

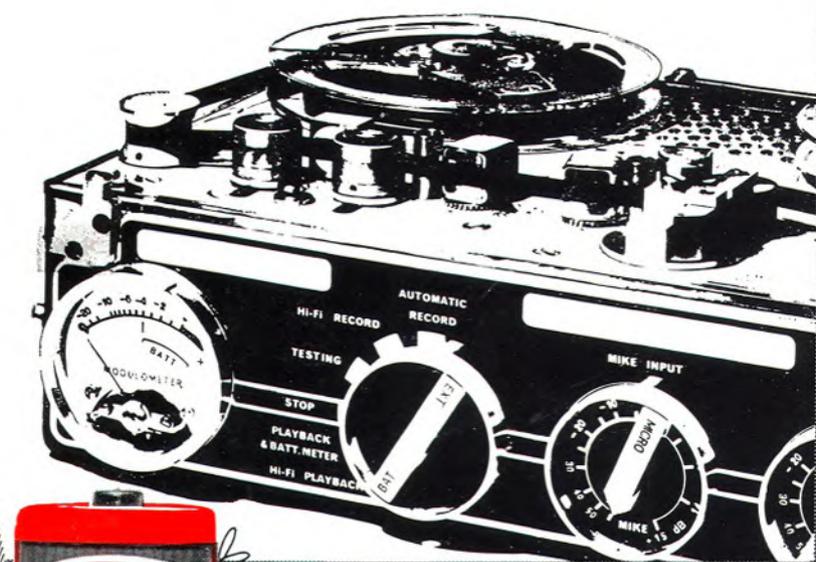
FEBRUARY 1966 TWO SHILLINGS

tape recorder



**THE MELLOTRON SOUND EFFECTS MACHINE – SERVICING THE AKAI M7
AMPEX 863 REVIEW – BUILD A STEREO TAPE PLAYBACK PREAMPLIFIER**

EVER READY HIGH POWER BATTERIES GIVE AT LEAST 4 TIMES LONGER LIFE IN TAPE RECORDERS



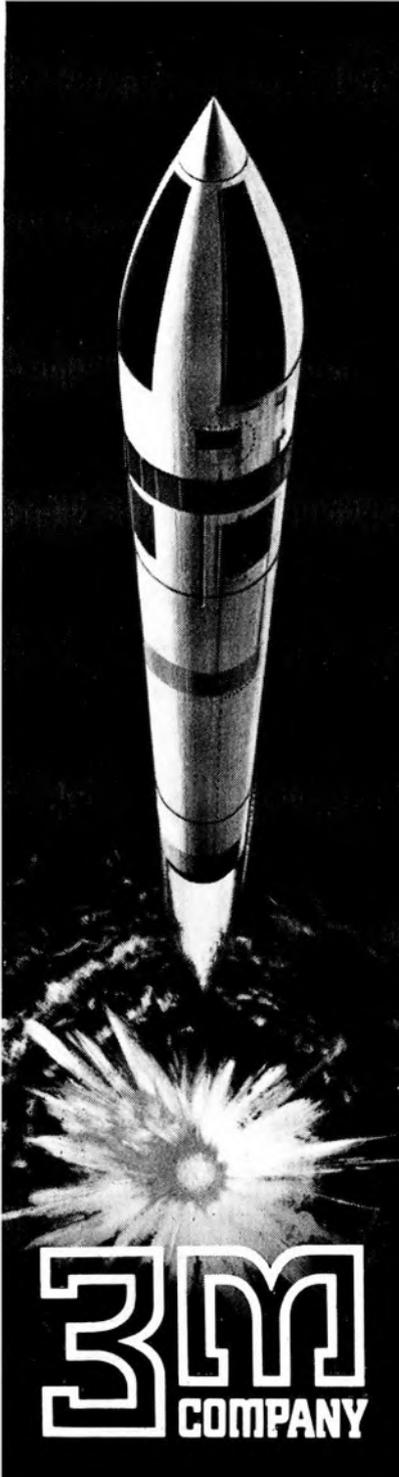
In portable tape-recorders* with power requirements around 300mA a standard battery will drop below the necessary voltage to power the motor and amplifier in a matter of hours. An Ever Ready High Power Battery in the same recorder will keep up its voltage for a working life at least 4 times longer.

*Record players too.

THE EVER READY CO (GB) LTD

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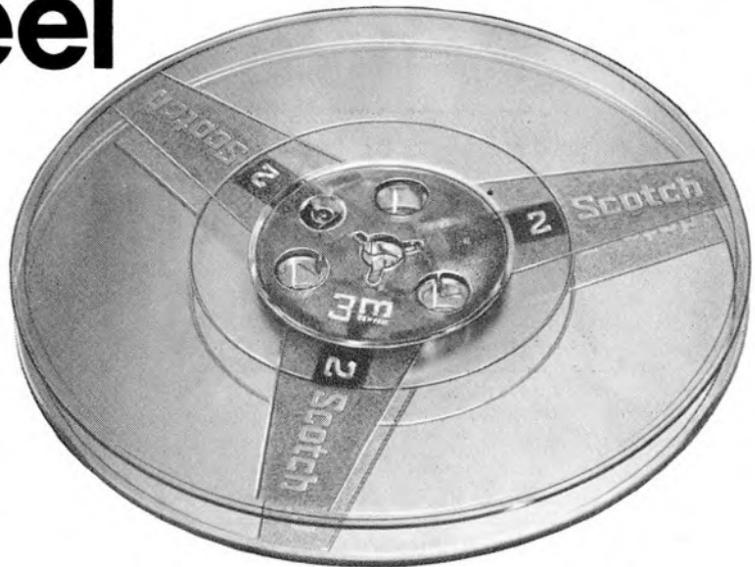
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COMPANY

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Simply lay the tape in the 'SCOTCH' Self-Threading Reel. Switch on. As the reel turns, it automatically grips the end of the tape and takes it up smoothly. It's the neatest, most practical idea ever. Saving you time! And temper! And wear on the tape.

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MAGNETIC TAPE
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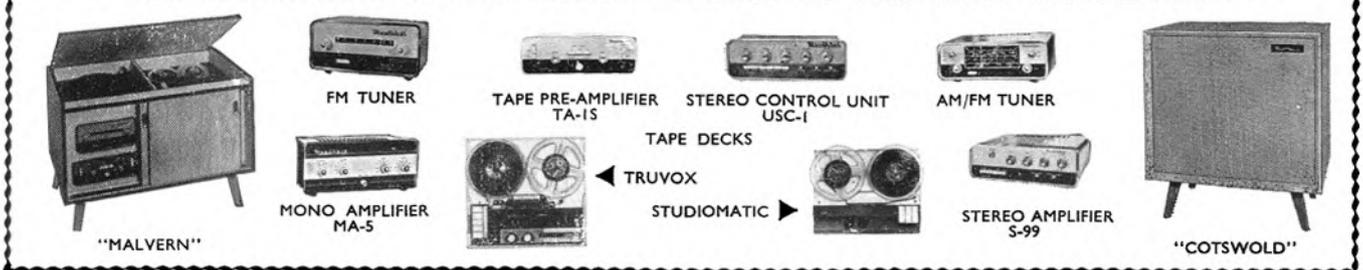
AUDIO
Cabinets, Turntable Units, Mono and Stereo Amplifiers, Pickups, Speaker Systems, Mono and Stereo Control Units, Tape Pre-amplifiers, Tape Decks, etc.

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A new concept in Heathkit Loudspeaker kit design. Completely finished, walnut veneered cabinet shell facilitates, faster, easier assembly, 2 speakers or 12" Bass unit and a 4" mid/high frequency unit plus a L/C cross-over network give a smooth 30-17000 c/s response. Power handling 15 watts. 15 Ω nominal impedance.
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Without obligation, please send me

FREE BRITISH HEATHKIT CATALOGUE

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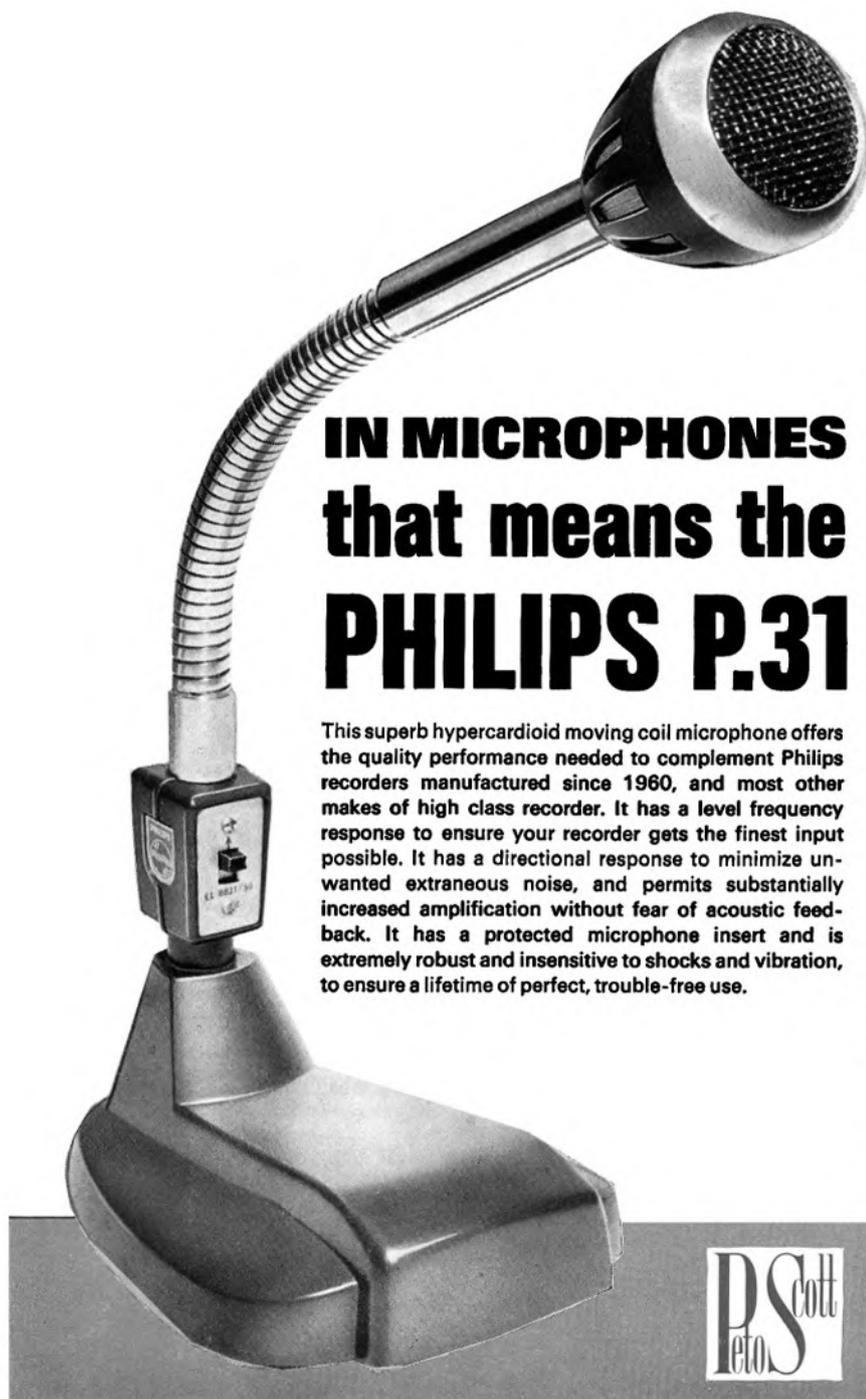
FULL DETAILS OF MODELS
Kindly write below in BLOCK CAPITALS

