the reverberation or the reverberation component can be determined by the mixer unit control.

ration effect can only be varied by the tape speed. This will be illustrated by an example:

Let the distance from the recording head to the playback head be 1.9 cm ($\frac{3}{4}$ in). At a tape speed of 4.75 cm/s ($\frac{17}{8}$ ips) this distance would be covered in 0.4 s, at 9.5 cm/s ($\frac{33}{4}$ ips) in 0.2 s and at 19 cm/s ($\frac{71}{2}$ ips) in 0.1 s. At $\frac{17}{8}$ ips the effect would be that of an echo, at $\frac{33}{4}$ ips that of a transition to reverberation and at $\frac{71}{2}$ ips of reverberation.

Reverberation is often used for vocal and instrumental recordings as is well known from gramophone records. The reverberation component is also used to produce a spatial sound effect.

Recording studios also use reverberation effects in the production of radio plays and for special sound effects.

Reverberation can also be recorded with a combined head machine if a reverberation chamber is prepared for example in a basement or a bathroom as shown in Fig. 38. The intensity of the reverberation effect or the reverberation component can in this case be determined by the mixer unit control.

There are also special reverberation appliances with endless-tape loops, magnetic discs or similar arrangements or several magnetic heads which can be used to obtain echo times of up to several seconds.

6. Which Sound Mixing for what Purpose?

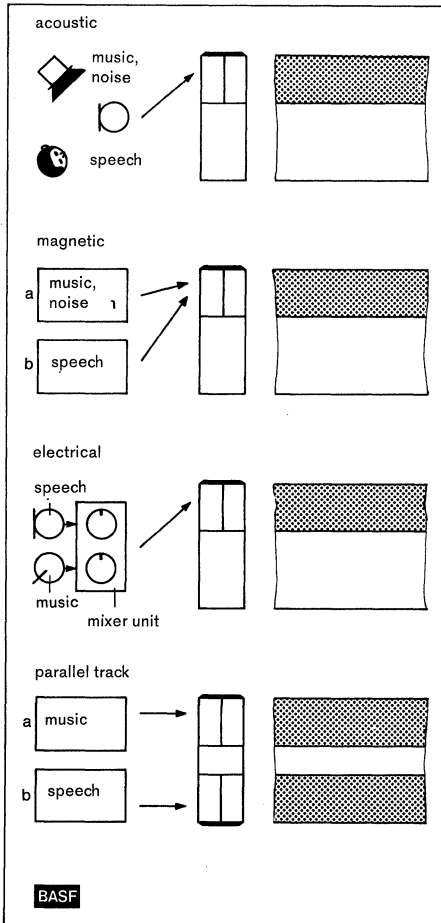
Mixing different sounds (speech, music, noise) offers the amateur the possibility of making "productions" of his own in the form of sketches, sound added to slides and 8 mm film and reports which may even be of studio quality. In such productions the technical execution of the recording process (type of sound mixing) and the realization of the idea (script and design) are of paramount

importance. The following are the most important kinds of sound mixing (see Fig. 39).

6.1 Acoustic Mixing

For acoustic mixing the spoken word and the background music or noise are recorded on tape via the microphone. The music is provided for example by a record player via its loud-speaker and the volume is adjusted as required by means of the volume control of the record player. The correct relationship between the volume of the individual sound components can at the same time be adjusted by direct monitoring during the recording process (headphones). Acoustic mixing will always be used if no other sound mixing facilities are available or if acoustics resulting from this type of mixing is desired (e.g., acoustic effect of a living room for a radio play).

Fig. 39. Acoustic, magnetic, electronic or parallel track mixtures of different sound components (speech, music, noise) are possible depending on the type of tape recorder and the accessories available.



6.2 Magnetic Mixing

Trick facilities that make the erase head ineffective (such as a trick switch) permit multiple magnetization to be made. In this way different sounds can be successively mixed with each other (sound effects for instance from a disc record). In order to build up a 'background' of sound, for example, fun at the fair.

Another possibility is the so-called noise concentration. A hubbub of voices, for example, can be produced by single voices being successively re-recorded (see paragraph 5.1).

6.3 Parallel Track Mixing

This means the recording of different items of sound on two separate parallel

tracks by the playback or multiplay principle. The first sound, for example speech, is recorded on the upper track, the other one, for example background music, on the lower track. For playback the two parallel tracks are scanned simultaneously. In parallel track mixing, however, the ratio between the volume of speech and that of music must be taken into account when the first track is being recorded (for example background music) by reducing the music component at the points where a different sound (for example speech) is later to be blended in on the parallel track.

Quarter-track machines with parallel track operation are often used to add sound to slides and 8-mm film. In contrast to half-track units with playback operation (half-track stereo machines) the lower track of the tape is left free in parallel track mixing for the pulses of the control units for synchronous sound accompaniment for slides and 8-mm film.

6.4 Electronic Mixing

When two or more sound sources are mixed electronically the result will be electronic sound mixing.

6.4.1 Mixable Inputs

Tape recorders with two or more inputs which can be mixed have separate recording level controls for each input and hence are built-in multi-channel mixer units.

6.4.2 Active or Passive Mixer Unit?

In addition, mixer units of various types for mixing on two or more channels are

available for the amateur as accessories. Each mixer unit has two or more inputs and one output for the combined channel signal (see Fig. 40).

Each channel has its volume control—on most modern amateur mixer units these are linear fading controls—for adjusting the volume of the individual channels as required.

There are active and passive mixer units. Active mixer units work with a built-in amplifier (in most cases transistorised) and are supplied by batteries

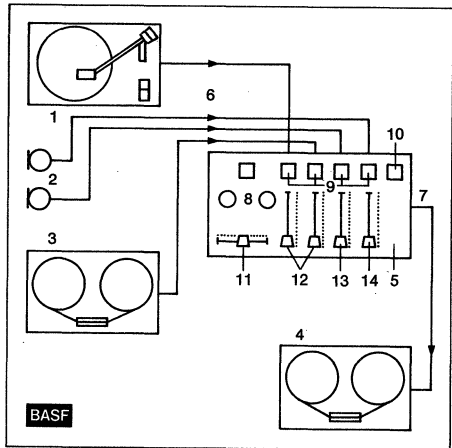


Fig. 40. Each mixer unit has two or more inputs and one output for the combined channel signal. In addition to the master controls—on modern amateur mixer units mostly linear fading controls—for adjusting the volume of the individual channels, level range controls are provided for adjusting the input sensitivity of the individual channels over a specified range. This is to avoid the tape being overloaded when the master controls are actuated. 1 Record Player, 2 Microphones, 3 Copy from tape recorder, 4 Recording tape recorder, 5 Mixer unit, 6 Mixer unit inputs, 7 Output, 8 Input Pre-selector switches for directional mixing, 9 Level range control, 10 Switches and battery control, 11 Directional mixing control, 12 Master control "phono", 13 and 14 Master controls-microphone.

or the mains, so that their output voltage is sufficiently high for the tape recorder into which they feed their output.

Passive mixer units work without amplifier elements and thus have a lower output voltage. They are also less expensive.

The various inputs to a mixer unit are not always of the same sensitivity because of the different functions they are designed to carry out. For example, to record an amateur music group, a mixer unit with several microphone inputs and only one phono input would be suitable. The microphones could be assigned to the soloists, and a tape recorder could supply additional effects via the phono input.

Sound accompaniment for slides, on the other hand, would call for a mixer unit with only one microphone input for the running commentary, and several phono inputs. The phono inputs can be used to connect a record player or a tape recorder for the sound effects and background music.

Inputs with independent volume controls permit the input sensitivity of the individual channels to be adjusted for a definite range. The level of the mixer unit can be adjusted, for example, by turning up one channel (in most cases the microphone input) fully to maximum sensitivity. The recording machine is then driven by the signal of this channel so that the recording level indicator is showing full level recording. The recording level control of the tape recorder remains in this position whilst the levels of the other channels are being adjusted. The master control of each channel is then adjusted each one

in turn so that the tape recorder indicator is also showing full recording level for each channel respectively.

In order to facilitate the level adjustment of the mixer unit, a standard level tape can be made with the aid of the standard reference tone 1,000 Hz) from an audio signal generator. This standard level tape is played on the tape recorder to be used. It should be noted that some types of tape recorder, when on playback, only supply the maximum output voltage at the standard radio or line output socket if the volume control is fully turned up. With other types of machines, the output voltage at the radio or line output socket is constant and thus independent of the setting of the volume control of the tape recorder.

Once the level of the mixer unit has been adjusted, all controls can be actuated as desired during the recording session without risk of overloading the tape.

6.4.3 Directional Mixing

Some modern stereo mixer units have a so-called directional mixer. With this, a mono recording can be gradually faded into a stereo recording or can be adapted for stereo respectively. For example in a radio play or for the sound track of a film, the passing of a train may be required. A mono recording of the travelling train is available from stock. A stereo tape recorder is connected to the mixer unit output, and the tape recorder with the mono recording of the moving train to one of the phono inputs of the mixer unit. At the mixer unit (see Fig. 40) the level control of the tape recorder input channel is set to zero. The master control, i.e., the linear

fading control, is opened up fully and this input is adjusted by means of the level control. The recorders are now ready for directional mixing. Say the train is to travel from left to right, i.e., low sound from the left-hand speaker, gradually becoming louder and then—coming from the centre—pass the listener and disappear at low volume in the right-hand speaker. For this purpose the linear fading control of the input used for the train noise is operated to control the volume of sound and the directional mixer is operated to control the effect of movement. The main recorder and then the tape recorder containing the mono recording of the train are started simultaneously. The directional mixer is placed against the left-hand stop and the input control is turned up very slightly. In this way the train can be heard at low volume from the left-hand channel as playback takes place. The input control is now slowly pushed over

to the full stop and at the same time the direction mixer is pushed slowly to the centre. When playback takes place the train then moves at gradually increasing volume from the left towards the listener. In order to let the train disappear on the right the input control is slowly pulled back again whilst at the same time the direction mixer is pushed to the right-hand stop, also slowly. When playback takes place the train will then “travel” towards the right and the noise of the train will fade away in the right-hand speaker.

If a microphone is pre-selected instead of a phono or high level signal a speaker or singer can be made to “walk” about the room by means of a microphone. During the recording session, the speaker will actually remain in one place, the effect of “walking about” being produced by the directional mixer.

7. Which Microphone for what Purpose?

The selection of a microphone is often facilitated by the fact that the range of accessories available from the manufacturer of the tape recorder includes one or more types of microphone which are compatible with the tape recorder as regards electro-acoustical characteristics, directivity and matching the machine.

However, many tape amateurs buy a second microphone to supplement their existing recording installation, and are faced with choosing the right make and type for their particular application, or their existing tape recorder respectively, from the very large range available.

The principal features of microphones are listed below, arranged by types, directivity and matching.

7.1 Microphone Systems

Microphones are sound transducers and their function is to convert sound waves (speech, musical sounds, noise) into electrical current variations. To this end two basic elements are used, a diaphragm induced by the sound waves to vibrate mechanically, and a transducer system which converts these vibrations into equivalent audio frequency voltages.

Depending on the principle on which the microphone operates, they are subdivided into carbon, crystal, capacitor and dynamic microphones.

7.1.1 Carbon Microphones

The designation refers to the carbon granules in the microphone cartridge.

Due to the mechanical vibrations of the diaphragm, the carbon granules are forced more or less strongly against each other which causes their electrical conductivity to vary with the impinging sound waves. The microphone forms part of a direct current circuit and depending on the sound intensity more or less pronounced voltage fluctuations occur at audio frequencies. Since they are very sensitive in the middle frequency range and very cheap to manufacture, they are used mainly for speech communication, for example, in telephones. They are quite unsuitable for music and are rarely, if ever, supplied even with cheap tape recorders. They have been replaced now mainly by dynamic microphones.

7.1.2 Crystal Microphones

Just as carbon microphones, crystal microphones are no longer adequate for present day recordings as they have a somewhat limited frequency range and the performance can be affected by temperature and humidity variations. The name refers to a system of crystals on which the sound waves impinge either directly or through a membrane in contact with the system. Crystal or piezo-electric microphones as they are sometimes called depend for their operation on the fact that a small electric current is produced when the crystal is subjected to a mechanical force.

7.1.3 Capacitor Microphones

Although rarely met with in amateur tape recording, they are classed amongst the top studio microphones.

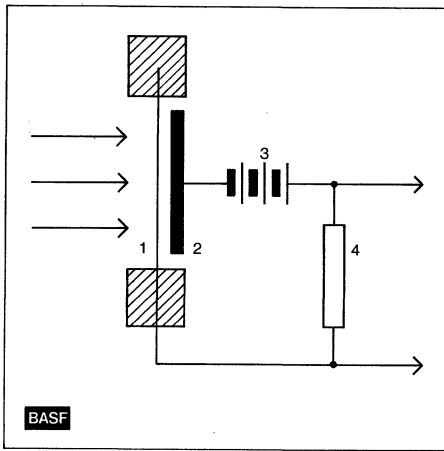


Fig. 41. Principle of the Capacitor Microphone. 1 = Diaphragm, 2 = Counter Electrode, 3 = Current supplying the Capacitor Charge, 4 = Resistance across which the audio frequency voltage is generated.

Their compact construction results from the design principle as in Fig. 41.

Capacitor microphones, as their name implies, operate by capacity variation. One plate of the capacitor is formed by a taut metallic diaphragm, often connected to the microphone casing, and the other plate, insulated from the first, by a rigid counter electrode to which direct current voltage is applied. This means that capacitor microphones depend on an external power supply for their operation. Whilst formerly only power packs were used for this purpose, capacitor microphones fitted with batteries have been available for some time. The diaphragm is moved in step with the variations of sound pressure, so that the distance between the two capacitor plates and hence their capacitance changes. The electric voltage across the microphone resistor varies in proportion to these changes and thus supplies the audio frequency signals. This frequency is fed to a built-in amplifier (earlier mod-

els used valves, to-day most of them are transistorised) to eliminate loss or interference introduced by cable fields.

7.1.4 Dynamic Microphones

Microphones which work on the electro-dynamic principle are grouped under the generic term of dynamic microphones. Depending on their construction they are divided into moving coil and ribbon microphones.

7.1.4.1 The Moving Coil Microphone

This is undoubtedly the most popular of all types mentioned above. This is due mainly to its rugged construction, its outstanding electro-acoustic characteristics and its flexibility which renders it suitable for indoor and outdoor recording.

Another advantage is the fact that it is available in a wide range of makes and types with many different quality and price classes so that all price and quality requirements can be met.

In operation the moving coil microphone is the inverse of a conventional electro-dynamic loudspeaker. A coil of wire is freely supported in the field of a powerful permanent magnet. The coil carries a diaphragm facing the side from which the microphone receives the external sound waves. This diaphragm and hence the coil move in step with the sound pressure variations. Audio frequency voltages are produced across the coil due to the influence of the magnetic field surrounding it (see Fig. 42). However, this voltage is so small that it must be stepped up by means of a transformer before it can be applied to the high-impedance micro-

phone input of a tape recorder. The connection to the low impedance moving coil terminals can be extended for distances up to 200 metres (over 200 yds). If the microphone is a low impedance type, a transformer must be used for connection to a high impedance input. The transformer can be incorporated either in the microphone or in the cable connecting the microphone to the tape recorder.

As dynamic microphones have an excellent response over the entire range of audio frequencies they are suitable for high fidelity recordings.

7.1.4.2 The Ribbon Microphone

These are less popular but as regards design principle it is better than a moving coil type. The moving coil

with a diaphragm mounted on it is replaced by a thin corrugated aluminium ribbon which performs the function of both the diaphragm and the coil. The audio frequency output voltage is generated across the two ends of the ribbon. Due to its construction however, the ribbon microphone is more susceptible to shock and to the effect of wind. This is the reason why ribbon microphones are used predominantly for studio recording (see Figs. 43 and 44).

The electro-acoustical characteristics of the ribbon microphone are excellent. It also requires a built-in transformer for stepping up the audio frequency voltage. As regards the use of an extended microphone cable, conditions are the same as for the moving coil microphone.

Fig. 42. Moving Coil Microphone (Unidirectional). Cardioid Characteristic. U = Transformer, M = Diaphragm.

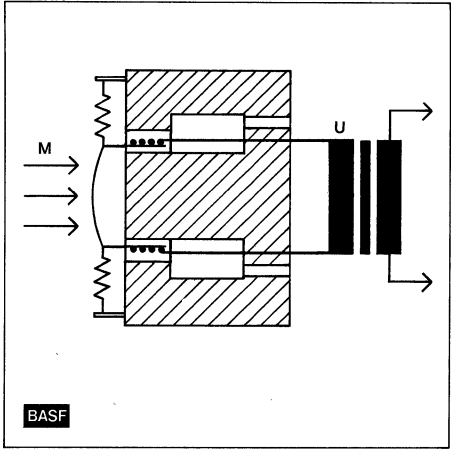
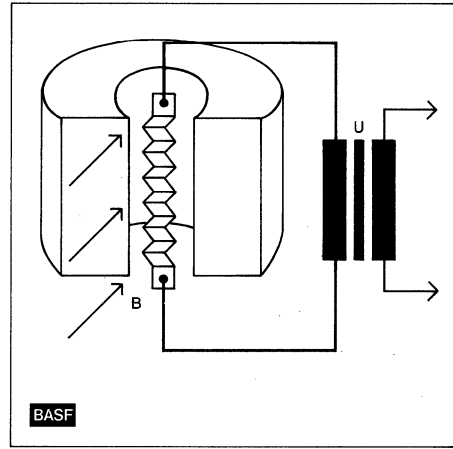


Fig. 43. Ribbon Microphone (Unidirectional). Cardioid characteristic. B = Ribbon, U = Transformer.