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ADDRESS

HT-2

**YOUR TAPE RECORDER
DESERVES THE BEST...**



**IN MICROPHONES
that means the
PHILIPS P.31**

This superb hypercardioid moving coil microphone offers the quality performance needed to complement Philips recorders manufactured since 1960, and most other makes of high class recorder. It has a level frequency response to ensure your recorder gets the finest input possible. It has a directional response to minimize unwanted extraneous noise, and permits substantially increased amplification without fear of acoustic feedback. It has a protected microphone insert and is extremely robust and insensitive to shocks and vibration, to ensure a lifetime of perfect, trouble-free use.



The Philips P.31 is supplied with flexible shaft, silent on/off switch, built-in matching transformer (giving adjustable impedances of 500 Ω and 25,000 Ω) and elegantly designed non-scratching stand. See it at your hi-fi dealer *today!*

The high quality Philips P.31 is supplied complete for only **18 gns.**

***Peto Scott for all Philips
Professional Sound equipment***



PETO SCOTT LTD

Addlestone Road, Weybridge, Surrey
Telephone: Weybridge 45511

Brand	Levels relative to Kodak P.200 tape			Absolute measurement levels		
	Low frequency sensitivity	High frequency sensitivity	Output at 2% distortion	H/F response at 12,000 c/s against a 400 c/s reference	Erase level	Modulation noise
Kodak P.200 Tape	0	0	0	+ 7.1	77.5	55
Brand 'A'	- 3.5	- 5.1	- 3.8	+ 5.5	75	52
Brand 'B'	- 0.3	- 5.0	- 2.3	+ 2.4	74	55
Brand 'C'	- 1.0	- 5.7	- 1.7	+ 2.4	74	54.5
Brand 'D'	- 2.8	- 10.9	- 3.5	- 1	72.5	55
Brand 'E'	- 1.9	- 4.7	- 5.0	+ 4.3	76	51.5
Brand 'F'	- 0.5	- 5.0	- 2.9	+ 2.6	78	54.5
Brand 'G'	- 2.3	- 4.8	- 3.0	+ 4.6	75.5	55
Brand 'H'	- 3.8	- 7.5	- 1.7	+ 3.4	72.5	55

See how Kodak P.200 Tape compares with other leading brands

Random samples of premium-quality Double Play Magnetic tapes on sale in Britain have recently been tested and compared.

The results demonstrate clearly that Kodak P.200 Tape is the *only* tape to provide both a better high-frequency response and a higher output level *without sacrificing other characteristics*. The advantages of this unique combination of features are obvious—whatever your recording need.

Study the chart above carefully, then try Kodak Tape on your own recorder and hear the improvement for yourself.

Kodak Tapes—Standard, Long, Double, Triple and Quadruple Play—are available through Kodak Photo Dealers everywhere.

To **Kodak** Ltd., Department 70, Kodak House, Kingsway, London, W.C.2.

Please send full details of the range of Kodak Sound Recording Tapes.

NAME.....

ADDRESS.....

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Kodak sound recording tapes... the best tapes in the world

The Q-Cord offers better value for money
at £33 12s. than any other battery portable.
But don't take our word for it . . .

SHORTLY after the recent price increase imposed on many foreign-made tape recorders, a reversal of the trend was set by *Colin Braddock Ltd.*, who promptly reduced the retail price of their Q-Cord battery portables by more than £4. Use of the plural covers both R.119K and 203 recorders which originally sold at £34 13s. and £35 14s. respectively. The two models now cost £30 9s. External appearance varies slightly, the 203 being slightly larger and more streamlined than its sister. My own opinion of the R.119K is that it looks a little too much like a lady's handbag, but that is a matter of taste! Internally the recorders are identical though the R.119K appears to have a sturdier case.

The Q-Cord is another of those infrequently met recorders which cannot be operated at first sight but require formal introduction through a descriptive manual. Mechanical functions are governed by the right-hand rotary switch. This faces forward in the STOP mode, is turned a little to the left for FAST REWIND and similarly to the right for PLAY and RECORD. The machine is rather unusual, however, in its incorporation of interlock buttons for both playback and recording, these being to the right and left of the centre button respectively. Mid-way between these interlocks is a temporary stop button. Two concentric rotary controls on the far left govern gain and tone. Record and playback interlocks are disengaged by selecting FAST REWIND.

Large plastic discs screw on to the hubs, keeping the spools tightly in place for vertical operation. A removable triangular-shaped door in the base gives



access to microphone and batteries. This was held in place by a screw which could be engaged easily with a coin. It was found difficult to replace the lid satisfactorily once the microphone had been extracted and replaced, this being another case of the microphone and cable being just a little too big.

When the machine was first switched on, negative results sent me, as I have mentioned, straight to the instruction book. But when, after the controls had been mastered, the recorder still failed to operate, the batteries came under suspicion. Examination of the battery compartment showed the fault to be a small one. One of the metal strips which curve out to press against the cells had 'lost its spring' and was not making circuit. It was a simple matter to bend this outwards and achieve a tight fit.

Initial microphone recordings were carried out in order to judge general quality and to become accustomed to the magic-eye. The recording level indicator is of the exclamation-mark valve type, a welcome change from sluggish meters. It is connected in a rather unusual way, however, since increasing input volume results in decreased indicator brilliance. The DM7?

connected in this way is quite effective since, strange as it may seem, a blank indicator stands out even better than a brightly glowing one.

Nevertheless, it was found difficult to produce a badly distorted recording at reasonable sound levels, even with the input gain at maximum, while, at the other end of the scale, volume level could be reduced to a very low point before it vanished in background noise. Recorded background noise is lower on the Q-Cord than on any battery machine I have yet field tested. Hardly a trace of hiss and absolutely no electrical motor interference. Acoustic noise was also very low.

Connected to an FM tuner and external amplifier, the recorder proved capable of extremely clean sound. Speed fluctuation was quite inaudible. Frequency response was not of hi-fi standards, but comparison of direct with recorded music showed the mid-range frequencies to have been sufficiently well recorded for the Q-Cord to serve as part-time replacement for a high quality mains recorder. This is no mean accomplishment for a £30 portable and this alone would have been sufficient, in my eyes, for strong recommendation. The Q-Cord has another beauty, however, in being very cheap to run. As most owners of portables will know, batteries which have retired from use in a recorder are invariably powerful enough to provide a good light in a torch. The Q-Cord, however, was fed with just such sets of lately retired cells, and worked quite happily until power fell below that needed to provide a good output from a torch. No means of checking battery life is incorporated, but the R.119K's own behaviour is a more than sufficient guide. Amplifier power tends to fall towards the end of battery life, but speed remains absolutely constant to the very end. And at the end speed drops to a very unsteady 2 1/s for a minute or two, after which the machine ceases to operate. In the battery world, this must be the ideal way to expire!

Sponge pads on the inside of the lid make it impossible to use the recorder in a closed position. The pads are fitted to prevent the spools rotating and spilling tape on to the deck when the machine is carried. They can, of course, be removed if desired and later re-stuck to the lid.

Some little trouble was experienced when lifting a tape from the head channel, caused by a curve in the plastic slot.

Rewind was not particularly fast, but indents in the spool locks made the tape easy to wind and rewind by hand. I look forward to the day when provision for hand rewind is included on all battery machines; it is faster, and exhausts less human energy than batteries exhaust patience. Fast winding, of course, is also an easy way to drain batteries.

Another admirable feature of the R.119K is the excellence of its internal power amplifier and speaker. This may be due to good design, or to the incorporation of a wooden cabinet. No brittle plastic trimmings are situated in the vicinity of the speaker, which gives a pleasant, well-balanced sound. Editing and head cleaning are simplified by removal of the head and push-button covers.

A small plastic-headed screw, which fits into the deck close to the right-hand mechanical switch, provides a means of locking the mechanism to prevent damage during transportation. Whether this is meant to apply to transportation to and from the distributor, retailer or manufacturer, or whether it is intended for use at all times by the owner, is not clear. It was assumed that the screw was not required for everyday use and no trouble in fact occurred.

My only criticisms of the R.119K, then, are that the microphone compartment is too small and the battery terminal strips a little weak. In all other respects, it is an excellent recorder. The sensible tape speed pays off in low wow and flutter while compromising with battery consumption. A reader recently showed me the complex hold-all he had constructed round his battery portable, providing electric illumination of controls and modulation indicator, and storage space for tapes and accessories. If I owned an R.119K I believe I should follow his example. The Q-Cord is too pretty to match oily fingers.

External appearance is nevertheless irrelevant and I consider the Q-Cord to offer better value for money than any other portable on the domestic market.

. . . reprinted from the July 1965 "Tape Recorder"

The Q-Cord is distributed by
Colin Braddock (Blackpool) Ltd.,
266 Waterloo Road,
Blackpool, Lancs.

tape recorder

INCORPORATING 'SOUND AND CINE'

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ADVERTISEMENT MANAGER **ROBIN WELLS**

Editorial and Advertising offices

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Telephone MUNICIPAL 2599 (12 lines)

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editorial

THE OTHER DAY a reader friend of ours bought some tape. He had been asked to transcribe some music on to a fresh reel, this reel being presented by a relative to an acquaintance, making an inexpensive and worthwhile gift. After clarifying the Copyright position on the material to be dubbed (!), he visited a local retailer to purchase some good-quality tape. One or two brands were kept in mind as being, at least according to our past reviews, reasonably free from dropout and up to the standard needed for $\frac{1}{4}$ -track equipment.

The retailer was very helpful. He advised our friend that the brands named were, unfortunately, not in stock. His shelves were filled with other equally good tapes, however, and he said that a purchaser was welcome to examine them against his price list (there was no resale price maintenance here).

The would-be buyer was at a loss. Most of the brands that met his eye were completely new to him. They had the most exquisite names and many were wound on spools that were both original and beautiful in design. There were some well-known brands that he did not like and one that he liked but could not afford. Feeling just a little confused, he turned to the retailer and enquired, just once more, whether he was certain he had no *XXX* brand. No, he was assured, but he should bear in mind that much of the tape sold in this country is made by one manufacturer.

This he knew, but the brand quoted was the exclusive trade mark of that very manufacturer. Confidence in the knowing retailer slowly returned as he announced his policy of refusing to stock *such-and-such*, an infamous brand of reject American data-recording tape. Nevertheless, our friend could not help but notice the price list, which included brands selling for only 12s. 6d. per 1,200 ft.—8ft. per penny—standard play. He decided to buy an 18s. 6d. reel, this being the cost of a 5 $\frac{1}{2}$ in. long play tape. This tape, the dealer assured him was used by the local College of Technology (he did not say what for) and a visiting representative of a very reputable American tape manufacturing company had himself bought several reels. He named the company. The innocent customer felt he ought to be delighted with his purchase. Money passed from pocket to cash register. Then came the bombshell: "Of course" continued the dealer "most of the stuff we get in here is rubbish. We throw out a lot of these tapes and substitute our own brands on the spools."

One bewildered tapist left the premises in a state of mental unbalance. What *had* he bought? Did brand names mean nothing

to the retail trade? Was tape merely a sort of brown sand-paper about a quarter of an inch wide, available in various thicknesses? Later that day he came to us, and we really began to wonder, for our nose (of average sensitivity) detected a peculiar smell when placed within a few inches of the reel. We recognised the smell, for only one other tape shared its pungency, and that other tape is very fine indeed. If our nose and experience conveyed the truth, our acquaintance had purchased none other than the "one he liked but could not afford" previously referred to, at little over half the listed price.

Back at home, the $\frac{1}{4}$ -track copying machine was very happy with its tape and a delighted relative departed later to present her gift; we can only assume that someone, somewhere, is enjoying some very pleasant music, for which he or she has to thank the dishonesty of a (not very well known) Essex audio dealer.

This joyful tale is slightly saddened by the after-thought that, at this moment, a wealthy Essex tape enthusiast is having his heads ground away by some of Uncle Sam's rejects, for which he paid the very highest price.

FEBRUARY 1966

VOLUME 8

NUMBER 1

- 11 WORLD OF TAPE
 - 12 BATTERY POWERED TAPE RECORDERS—Part 3
By Michael Gordon
 - 15 A STEREO TAPE PLAYBACK PREAMPLIFIER
By L. J. Bishop
 - 16 SYSTEMATIC SOUND
By David Kirk
 - 19 READERS' LETTERS
 - 20 SOUND INTO SIGNAL
By G. T. Rogers
 - 23 HAMMOND M.100 MICROPHONE FIELD TEST
By M. F. Woodward
 - 25 SOUND AND CINE
By Anthony Wiggins
 - 26 TAPE RECORDER SERVICE—No. 50
By H. W. Hellyer
 - 29 NEW PRODUCTS
 - 31 AMPEX 863 REVIEW
By Alec Tutchings
 - 33 PHILIPS EL3552 REVIEW
By Alec Tutchings
 - 37 CLASSIFIED ADVERTISEMENTS
 - 38 ADVERTISERS' INDEX
-

COVER PICTURE

It is an irrevocable fact of audio life that you get what you pay for. With the *Ampex 863* you get a flutter trace (page 31) far removed from the drunken meanderings of certain unmentionable tape transports. You also get meticulous attention to component tolerances, followed by comprehensive testing and measurement. Our cover picture shows an 863 undergoing just such routine testing prior to despatch.

SUBSCRIPTION RATES

Annual subscription rates to *Tape Recorder* and its associated journal *Hi-Fi News* are 30s. and 32s. 6d. respectively in the U.K. Overseas rates are 32s. 6d. (U.S.A. \$4.50) for each magazine, from Link House Publications Ltd., Dingwall Avenue, Croydon, Surrey.

Tape Recorder is published on the 14th of the preceding month unless that date falls on a Sunday, when it appears on the Saturday.

SONY Model TC-357-4 is a 4-track monaural multi-purpose portable tape recorder with **SONY-O-MATIC** control, enabling speeches, lectures and interviews to be recorded without manual adjustment. Loud or soft, it automatically adjusts the recording level.

Other outstanding features include
 ■Self-threading "SONY-O-MATIC" reel —no more awkward threading of tapes
 ■3 speeds, 7 inch reel capacity
 ■Easy tape loading with newly developed "retractomatic" pinch roller
 ■Speaker monitoring while recording
 ■Mic/line recordings
 ■Public address facility
 ■High performance SONY dynamic stick microphone
 ■Instant stop lever with lock facilities, speaker on-off switch, tape index counter, record lock button, professional levelmeter, individual recording and playback control, voltage selector.

Other tape recorders in the SONY range featuring the SONY-O-MATIC recording level control include

MODEL TC-900, a mains/battery portable with two track monaural recording and playback system at 32 gns. and

MODEL TC-135—an easy to carry two speed, two track extra lightweight portable with 5" reel capacity. Complete with highly sensitive SONY microphone. 28 gns.

Studio models also available—Send for details.

SONY

SONY U.K. SALES DIVISION

Mercia Road, Gloucester. Tel: Gloucester 26841

A division of Debenhams Electrical and Radio Distribution Co. Ltd.

NAME

ADDRESS

London Showroom, 70/71 Welbeck St. W.1.

T.R. 1.

SPECIFICATION TC-357-4

Power requirement: 100, 110, 117, 125, 220 or 240 volts, 60 watts, 50/60 cps

Tape speeds: Instantaneous selection 7½ ips, 3½ ips or 1½ ips (19, 9.5 or 4.75 cm/s)

Tracks: 4 tracks, monophonic

Recording time: 45 minutes per track, 3 hours in total at 7½ ips (With SONY Tape Supor 7) 1.5 hours per track, 6 hours in total at 3½ ips 3 hours per track, 12 hours in total at 1½ ips

Reels: 7 inches or smaller

Frequency response: 40-15,000 cps at 7½ ips 40-12,000 cps at 3½ ips 40- 6,000 cps at 1½ ips

Flutter and wow: Less than 0.12% RMS at 7½ ips

Less than 0.2% RMS at 3½ ips

Record/Playback head: In-line quarter track (2 channel)

Erase head: In-line quarter track (2 channel)

Bias frequency: Approx. 55 Kc

Inputs: High impedance microphone input (1)

High impedance auxiliary input (1)

Outputs: High impedance line output (1)

8 ohm external speaker output (1)

Speaker: 4 x 6" (10 x 15 cm) dynamic

Power output: Max. 2 watts

Tube complement: 6267 (x 1), 6AN8 (x 1), 6BM8 (x 1)

Diodes: 1T22 (x 1), SE-05D (x 1)

Weight: Approx. 22 lbs. (10 kgs.) (without accessories)

Dimensions: 14.8"W x 7.9"H x 12.2"D (375 x 200 x 310 mm)

SONY®-O-MATIC

The tape recorder with completely automatic recording level control*.



MODEL TC-357-4:
62 gns.

*Can also be manually adjusted

world of tape

RAY-O-VAC PRICE REDUCTIONS

THE peril of corrosion, which lurks within every battery tape recorder fitted with conventional cells, would seem to have been conquered, as recent price reductions by *Ray-O-Vac* are claimed to bring the cost of their 2LP and 1LP leakproof cells down to the same price as conventional cells produced by other manufacturers. The steel-cased 2LP has been reduced from 10d. to 8d. and the 1LP from 8d. to 7d.

NEW NAME FOR TELEFUNKEN DISTRIBUTOR

WELMEC Corporation, U.K. agents for *Telefunken*, recently adopted a new name. The company will now be known as *AEG (Great Britain) Ltd.* AEG, the mother company producing *Telefunken* equipment, was formed in 1887 and is one of the largest electrical manufacturers in Europe. Some 126,000 people are employed in the group's 58 factories, associated companies being located throughout the world.

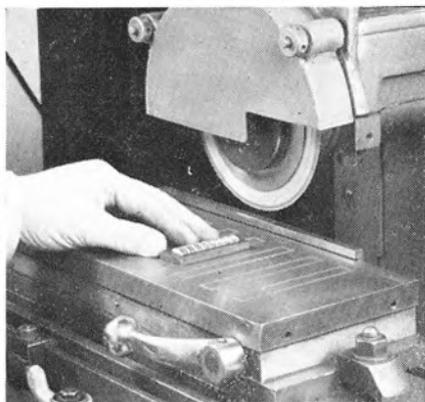
DEBENHAMS ELECTRICAL CHANGE ADDRESS

THE distributor of *Sony* and *Bang and Olufsen* equipment, *Debenhams Electrical*, has moved its sales and publicity departments to Mercia Road, Gloucester. Telephone number remains Gloucester 26841. Service and technical information are still provided from Eastbrook Road (Gloucester 25428).