7.2 Directivity

This is a further characteristic which must be taken into account when selecting a microphone. The directivity or directional characteristic of a microphone determines its sensitivity in relation to the direction from which the sound travels. The directivity called for in a particular application is achieved by a suitable mechanical construction of the microphone. High-grade studio microphones even have provision for changing the directivity of the microphone by a switch.

There are three main categories: —

Unidirectional microphones (with a cardioid characteristic)

Bidirectional microphones (with a figure-of-eight characteristic)

Omnidirectional microphones (with a circular characteristic).

7.2.1 Microphones with Unidirectional Characteristic

These are preferred by the majority of tape recording enthusiasts. The trade therefore stocks more makes and types of these than of most others. Their advantage lies in the fact that they can be used in rooms in which domestic microphone tape recordings are made and which are, in most cases, not specially prepared acoustically i. e., not properly placed to suppress unwanted indirect sound (echos) as well as unwanted background noise. They are essentially designed to accept sound coming from the front and are very insensitive to sound incidence from the rear (see Fig. 45). Both amateurs and professionals always use these microphones whenever specific focus on interviewees, individual musical instruments in an orchestra etc. is required.

Fig. 44. Ribbon Microphone (Bidirectional). Figure of eight characteristic. B = Ribbon, U = Transformer.

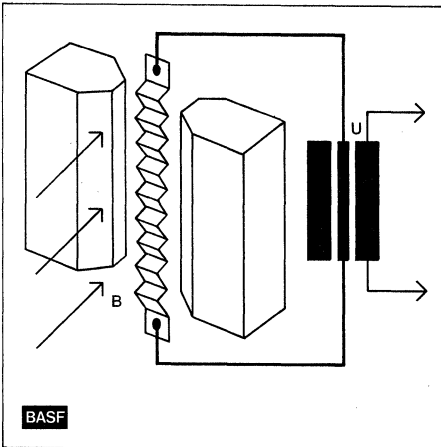
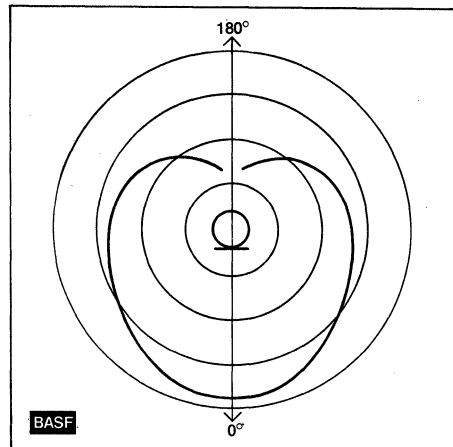


Fig. 45. Cardioid Directional Characteristic (Unilateral).



7.2.2 Microphones with Bidirectional Characteristic

These are not often used by amateurs. In the professional field they are always used where sound coming from two opposite directions is to be recorded. This is the case for example in the studio or the theatre if two speakers or instrumental soloists have to be recorded simultaneously. Both can then be placed at an optimum distance from the back and front of the microphone (see Fig. 46).

Mechanically this characteristic can be achieved with a ribbon microphone by suspending it so that sound will reach it from either side (see Fig. 44).

7.2.3 Microphones with Omni-directional Characteristic

These are used whenever a whole acoustic scene is to be recorded, for example at round table conferences or for public events or as a single microphone for orchestral recordings (Fig. 47).

7.3 Electrical Matching

Another aspect to be considered when purchasing a microphone is suitable provision for connection and more important, matching with the microphone input of the tape recorder or mixer unit.

Dynamic microphones, which many amateurs prefer, can be divided into types of high, medium, and low impedance.

Fig. 46. Figure-of-eight directional characteristic (bi-directional).

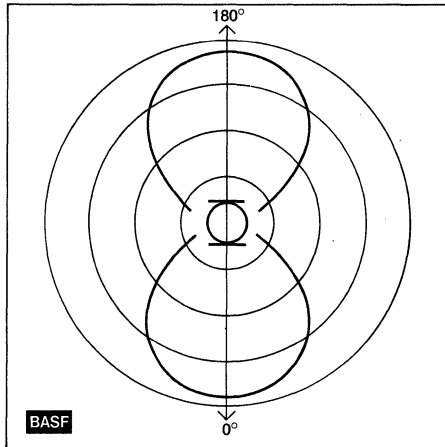
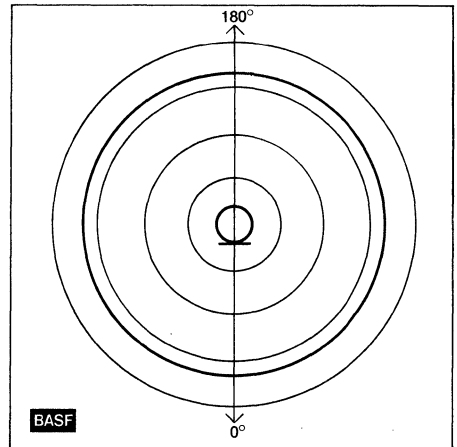


Fig. 47. Circular directional Characteristic (omni-directional).



7.3.1 Connections and Matching for 3-pin Microphone Inputs

The following table shows the contact

arrangement of the "live" terminals of a 3-pin mono microphone plug for three matching values (contact No. 2 is the earth connection).

Type of Microphone Abbreviation	High Impedance H	Medium Impedance M	Low Impedance N
Number of Contacts	1	1	3
Internal Impedance	5000–50,000 ohms	500–5,000 ohms	50–500 ohms

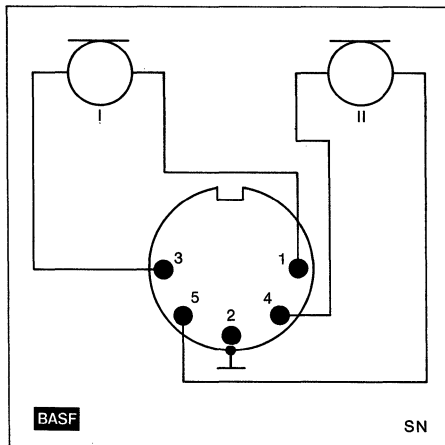
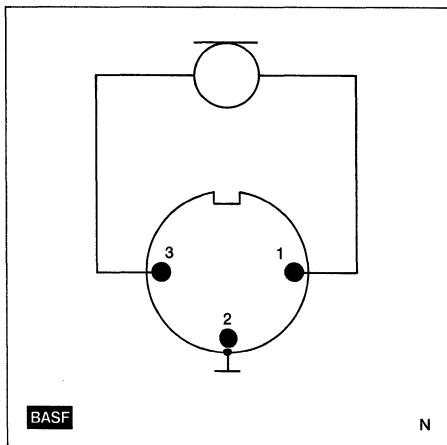
7.3.1.1 Low Impedance Microphones

The connections are shown in Fig. 48. Such microphones can be connected to tape recorders or amplifiers with low impedance inputs (without a transformer) by twin-core screened cables up to 200 metres (over 200 yds). With high impedance inputs a cable transformer (see Fig. 49) will in every case be required at the end of the cable

unless a transformer is incorporated in the recorder or mixer.

Low impedance microphones can be used for all tape recorders with low and high impedance microphone inputs. For high impedance inputs the length of the cable does not matter if the transformer is inserted into the cable the end nearest the recorder.

Fig. 48a & b. Microphone Connections N and SN.



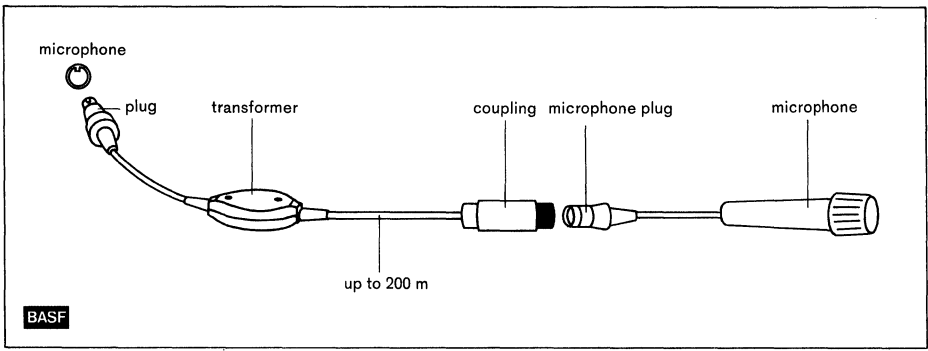


Fig. 49. Cable transformers are for example required for HL microphones if the cable is to be more than 2 m (over 2 yds). The correct plug connection is shown in the diagram. However, instead of cable transformers it is also possible to use extension cables incorporating a cable transformer in the extension connector.

7.3.1.2 High Impedance Microphones

The connections are shown in Fig. 50. Since hardly any domestic tape recorders except older ones have high impedance inputs, high impedance microphones are only very rarely used.

7.3.1.3 High/Low Impedance Microphones

The connections are shown in Fig. 51. HL types can be connected directly to almost all commercial tape recorders equipped with valves. If cables longer than 2 metres (over 2 yds) are required, a transformer may be necessary to prevent hum.

Fig. 50a. Microphone Connection H or M.

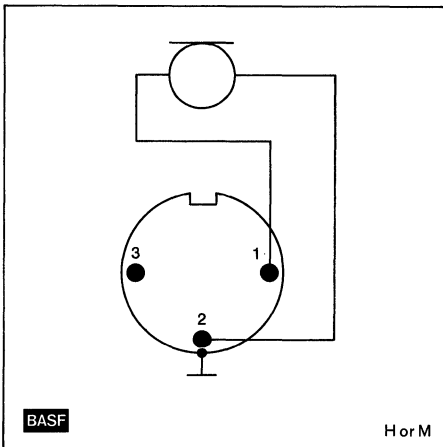
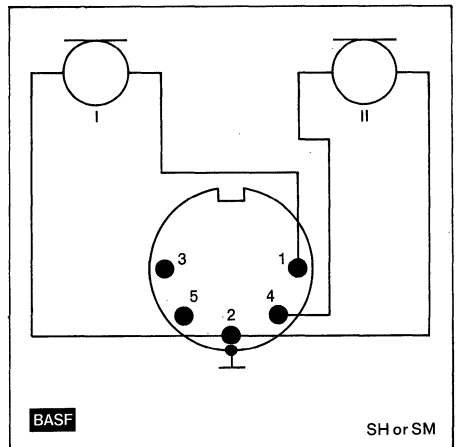


Fig. 50b. Microphone Connection SH or SM.



7.3.1.4 Medium Impedance Microphones

The connection arrangement is identical with that of high impedance microphones (see Fig. 50). Since most transistorised tape recorders have medium impedance microphone inputs, this microphone will probably provide the best matching and thereby the best quality recording.

7.3.1.5 Universal Microphones (High/Low/Medium Impedance)

The connections are shown in Fig. 52. In addition to the HL (high/low impedance), this microphone also has an M connection. The change from HL to M is carried out by means of a switch on the microphone itself (see Fig. 53). Such microphones permit matching to all domestic tape recorders. A universal microphone is therefore to be recommended for any given tape recorder.

If it is not known whether the microphone input of a particular tape re-

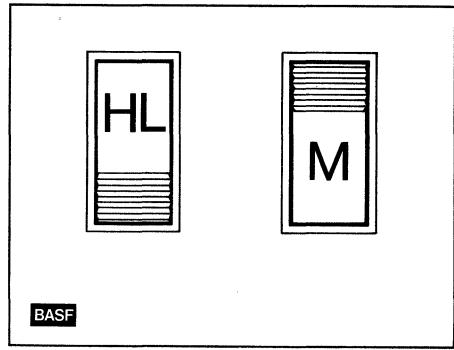


Fig. 53. With Universal Microphones the change from HL to M is carried out by means of a switch on the microphone itself.

order is of high, medium, or low impedance, the necessary data about the input impedance of the relevant microphone input can be obtained from the supplier's leaflet or directions for use. The impedance is specified in ohms (Ω) or kilo-ohms ($k\Omega$), or in Megohms ($M\Omega$).

Fig. 51. Microphone Connection HL.

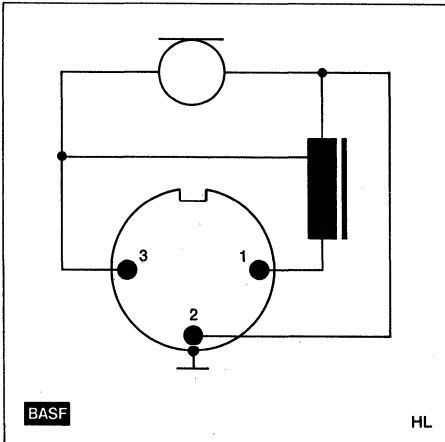
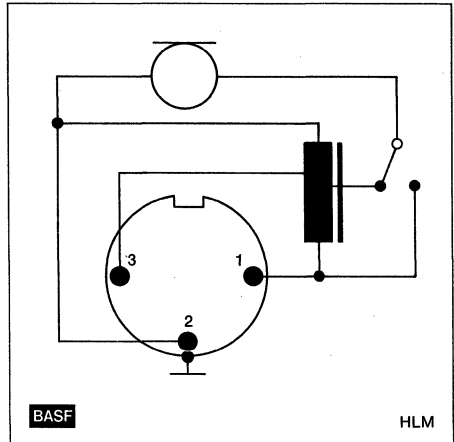


Fig. 52. Microphone Connection HLM.



The value of the comparable input impedance is higher by at least a factor of ten than the internal impedance (source impedance) of a microphone. Thus a high impedance microphone input has an impedance of 500 Kohms (0.5 Mohms) and higher, a medium impedance is 30 to 50 Kohms and a low impedance 500 to 5000 ohms.

Standardised connections ensure the correct contact arrangement for the user when he inserts his microphone into the tape recorder socket provided for the purpose. However, other microphone connections have been selected

which, although limited to a few exceptional cases, are of little significance to the tape amateur. Should such a case arise the manufacturer of the particular microphone or tape recorder will no doubt be pleased to supply details on how to effect the connection.

The firm Sennheiser Electronic of 3002 Bissendorf, Germany for example have published a microphone primer for such purposes which supplies the information on how to connect all the microphones made by this company to German domestic tape recorders, including older models.

8. Recording with Microphones

8.1 Correct Microphone Location

Correct location of the microphone is important to the recording quality that can be achieved. As far as possible its position should be fixed. For this purpose a variety of stands can be obtained. Mounted on a suitable stand the microphone is positioned at the best distance from the source to be recorded.

The stands or accessories for stands available are: table stands, table clamps for attaching for example a microphone to a speaker's rostrum, screwed bases, floor stands, collapsible stands which are screwed into floor stands and can carry up to three microphones, and adjustable microphone booms. A boom can be rotated, raised and lowered and permits optimum positioning of the microphone, for example for musicians, particularly in situations where a microphone on a floor stand would be too far away.

For recording speech, the best distance from the microphone is 12 to 18 ins.

For very close speaking the microphone should be provided with a wind-shield. Close speaking also helps to keep down background noise.

Once the microphone distance has been fixed it should be maintained during the recording session, otherwise it will become necessary to change the recording level. Movement of the microphone would also change the acoustic background.

When music is being recorded, the optimum distance must in each case be determined by microphone tests.

8.2 Microphone Location for Stereo Recordings

It is generally possible to take stereo recordings with two microphones having the same directional characteristics. With many high quality microphones the difference in their performance is so small that the quality or stereo effect would not be spoiled so long as two microphones of the same type are used. With medium priced microphones it is however, advisable to purchase a matched pair or a twin microphone. This will ensure that the performances of the two microphones are compatible and that they will provide optimum recording quality. For amateurs there are three main microphone arrangements which are used for stereo recording. Depending on the arrangement of the microphones these are referred to as the AB, XY and head reference stereophonic methods.

8.2.1 The AB Method

Two microphones having the same directivity and attached to separate stands are positioned at the same distance from the source of sound and at a certain distance from each other (see Fig. 54). During the recording this will result in differences of recording time and intensity between the right-hand and the left-hand microphone which on playback amount to the stereo effect. At the same time the distance of the two microphones must not be excessive so that the left/right effect becomes too marked. This is sometimes called the "hole-in-the-middle" effect.

8.2.2 The XY Method

Two microphones, again having the same directivity, are mounted on a stand, and turned at an angle of about 90° to 110° from each other (see Fig. 55). During recording there are differences of intensity which on playback amount to the stereo effect (intensity stereophonics). Here again, however, the angle between the microphones must, for the reasons mentioned for the AB method, not be too large.

8.2.3 Head Reference Stereophonics

This means that the two microphones must be spaced only a few inches apart and for this purpose they may be attached to a cross member at the top of a microphone stand. The microphones are mounted so that their distance corresponds to that of the ears. The cross member may also be used for the XY method. The best reproduction from head reference stereo-

phonics is obtained by using suitable dynamic headphones.

8.3 Microphone Recording

8.3.1 Trial Recording Level

Before a recording is made from a microphone, tests should be made for correct recording level. For speech, the tape recorder is switched on, the microphone cable is plugged into the microphone socket and the recording level control turned up. With some machines a switch must be set to "Recording" in order to obtain a reading on the VU meter. On tape recorders with several inputs the input selector switch must be turned to "Micro". The recording level can be checked with the tape stationary if the temporary stop or pause key is pressed. The correct setting of the recording level control is determined by reference to the recording level meter (see paragraph 4.1.5 on Recording Level).

Fig. 54. Stereo Recording A-B Method.

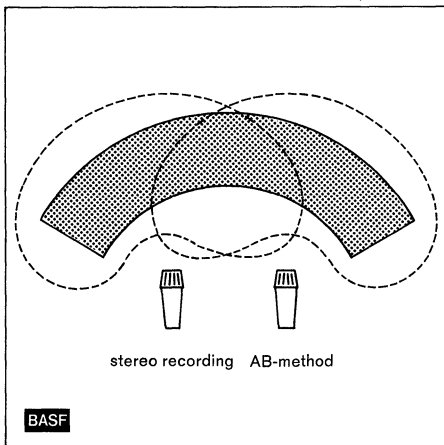
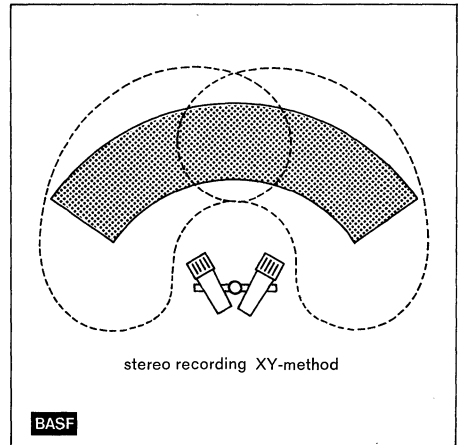


Fig. 55. Stereo Recording X-Y Method.



On stereo tape recorders the microphones must be connected to the sockets for the left-hand and right-hand channel and the track selector switch must point to "Stereo" if a stereo recording is to be made. On some machines the recording level for stereo microphone recordings must be adjusted by means of separate recording level controls. If a stereo tape recorder is used for a mono recording the left-hand channel should be selected. This includes the track selection, the microphone sockets and the recording level control. The left-hand channel is recorded on the upper track which is the international designation for mono recording.

If the VU meter does not respond in spite of correct operation of the recorder, the reason might be the microphone matching. If necessary the switch on the microphone should be used to change the matching.

After completion of a trial recording the tape should be re-wound and listened to. If necessary the built-in loudspeaker must again be switched on. For this purpose the volume control (in the case of stereo recording, both of them) is turned up. If the recorder does not incorporate an output stage with loudspeakers, then headphones or external reproduction facilities can be used for listening.

During a microphone recording it is not possible, because of so-called acoustic feedback, to monitor by means of the built-in speaker of the tape recorder, particularly if the tape recorder and the microphone are in the same room.

Monitoring is best done by headphones. When the tape is stationary, monitoring

can of course only be direct. For off-tape monitoring the tape must run in the "Recording" position (see paragraph 4.6.1).

8.3.2 Elimination of Background Noise when Recording with a Microphone

The quality of recording apparatus alone does not determine the quality of the recording of speech or music. For the recording of music it is understandable that the selected musical instrument(s) must at least be mastered in order to ensure satisfactory interpretation of the composition. For speech, much practice is also necessary in order to read the text accurately which the speaker has before him. Errors, ums and ahs, throat clearing, unnecessary intervals, rustling the sheets of manuscript and other unwanted noises will spoil the presentation of the recording. Of course a poorly produced recording can easily be improved by editing the tape (see paragraph 10.3 about editing), but a good deal of patience is required to do this.

Microphones are so sensitive that they will pick up even the slightest noise coming from elsewhere in the house. Noises of this kind are not always heard whilst the recording is being made but can become very audible on playback.

If a hum should be audible during playback this may be due to the motor or transformer of the tape recorder. For example, a microphone standing on the same table as the tape recorder, may pick up stray magnetic fields from the mains transformer in the recorder. The answer to this is to move the microphone away from the recorder. Inadequate earth connections can also cause hum to appear on a recording.

Many microphones are sensitive to being handled. Unless this is necessary, the microphone should not be handled during recording.

9. How to Record Direct

Direct recording from a radio, or a record player or from another tape recorder is possible with any domestic tape recorder. For this purpose the output socket of the signal source — radio, tape recorder, record player — is connected to the appropriate input socket of the tape recorder. On machines with several inputs and parallel running tracks, it may also be necessary to pre-select the desired operation (for example the upper or lower track, mono or stereo) or the connected input (see Fig. 56).

Recording from external signal sources is facilitated by the fact that most audio equipment has DIN socket connections in accordance with the German Standard Specifications. In the UK and U.S.A. both DIN and Phono sockets are in common use. The most important

input and output sockets are discussed, with their connections, in paragraph 4.7.

9.1 Connecting a Radio to a Tape Recorder

The standard radio socket of the tape recorder is connected to the diode socket of the radio by a screened lead sometimes called a diode cable. The plugs have three-pins for mono and five pins for stereo machines.

Direct recording of radio broadcasts on tape is possible without having to listen to the broadcast as the radio recorder connection is made prior to the output stage controlled by the volume control on the radio. For recording, the desired waveband button is depressed on the radio set and the corresponding station selected. On the

Fig. 56. The Operations switch is used to pre-select the required track pattern and the input selector switch for the input to which the connection is made for re-recording.

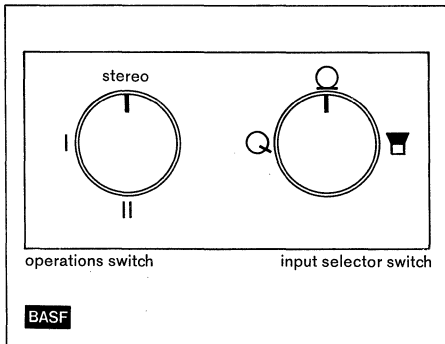
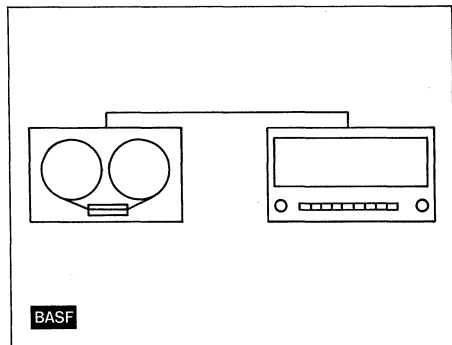


Fig. 57. To couple a radio to a tape recorder a screened cable is connected to the diode socket of the radio and the standard radio socket of the tape recorder.



tape recorder the pre-selector switch is set to "Radio".

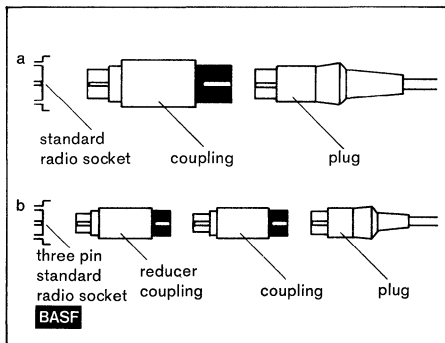
For reproducing pre-recorded tapes via a radio the pick-up key on the radio should be depressed.

In order to connect a five pin stereo plug with a 3 hole mono socket modern mono tape recorders are equipped with 5 hole sockets of which only 3 are wired. Thus radio programmes can be recorded in mono with a stereo tape recorder, however only on the left channel.

If, however, two separate tracks are to be recorded successively and in the same direction for example, from a monophonic radio, on the upper and lower tracks of a stereo tape recorder then a special coupling (see Fig. 58a) is needed. When plugged into the standard diode socket of a monophonic radio set, this coupling permits the upper or lower track or both to be recorded depending on the setting of the track selector of the stereo tape recorder.

Fig. 58a. By the insertion of a universal attenuator coupling the standard radio socket is converted into a combined radio-phonos socket. By the insertion of special 5 to 3-pin coupling a five-pole stereo audio cable can be connected with a three-pole standard radio socket.

Fig. 58b. If a recording is made from a stereo record player or a stereo tape recorder onto a mono tape recorder which is only provided with a standard radio socket, a 5 to 3-pin coupling must be provided, so that both channels of the stereo record can be recorded together on the mono tape recorder.



A special coupling of this kind also permits the use of five-pole plugs and cables with for example, an older radio set with a three hole diode socket.

9.2 Connecting a Record Player to a Tape Recorder

If a record player is connected to a radio receiver through a pick-up socket, only the pick-up key has to be depressed on the radio after which the recording procedure is the same as for a radio broadcast. There are no losses in quality. In addition this has the advantage that the records being recorded can be listened to on the audio frequency section of the radio receiver.

If a recording is made directly from a record player it must be checked that the tape recorder has a standard radio socket or a separate pick-up socket (which is usually the case with medium and high priced tape recorders) or a combined radio/phonos socket (customary on tape recorders of the medium price class) or a standard radio socket (customary on older and simple tape recorders).

9.2.1 Tape Recorders with Phono Socket

The plug of the record player cable is inserted into the phono socket in which the contacts are arranged to match those of the record player plug. The input selector switch of the tape recorder is set to "phono".

9.2.2 Tape Recorders with Radio/Phono Socket

The radio/phonos socket is so wired that it performs two functions, that of the

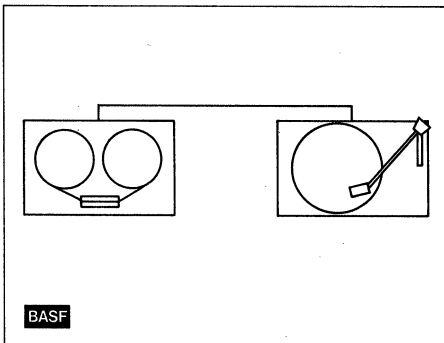
standard radio socket and that of the phono input socket.

9.2.3 Tape Recorders with Standard Radio Socket

If records are to be re-recorded onto tape via the standard radio socket it may be necessary to reduce the signal level from the record player. In this case a special attenuator coupling (see Fig. 58a) inserted between the record player plug and the standard radio socket can be used. This reduces the signal voltage to an appropriate level.

If a recording is made from a stereo player onto a mono tape recorder, a stereo to mono signal coupler must be inserted between a special attenuator coupling and the standard radio socket of the mono tape recorder, so that both channels of the stereo record can be recorded together on the mono tape recorder (see Fig. 58b).

Fig. 59. To record from a gramophone record, the plug of the record player cable is inserted into the input socket of the tape recorder provided for that purpose.

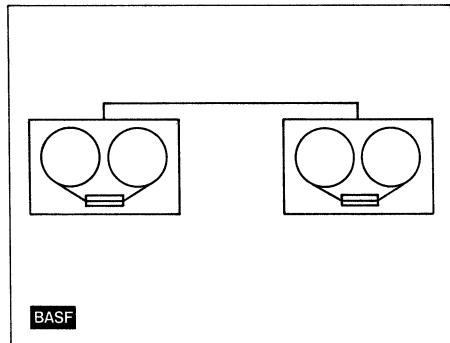


9.3 Connecting one Tape Recorder to Another

Two tape recorders (see Fig. 60) are to be connected so that one is used for playback of the tape to be re-recorded (master tape) and one for the production of the copy (copy tape). It is useful to play the master tape on the machine (see Chapter 14 on Tape Exchange) on which it was recorded; provided, of course, that the same machine is available.

As regards its reproduction quality the copy can never be better than the original. However, if machines having the same track designation, tape speed and head equipment are used, the difference of quality between master tape and copy will be negligible. If, however, to take an extreme case, a master tape recorded at 19 cm/s ($7\frac{1}{2}$ ips) half-track on a triple head machine is to be re-recorded on a combined head machine for quarter-

Fig. 60. If two tape recorders are connected for re-recording, one is used for playback of the tape to be re-recorded and the other for the production of the copy.



track at 4.75 cm/s ($1\frac{7}{8}$ ips) the quality of the recording will be reduced in respect of signal-to-noise ratio and frequency range. It must also be considered whether the machine being used for recording is connected to the re-play tape recorder via a pick-up socket, a radio/phono socket or a standard radio socket.

9.3.1 Copying Machine with Pick-up Socket

The standard radio socket of the playback machine is connected to the pick-up socket of the copying machine, the input of the recorder being switched to "Phono".

9.3.2 Copying Machine with Radio/Pick-up Socket

The standard radio socket of the playback machine is connected to the radio/pick-up socket of the copying machine by means of a screened cable. The input selector switch is set to "radio".

9.3.3 Copying Machine with Standard Radio Socket

The standard radio socket of the playback machine is connected to the standard radio socket of the copying machine, the input selector of this being set to "Radio". If required a direct recording audio cable fitted with a voltage divider in the plug can be used to connect the two standard radio sockets with each other.

A normal audio lead with a special coupling can be used.

When a stereo recording is to be recorded direct onto a mono tape re-

order, an attenuated special coupling must be used so that the two channels of the stereo recording can be re-recorded together.

9.4 Copying at Multiplied Tape Speed

When copying from tapes it is possible to use a higher tape speed in order to shorten the copying time. A speech recording made at 4.75 cm/s ($1\frac{7}{8}$ ips) played back at 19 cm/s ($7\frac{1}{2}$ ips) tape speed and re-recorded at the same tape speed, reduces the copying time to a quarter of the original playing time.

Professional copying systems work at even eight times the speed of the original recording. For example, tapes for compact cassettes are made at 38 cm/s (15 ips) whereas the normal running speed is 4.75 cm/s ($1\frac{7}{8}$ ips). (Note $8 \times 4.75 \text{ cm/s} = 38 \text{ cm/s}$.)

When carried out at a multiple of the original tape speed however, the copying of recordings made on domestic recorders involves the risk of frequency losses. This will be illustrated by the example represented in Fig. 61. An original recording whose frequency range from 40 Hz to 16 kHz is recorded at a tape speed of 9.5 cm/s ($3\frac{3}{4}$ ips) and is to be copied at double that speed. The copying process thus means that all frequencies within the range 80 Hz to 32 kHz have to be re-recorded at a speed of 19 cm/s ($7\frac{1}{2}$ ips). Assume now that the limiting frequency of the domestic tape recorder used at that speed is only 18 kHz. When the copy is played back at 9.5 cm/s ($3\frac{3}{4}$ ips) it will be found that only the range from 40 Hz to 9 kHz has been recorded, i.e., the

higher frequencies have not been re-recorded. The method of copying at a higher tape speed must therefore, be used in connection with domestic tape recorders only where the content is more important than high quality.

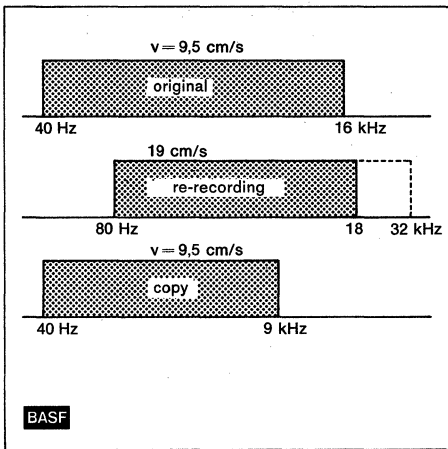


Fig. 61. Re-recording at double tape speed may involve frequency losses.

10. Editing and Splicing of Magnetic Tape

10.1 Cutting and Splicing

The cutting and splicing of tape and film is an art. This will be confirmed by anyone who has ever tried to cut out a single word or even a letter, due to a slip of the tongue, from speech recorded on tape. At the same time, tape editing as it is called, can be used so as to change the whole meaning of a complete sentence. For example take the sentence — 'There is a big difference in whether I have offered one, or whether I have offered none.' Here we wish to eliminate the letter 'n'.

In studio practice and at a tape speed of 38 cm/s (15 ips) this could be done quite easily by a skilled studio cutter. It may be a little more difficult for the tape amateur, as at 19 cm/s (7½ ips) the words would occupy a smaller length of tape. Studio tape machines are also equipped with a semi-automatic cutting mechanism which in most cases is fitted behind the playback head and makes editing fairly easy. With domestic tape recorders tape editing and cutting is somewhat more difficult and an explanation of how it is done follows: —

In the first place it is advisable, with domestic tape recorders to use the highest tape speed if important recordings are to be made, regardless of whether these are recordings of speech or music. This, as will be seen from the example of the words 'none' and 'one,' substantially simplify editing of the recording which may become necessary afterwards. In addition, any tapes which are to be edited later must of course only be recorded on once, monaurally or stereophonically, as recordings on the other tracks would be mutilated.

The recording is first played through, and the parts to be cut out are marked

at each end by drawing a vertical line on the back of the tape. The lines can be made by using a wax (chinagraph) pencil of the type supplied with BASF Hobby Box. This makes it possible to mark the tape accurately as it passes directly over the playback head.

Let us suppose that the word 'none' has a speaking time of one second and the letter 'n' just one fifth of a second. In a studio using 38 cm/s (15 ips) this letter 'n' would use a tape length of 7.6 cm and could easily be removed by a skilled cutter. However for the amateur user recording at 19 cm/s (7½ ips) the length would only be 3.8 cm and at 9.5 cm/s (3¾ ips) a mere 1.9 cm length.

Furthermore studio machines are usually equipped with a semi-automatic cutting mechanism fitted behind the replay head which makes editing fairly easy. With many tape recorders this work is simplified by the fact that the head cover is held by a clip or by one or two screws and can readily be removed. This makes it possible to mark the tape accurately as it passes directly over the playback head. In order to be able to find and mark the beginning and end of a portion of tape which has to be removed, the procedure is as follows. The tape is allowed to run as far as the passage to be cut out, and then the temporary stop button is pressed. Since no playback is possible when the tape has stopped, the tape is now pulled past the magnetic heads by hand by turning the two spools first to the right and then to the left so that the recording becomes audible and until the portion to be cut is directly behind the playback head.

Once correctly marked, the magnetic tape can be cut, using suitable tools, which will be discussed below. The two ends are then spliced together.

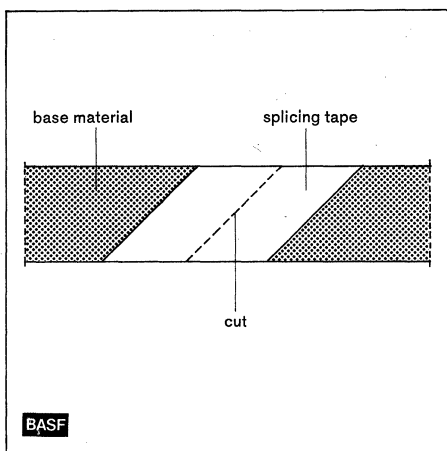


Fig. 62. For a correct splice the parts of the tape to be joined — cut at an angle of about 45° — should butt without gap. The adhesive splicing tape is then so attached to the back (base side) of the magnetic tape that it does not extend beyond the edge.