INDEFINITE LIFETIME FOR CERAMIC HEAD

TAPE heads that never wear out, and give a minimum 5,000 hours constant performance, are now being produced by *Mullard*. They are the first to be produced entirely from ceramic materials and are aimed at the professional market. Prices, at present, are a little higher than the £9 or so normally paid for a top quality head but are expected to fall in the coming year to under £7.

Lower bias level and higher oscillator frequency than practical with conventional heads may be employed with the ceramic models, with the possibility of reducing background noise. The head materials are already used in the Philips helical-scan video recorder where they have shown no performance deterioration in more than 2,000 hours use at head-to-tape speeds of 940 i/s. The material is expected to appear in non-professional equipment when production methods become more economical. A block of twin-track heads about to be sliced is shown in the photograph.



SYNTHETIC TRUMPETS FROM TAPE

A TRUMPET that cannot be blown has been developed by physicists of the *Bell Laboratories* in the USA. A tape-controlled computer was employed to synthesise single trumpet tones that proved indistinguishable from 'the real thing' when heard by an audience including professional musicians. The system was based, by Jean Claude Risset, a French composer and physicist, on a computer programme produced by Max Mathews and Joan Miller of *Bell Laboratories*.

GRUNDIG TEACHING EQUIPMENT AT HULL

SWEDISH, Russian, Hebrew, French, Italian, German and Spanish languages are now being taught on *Grundig* audio equipment at the University of Hull. The installation is in the new Faculty of Arts building, where it fills a complete floor of one wing. A total of 40



student booths are positioned in two rooms, each set of 20 being connected to a master console. Each booth is equipped with a tape recorder, head-set and microphone. A third room contains 16 complete booths and is intended for private study without a lecturer. Three separate listening rooms, each having a tape recorder and disc reproducer, enable small student groups to study together, taking advantage of material in the tape library that will grow in coming months and recordings produced in a fully-equipped studio at the University. A technician is employed full-time to advise on the use of equipment and to undertake service when necessary.

ELECTRONIC OPERA

UNDER the conductor's baton comes a bank of *Telefunken* studio tape recorders when the Hamburg state opera *Notlandung* commences on February 2nd. The title loses something of its beauty when translated into the English *Incidents During an Emergency Landing* but explains the reason for the composer's choice of electronic music to convey an atmosphere of tangled steel. An engineer controlling the stereophonic mixing and playing equipment will receive his cues from the conductor through closed circuit television, these being included as coloured symbols on the score. Boris Blacher, the composer, prepared the opera in collaboration with Professor Fritz Winkel at the Berlin Technical University.

AUDIO ANNUAL

THE spring of 1966 will see publication of the first *Audio Annual* containing many interesting feature articles and reprints of the more important equipment reviews that appeared in *Tape Recorder* and its sister magazine *Hi-Fi News* during 1965. The *Audio Annual* will be on sale at bookstalls or can be purchased direct from the publisher. More details later.

QUARTER-TRACK PORTABLE

TELEFUNKEN recently announced a $\frac{1}{4}$ -track version of the *M.300* battery portable tape recorder, selling for £56 14s. The machine is particularly suitable for cine and slide use, since a multiplay facility permits commentary and music to be recorded on separate tracks and replayed together. The new machine is designated the *M.301*. An automatic mains/recharger unit is now available for the two portables. This is described as an improvement on the former design; it is also less expensive, selling for £9 19s. 6d.

FI-CORD SERVICE ARRANGEMENTS

SERVICING of the *Fi-Cord 101* battery dictaphone is now being organised through *Fi-Cord International* at their Charlwoods Road address, East Grinstead, Sussex. The association between *Fi-Cord* and *Audac-Audio Associates Ltd.* no longer exists.

NEXT MONTH

Monday 14th February is publication date for the March issue of *Tape Recorder* which will contain reviews of the *Akai M7* and *X-4*. David Haines will contribute a tape sketch for man and dog, while Gordon Compers describes an ingenious method of changing tapes without interrupting a recording. *Personal Bias* is the title of a light-hearted column which will make its debut in March under the pen of John Ashcroft. In *Sound and Cine* Anthony Wiggins will report on a recent visit to the *Zonal* factory.

PART THREE
 improved
 drive
 techniques
 BY MICHAEL GORDON

BATTERY POWERED TAPE RECORDERS



ELECTRIC motors requiring direct-current for their powering have been with us and our grandfathers for a century. There has not been a great deal of fundamental development in these over the ages, though points of detail have altered somewhat, including the use of ceramic magnets to take the place of the earlier alloy counterparts.

A system of electromagnets, of course, can be adopted instead of permanent magnets, but this tends to increase size, cost and decrease overall efficiency relative to the latest permanent magnet designs. Small DC motors, therefore, nearly all feature a permanent magnet field system.

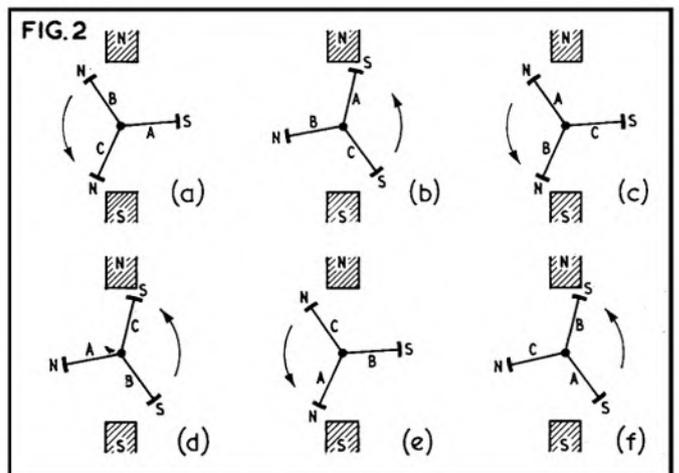
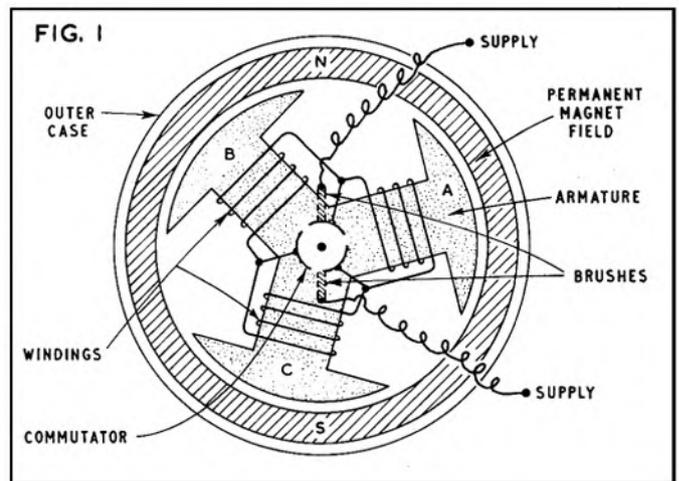
Such motors used in tape recorders, record players, electric clocks and so forth must be designed so that their turning moment is as independent as possible on the position of the motor rotor. This ensures that they are 'self starting' and that they deliver a high torque immediately they are energised.

A three-pole motor is essential to meet these requirements, and all serious DC motors of fractional power are of this kind. The armature has three poles and each one has its own winding, while the field is produced by a magnetic arrangement giving north and south poles across its axis. Larger DC motors sometimes use the multi-slot armature technique, but as these generally deliver upwards of 10W they do not concern us particularly for tape-drive systems.

The design of the field influences the torque which is available immediately the motor is energised, as also does the shape of the armature. By the use of ceramic ring magnets, for instance, the magnetisation can be specially tailored to optimise this parameter. It is not proposed to delve into the design of small DC motors (in spite of this being a fascinating subject!), but it would be as well for us to get some basic idea of how a small three-pole DC motor works. After all, it is the heart of the battery-powered tape deck. This knowledge will also set us up towards a better understanding of the latest type of DC motors employing switching transistors instead of the decades-old commutator and brushes.

The commutator-brush system of DC motors is the biggest fly in the ointment, but later in this article it is shown how new thought may soon delete this adversity. The commutator is formed of three metal segments, each insulated from its neighbours, and each one being connected to the armature windings in a special way. Metal or carbon brushes shaped to match the radius of the commutator press under spring tension against the metal segments and thus convey battery power to the windings.

The arrangement is such that the poles of the armature become



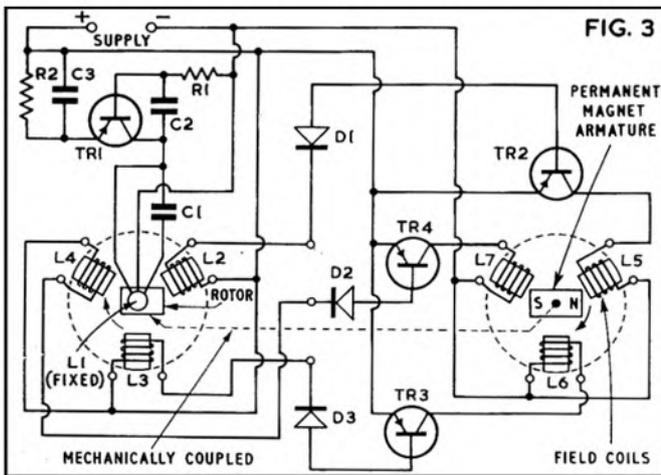
magnetised so that they develop a turning moment relative to the field of the permanent magnet. This turning moment is maintained by the commutator-brush system switching the current through the armature windings so that there is a continuously 'revolving' interaction between the armature and the permanent magnet field. The armature thus rotates, picking up its current from the brushes, via the commutator segments.

Fig. 1 shows a cross-section drawing of a three-pole motor with the various components identified. This and the foregoing should be considered in the light of the photograph of the three-pole motor given in fig. 2, last month.

The commutator is orientated on the armature spindle in such a manner that current from the brushes passes through the windings on one armature pole (pole A in fig. 1) direct and through the windings on the other two poles (B and C) in series. This action, of course, is also facilitated by the mode of connection of the windings to the commutator segments. This means that in the position shown winding A will pass two-thirds of the total motor current while the two series-connected windings (B and C) will pass one-third of the total current. These current conditions change about as the armature rotates.