Apart from an extreme case like the words 'none' and 'one' it should be ensured when editing, that the ends of the tape which have to be joined, do not carry any recording where the tape is to be cut so that a correct joint, as illustrated in Fig. 62 can be made. For this purpose the parts of the tape which have to be spliced are first accurately laid one on top of the other (with the coated side downwards) and then cut at an angle of about 45° . After cutting, the two ends of the tape are inserted into a splicing groove with the coated side downwards so that they will butt without a gap. A piece of splicing tape is then placed across the join and if necessary trimmed to the natural width of the magnetic tape.

10.2 Editing Accessories

10.2.1 Anti-magnetic Scissors

If editing and cutting is to be carried out frequently a pair of non-magnetic scissors should be used (see Fig. 63). Any pair of household scissors would of course suffice providing they are not

magnetized. Scissors which have become magnetized by contact with magnetic material will leave residual magnetization on the tape which will be audible as a form of background noise. This danger is eliminated if special anti-magnetic scissors are used.

Working with anti-magnetic scissors has a number of advantages for the tape amateur. In the first place editing can be performed without marking, since the scissors can be used to cut the tape directly behind the playback head. The scissors with angled shape held parallel to the tape will cut this in the right angle.

10.2.2 The Hobby Box

The BASF Hobby Box contains a large variety of accessories for editing: leader tape in three colours, switch foil, wax (chinagraph) pencil, tape clips, spool labels and a semi-automatic splicing and cutting tool. This simplifies the cutting and splicing process since the tape is held by means of two fixing clips (see Fig. 64). The adhesive tape is contained in a special holder and is cut off, as required, with a pair of scissors. The join is made as shown in Fig. 65. The Hobby Box and also the splicing channel have holes for permanent attachment by means of wood or machine screws.

10.2.3 The Splicing Block

The BASF splicing block is a studio type of tape splicing appliance for those who use an anti-magnetic pair of scissors but wish to simplify splicing. As shown in Fig. 66 it consists of a splicing groove with two metal cutters, a dispenser for adhesive splicing tape, and a cutting tool. In use, the ends of the tape to be joined are inserted into

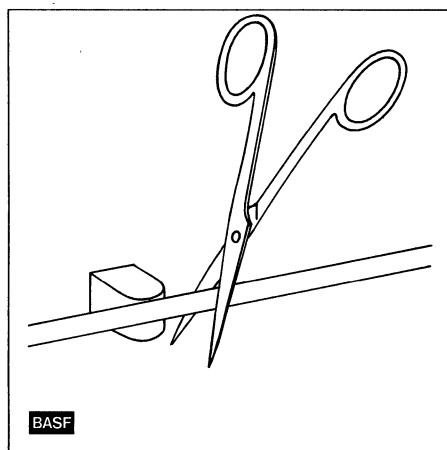
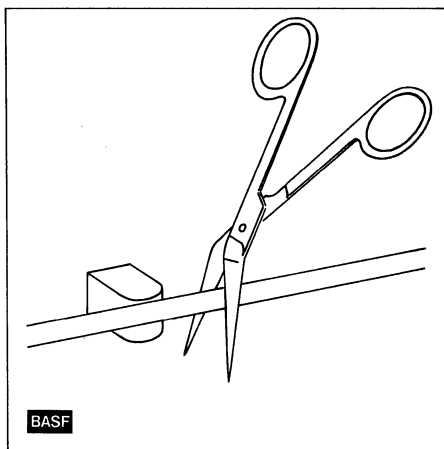


Fig. 63. With anti-magnetic scissors, of straight or angled shape, the magnetic tape may be cut directly behind the magnetic head.

the groove on the splicing block, coated side downwards, so that they butt together at the marked line (not shown in the diagram) without overlapping. The adhesive tape, which is 0.7 in. wide is then placed across the tape and pressed on the two steel cutters. The cutting tool is then used to trim off the overlapping splicing tape by sliding it through the groove.

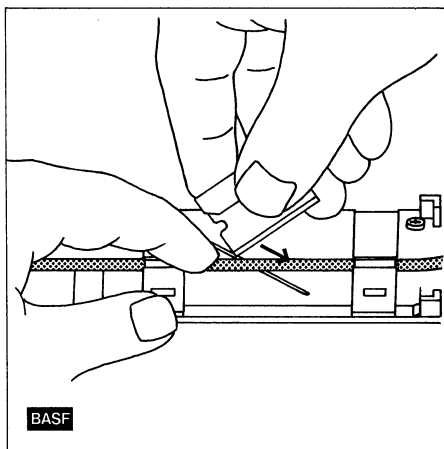


Fig. 64. The Hobby Box assists in Editing. In the semi-automatic splicing and cutting tool the tape is held by two clips and cut by a blade.

The BASF splicing block facilitates precise and rapid splicing of magnetic tape 1/4 in. wide.

It can be permanently attached to the work bench.

10.3 Editing and Tape Montage

The amateur who wishes to make studio-like recordings should use only one track, leaving the other free or for example for stereo recording a pair of tracks. For the recording take a blank tape which has sufficient length. After the recording cut the recorded section off so that the remaining tape may be reserved for other recordings. To the ends of the recorded tape a leader (green) and a trailer (red) should be added and the recording can then be put into the tape library.

Short recordings of the same kind (for example interviews, sound effects, music, voices of rare animals or of celebrities etc.) can be collected on

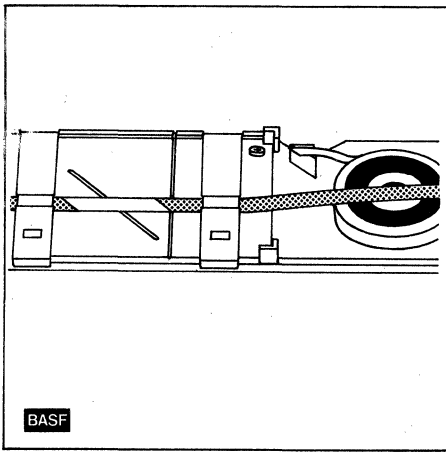


Fig. 65. In the Hobby Box the tape is held in special fixing clips. The inch length of adhesive tape required for splicing is unwound and cut off by means of a cutting edge which also holds the beginning of the roll of adhesive tape.

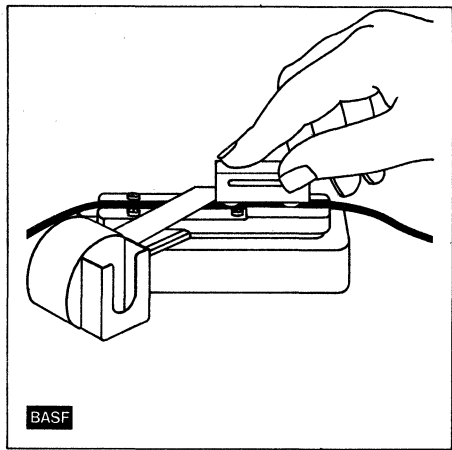


Fig. 66. The BASF splicing block is a studio type of tape splicing appliance.

the same spool with separating leader tapes of different colours spliced between each separate recording. The various recordings are then listed on an index card so all that is needed is to count the number of separating coloured leader tapes during fast wind in order to locate the required recording.

Before recorded tapes are put into a library, however, they should be edited. With speech recordings long pauses, repetitions, ums and ahs etc. should be cut out. If necessary poorly recorded parts should be recorded again and the new recordings spliced in, in place of the old.

In the preparation of a music library it is sometimes annoying to hear the broadcasting announcer's voice between programme items. These announcements can also be cut out before the tape is put into the library.

Trick montage is a special field open to all owners of spool tape recorders. This is the production of special effects by cutting out or adding lengths of tape. For example to make a recording sound completely different from an original or to take parts of different recordings and mix them by cutting and splicing techniques. Unusual musical effects can also be achieved by tape montage, i.e.,

the production of a musical montage from one single sound by re-recording and intersplicing different versions of the sound. This is often called **Musique**

Concrète which can also be derived from many different sounds that have been altered by tape cutting and splicing and re-recording.

11. Endless Tape Loops

Every owner of a spool tape recorder can produce an endless tape loop of several seconds playing time. A tape loop made of, say 20 inches of magnetic tape by splicing the two ends of the tape and played at 9.5 cm ($3\frac{3}{4}$ ips) tape speed provides a recording time of approximately 5 seconds. The tape loop is inserted into the tape recorder so that it passes in front of the magnetic heads. The tape loop is now held under light tension by a pencil whilst a recording is being made upon it. The recording made on the tape loop will simply repeat itself continuously when replayed.

Home made tape loops as above are adequate for producing repetitions of short duration recordings for amateur recording but are unsuitable for professional recordings, for example, repeating announcements etc. For this purpose there are special endless tape cassettes which can be recorded and replayed on spool tape recorders.

11.1 Endless Tape Cassettes for Spool Tape Recorders

In contrast to spools and compact cassettes, endless cassettes have only one tape reel. The tape is carried from the inside to the outside diameter of the reel. The special BASF tape of type LP 36 is provided with a coating of lubricant, in addition to the magnetic coating, in order to reduce the friction between layers of tape as they unwind. LP 36 tape is a long playing tape (labelled LP 35) which has a coating of lubricant about 1 μm thick.

Thus the type number results from the total thickness (LP 35 = long play with a total thickness of approximately 35 μm + 1 μm backing = LP 36).

The playing time and track position of endless cassettes is comparable with spool tapes but the cassette cannot be turned round. Hence only one track can be recorded on half-track mono sets and only one pair of tracks recorded on quarter-track or half-track stereo machines. BASF endless tape cassettes can be supplied with 45 or 90 m (150 or 300 ft) of tape, resulting in the playing times listed in Fig. 67. However, in contrast to a spool tape the recording can be played continuously according to the time stated in the table.

Depending on whether speech, music or sound effects etc. are recorded it is necessary for the transition to take place smoothly. The procedure for this is as follows: From the table in Fig. 67 the playing time is selected for a tape length of 45 or 90 m (150 or 300 ft) and a tape speed chosen which complies with the intended duration of recording. For a playing time of 15 minutes the recording should be so arranged on the tape that it lasts for the whole duration of the running time, so that after that period has expired the recording will repeat itself without an appreciable pause.

The table shows that for LP 36 at 45 m (150 ft), a playing time of 15 minutes is achieved with a tape speed of 4.75 cm/s ($1\frac{1}{8}$ ips). For LP 36 at 90 m (300 ft) a playing time of 15 minutes with a tape speed of 9.5 cm/s ($3\frac{3}{4}$ ips) can be obtained.

tape speed	LP 36 45 m 150 ft	LP 36 90 m 300 ft
	minutes	
4.75	15	30
9.5	7½	15
19	3¾	7½

BASF

Fig. 67. Table of Playing Times of BASF Endless Tape Cassettes LP 36 45 m and 90 m (150 and 300 ft).

The quality of the recording is however, affected by the tape speed. The higher the tape speed, the better the dynamic range and the frequency range that can be achieved.

If an endless recording of sound effects or music etc., is to be absolutely continuous, i.e., without perceptible beginning and end, the transition at the beginning and end must be arranged so that they are not perceptible to the ear. For speech the text should be so arranged that the repetition of the recording begins without perceptible pause.

The endless tape cassette is placed on the left-hand hub of the spool deck (see Fig. 68). If the hub should turn of its own accord as it may with a triple motor system, then the cassette will have to be fixed to the deck. The tape loop is then pulled out until it can be threaded.

Recording or playback can now commence. After use the cassette should be returned to the box supplied with it and with the loop pulled back into the cassette.

Endless loops can normally only be used when the tape recorder is horizontal. Endless cassettes have many uses both in the home and professionally.

They can be used for repeating announcements, comments on merchandise, poems to be learned by heart, passages of foreign languages and musical phrases etc. etc.

Most tape recording enthusiasts will find uses for an endless tape cassette which like spooled tapes can be erased and used over and over again.

11.2 Endless Cartridges for Special Machines (Lear Jet, Fidelipac)

In addition to the endless cassettes which are used on spool tape recorders there are some which can only be used on special machines and are usually referred to as cartridges in order to distinguish the cc system and the 8-track system. These are not necessarily compatible and can normally only be used with the type of cartridge intended for them. The cartridges most widely used—particularly in the USA—are four-track (Fidelipac) and eight-track (Lear Jet) cartridges for stereo. Both systems use quarter inch tapes which are often BASF type LP 36. In these cassettes the tape is unwound from the inside of the reel and wound up again on the outside in the same way as endless tape cassettes for spool recorders.

The tape is driven by a capstan and rubber pressure roller which, depending on the design of the machine, is either

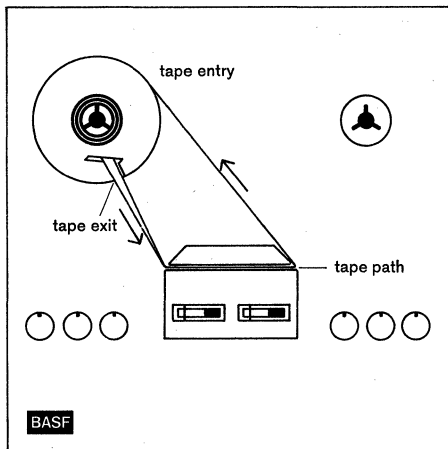


Fig. 68. Endless cassettes for spool tape recorders are placed on the left-hand hub of the recorder. If the hub should turn its own accord due to the spool motor arrangement, the cassette must be secured to the deck.

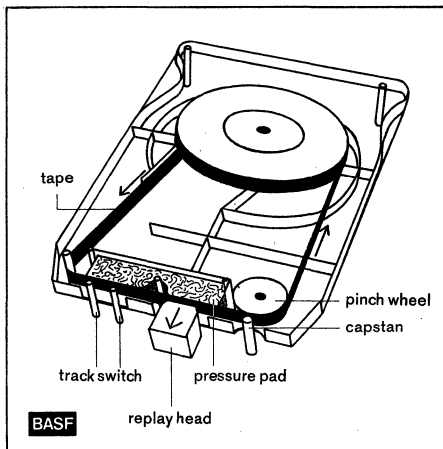


Fig. 69. The tape is unwound from the inside diameter of the reel and wound up on the outside diameter.

incorporated in the machine and extends into the cartridge through a hole, or is incorporated in the cartridge itself (see Fig. 69). Because of the relatively high tape speed 9.5 cm/s ($3\frac{3}{4}$ ips) it is possible to achieve a fairly high quality of reproduction. Most of these cassette players are intended for permanent installation in restaurants etc. or in motor cars.

These special endless cartridges are normally fitted with duplex head systems, the choice of track depending in which direction the tape is running. In the case of the eight-track cartridge system, four stereo programmes can be recorded on the same tape.

Since endless cartridges for spool tape recorders and for special tape recorders have no fast wind or rewind, it is not possible to locate a particular programme title quickly at any point

along the tape as with reel to reel operation or compact cassettes.

In most cases it is not possible to prepare one's own programmes for these cassette systems as most machines available have no recording facilities. Exceptions to this however, are spool tape recorders with a built-in cartridge recorder (see Fig. 70). Such machines have an additional selector switch by which straight spool operation, straight cassette operation (cartridge) or copying spool tape recordings to cartridges can be selected. Track selector switches permit the selection of a track for recording and playback as on spool machines.

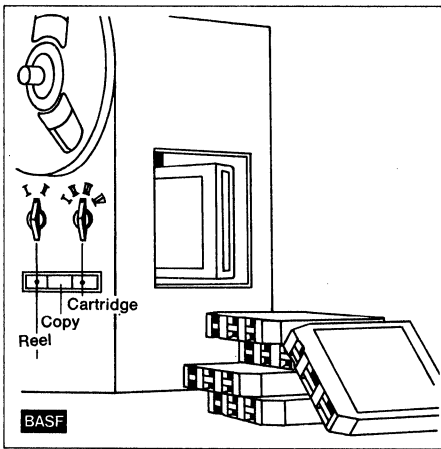


Fig. 70. Spool Tape Recorder incorporating a Lear Jet Cartridge Recorder Eight-track stereo. By actuating the press button the selector can be switched to reel operation (Reel), cartridge operation (Cartridge) or Copy. The track desired in any particular case can be selected on the spool tape recorder (Reel I and II) and cartridge recorder (Cartridge I, II, III, IV) by the Track Selector Switch.

12. How is a Tape Library Arranged?

In the first place the library should offer the best conditions for storing magnetic tape so that these, as well as the recordings which they contain, are kept in perfect condition. In addition the "access time", i.e., the time taken to locate a particular tape and recording should be as short as possible.

12.1 Storage Conditions for BASF Tapes

The following recommendations are the result of many years of experience in storing and handling recorded tape.

12.1.1 Air Humidity

The mechanical and electro-acoustic properties of BASF tapes are practically unaffected by humidity of the air during storage. This is not so with magnetic tapes on acetate base (these are not manufactured by BASF) which are sensitive to humidity and temperature and thus require air conditioned rooms to prevent the tapes becoming brittle during prolonged storage.

12.1.2 Storage Temperature

Temperatures above 50° C should as far as possible be avoided. Thus tapes should not be exposed to the direct heat of the sun. The same, incidentally, applies to gramophone records and compact cassette tapes.

Because of the risk of print-through, which depends on temperature to a

marked extent, recorded tapes should be stored at temperatures well below 50° C. Print-through is the effect of the recorded sound being copied on adjacent layers of tape on the spool, Print-through may also be more pronounced if the tapes are exposed to higher temperatures for a short time, for example above 40 or 50° C. Recorded tapes are therefore best stored at room temperature. In that case print-through will not occur with spool tapes and compact cassettes manufactured by BASF which have good anti-print properties.

12.1.3 Magnetic Stability

The magnetic stability of BASF tapes does not depend on storage time. The extent to which the reproduction level changes in time is merely a matter of the frequency at which the tapes are played. It is important that the tapes are only played on well maintained machines in order to prevent mechanical damage. Thus the tape and the tape recorder should be regularly serviced (see Chapter 13). If these precautions are observed the life of a magnetic recording on tape is practically unlimited.