Now, fig. 2 reveals the magnetic conditions during one complete revolution of the armature. At (a) the current through the winding on pole A makes this south, while poles B and C are north owing to the opposite current flow in their windings.

A is thus attracted by the north pole of the field and B is repelled by it, while at the same time C is attracted by the south pole of the field magnet (remembering, that unlike poles attract and like poles repel).



As soon as pole C passes the south pole of the field the commutator reverses the current in winding C and makes it south. A repulsive action results and sends the armature on its way, with the south pole of A being attracted by the north pole of the field and the north pole of B being attracted by the south pole of the field, as at (b).

In (a) the winding on pole A carried two-thirds of the total current, but in (b) this condition is changed so that the winding on pole B now carries two-thirds of the total current, the other two windings on poles C and A carrying one-third of the total current.

As the armature rotates so the polarity changing and current dividing action continues from pole to pole. In (c), for instance, when A leaves the north pole, pole A changes from south to north; in (d) pole B leaving the south pole changes from north to south; in (e) pole C leaving the north pole changes from south to north; and in (f) pole A leaving the south pole changes from north to south.

From this, then, we can see that it is the armature pole that is passing the axis of the force of the field magnet that changes in polarity, giving the continuous rotating moment. This is arranged by the position of the commutator relative to the armature pole pieces, assuming that the brushes are diametrically opposite each other and in line with the major axis of the permanent magnet field.

The commutator-brush system in DC motors thus provides the rotating magnetic field effect, and the aim over the years has been to delete this system which is subject to extreme wear and decreases the reliability factor of the motor.

Resulting from space-age development, for use in environments not normally encountered on earth, is a new DC motor of great reliability that is devoid of brushes. This was developed by Sperry Farragut Co. of Bristol, Tennessee for NASA, and is well worth a few words.

The motor employs photo-optical sensors and transistor switches that undertake the action of the commutator-brush system absolutely electronically and without mechanical contact. The rotor itself is a permanent magnet in this motor, and the stator and 'electronic commutator' sections are hermetically sealed to keep out damaging atmospheres, thereby avoiding bearing contamination.

The electronic commutator has built-in power amplification, which means that the control of mechanical output is possible. This would be ideal as a speed controller in tape recorders.

It seems, however, that it may be some time before this kind of motor becomes available for our activities. Nevertheless, a brush-less DC motor that may not appear so sophisticated compared with space requirements has been developed for battery-powered tape recorders by an association of the German Allgemeine Elektrizitäts-Gesellschaft organisation and the German Grundig company. In addition to the electro-mechanical elements of the motor, the design features four transistors, three diodes and a small selection of resistors and capacitors.

How the device works from the electrical aspect can be gleaned from the diagram in fig. 3, but it must be pointed out that this does not conform essentially to the mechanical features of the motor.

Here Tr1 is a transistor arranged to work as an oscillator in conjunction with the oscillator coil L1. This is a tapped coil that is fixed close to the 'rotor' so that the oscillatory energy in it is coupled through the rotor which is of low-loss ferrite material. Optimum oscillatory energy is derived by tuning the circuit by C1. C2 is the oscillator feedback capacitor, R1 the base bias resistor, R2 the emitter resistor and C3 the emitter bypass capacitor.

Now, depending on the position of the rotor, oscillatory energy is coupled from L1 to L2, L3 or L4. Let us suppose that the rotor is coupling energy to L2, then signal in that winding is fed to diode D1. The diode rectifies this signal and makes the base of Tr2 negative, thereby causing this transistor to conduct. Ordinarily, transistors Tr2, Tr3 and Tr4 are non-conducting, and it is only when signal energy is passed to its partnering diode, D1, D3 and D2 respectively, that it conducts, as just described.

When Tr2 conducts, therefore, a current flows from its collector through the field winding L5. A magnetic field thus develops at the pole of L5 and attracts the opposite pole of the armature magnet towards it. The armature thus rotates along with the rotor.

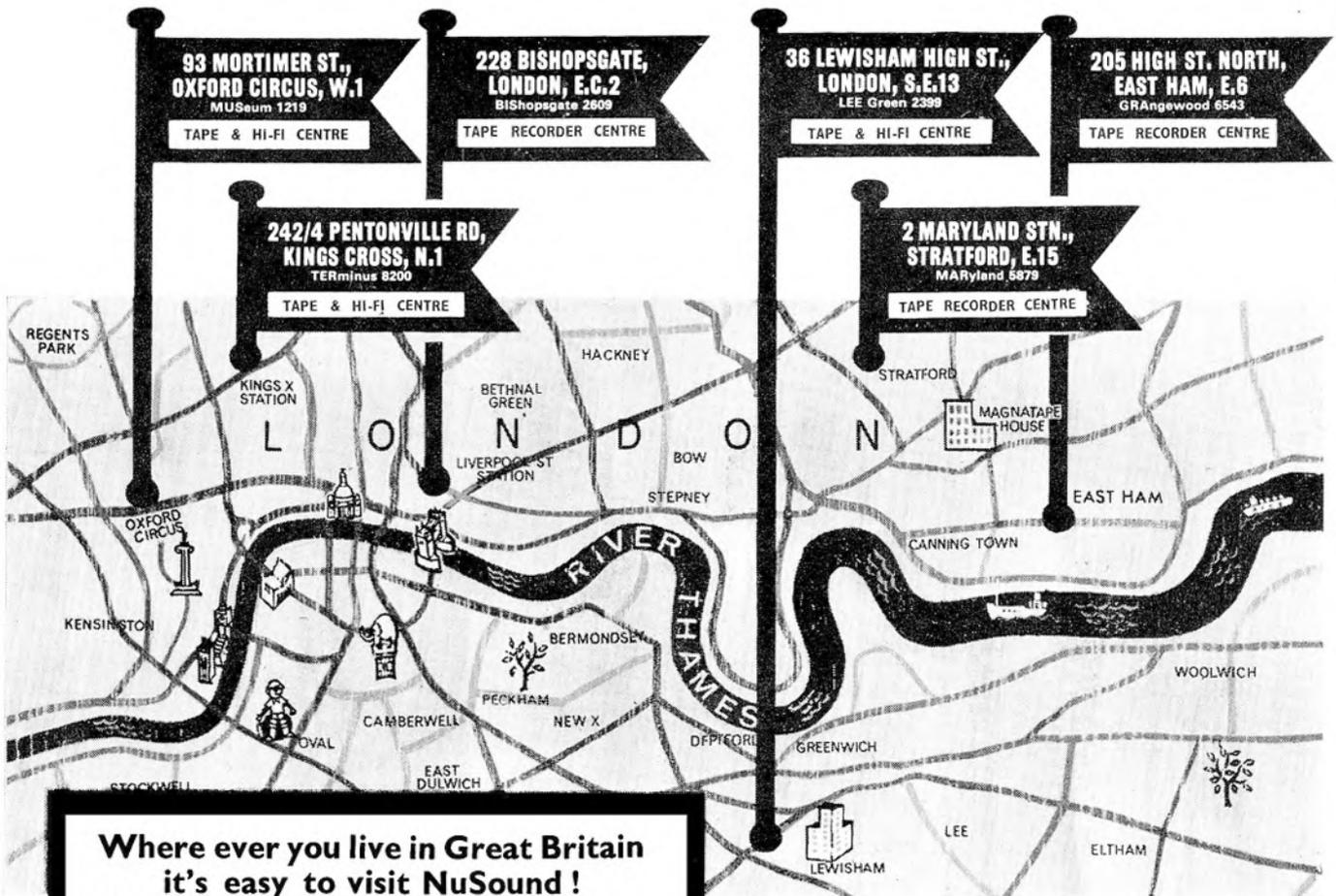
When the rotor couples oscillatory energy into L3, diode D3 rectifies and switches on transistor Tr3, thereby energising field coil L6, pulling the armature again in the direction of rotation. The process develops when the rotor couples oscillatory energy into L4, this time diode D2 switching on transistor Tr4 to energise field coil L7.

The electronic commutator, therefore, creates a rotating magnetic field by virtue of the field coils and the switching action of the transistors, and this rotating field is followed by the permanent magnet armature.

Of course, when the rotor (of the electronic commutator) turns away from the coil to which it was previously coupling oscillatory energy, the corresponding transistor switches off and cuts the magnetic field that was developed by the corresponding field coil.

The oscillator works at about 100 Kc/s and losses are minimised by the use of ferrites. The efficiency of the system is said to be in the order of 40 per cent—which is very good. When or even whether this system will be used in domestic equipment is not known definitely, but there is very little doubt that brush-commutator DC motors, with their attendant wear and interference problems have a serious rival.

Next month in this series we shall explore voltage stabilisation systems and discover how we can run a battery-operated tape recorder, say, from a car battery.