12.1.4 Print-Through

This means the transference of a sound recording on the adjacent layers of tape in a reel. Print-through depends on a variety of factors, one being the storage temperature of the recorded tape. This should be between +15 and +25° C which in most cases is average room temperature and best for storage. Print-through is also affected by storage

time, the recorded wave-length, properties of the oxide, the thickness of the coating and the distance between neighbouring turns of the tape coil.

In order to keep print-through at an absolute minimum even with prolonged storage at elevated temperatures it is recommended that recorded tapes are unwound and then re-wound once a year.

Alternating magnetic fields also counteract the anti-print effect if the field strength is more than 1 amp/cm. For example the earth magnetic field is 0.16 amp/cm but is of negligible effect in this respect, particularly as the magnitude of the field is constant.

However, with domestic tape recordings print-through hardly matters, even if LH tapes are used which, compared with a normal tape, have a slightly lower anti-print effect because of their higher density and finer oxide coating material. Print-through does to some extent depend on the wave-length of recorded signals and is more likely to occur on recordings made at high tape speeds. In addition, the thickness of the oxide layer is not fully utilized with domestic machines, since combined heads are used and even when thinner magnetic tapes are used the distance from the recording to the adjacent tape layer is relatively large. This all helps to keep print-through to a minimum.

12.1.5 Stray Magnetic Fields

These are magnetic fields which in most cases are due to mains transformers and should not exceed a field strength of 1 amp/cm. However, a tape placed

close to a magnetic field of this strength could be affected by it. Tapes should be placed 1—2 yards away from all electrical appliances that have a fairly strong magnetic field.

12.1.6 Storage in Confined Space

In the library the spools should be placed side by side. Possible containers for such arrangements are BASF plastic swivel boxes (see Fig. 71). These permit storage at various levels and also allow immediate access at each level due to the low pivots. With this arrangement of the library, only very little space is required and the mechanical forces exerted upon the tape are extremely small. Flat stacking of a considerable number of tapes should be avoided since in this case, and in particular when storage takes place for a prolonged period, the spool flanges may become distorted.

12.2 Library Storage System

As soon as the number of magnetic tapes to be stored in a library exceeds three, a system of library storage should be arranged which permits as brief an access time as possible not only to the tapes but also to the recordings stored on them. Three was chosen, since the BASF library box holds exactly three tapes and presents no problem as a unit for either labelling or space.

Before the library system is planned one should decide whether all magnetic tapes are to be put into the library on their original spool without editing, or whether to adopt the studio practice of

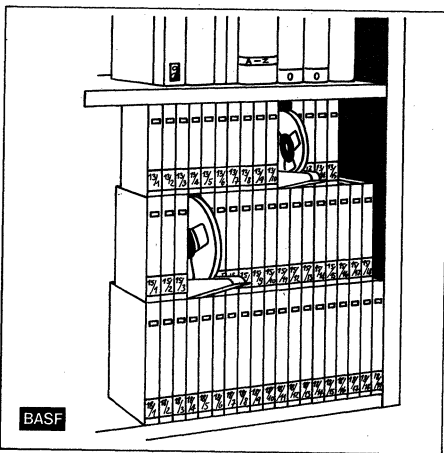


Fig. 71. BASF plastic swivel boxes allow tapes to be stored at various levels and permit immediate access at each level due to the low support of the pivots.

similar subjects on collective spools (see Chapter 10).

12.2.1 Numerical Sequence

It is sufficient to number all tapes consecutively, starting at 1. Tape labels are supplied with all BASF plastic swivel boxes for spools and compact cassettes. An index card can be prepared for each tape or compact cassette.

12.2.2 Numerical Sequence of Spools

If the studio system is adopted, tapes with spools of various sizes will in the course of time accumulate in the library. BASF offer tapes in plastic swivel boxes for spools of 8 to 18 cm (3 to 7 in) diameter and slide-in boxes, available for spools of 22, 25 and 26½ cm (8¾, 10 and 10½ in) diameter. See para-

graph 1.7 for details of spools. For spools of different sizes it is advisable to introduce a number for each spool beginning at 1, preceded in each case by the size of spool, for example 18/1, 15/1, 22/1.

Here an index card should be prepared for each tape. The advantage of such an arrangement is that the index card shows immediately the size of spool so that access time is reduced.

12.2.3 Chronological Sequence

Although a chronological sequence is very rarely required, an additional index card could also be prepared on which all tapes with their tape numbers are listed in chronological order.

12.2.4 Order by Category

In order to arrange tapes by categories, such as light music, classical music, dance music, interviews etc., the index cards may be given a numerical sequence, the spools being arranged by categories or vice versa.

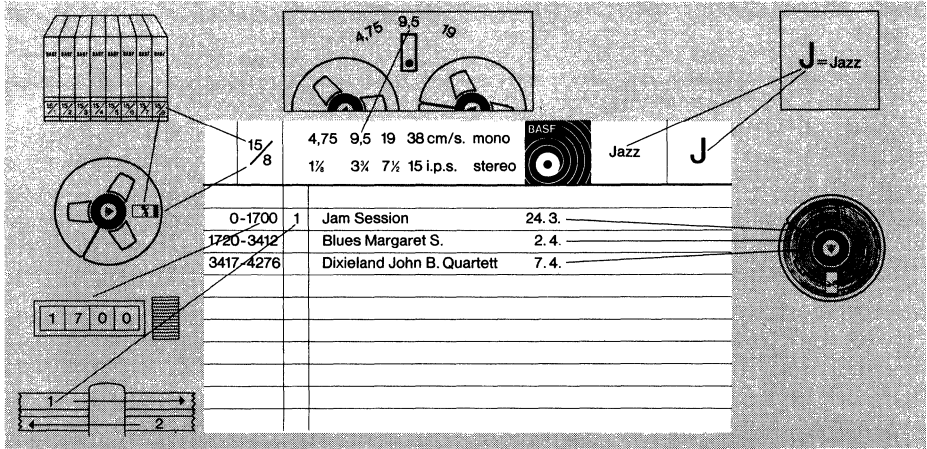
12.2.5 The Tape Index

A completed index card (see Fig. 72) should contain all the information for quick reference to a given recording on a tape. This comprises: Date, track position, type of recording (mono or stereo), counter reading, tape speed, tape number, tape content. There is enough room on the BASF index cards for detailed notes on the contents of a tape. The layout of the index card is left to the user. Incidentally, BASF card

indexes can be obtained free of charge from shops or directly from BASF. The

address is: BASF, Tape Questions — Tape Answers, D 67 Ludwigshafen.

Fig. 72. The BASF Library Index Card enables an individual recording to be located quickly on a spool of tape containing many recordings.



12.2.6 **Tape Inscription**

It is advisable to write the tape number on the spool label of each tape.

Labels for spools are available in the BASF Leader Tape Set and the BASF Hobby Box. In addition the spool num-

ber may be written, for example by means of a ball point pen, on the leader tape. A wax pencil (chinagraph) like that supplied with the BASF Hobby Box can be used to write on the back of the tape, for example for adding sound to 8-mm film (see chapter 17).

13. Tape and Recorder Maintenance

As already pointed out in paragraph 12.1.3 it is necessary to keep both the tape and tape recorder in good condition. Complete servicing and maintenance of a tape recorder requires the use of testing equipment to check the mechanical and electrical performance of the instruments. The following will therefore, be limited to those jobs which the amateur may carry out himself.

13.1 Cleaning the Tape

Many modern tape recorders are fitted with special cleaning pads which automatically clean the tape whilst it is running through the machine.

For this a soft leather cleaner of the kind used for spectacles can be used. These are obtainable from most opticians. However, a piece of linen or soft chamois leather would be satisfactory. The cleaning material is gently held against the tape during fast wind or rewind. Both sides of the tape should be cleaned.

After this has been completed it is advisable to rewind the tape again as the extra pressure exerted upon it may have wound it too tightly which, in the case of extremely thin tapes, could cause stretching.

13.2 Cleaning the Tape Recorder

The tape deck should be cleaned regularly so that dust does not settle on the tape during operation. In addition it is advisable to clean all parts in contact with the tape frequently, such as the tape guides, magnetic head, capstan and rubber pressure roller. This may also be done by means of a piece of linen or soft leather. Accumulation of tape dust can be removed with alcohol. In addition the guide pins and the head channel may also be cleaned by means of cotton wool wrapped around the top of a match stick. Never use metal tools, which may have become magnetized, on the heads or guides as this could result in magnetization of these parts and hence a high noise level on recording.

If fine scratches are noticed on the back or the front of the tapes, all parts in contact with the tape should be examined for rough surfaces.

Deposits on the magnetic heads reduce head-to-tape contact which in turn can cause loss of high frequencies (the recording sounds dull), drop-outs (brief recording failures or volume fluctuations) and hence a reduction of recording quality (see Fig. 73).

13.3 Demagnetization

If parts in contact with the tape become magnetic, for example because they have been touched by magnetic objects, the recording can be magnetically affected. This results mainly in a

high noise level which will remain on the tape until it is erased. In this case it is necessary to demagnetize all parts in contact with the tape, including the magnetic head channel and the capstan. For this purpose a demagnetizer can be purchased. After the demagnetizer (see Fig. 74) has been connected to the mains it is passed with a stroking motion over all parts that come into contact with the tape but without actually touching them. It is then pulled away and only then is the mains plug withdrawn. This ensures that any residual magnetism is completely removed from parts likely to have become magnetized. Note: Demagnetizers are not meant to be used for erasing magnetic tapes. If a recorded tape is so treated, the recording will be only partly erased. To erase the recording on a tape it is only necessary to run the tape through with the recorder in the "Recording" position and with the

recording volume control turned down. In studios special magnetic bulk erasers are often used to erase a whole tape quickly without having to run it through a recorder.

13.4 Alignment of Magnetic Heads by BASF Alignment Tape

The playback and recording heads or combined record/playback head of domestic tape recorders are arranged so that they can be adjusted for height and for their vertical position relative to the edge of the tape. Correct height of the magnetic head is required in order that tapes are playable on any tape recorder with international track pattern (see paragraph 4.2) and can be reproduced with the best possible quality.

Fig. 73. If foreign bodies (for example grains of dust) are present a supple tape still provides better tape-to-head contact than a stiff one.

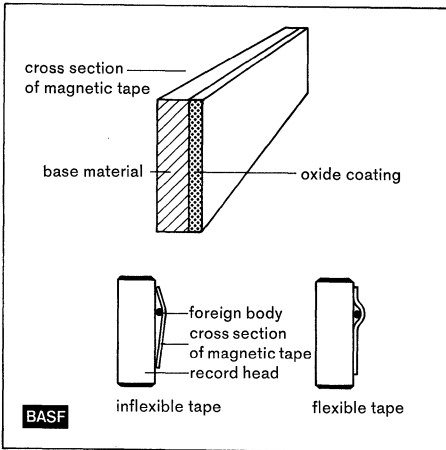
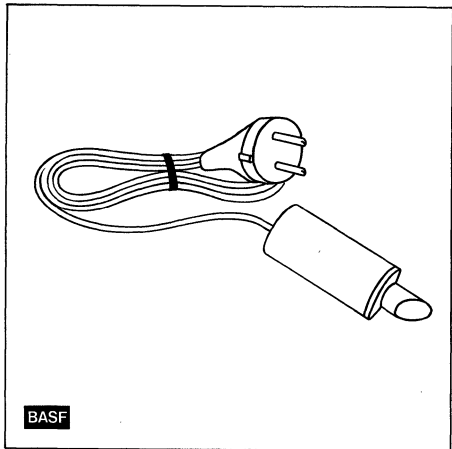


Fig. 74. The demagnetization tool serves to demagnetize all parts in contact with the tape, including the magnetic head channel and the capstan.



The height adjustment of the magnetic heads of quarter-track machines is more critical than for half-track machines. Maximum cross talk attenuation can only be obtained on both tracks of quarter-track machines if the height of the magnetic head is correct. The BASF Alignment Tape can be used to adjust the height of quarter-track heads without having to use other instruments.

The vertical position of azimuth alignment of the magnetic heads, on the other hand, is particularly important for half-track machines less critical for quarter-track machines.

It is laid down internationally that the angle between the edges of the gap in the magnetic tape head and the direction of travel of the tape shall be 90° . This is necessary to prevent scanning losses at high audio frequencies when recorded tapes are exchanged.

For this it must be imagined that an oblique head gap has the effect of being wider than an exactly vertical one. With combination heads this would not result in reduction of tonal quality when the tape is played on the machine on which it was recorded. If the tape is played back on another machine on which the head gap is accurately aligned, then there would be a perceptible loss of high audio frequencies. Accurate vertical alignment is when the angle is exactly 90° . Since 1° can be divided into 60 minutes and a few minutes deviation has an audible effect then adjustment is obviously critical. Such a small deviation is not visible with the naked eye but the BASF Alignment Tape enables a head gap to be aligned accurately by listening.

13.4.1 The BASF Alignment Tape

For this purpose, a standard recording is made on the BASF Alignment Tape. This enables the playback head to be adjusted properly by the ear alone.

The recording on the alignment tape is called 'white noise' which at a tape speed of 9.5 cm/s ($3\frac{3}{4}$ ips) is made up of frequencies from 5.6 kHz to 16 kHz. At a tape speed of 4.75 cm/s or 19 cm/s ($1\frac{7}{8}$ or $7\frac{1}{2}$ ips) respectively the noise contains frequencies of 2.8 kHz to 8 kHz or from 11.2 kHz to the upper limit of the audible range. Track 3, relative to standard quarter-track, contains no recording.

13.4.2 Azimuth Alignment of the Head Gap

The playback head or combined record playback head is best adjusted at a tape speed of 9.5 cm/s ($3\frac{3}{4}$ ips). The alignment tape is run in the "playback" position (selecting track 1 on quarter-track machines) and the tone control of the tape recorder or replay amplifier is adjusted to give a 'treble' boost. The adjusting screw on the magnetic head (playback or combined head) is turned one way and the other changing the position of the head until the noise becomes a high pitched hissing sound and is as loud as possible. This indicates the point of correct azimuth alignment.

On machines which have separate recording and playback heads the BASF alignment tape can only be used for the adjustment of the playback head. The recording head must be adjusted for gap position and height of tracks

independently. However, it is possible to do this by first aligning the playback head by means of the alignment tape. Another tape is used to record, for example, via an FM receiver without aerial—a uniform steady noise that becomes as loud as possible when the point of correct azimuth alignment has been reached. The recording head is aligned by monitoring the noise off tape from the playback head of the tape recorder.

It should be noted that recordings made with heads that were originally out of alignment may well exhibit a loss of high frequencies when played after the head(s) have been re-aligned. New recordings will of course have correct azimuth alignment.

13.4.3 Adjustment of Height with Quarter-track Playback and Combination Heads

To adjust the playback head on quarter-track machines for height, the tape is run in the same way as for the adjustment of the gap position, except that the blank track 3 is listened to instead of track 1. The adjusting screws provided for raising or lowering the height of the head or suitable shims are used to change the height of the head until the noise from the recorded track is reduced to a minimum. Since azimuth alignment and the adjustment for height affect each other it is advisable to repeat both alignment procedures.

For alignment of the recording head on machines with separate recording and playback heads see paragraph 13.4.2.

14. Exchange of Recorded Tapes

The points to be remembered when exchanging recorded tapes include:—

- The tape speed
- The track pattern
- The maximum spool size
- The alignment of the magnetic heads

14.1 Tape Speed

Almost all tape recorders run at a tape speed of 9.5 cm/s ($3\frac{3}{4}$ ips). This speed should therefore, always be used when tapes are exchanged unless a different speed has been agreed with the correspondent.

If, when playing back recordings made on a tape recorder other than one's own, the pitch is too low or too high, this may be due to speed deviation of either machine. According to Standard Specifications the permissible tolerance for

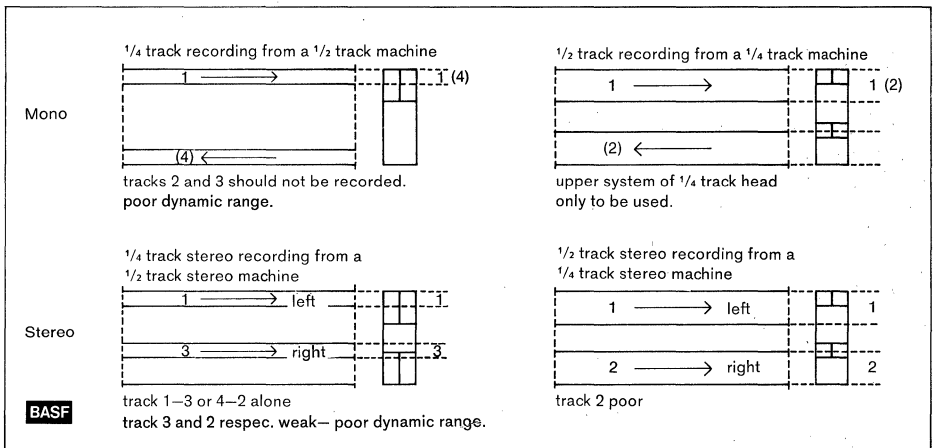
domestic tape recorders is $\pm 2\%$ and for HiFi machines $\pm 1\%$ deviation between nominal and actual speed.

One can carry out this test easily with the aid of a stopwatch and a tape 9.5 m ($31\frac{1}{4}$ ft) long. At a tape speed of 9.5 cm/s ($3\frac{3}{4}$ ips) a piece of tape 9.5 m long should run through in 100 sec. A domestic tape recorder is therefore within the permissible tolerance limits if, at a speed of 9.5 cm/s the 9.5 m length of tape passes through within 98 to 102 seconds. With a HiFi tape recorder the tape should pass through within 99 to 101 seconds.