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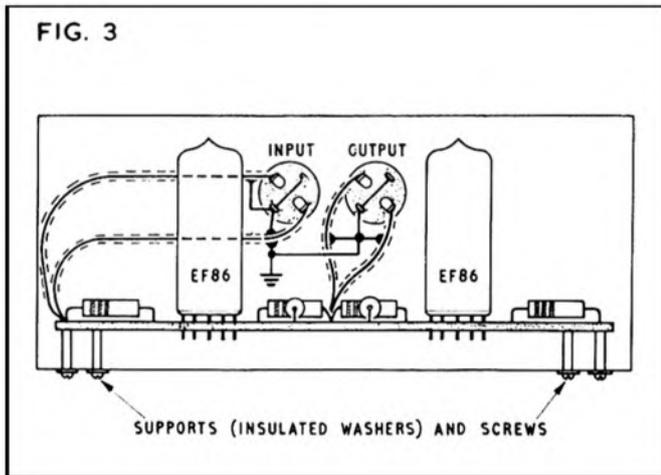
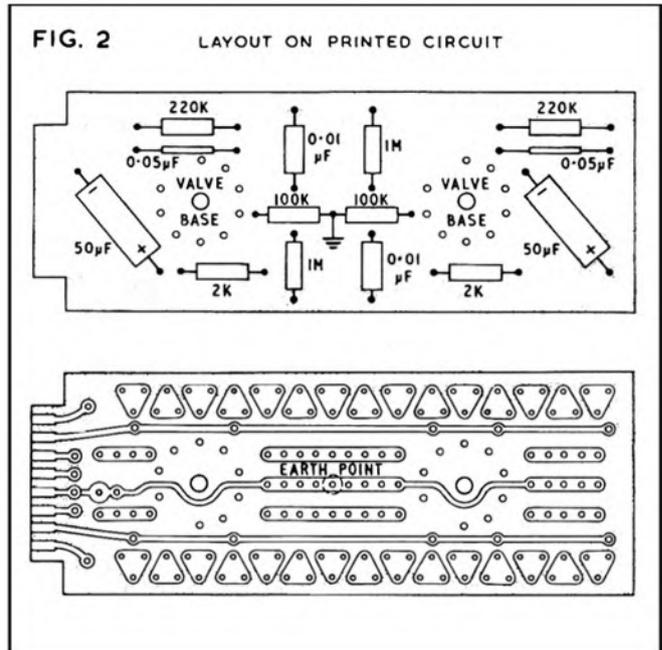
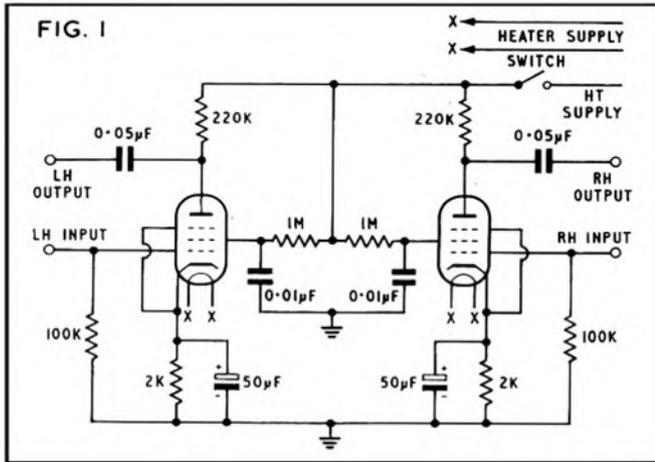
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*Britain's Largest Tape
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A STEREO TAPE PLAYBACK PREAMPLIFIER



**L. J. BISHOP
DESCRIBES
A USEFUL
ACCESSORY**

HIGH quality stereo reproduction from a low-price ¼-track recorder may seem a little difficult to attain. One way to achieve it would be to feed one channel of a stereo amplifier or gramophone from the recorder's preamplifier output and the other from a tape replay preamplifier. Quality is impaired, however, by the preamplifier in the recorder.

Another way, and the one which I have used, is to connect the heads to an output socket on the recorder. From here it is taken to a small two-valve stereo preamplifier which, in turn, feeds the gram socket on the radio.

The amplifier here described steps up the 1mV-5mV head output to 150mV-200mV, which is the right level needed for the gram socket. This is usually about 50K-1M impedance. The preamplifier is very simple to construct. An ordinary tin can be used—a baby powder tin (oblong but not round) is ideal. Being metal, this makes a good hum shield but it must be earthed.

The circuit (fig. 1) was built on an ordinary paxolin printed circuit shown in fig. 2 which can be bought for a few shillings from any good radio spares dealer. There are two basic types of boards. One is for transistor circuits and the other specially cut and printed for valves. Be sure to get the latter.

Valves used are two low-noise EF86 pentodes. Power for screen, plate and heater supply can be taken from either a specially built external power supply or from the recorder or radio. A Japanese

four-pin plug and socket proved perfect in my case, two pins being used for the heater and two for HT and earth.

No controls for gain, tone or balance are included on the pre-amplifier, these being set on the radio or power amplifier. This makes things much simpler to operate. Only one switch is used at the rear (base) of the tin, for HT on and off. This is a safety measure. The cover on top of the tin, when the amplifier is mounted inside, is merely a piece of wood lined with tin foil for screening and secured by four ½ in. wood screws with countersunk heads. Three slits of about 3 in. x ¼ in. should be let in the top of the tin to prevent overheating.

Input and output are to a pair of three-pin DIN sockets, shown in fig. 3, though the choice of connectors depends on the sockets most widely used on the constructor's existing equipment. Pin 1, in both cases, is Channel 1 (left-hand) and Pin 3 is (right-hand) Channel 2. Pin 2 is a common earth, connected to the screen on either the amplifier or the recorder. Connecting to both screens can cause a hum loop. Ensure that all earth points are connected to a common line on the printed circuit, or hum may prove troublesome. Most suitable is the line running down the middle of the printed board.

When the preamplifier was first tested, it was found to give a pleasant mellow tone on both channels. I was, in fact, expecting less than I obtained. As long as input and output are high impedance, a good signal will be produced.



systematic sound

an examination of the Mellotron Sound-Effects Console

BY DAVID KIRK

THOUGH often pleasurable, tape editing is a time-consuming and repetitive method of programme compilation. Yet how can one mechanise an operation that requires such close co-ordination between tape and handler? Automation has its limits, but, even in this unlikely field, instruments are slowly taking over the more arduous tasks, allowing the editor to pay more attention to the intricate business of timing.

The invention which gave rise to the *Mellotron Sound-Effects Console* was conceived as a musical instrument. The *Mellotron*—for such is its name—vaguely resembles a piano or electronic organ but is substantially more versatile than these, having facilities to reproduce the tone-colours of many conventional instruments. Versatility apart, the feature which makes the Mellotron unique is its employment of magnetic tape as the tone source. Musical instrument and sound-effects console are similar in appearance and design, differing mainly in respect of the recorded material. Both are complex tape playback mechanisms—their complexity resulting from the ability to replay any or all of seventy tapes at one moment.

We shall concern ourselves in this article, however, with the effects console, since an examination of this was the purpose of a recent visit to the London offices of *Mellotronics Ltd.*

Essentially, the effects console is a memory device capable of reproducing 1,260 separate sound-effects—each lasting up to eight seconds when played at the recorded speed of $7\frac{1}{2}$ i/s. A variable speed control allows 20% deviation above and below that tape velocity and can be employed to alter the character of the effects or to simplify the timing problem.

To find an individual effect, or set of effects, the operator examines a list supplied with the machine, against which is given the appropriate switch coding. This shows which of the seventy tapes (each referred to a key on the piano-style panel shown in fig. 1) contains the required effect. Each of these tapes is $\frac{3}{8}$ in. wide and is scanned by a single head capable of aligning against any of three recorded tracks. Having detailed *Aircraft Wheel Skid* against, say, Key 39, the list continues to state the track number.

The seventy keys are divided into four groups, Keys 1-18 being controlled by one track selector, Keys 19-35 by another, and so on. These sets are paired into two separate keyboards, there being no special significance in the fact that each 'manual' covers nearly three octaves: two rows of toggle-switches might have served, though they would have been less easy to operate. As it happens, piano-style keys also simplify the tape transport mechanism, but this we shall leave until later.

Noting the desired effect to be on *Key 39, Track 2*, the operator then presses the Channel Selector (independent selectors are fitted to each of the two keyboards) to run the appropriate tape reel backwards or forwards to the start of the required eight-second sequence. The Channel Selector is a fast-wind device, operated through six push-button switches, each referring to one of six sequences on every reel. To culminate the selection of *Aircraft Wheel Skid*, therefore, the operator simply presses the listed channel button, whereupon, on pressing *Key 39* he can monitor the effect. It is no coincidence that several other aircraft effects are immediately to hand, since careful planning when the machine was originally programmed ensures that groups of effects are aligned across the seventy tapes. Thus, by accurate combination of individual sequences, the operator can 'play' the entire cycle of an aircraft taking off and landing, pressing one key to obtain *taxi*, another for *take-off*, continuing to *constant flight* and culminating with the three *landing, wheel skid* and *reverse thrust* effects.

Fig. 2 shows the schematic layout of the sound-effects console. Here are seen the four blocks of some 18 heads into which the 70 are divided, each block feeding a preamplifying network, on to a mixing network and then to the line amplifier, where the four blocks meet. Two outputs are provided from the amplifier, one feeding a master fader and jack socket to external equipment, and the other supplying a monitor circuit through a pre-fade listen control mounted on the far right end of the console keyboard. The effects can be monitored on headphones or through an external amplifier and loudspeaker.

The secret of the Mellotron music and sound-effects machines lies in the very original tape transport mechanism which uses a single capstan to drive all seventy tapes. The main problem the designers had to overcome was how to return the tapes to the start of each sequence rapidly without risk of snapping or stretching the tape, and without undue complexity. The description that now follows refers to just one of the 70 tapes, each having an identical transport and sharing only the capstan and spool spindles. Each of the tapes is wound on two spools (see fig. 3), actual position of the tape on each spool being governed by the Channel Selector. Pressing *Switch 1* thus positions the last five sequences on the feed spool, the beginning of the first sequence being located just before the playback head.

The tape is threaded from the supply spool down some 2ft. to a plastic pulley. Fig. 4 shows these pulleys and the seventy tapes passing round them. From the pulley the tape returns up to another horizontal guide, down to another pulley, and up to a further guide. It then feeds over the playback head, across the capstan and straight on to the take-up spool. A pinch-wheel mounted half-way along a wooden slat

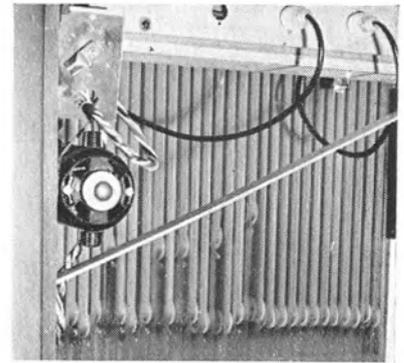
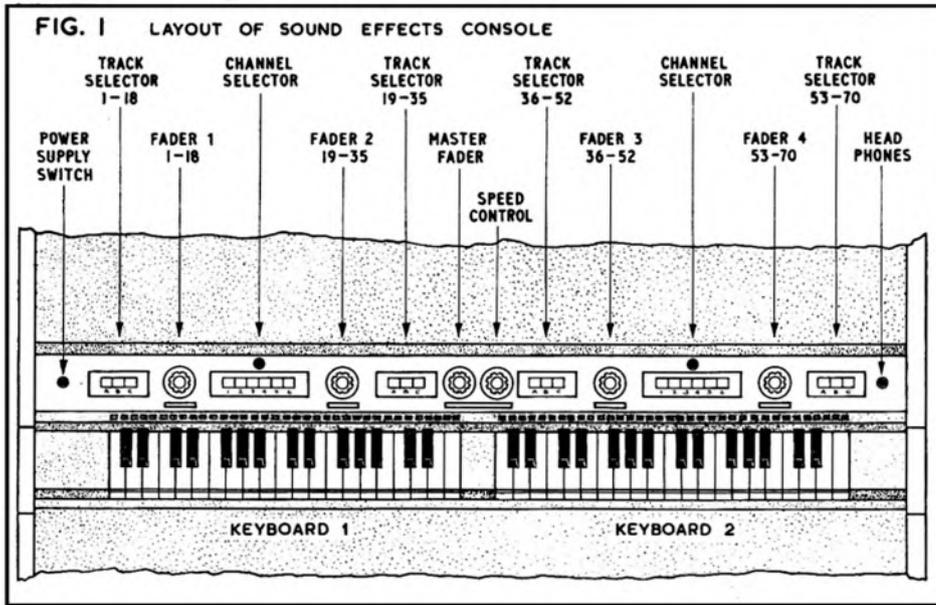
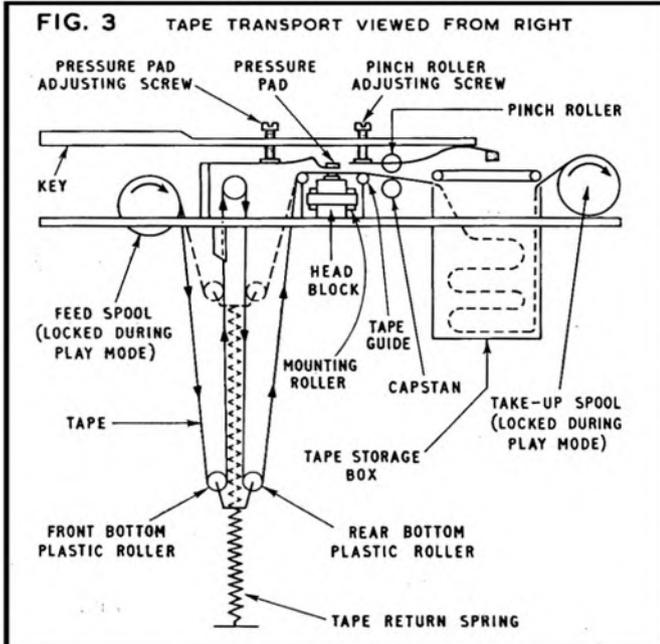
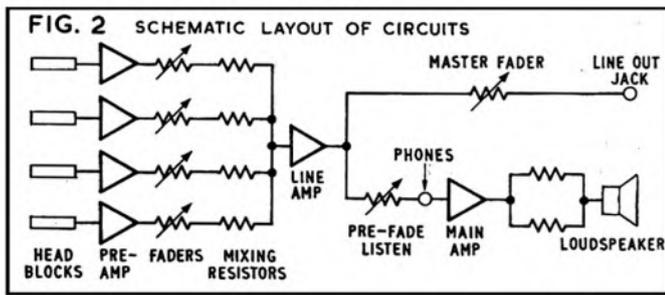


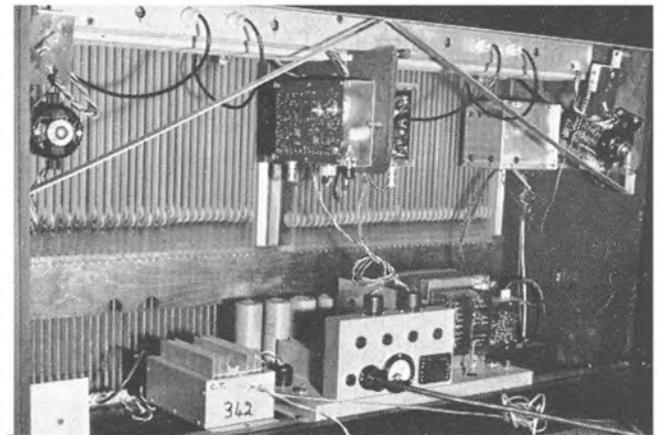
Fig. 5 (above) provides a close-up view of the tensioning pulleys an instant after keys have been pressed.

Fig. 4 (below) is a rear view of the Console, with the back cover removed. Note pulleys in rest position.



connected to the relevant keyboard tab moves down, when this tab is depressed, to force the tape against the capstan. Releasing the key causes the pinch-wheel to retract and halts further forward movement of the tape.

Except when the 'fast wind' Channel Selector is in operation, all feed and take-up spools are locked. The required tape sequence is temporarily stored in the loops formed by the plastic pulleys. The



axis of each pulley is attached to the cabinet base by a spring of some 10in. length (when contracted). These springs are partly visible in fig. 4, to the left of the power supply components in the base. Pressing a key applies the tape to the capstan (a servo unit and a large flywheel keeping the speed steady), reducing the length of the loop and moving the plastic pulleys upwards. The spring provides a degree of back tension to this movement and is also responsible for the fast tape return when the pinch-wheel is released. Excess tape is fed into a temporary storage box as it passes between pinch-wheel and capstan. This amounts simply to an organised 'spilling' and ensures that the pulley spring will have no tension to fight against when the tape makes its return journey. The photograph labelled fig. 5 shows a close-up of the pulley movement, several keys having been pressed together.

In the broader view of fig. 4, the capstan motor (far right of photo) and the tape wind motor (far left) are visible, while most of the circuitry is incorporated on the single chassis suspended beneath the centre of the frame. Power unit and variable motor supply are located on the base of the cabinet.

The $\pm 20\%$ variation of tape speed from $7\frac{1}{2}$ i/s is obtained by using a DC motor, rotation speed of which is directly governed by the supplied power. There is, of course, no parallel between this type of DC motor drive and that which gives the 'variable speed' (intentional or otherwise) found on many toy battery tape recorders. To overcome the inherent instability and inconsistency of DC drive, the mechanism of the sound-effects console is servo-controlled and as stable as any conventional professional recorder. Mellotronics quote the wow and flutter to be 0.3% RMS maximum. While on the subject of performance specifications, the signal-to-noise ratio with all outputs set to

(continued on page 22)



WHO SAID BEAUTY AND BRAINS DON'T GO TOGETHER?

This great new tape recorder is best in its price range for performance and looks!

Philips 'High Performance' Tape Recorder with Furniture Look Model EL3556 62 gns.

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PHILIPS—THE FRIEND OF THE FAMILY

OUR READERS WRITE . . .

. . . about cassettes and players

From: R. W. Merrick, Director, The Ferrograph Company Ltd., 84 Blackfriars Road, London, S.E.1.

DEAR SIR, Your Editorial of October concerning cassettes has come to the notice of the undersigned.

Over the years—particularly in America—cassettes have received considerable design attention, but have not at any time been accepted by the purchasing public in any great numbers.

This may well be due to the fact that the under-lying motive of the cassette designer has been to offer pre-recorded material as an alternative to the gramophone record and turntable—an effort that, in the writer's opinion, is a wasted activity.

My Company has always maintained that the real purpose of a tape recorder is to confer on the user the inestimable blessing of an ability to record and replay at will, any material—music, speech or signals—falling within the compass of its attainment. We did, indeed, for a year or more use the advertising slogan "recording is our business" and emphasised the importance of recording as a facility in entertainment, industry and research. To attempt to compete with the gramophone record—with its vast financial investments spread throughout the world—is a project doomed to failure and the pre-recorded cassette will, most probably, be no more successful in this context than the pre-recorded tape reels which enjoy a very limited sale. Until an entirely new recording medium is perfected, it seems to the writer that the tape reel serves the recordist well, whilst the needs of the 'playback' are well met by the superb and vast selection of records available everywhere.

Yours faithfully,

. . . about premature advertising

From: Tom Robinson, 'Belgrano', Ham Shades Lane, Whitstable, Kent.

DEAR SIR, I strongly disapprove of the current habits of manufacturers who advertise their goods long before they are available to the public.

Some three months ago a well-known distributor of tape recorders advertised a new condenser microphone—"See and hear it at any of the following dealers". A huge list of dealers appeared, but at the time of writing five of my acquaintance whom I have contacted have not had even one of these microphones. At about the same time a new version of a famous tape appeared in the advertisement columns, with the bold announcement "At your local dealer now." Neither of my local dealers has any, nor have two very well-known London firms of whom I have enquired.

By these tactics the manufacturers are frustrating would-be customers and also doing themselves a lot of no good. They should remember that if we cannot get things they tell us are available, then we shall go to, and stay with, other more reliable suppliers.

Yours faithfully,

. . . about incompetence and pressure

From: E. W. Walker, 58 The Brambles, London Road, Salisbury, Wilts.
DEAR SIR, Having been a reader of *Tape Recorder* since June 1959, I feel I must disagree with the view expressed by Mr. W. J. Tomlinson (*Readers' Letters*—November 1965) that too much time and space are given to complaints about bad service to tape recorder owners.

First, I believe a fair balance is kept in the subject matter of the magazine. Second, we expect fair comment on all subjects dealt with—which means criticism as well as bouquets. Mr. Tomlinson should remember that justifiable criticism—or fear of it—keeps manufacturers and dealers on their toes.

I should like to relate an experience I had which will illustrate this point. Having owned a recorder for more than five years, I decided

to replace it with a more ambitious machine. I made a careful choice, and purchased from one of the most reliable dealers in the district. Unfortunately, the recorder gave trouble from the day it arrived, and during most of the first four weeks it was under repair. Eventually the dealer decided to send it back to the manufacturer, but the recorder was no better when it was returned to me. Then I discovered the trouble: I had a *pipper* on my hands! What is a pipper? It is a capstan spindle that has a small crack down the outside, parallel to its axis. This has the effect of turning the metal on each side of the crack into the north and south poles of a small magnet, with disastrous effects on the tape. I could just detect the minute hair-crack with the edge of a fingernail—though could not see it without dismantling the machine.