14.2 Track Pattern

Fig. 75a shows the track pattern when recorded mono or stereo tapes are exchanged for playing on half-track and quarter-track machines.

Fig. 75a. Possible reproduction alternatives: Quarter-track recording on a half-track machine (left half of diagram) and half-track recording on a quarter-track machine (right half of the diagram).



14.2.1 Exchange between Quarter-track and Half-track machines with Mono Recording

Only the edge track may be recorded because a half-track head will play back the edge track and in addition, part of the inner track in the wrong direction, i. e., in reverse. When half-track recordings are played back on a quarter-track machine, only the upper head system should be used on the latter. If the lower head system is switched on as for duo-play or for stereo operation, part of the second track is replayed backwards.

14.2.2 Tape Exchange between Quarter-track and Half-track machines with Stereo Recording

When a quarter-track recording is played back on a half-track stereo machine, only one pair of tracks may be recorded otherwise the other pair of tracks would be heard replayed backwards.

When quarter-track stereo recordings are played back on half-track stereo machines or when half-track stereo recordings are played back on quarter-track stereo machines, only part of the right-hand channel is scanned and its reproduction is therefore weak.

14.3 Maximum Spool Size

The BASF Letter Tape is preferred for tape corresponding. In its new form it is packed in the plastic swivel box 8 cm (3 in) and it is available with 65 m (210 ft) of long play tape, 90 m (300 ft) double play tape or with 135 m (450 ft) of triple play tape. The mailing weight of the new BASF Letter Tape is, for all the above types of tape, less than 4 oz (see also paragraph 1.7). The letter tape can therefore be sent at low postage rates both to home and abroad.

Depending on the type of tape the playing times at 9.5 cm/s ($3\frac{3}{4}$ ips) varies from 11 to 22 minutes per track.

If larger spools are used for tape exchange it is necessary to enquire from the correspondent the maximum spool size his recorder will accept.

14.4 Head Alignment

Adequate head alignment is necessary in order to achieve perfect reproduction on tape recorders used by tape correspondents. The points to watch, and an easy method or do-it-yourself alignment of the heads by using the BASF Alignment Tape is described in detail in paragraph 13.4.

15. Exchange of Recorded Cassettes

Exchange of recorded cassettes is only possible within the same system. The following remarks refer to the exchange of recorded cassettes, using the most important varieties of cassettes. Compact cassettes are particularly suitable for exchange. It will be seen from Fig. 75b that stereo recordings can be played back without difficulty on mono machines and mono recordings—although of course in each case without stereo effect—on stereo recorders or players. (See also paragraph 3.4.)

The BASF plastic swivel box KK 8 is particularly suitable for the exchange of recorded compact cassettes. It is a mailing box closed by a split clip. This enables the closing tab to be easily opened for checking so that when such a package is sent a reduced postage rate applies. The mailing weight of the plastic box, containing a C 60, C 90 or C 120 compact cassette is less than 4 oz.

Each BASF plastic swivel box KK 8 with compact cassette is provided with a hub clip. This is inserted into the plastic hubs of the compact cassette when it is put into the library or when it is sent by post so that the hubs cannot rotate and form tape loops within the cassette.

Despatch labels are enclosed to permit easy writing on the plastic cassette. These labels, which are self-adhesive, can later be removed if the compact cassette is to be put into the library.

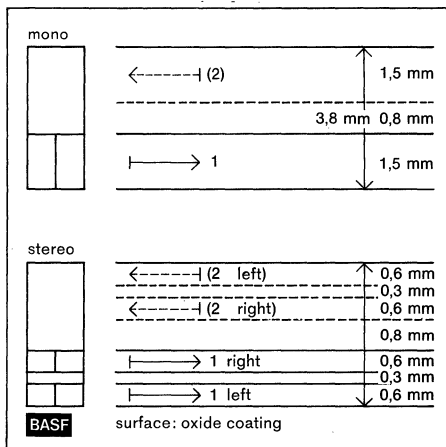
Since the compact cassette system is now widely used and since the mailing weight of a cassette is low, compact cassettes are very popular for tape-sponding.

The DC (double cassette) is not compatible with the compact cassette. Thus DC cassettes cannot be played on compact cassette machines and vice versa. Since DC machines are no longer manufactured, DC cassettes are only employed for the exchange of letter tapes if previous enquiries have established that both correspondents are in possession of this type of cassette recorder.

Eight-track and four-track stereo cartridges are less suitable for tape letter correspondence as few of these machines are used for domestic recording (see also paragraph 11.2).

Endless cassettes for pool tape recorders can be exchanged if the notes given in Chapter 14 are observed. How-

Fig. 75b. Track Pattern of Compact Cassettes.



ever, care should be taken to ensure that the tape loop extending from the cassette is not damaged. BASF endless cassettes are therefore supplied in a folding box in which the hub is

locked and which guarantees firm support for the endless cassette during transport so that damage to the tape loop is prevented.

16. How is Sound Added to Slides?

The number of people who take colour slides increases from year to year. Reversal film offers an uncomplicated way of taking photographs. The 35-mm film cartridge or cassette is loaded into the camera, the exposed film is sent to the processing laboratory which sends back the set of slides, framed, post paid, at an inclusive charge.

As the number of slides taken increases—camera owners with more than 1000 slides are no longer a rarity today—there arises the problem of a suitable commentary for the set of slides being shown. Not every amateur photographer can make improvised speeches or tell amusing stories about the slides in order to make the show entertaining.

This is where tape comes in—and the slide show becomes a sound picture. However, many are under the impression that adding sound to slides is very complicated. In addition many people think that adding sound to slides is relatively expensive both as regards the projection equipment and the sound equipment, and involves the purchase of new machines (slide projectors, tape recorders, slide control appliances). In principle it is possible to add sound to slides with any commercial tape recorder and any projector. The following points should be noted for the projected picture and sound show.

16.1 The Pictures

The slides chosen for a slide/sound show should be selected with special regard to the subject. Next the sequence of the slides within the series

should be determined. Advanced photographers do this by means of a slide show slat—a wooden rod with a deep milled groove into which the slides can be placed vertically side by side—or a pre-viewer, a box containing a piece of ground glass illuminated from the rear so that the slides can be viewed clearly. Both these accessories could be made at home but are obtainable from photographic dealers.

When the various slides have been chosen, some thought should be given to projected length of the slide show. As a rough rule it should be assumed that if a single slide is shown for approximately 10 seconds, 30 slides will have a showing time of 5 minutes.

16.2 The Sound

With the most common tape speed of 9.5 cm/s ($3\frac{3}{4}$ ips) a 5 minute slide show requires a tape length of approximately 100 ft. Thus a spool of 8 cm diameter (3 in) containing 65 m (210 ft) of long playing tape or 90 m (300 ft) of double play tape is sufficient for a playing time of 2 or 3 five minute shows respectively. As regards the sound accompaniment there are no limits to the possible variations. They range from a simple commentary by one speaker to a carefully written script for commentary by more than one person, together with background music and sound effects.

A properly written script costs nothing and no extra equipment is required other than the tape recorder and a microphone to record it. On the other hand all kinds of sound mixing with an external multi-channel mixer unit and other equipment is possible.

16.3 Preparing a Script

If the sound track involves musical fade-ins, sound effects and roles for several speakers, a script should be prepared. Our example (Fig. 76) shows a page from a sound picture show entitled "Lake Constance". On the left-

hand side are the directions for the fade-ins to be used at the various points, in the centre the slide numbers and on the right-hand side the text for the two speaking parts. The three crosses each point during the sound track indicate where the slides are to be changed.

Fig. 76. Example of a script.

Directions

Slide No. Speakers

		"Oldest castle in Germany, Annette von Droste-Hülshoff, many tourists, picturesque little alleyways, magnificent wines ..."
	12	... and nice cosy inns. xxx
		At the inn "Zum Bären" at the Obertor, my Peter suddenly came to life ...
		Peter: ... such a good Weißherbst wine. Ha, keeps body and soul together.
		Helga: Never mind, Peter; our landlord could do that much better.
End of Music Title		
	13	Peter: Your health, Helga! xxx
Hubbub in the inn as moderate back-ground		Helga: Your health, Peter! To the Lion of Lindau and the happiest man in the world!
	14	Peter: Ah – Tell me, landlord, why is that xxx lion at the harbour entrance of Lindau?
		Landlord: That lion that is to remind people that Lindau came to Bavaria in 1806 and still is Bavarian.
		Peter: Ha, in that case we should really drink Bavarian beer.
		Landlord: It is all right for you to drink our Meersburger Weißherbst. That is certainly no worse than Munich beer.
Fade-out hubbub		
	15	Helga: Constance! xxx
		Peter: The old free imperial city!
		Helga: Here we are at the arch, quite recovered.

16.4 Slide Control

The correlation of picture and sound depends in each case on the projector used. Basically slide projectors are divided into 4 different groups: —

- The manual projector
- The semi-automatic projector
- The automatic projector
- The fully automatic projector

16.4.1 Manual Projector

With these projectors the slides are put individually into a slide changer by hand, projected and returned again to the slide box (see Fig. 77).

16.4.2 Semi-automatic projector

This is fitted with a slide magazine. The slides—30 or 50 depending on the capacity of the magazine—are inserted into the slide magazine. The change-

over is controlled manually by the actuation of a slider.

16.4.3 Automatic Projector

This has a slide magazine and the slides are automatically changed either by a mechanism on the projector itself or remotely by means of a cable (Fig. 78).

16.4.4 Fully automatic Projector

With this projector the slides can be changed and the lens refocused automatically. Reversal of the magazine movement can also be effected by remote control.

When a manual or semi-automatic projector is used care must be taken at every show that the slide to be projected fits the commentary. For this purpose a warning signal such as a brief tapping sound could be recorded on the tape. When this signal is heard the projectionist knows that the next slide must be shown.

Fig. 77. Manual Slide Projector. The slides are put into a slide changer by hand, projected and again returned to the slide box.

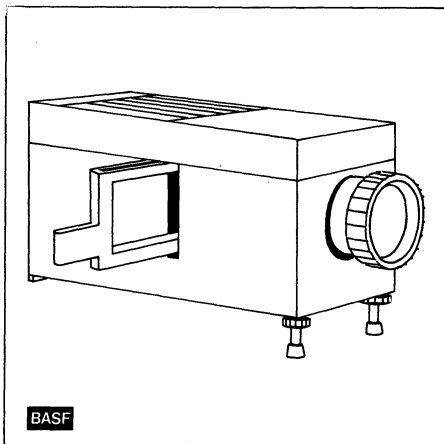
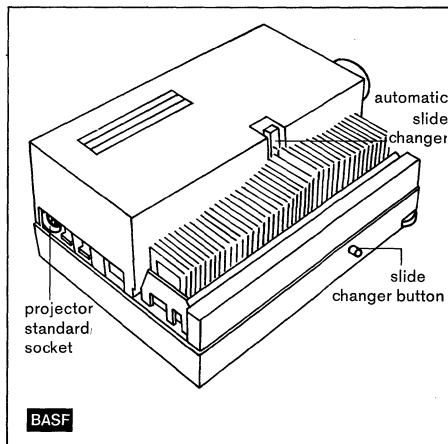


Fig. 78. Automatic Slide Projector.



With an automatic projector the procedure is identical unless a slide control unit is available. Because of the remote control cable it is not necessary for the projectionist to stand next to the projector. For lectures with demonstrations the slide projector and the tape recorder may thus be remotely controlled. The tape recorder must however, be equipped with a quick-stop or pause button.

16.5 Automatic Slide Control—External and Internal Systems

When automatic slide control is used, the slides are changed by signals recorded on the tape. The sound track is first produced without the projector and slide control unit the pulses for the slide control unit being recorded afterwards. There is, however, an internal and an external slide control system.

16.5.1 The External System

Fig. 79 shows the arrangement of the equipment. The slide control unit is placed on the right of the tape recorder, and the tape loop is put into the tape guide. In principle the slide control could also be placed at the left of the tape recorder, but this might give rise to wow and flutter due to drag on the tape.

As will be seen from Fig. 80 the slide control unit has a pulse head—in most cases a reversed quarter-track head whereby the head system covers the bottom 1 mm of the magnetic tape. The same head system is so wired that it is used for erasure, recording and playback of the pulses. Normally the slide control unit has no on/off switch. When connected to the mains it is ready for operation.

The selector switch of the slide control is first set to 'record' and on most units a red light comes on to indicate this. Erase is automatic by means of direct current through the head. An additional

Fig. 79. Arrangement of Equipment for Automatic Slide Control with External Control Unit.

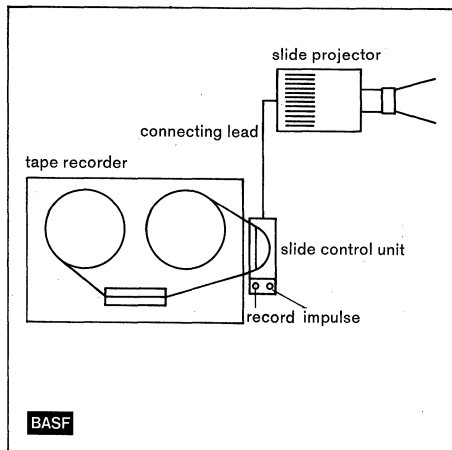
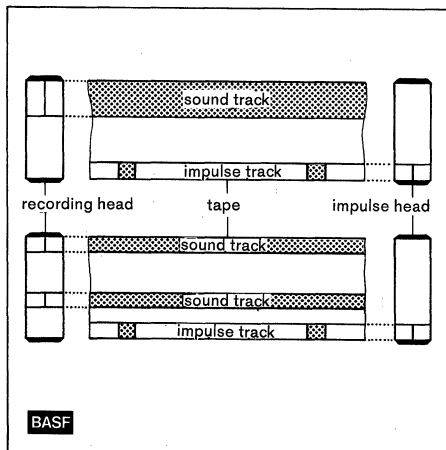


Fig. 80. Position of Pulse Track for Slide Control on Half-Track and Quarter-Track Machines.



button, the pulse button, supplies a low frequency pulse, which is recorded on the tape. When this button is pressed the slides are changed as well. The control unit is then set to playback. The pulses recorded on the tape will now change the slides automatically.

There are also external slide control units whose operating voltage is supplied through the standard projector socket (Telefunken Diachron Universal). On these the projector cable of the slide control unit is connected to the standard remote control socket of the projector.

16.5.2 Recording the Pulses

The tape recorder is made ready in the "Playback Position". The tape loop is put in position on the slide control unit. Each time a slide is to be changed, the pulse button on the control unit must be pressed. This records the pulse and the projector will then change one slide at that point. If the pulse button is kept depressed for one second the pulse recording will occupy $3\frac{3}{4}$ in. of tape if the tape speed is 9.5 cm/s ($3\frac{3}{4}$ ips).

When all the pulses have been recorded, the slide control unit is set to "playback". The tape loop is removed from the guide of the control unit and the tape rewound. For replay the tape is threaded through the guide and the slide show can commence. If, however, the tape is inadvertently rewound via the slide control unit without the latter being set to Playback, all pulses will be erased.

A wrongly recorded pulse can be erased and a new one recorded. The slides are projected as far as the wrong pulse and the tape is stopped. The selector switch on the slide control unit

is set to "recording," and a new pulse is recorded to replace the previous one. Should the wrong pulse have passed the head, the left-hand spool can be pulled back manually with the machine in the "quick stop" or pause position.

16.5.3 The Internal System

Certain types of tape recorder—see the table on "Slide Control Units"—are, or can later be, fitted with a pulse head in the tape recorder. This has the advantage that no tape loop need be extended. If the tape recorder incorporates all the functions for internal slide control it need only be connected to the automatic slide projector.

The track position is selected and the tape recorder set to the "Slide Pulse Recording" position by appropriate selector switches. The tape carrying the sound commentary is then run, the pulses being set at the same time by actuation of the pulse button on the tape recorder in the same way as for an external slide control (see paragraph 16.5.2) (see Fig. 81).

Tape recorders which are later equipped for internal slide control may sometimes require additional external fittings incorporating the pulse button.

16.5.4 Table of Slide Control Units

The table of Slide Control Units (Fig. 82) lists the German brands of slide control units for domestic tape recorders which can at present be obtained from retailers. It is sub-divided into external and internal appliances. With the internal system the bottom track is always used for the pulses.

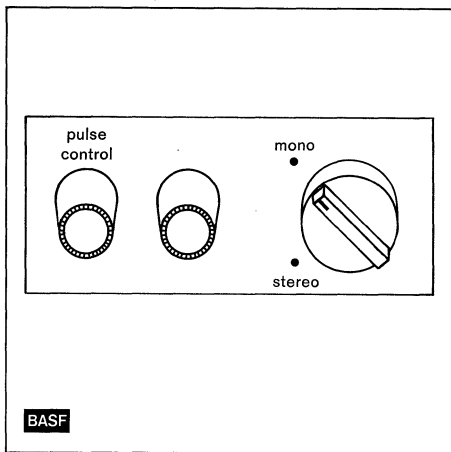


Fig. 81. Tape recorders incorporating an internal slide control are provided with additional selector switches for pulse control and in some cases for track selection of the pulse track. The pulses are recorded after the machine has been set to "Recording Slide Mono" or "Recording Slide Stereo".

Fig. 82. Table of Slide Control Units.

Table of Slide Control Units (Position January 1971)

A. External Slide Control Units

Make	Power Supply	For Use with all Tape-Recorders?
AEG Diachron Universal S	Standard Projector Socket	yes
Grundig Sonodia	Mains	yes
Philips EL 1995	Battery	yes
Saba Diataktgeber		only for certain Saba Tape Recorders
Uher Diapilot II F 422	Mains	yes

B. Internal Slide Control Units

Make and Type	Pulse Head built-in or can be fitted afterwards
Braun TG 502, TG 504	can be fitted afterwards
TG 1000	can be fitted afterwards
Grundig TK 246, TK 248	can be fitted afterwards
TK 600/TS 600	can be fitted afterwards
Philips PRO 12	can be fitted afterwards
Saba TG 543	built-in
600 SH	built-in
Uher Royale de Luxe	built-in

Use of different Control Unit. If the impulses were recorded by means of one slide control unit and the slide show is to be projected with the aid of a different slide control unit, it may be necessary to check whether the pulses have all been recorded in the first place.

16.5.5 Exact Synchronism between Slides and Sound

When a slide projector is pulsed for the next slide, there is a short interval before it appears on the screen. This interval depends on the type of projector. If absolute synchronism between slides and sound is required at specific points of a sound picture show, the slide should appear on the screen exactly on cue. Although it

would be possible for the pulses to be recorded a little earlier, this is not accurate enough in most cases. For any given tape speed and for a given operating interval the delay can be allowed for as follows: — (Fig. 83).

Let us assume that we have a projector requiring two seconds to change a slide, and a tape recorder running at 9.5 cm/s ($3\frac{3}{4}$ ips). If the pulse is to start two seconds before the appropriate point on the tape, it must be recorded so as to be advanced by 19 cm ($7\frac{1}{2}$ in). To do this the slide control unit must be moved 19 cm ($7\frac{1}{2}$ in) to the right of the tape recorder, when the pulses are being recorded. The slide control unit must of course be returned to its original position when the slides are being projected. The distance x by which the slide control unit must be moved towards the right when the pulses are being recorded can be calculated from the formula $x = v \cdot t$ where x is the distance in inches of the slide control unit from the recorder, v is the tape speed in inches/sec and t the time in seconds required by the projector to change a slide.

When really accurate picture/sound synchronisation is required, the pulse button must be depressed precisely on cue from the sound track and not fractions of a second earlier or later. If for example, the projector requires $1\frac{1}{2}$ seconds to change a slide and the commentary for the slides was taped at 19 cm/s ($7\frac{1}{2}$ ips), the distance x would be $11\frac{1}{4}$ inches. The distance in inches must be measured accurately before the slide control unit is moved towards the right since an error of about an inch would introduce an inaccuracy of $\frac{1}{10}$ second). The lower the tape speed, the more accurate must be the measurement. An error of one inch results in a deviation of about $\frac{2}{10}$ second at $3\frac{3}{4}$ ips and of about $\frac{1}{2}$ second at $1\frac{7}{8}$ ips.

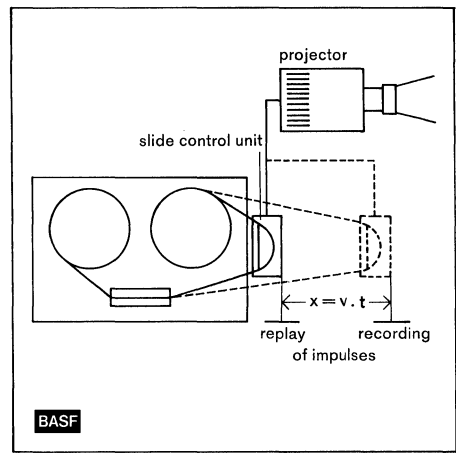


Fig. 83. Picture/Sound synchronism to an accuracy within fractions of a second can be attained by placing the slide control unit at a distance x away from the tape recorder when the pulses are being recorded. The distance x can be calculated from the tape speed (v) and the time (t) required by the projector to change a slide.

17. How to Add Sound to 8-mm Films

Picturegoers and television viewers are accustomed to perfect synchronism of picture and sound. Even so most of the sound tracks for cinema films are, for technical reasons, completed after the film production.

Most cine amateurs only possess silent film projectors and believe that adding sound is so complicated that they do not even try it.

The principle of adding sound to 8-mm film will now be described together with the most important methods of synchronization which may also help in choosing the correct kind of equipment.

17.1 8-mm Film Formats

With the exception of films for panoramic screens, the standard cinema film in use to-day has a width of 35-mm. Approximately halving this film gave us the 16-mm film which to-day is used mainly for television newsreels and by wealthy cine amateurs. By halving again, the 8-mm film was introduced during the early thirties. However, since the film itself had a width of approximately 16-mm it could be run twice through the camera. In the same way as half-track recording with magnetic tape. This format was also called "Double 8". The two tracks are cut apart and joined in the processing laboratory so that the developed film becomes one long film 8-mm in width.

In 1964 a new film format appeared in the shops, the so-called "Super 8" film followed later by another one called the "Single 8" film. The word "Super"

indicates the quality of the picture which was claimed to be better than that of normal 8-mm format. "Single" means that in contrast to the "Double 8", the film passes through the camera only once, which incidentally also applies to the Super 8.

In Fig. 84, the 8-mm formats are compared. It can be seen that Super-8 and Single-8 are identical with respect to perforation, format and track division. Thus, a Super-8 film can also be shown by any Single-8 projector and a Single-8 film by any Super-8 projector.

It is rather different when the film is taken. The two film formats are supplied in cassettes of different dimensions and design, and the film reels are accommodated differently inside the cassettes, the Super-8 cassette is wider than the Single-8. The construction of the cassette also affects the dimensions of the cameras for the two formats. Again the Single-8 camera is narrower whereas the Super-8 camera is wider.

The two film formats are therefore only compatible for reproduction. However, it will be seen from Fig. 84 that normal 8-mm film, i.e., the so-called Double-8 method, differs from the two remaining formats by picture, track and perforation arrangement. Hence a normal Double-8 projector is not suitable for the projection of Single or Super-8 films. Neither is a Single or Super-8 projector suitable for the projection of a Double-8 film.

However, there are twin format projectors which can show all 8-mm formats.

17.2 Which Film Format should be chosen?

The 8-mm beginner can choose from three film formats:

17.2.1 The Double-8 System

This is gradually losing popularity. There are already several manufacturing companies who have changed their camera or projector production for Super or Single-8 format. Ordinary 8-mm films, on the other hand, continue to be available and will no doubt continue to be sold for some years.

The Double-8 method is still worth considering and offers of second-hand apparatus for this system may be worthwhile. With a little luck it is possible to pick up high quality Double-8 equipment second hand quite cheaply. Although the price of the film material is the same as for Super-8 actual filming will be a little cheaper as with the Double-8 system the frame or picture speed is usually 16 Fps (frames per second) compared with 18 Fps for the other systems. Thus with the Double-8 method the film consumption is about 25% less.

17.2.2 The Super-8 System

This is the most popular at the moment and is steadily becoming more so. Many wellknown makers of 8-mm cameras and projectors manufacture apparatus for this system. The price of film is compatible with the Double-8 type and the Super-8 system has several advantages.

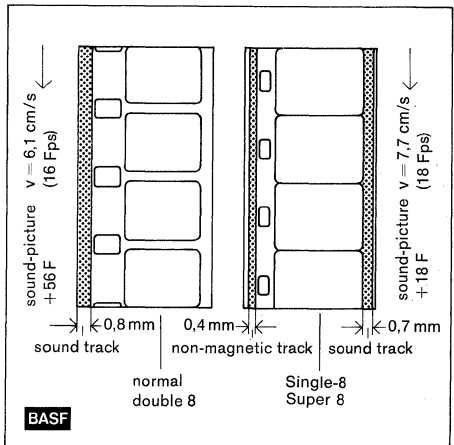
It will be seen from Fig. 84 that the format of the picture is larger and that the picture frequency has been increased to 18 Fps. All other projection conditions being the same this means that a larger picture is projected onto the screen and at the same time there is less frame flicker. The camera and film cassettes are broader than for the Single-8 since the two film coils are arranged side by side in the cassette.

17.2.3 The Single-8 System

The number of companies manufacturing cameras, projectors and films to this system is somewhat limited. As a result the films are more expensive.

Single-8 films are manufactured with a polyester base and are not subject to any special storage conditions as in the case of the two other formats, which have an acetate base (see also paragraphs 12.1.1 on Tape Storage).

Fig. 84. 8 mm Film Formats, Position of Sound Track, Picture/Sound Offset.



In the meantime the problem of splicing Single-8 film has also been solved by suitable splicing appliances so that these films can also be edited. In choosing a Single-8 system, and if the sound strip system is to be used later on, it is expedient to inquire which local specialist is capable of attaching the magnetizable track to the Single-8 film. All the advantages described for the Super-8 system apply also to the Single-8 system. Single-8 cassettes and cameras are narrower than those of the Super-8 format as the film reels are placed above one another in the cassette.

17.3 Synchronizing Systems

A sound film is perceived both by the eye and the ear. If you convert a narrow gauge silent film into a sound film you normally do it by post synchronization (Greek: *synchronos* = at the same time), that means by adapting the sound to the picture.

The sound track may be a simple one of background music or a complex track with dialogue, sound effects and synchronized speech (lip sync). When a script is prepared the degree of difficulty of adding the sound may also be determined at the same time. For example it is much more difficult if two people are speaking and are always shown in close-up. In this case the speech should be synchronized with the lip movements. If two people are engaged in conversation at a distance from the camera the speech need not be synchronized as the movements of their lips cannot be followed accurately. Synchronization of recorded speech with movement of the lips (lip sync) must not involve deviations between picture and sound exceeding a maximum of $\pm 1/10$ second even after the film and sound tracks have been run several times. In addition it should be

possible to repair a break of the film and/or a break in the tape—which is very unlikely—without affecting synchronism between sound and film.

In principle there are two methods of adding sound to 8-mm film, the single tape system (film sound strip system) and the double tape system (sound on magnetic tape and pictures on film).

17.4 The Film Sound Stripe System

This is the method used whereby the sound is recorded on the film itself. It will be seen from Fig. 84 that this method can be applied to all three film formats.

After the film has been sent back by the processing laboratory, it must first be edited as required and then sent to a specialist firm to have a magnetizable edge track attached to it. In most cases it is necessary to have a non-magnetic track on the opposite edge of the film to prevent it being wound unevenly onto the reel. The magnetic track is the same as magnetic tape but very narrow and is cemented directly on the film.

To record on sound stripe requires a sound-film projector which, depending on its design, is provided with manual or automatic recording level control and with one or more mixable inputs for the sound sources. These are usually microphone and record player or tape recorder. The price of an expensive sound film projector greatly exceeds that of a silent film projector or of a normal tape recorder. The high price of a sound film projector is due mainly to the rather sophisticated design and to the relatively small demand.

Of the three 8-mm formats the advantage of Super-8 and Single-8 as against Double-8 is that the higher film speed is better for the sound quality. The substantially more supple polyester base ensures better tape-to-head contact (see Chapter 13).

The advantages of the magnetic stripe system are: easier operation, excellent synchronization, even after years of use (provided that the exposed films are stored under the best conditions) and international film exchange, providing compatible projectors are available. The disadvantages of the magnetic stripe system are: the low film speed of 6.1 or 7.7 cm/s respectively and the narrow sound track of 0.8 or 0.7 mm respectively, and the use of a thick base material (for the Double-8 and the Super-8 formats) which reduces the quality of the sound.

Since the sound is offset with respect to the picture by a standard number of frames (see Fig. 84) if a break should occur in the film, it is not the picture and sound parts belonging to each other that are spliced but picture parts carrying the sound parts for other pictures. If some frames have to be cut out during the splicing there is no sound on the part of the film where the pictures are projected on the screen.

The offset of picture and sound is necessary for the sound strip system because the pictures must be transported abruptly, the sound on the other hand with constant tape speed.

In spite of the offset of sound and picture a sound film projector will never reach the same technical data for wow and flutter as a tape recorder. A film projection with high fidelity sound quality is not possible in any case with a sound strip system.

17.5 The Double Tape System

In many countries sales of sound synchronization equipment for narrow gauge films is usually for the double tape system, there are several reasons for this which we explain.

Prices of silent film projectors with an incorporated sound synchronizer are much lower in comparison with a sound film projector. On the other hand with many makes and types of projectors it is possible to buy the synchronization equipment afterwards. The transforming of a silent film projector into a sound film projector is made difficult by the high costs involved.

The Double Tape System means that picture and sound are on two different carriers, the picture on the 8-mm film and the sound on $\frac{1}{4}$ " magnetic tape, a Compact Cassette or an 8-mm sprocketed magnetic film.

8-mm sprocketed magnetic film has the same perforation as 8-mm optical film. A special sound film projector allows the picture and sound parts on both carriers to be run at the same speed, normally the film speed, so that synchronization, as with the sound strip system, is guaranteed. Sound quality, however, is far better due to the wider recording track on the 8-mm film.

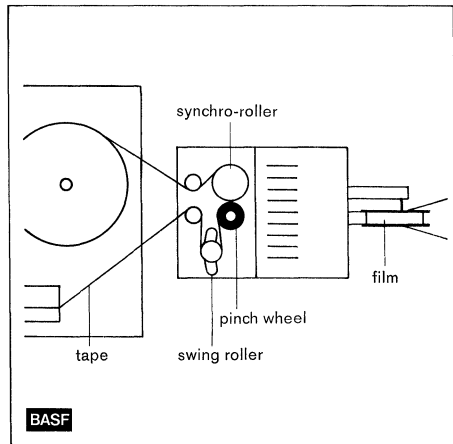
Since the number of such projectors available is very small, this system will not be considered below. Demand for 8-mm magnetic films is so small that BASF do not include them in their range of magnetic films.

17.6 Film Sound Tracks with Spool Tape Recorders

In this system the run of the film is synchronized with the tape recorder which is coupled to the projector by a suitable transmission.

Tape recorder projector synchronizing units and their method of operation are as follows:

Fig. 85. Electro-mechanical 8-mm Film Control with Swing Roller.



17.6.1 Mechanical Sound Coupling

As with colour slide control using an external control unit, a tape loop is also brought out for operating a film projector synchronising unit from a tape recorder. The tape loop passes through the synchronising unit which may be permanently fitted to the projector (see Fig. 85).

The method of operation of the mechanical synchroniser is as follows.

The magnetic tape is inserted into the synchronizing unit. It passes round a swing roller and then between a rubber pressure roller and sync control roller and returns via a guide pin to the tape recorder. The peripheral speed of the sync roller and the speed of the tape recorder should be the same, for example, 9.5 cm/s ($3\frac{3}{4}$ ips). If a different speed, for example 19 cm/s ($7\frac{1}{2}$ ips) is required a sync roller with correspondingly different dimensions must be used.

If precisely 9.5 cm of tape is fed every second to the synchronizing unit by the capstan and rubber pressure roller of the tape recorder and if the sync roller driven by the projector has a peripheral speed of precisely 9.5 cm/s, the swing roller will be stationary. If, however, the sync roller and hence the projector run too fast, the tape loop becomes smaller and detracts the swing roller. This movement brakes the projector motor, the speed of the synchronous roller drops again to 9.5 cm/s and the swing roller returns to the central position. If the projector motor and hence the sync roller are too slow, the tape loop becomes larger, the swing roller moves out and the projector motor increases speed.

With this system it is also possible to have a slow synchronised return movement which can be produced on tape recorders specially fitted for this by the actuation of a press button. On normal tape recorders the spools are rotated backwards simultaneously by hand in either the record or playback position in order to repeat or re-record parts without full rewind of both the film and magnetic tape.

Advantages of mechanical synchronizing:

Easy precise adding of sound with synchronized movement of the lips particularly on projectors which are provided with single frame projecting facilities, since successive scenes or successive effects can be re-worked.

Best sound quality depending on the choice of tape recorder employed.

Disadvantages of mechanical sound coupling:

Exchange of films with added sound is only possible within the same system. Synchronization difficulties possible with unsuitable types of tape. Robust tape such as LP 35 or LP 35 LH is recommended. With insufficient pressure of the rubber rollers the tape can slip through the capstan and cause loss of synchronization.

17.6.2 Electrical Synchronization

With this system a tape loop is brought out from the tape recorder and inserted into the synchronization apparatus. This has a sync roller of dimensions that match the speed of the tape recorder. The roller is driven by the magnetic tape.

The synchronizing unit is connected to the film projector by a cable. Thus the tape recorder and the film projector may be positioned some distance apart. For both sound recording and playback the film speed of the projector is controlled relative to the speed of the tape recorder by means of suitable electrical circuits, depending on the make and design of the machine.

Advantages of electrical sound coupling:

Easy precise adding of sound with synchronized movement of the lips. On special machines a suitable film camera may also be connected in place of the projector so that instead of dubbing a film it is also possible to take synchronous sound films.

Disadvantage of electrical synchronization:

This system is little used because of the high cost and limited choice. Exchange of films with sound tracks is limited to those who use the system.

17.6.3 Standard Synchronization

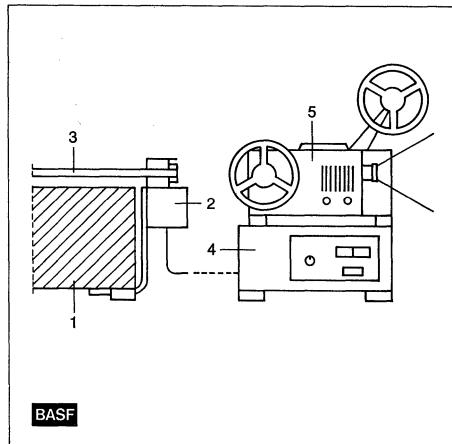
This is called the standard system because a number of manufacturers of 8-mm projectors, mainly German firms, announced early in the 1960's that they were prepared to adopt this system.

With the systems previously mentioned tape slip can interfere with accurate synchronization. This is not so with the standard system where it is not the length but the content of the tape which controls synchronism.

As with a colour slide control unit, pulses are recorded on a free sound track by means of a pulse head which is incorporated in the tape recorder or in a pulse adaptor, i.e., one designed for external attachment (see Fig. 86). The pulses are recorded automatically whilst the film runs through. For this the pulse track (see Fig. 87) will depend on the position of the pulse head.

Any normal spool tape recorder may be used for this system. The projector speed is controlled purely electrically by pulses which are recorded before the sound is added. Sound can subsequently be added by the method explained on the next page.

Fig. 86. Assembly of Equipment for the Standard Synchronization System. 1 = Tape Recorder, 2 = Pulse Adaptor, 3 = Magnetic Tape, 4 = Synchronization Apparatus, 5 = 8-mm Projector.

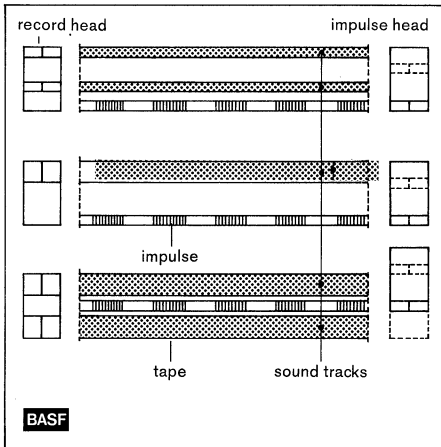


Advantage of the Standard Synchronization System:

Synchronization depends on pulses recorded on the tape that carries the sound track and not on the tape transport. Thus, changes of tape length and slip cannot affect the synchronization.

Quite a number of 8-mm film projectors can be adapted for this method. Your film projector maker will advise you on this point. The high degree of synchronization possible with this system and the fact that sound films, to which sound has been added by this method, means that films and sound tracks can be exchanged.

Fig. 87. Position of Sound and Pulse Tracks for 8-mm Film Control by the Standard Sync System. Top: Quarter-Track Sound (mono, Parallel Track, Stereo). Centre: Half-Track (mono). Bottom: Half-Track (Parallel Track, Stereo).



Disadvantages of the Standard Synchronization System:

The purchase of this system is more expensive than others employing external synchronizing systems.

17.7 The Synchronization System with Compact Cassette Recorders

Synchronous systems using compact cassettes have only recently come onto the market.

If a choice has to be made between a tape controlled system with spool or compact cassette machines, Chapter 2 should be read.

17.7.1 Mechanical Synchronization System with Recorder attached

Such a machine is shown in Fig. 88. A compact cassette recorder is attached to an 8-mm film projector. Since the tape and film drives are coupled, precise synchronization of picture and sound track is ensured. With this system it is the tape length in the compact cassette which determines synchronization. The comments made in paragraph 17.6.1 about mechanical coupling with spool tape recorders applies in principle, although synchronization will still be more precise due to the direct coupling of tape and film drive since the swing roller and sync roller system is not part of the mechanism.

Advantage of this System:

Easy synchronization of sounds which can be recorded on the compact cassette simultaneously by means of an external mixer unit. Since the machine incorporates a complete compact cassette recorder it can also be used for other purposes, although in some cases it may have to be accepted that the projector runs as well unless provision is made to switch it off.

Disadvantages of this system:

Recording facilities are not so flexible as those of a spool tape recorder. Editing of the tape recording is much more difficult than on a spool tape recorder.

17.7.2 Electrical Synchronization with separate Recorder

It will be seen from the assembly of equipment shown in Fig. 89 that this is not the same as the system mentioned in paragraph 17.6.2 but rather an intermediate film control system using the pulse synchronizing method.

As has been described in paragraph 17.6.3 the sync pulses are recorded on the tape. In contrast to the standard system, the sound tracks are recorded whilst filming.

This is done as follows:

To film and record the sound synchronously, a compact cassette recorder

Fig. 88. 8 mm Film Control with Cassette Recorder attached for adding Sound.

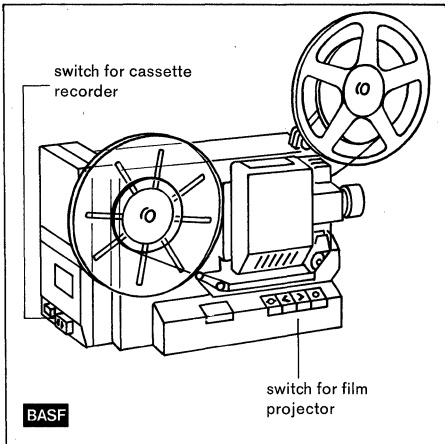
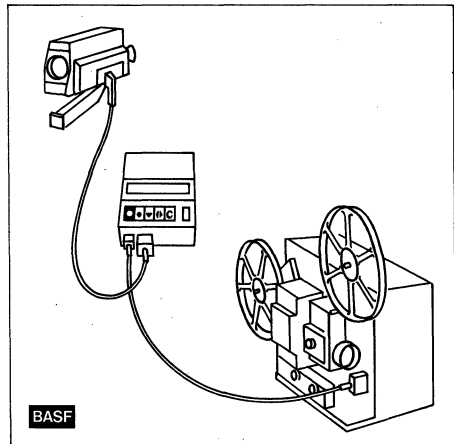


Fig. 89. Electrical Sound Coupling with separate Compact Cassette Recorder. Recording: Recorder is connected to Camera. Playback: Recorder is connected to Projector.



and a microphone are required. The film camera is provided with a built-in pulse generator, a mechanism which applies an optical starting signal on the film strip and a socket to connect the compact cassette recorder. The latter is provided with sockets for the connections to the camera and—for later reproduction of the sound track—to the projector. In addition the compact cassette recorder is provided with a duplex head system, since there is not sufficient room for an additional impulse head, as in the case of spool tape recorders. The duplex head is used to record the sync pulse track in parallel with the sound track.

The compact cassette recorder can be used with commercial compact cassettes. Since at 18 Fps the running time of a Super-8 cassette is not quite 4 minutes, a C 60 cassette is sufficient.

For recording, connection is made between the camera and the cassette recorder. The microphone is attached to the recorder and filming with synchronized picture and sound, can commence. When the camera is actuated the cassette recorder is started automatically and the recording level is also controlled automatically.

A special starting signal is marked on the edge of the film strip. Whilst the film is being taken the camera continues to transmit electrical pulses to the cassette recorder in step with the exact running speed (one pulse per frame). These are recorded on a track parallel to the sound track.

After the recording has been completed the camera and recorder can be uncoupled. After the film has been processed it may be projected. To do this a cable is required to link the cassette recorder and the film projector. For the transmission of the control pulses the cassette recorder should be in the playback position. To improve reproduction quality an external speaker with or without an additional amplifier may be used, providing the recorder is equipped with the corresponding output.

The compact cassette used during the recording, with the camera is placed in the recorder and stopped at the starting signal. The film projector starts its run, passes the starting signal on the film and starts the tape in the compact cassette. The pulses recorded on the tape of the compact cassette now control the running speed of the projector whilst at the same time the sound is reproduced, synchronized to the picture, via the speaker.

For those who require to film longer than four minutes it is essential to edit. This is no problem with film since suitable splicing equipment is readily available, however with Compact Cassettes the same is not true. Only very few splicers are available and few outlets stock them. In addition the Compact Cassette must be removed from the recorder if a cut is to be made in the tape, directly behind the magnetic head.

With a little skill it is possible to make a cut, the principle being the same as described in chapter 10, here again we recommend the use of non-magnetic scissors. If no special splicing tape is available a 17.8 mm reel from the BASF accessory programme may be used by cutting small strips under 3.81 mm (the width of the tape) wide.

The cassette is then played back. At the beginning and end of the part which is to be cut the recorder is stopped, the cassette removed and the tape marked with a suitable pencil. The tape is then drawn out of the cassette so that both marks are visible, a cut is made on each mark, the ends can then be joined together with splicing tape.

Contrary to 1/4" tape on spools, the oxide coating on the tape in compact cassettes faces outwards, it should therefore be remembered to attach the splicing tape to the back of the tape.

Advantage of this system:

Easy direct sound filming with lip sync recording. Compact cassette recorder can also be used for other sound recording.

Disadvantage of this system:

Here purchase price is relatively high because camera, recorder and projector of the same make must be bought as long as different units in the systems are not interchangeable with those of other makes.

As post synchronization is usually sufficient for the amateur those who already possess a camera, a spool tape recorder and a film projector must either want to buy the additional system or invest in a synchronizer adaptable to the systems already in their possession.

17.8 Adding Sound

The sound recording system must be compatible with the system for synchronization. If sound is to be added after the film has been shot, a good deal of planning is necessary if the sound track is to be effective.

17.8.1 The Script

If more than background music with an occasional commentary is to be provided, it is necessary to prepare a script before sound is added.

The sound script should contain all information relative to both sound and film. This includes: numbering and duration of scenes, sound effects and background sounds and all background music. All dialogue should also be scripted and sound control instructions noted, i.e., "fade in", "fade out" etc. If a large number of sound effects are to be used they may be recorded on separate tapes if there is no provision for parallel track mixing (see paragraph 6.3).

In that case one tape may contain sound which is only for background etc., and the other, spot sound effects or music etc. The script must show clearly which sound comes on which tape.

17.8.2 The Guide Text Method

The purpose of the guide text is to facilitate the later addition of sound and also to assist in the preparation of the sound script. First a starting mark is located on the projector for the starting of the film, for example, a mark above the inspection window. Another mark is located on the tape recorder (see Fig. 90). Now the end of the film leader tape is marked as the starting point for the film, and the end of the tape leader as a starting point for the tape. Both film and tape can be started together by lining up the film and tape with their respective start marks.

Next the guide text is recorded on a free sound track via the microphone.

The points along the tape where sound effects occur can be cued by recording a short acoustical signal, for example, a tap with a pencil. Example: pencil tap, beginning of scene 5, fireworks.

In the case of tape recorders with parallel track operation (see paragraph 6.3), the guide text track can be listened to later whilst sound effects etc. are recorded on the other track.

In the case of tape recorders not equipped for parallel track mixing, visual markers made on the tape with a wax pencil can be used to locate the points where sound effects are to be dubbed on.

In the case of standard synchronizing systems it is advisable to set the synchronizing appliance to "pulse" before the guide text is recorded so that sound can be added immediately afterwards.

With the guide text method, all sounds can be added without a projector and synchronizing unit.

17.8.3 The Sound Track

It is possible, depending on the nature of the tape recorder employed, to make use of all types of tape recording tricks and mixing (see chapters 5 and 6). With the sound stripe on film system a tape recorder can be used in many ways for the production of the sound track, by re-recording from tape to film sound stripe. The parallel track method of mixing is very useful when the guide text method is used, in addition to which the sound effects can be copied from

a second tape recorder or record player.

If the guide text is recorded on the upper track, all the sound effects should be recorded on the parallel lower track, particularly when absolute synchronism such as a gun shot, door slamming etc., is required. If sound is added with synchronism of lip movement it is sufficient in most cases if synchronism between picture and sound is achieved at the beginning and end of the lip movement.

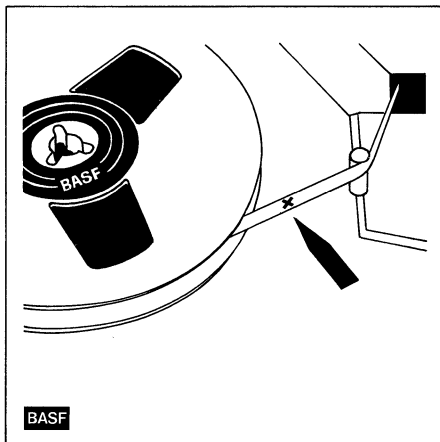
Background music and sound effects can be recorded with sufficiently accurate synchronism simply, by marking the appropriate points on the tape with a wax pencil.

17.9 Summary: Adding Sound to Film

Those who contemplate adding sound to 8-mm film should note the following points:

- a) Use a synchronizing system which is suitable for your purpose.
- b) Always edit the film ready for performance and prepare a script for the sound before the sound track is recorded.
- c) Assemble the equipment required for adding sound and in the case of the standard sync system record the pulses.
- d) Record the guide text if this method is to be used for cueing.
- e) Mark the magnetic tape where the sound effects are to be recorded in accordance with the script. This applies when using the guide text method without running the film projector.

Fig. 90. Starting Mark on the Tape Leader.



f) Produce the sound effects tape or have the right effects discs ready.

The following points should be noted for the performance:

- a) Always project the film above the heads of the audience.
- b) Place the loudspeaker near the screen.
- c) Always have a replacement projector lamp in reserve.

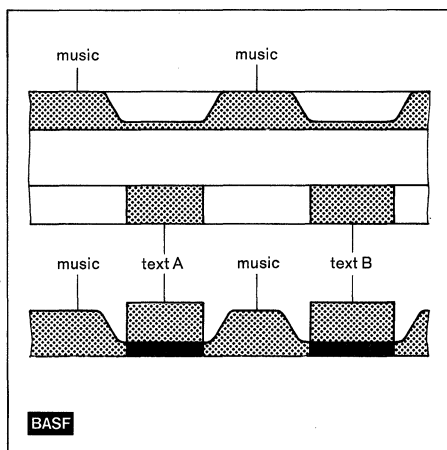


Fig. 91. Parallel Track Mixing (see also Fig. 35).

Diagrams**Tables**

Table 1	Playing Time	12
Table 2	Tape Length/Reel Size	17
Table 3	Spool Diameter	18
Table 4	Compact Cassettes	19
Table 5	Hi-Fi Data	25

Diagram Number

1	BASF Tapes (are becoming increasingly thinner)	13
2	BASF Tape Range (explanation of type descriptions)	13
3	Low Noise/LH Dynamic Range Gain (Increase) in output	15
4	Compact Cassette Storage	21
5	8 cm (3") Plastic Mailing Box	21
6	Stereo recording/reproduction	26
7	Stereo Unit	27
8	Best listening area for stereo reproduction	27
9	Compact Cassette Layout	29
10	Compact Cassette Track Position	30
11	Cassette Player	32
12	Cassette Changer	32
13	Stereo Car Radio Player	34
14	Car Stereo Player	34
15	Portable Compact Cassette Recorder	35
16	Stereo Cassette Recorder	37
17	Radio Recorder	37
18	Casseiver (Radio Cassette Recorder)	38
19	Cassette Radio	39
20	Tape Transport	40
21	Stereo Tape Recorder Controls	41
22	Overloading	44
23	Under Recording	44
24	Correct Recording Level	44
25	Stereo Recording Level Control	45

26	Track position on reel to reel recorders	46
27	Schematic Diagram of the magnetic sound recording	51
28	Standard DIN Connection	54
29	Record player plug for mono and stereo	55
30	Connection Panel	56
31	Distribution box for headphones	56
32	Mechanical Trick Switch	57
33	Electrical Trick Switch	57
34	Magnetic Mixing with Trick Switch	57
35	Duoplay	58
36	Multipley	59
37	Triple Head Arrangement	60
38	Reverberation Chamber	60
39	Types of Mixing	61
40	Mixer Unit	62
41	Capacitor Microphone	66
42	Moving Coil Microphone	67
43	One Sided Ribbon Microphone	67
44	Double sided ribbon	68
45	Orientation Characteristic Kidney shaped	68
46	Orientation Characteristic Figure of Eight	69
47	Orientation Characteristic Spherical	69
48a	Microphone N	70
48b	Microphone SN	70
49	Cable Transformer	71
50	Wiring Diagram for Microphones H or M and SH or SM	71
51	Microphone HL	72
52	Microphone HLM	72
53	Changeover Switch HL/M	72
54	Stereo Recording AB System	75
55	Stereo Recording XY System	75
56	Operation and Input Switch – Direct recording	78
57	Direct recording from radio	78
58a	Standard radio socket (mono) with reducing connector and stereo sound cable	79

58b	Standard radio socket with reducing connector and universal coupling	79	75b	Compact Cassette Recorders —	
				Track Position	103
59	Recording from Discs	80	76	Script	106
60	Recording from one Tape Recorder to another	80	77	Non automatic projector	107
61	Recording with multiplied tape speeds	82	78	Automatic projector	107
62	Splice	84	79	Equipment Layout external control	108
63	Non-Magnetic Scissors, straight and curved	85	80	Track Position Slide (Dia.) Control	108
64	Hobby Box / Editing	85	81	Internal Slide (Dia.) Control	110
65	Hobby Box / Splicing	86	82	Table showing Dia (Slide) Control Equipment	110
66	Splicing Block	86	83	$x = v . t$	111
67	Playing Time Table LP 36	89	84	Film Formats	113
68	Endless Tape Cassette	90	85	Electromechanical Control of Narrow Films	116
69	Lear Jet Cartridge	90	86	Equipment Layout Standard Synchronization System	118
70	Tape recorder with Cartridge Recorder	91	87	Impulse Track Standard Synchronization System	119
71	Storage in Library Boxes and Plastic swivel boxes	94	88	Film Projector with (Built-in) Compact Cassette Recorder (Fitted)	120
72	Tape Index	95	89	Film Projector and Film Camera with Separate Compact Cassette Recorder	120
73	Flexibility	98	90	Starting Mark	123
74	De-magnetizer	98	91	Parallel Track Mixing	124
75a	Track Position during playing of recorded tapes	101			

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In his replies to constantly recurring questions he endeavours to describe the basic principles of domestic tape recording technicalities in a simple and comprehensive manner. This has also been adopted for the explanations given in this booklet which is an extension of a series of specialist articles entitled "Tape Questions – Tape Answers" which appeared in the Radio-Fernseh-Händler, a publication for the radio and TV trade issued by the Keller-Verlag, Starnberg, Germany.

"Tape Questions – Tape Answers" are intended to provide guidance and assistance for the trade and for tape recording amateurs. They relate to the leading concepts of tape recording equipment and its use in the domestic field and will be brought up to date with each new edition. This is the second edition, which compared with the first, has been enlarged by the inclusion of chapters on Compact Cassettes and endless tape cartridge machines, tape libraries, tape and recorder maintenance and the adding of sound to 8 mm film.

Since this booklet is translated into several languages and appears in a number of countries, makes and types of equipment which may differ from country to country, have been omitted, except where special devices, such as those for internal slide control are concerned. Explanations given regarding the function of equipment should enable the trade in particular to obtain information about make and type, if enquiries are made.