With this information, the dealer sent the recorder once more to the manufacturer. Again it returned—with the same capstan and the same trouble. The manufacturer either disbelieved the diagnosis, or had never heard of this particular form of trouble. Back went the machine; but this time the firm kept it so long that I now had something else to complain of.

During the six months which had elapsed since its purchase, I think I had possession of the recorder for a total of six weeks; and during that time it had been a useless squatter. With ill-concealed anger, I wrote to the Editor of *Tape Recorder* and asked if he could help me. Within three days I had a letter of apology from the manufacturer, and within a week the recorder was back with me. Alas—so was the pipper!

Another angry letter to the firm, then another long silence. Yet another letter: either a new machine or my money back. Still no action. Finally, a letter demanding that my money be returned or I would send copies of the whole correspondence to *Tape Recorder*. By telephone, the dealer was asked to return my money! Victory at last.

The manufacturer was one of Europe's largest and most reputable; my dealer one of the best to be found. But where would I have been without the first prod given as a result of my letter to the magazine. And without the final threat? I should have been left with £70 of junk on my hands.

It is with the knowledge that such things can—and all too frequently do—happen, that Editors keep a sharp eye on the products of firms, both large and small; it is part of the service they give to their readers, and for which I hope Mr. Tomlinson is grateful.

Yours faithfully,

. . . about competitive designs

From: D. J. Bolt, 14 Marston Road, Clayhall, Ilford, Essex.

DEAR SIR, I have just heard and seen the new solid state stereo tape recorder by *Sony* of Japan. Once again I ask myself: what have we, the British, to offer in competition with such a product.

In my opinion manufacturers of tape recorders in this country must be asleep. Indeed the many potential hi-fi and tape recorders fans here are still stuck with the same old range of clumsy, Victorian styled valve machines with mechanisms that clank like anchor chains.

What the hi-fi man today wants is a good quality tape recorder with the following main features.

1/ Transistorise it completely and make it preamplifiers only. Elimination of power amplifiers and speakers will cut the cost and make for compactness.

2/ Give it three good $\frac{1}{2}$ -track stereo heads.

3/ One good $7\frac{1}{2}/3\frac{1}{2}$ i/s synchronous motor to provide all wind and drive functions. Elimination of fast forward and rewind motors will also cut the cost.

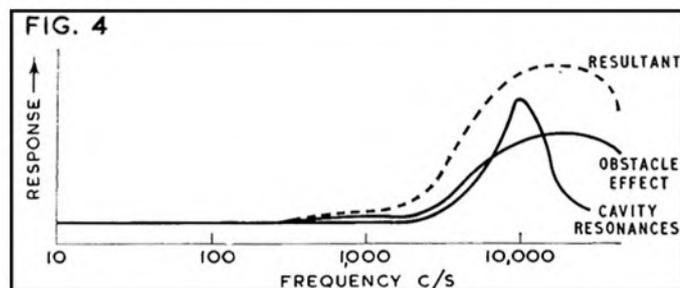
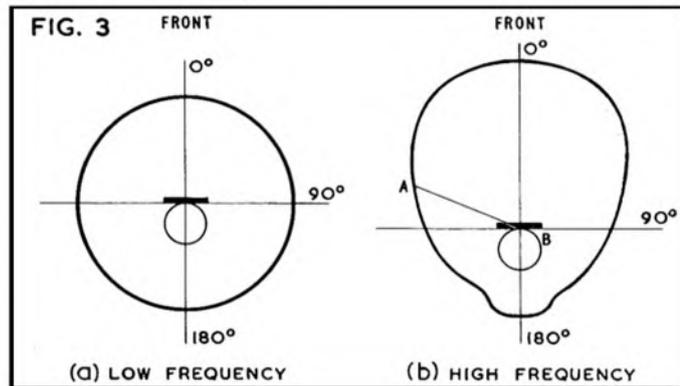
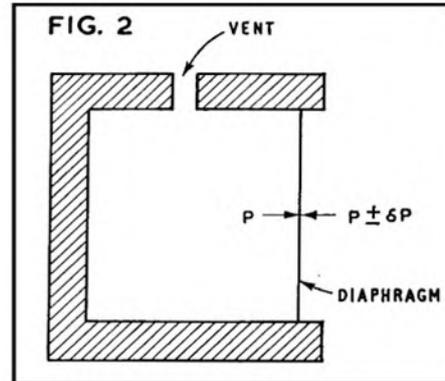
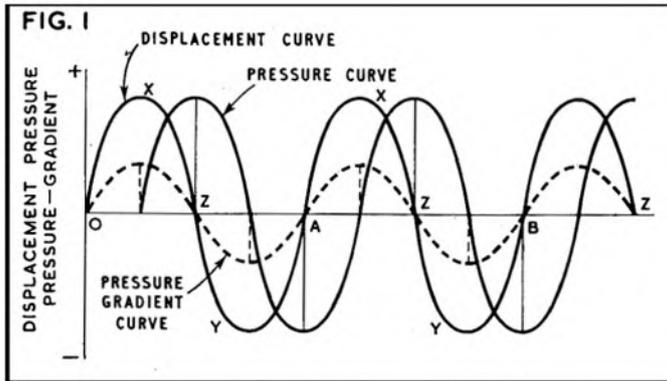
4/ With today's modern tapes, 7 in. spools will be adequate.

5/ Vertical working, so that we can mount the machine out of the way and see what is going on.

6/ Lastly, let us style it clean and smartly and here we can take a leaf from the Japanese and Americans.

I urge you to print this letter as it may help to shake a few cobwebs from the British tape recorder manufacturers and save us all that import tax.

Yours faithfully,



IN the recording of live music, speech or perhaps a play with sound effects, the quality of the subsequent reproduction depends largely on the proper use of the microphone, which is the foremost item of equipment in the audio chain. In addition to choosing the correct type for any particular purpose, its position relative to the sound source and acoustics of the room or studio is very important. For high quality recording of live music, a wide-range microphone with a flat response is really necessary, although for intelligible speech this is not the case and acceptable results can be obtained with the microphones normally supplied with a domestic recorder.

In order to understand how microphones work it is useful to consider, first, the nature of sound and its propagation through the air. The term *sound* denotes both the sensations registered by the normal ear when periodic variations (30 c/s—20 Kc/s) in the form of sound-waves, are superimposed on the steady atmospheric pressure, and the physical vibrations themselves. The magnitude of pressure variation which is just perceptible to the ear corresponds to the *threshold of hearing* and is an extremely small fraction of atmospheric pressure.

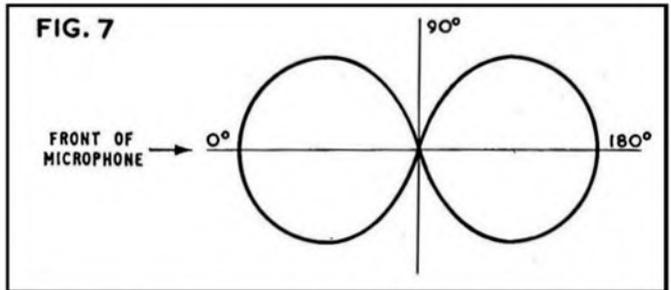
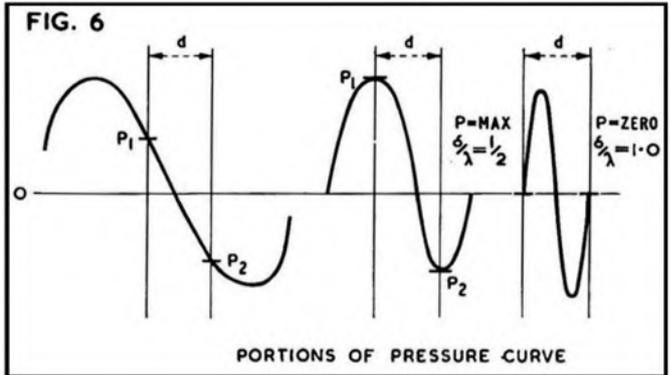
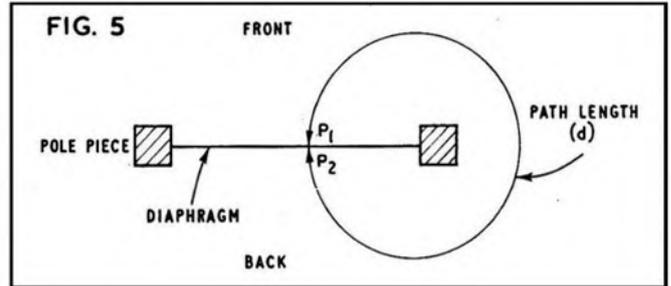
Everyday experiences teach us that the *source* of sound is in a state of vibration, and this sets the adjacent air particles into vibration at the same frequency. As a result the sound is propagated by wave motion which is longitudinal in character, the air particles having an oscillatory displacement along the axis of propagation. In its simplest form a sound-wave can be plotted as a displacement of air particles against time, and such a curve is known as a sinusoidal displacement wave, fig. 1. In this diagram a cycle is the name given to a complete set of variations of the vibrating quantity which is

shown from O to A and from A to B; the number of cycles passed through in one second is known as the *frequency*.

It can be shown that the air particles are in a state of increased particle density in regions where the forward displacement decreases with distance and where the backward displacement increases—that is where the slope of the displacement curve is negative, X to Y in fig. 1, and the density reaches a maximum at the point of maximum slope Z. Similarly, the density of the air particles is a minimum at points of maximum positive slope, A or B in fig. 1. Since pressure is proportional to the number of particles per unit volume it is possible to represent the variations in density of the air particles by a pressure curve. This is also shown in fig. 1 together with a *pressure-gradient* curve. Pressure-gradient is another important quantity which measures the rate of change of pressure with distance and is given by the slope of the pressure curve. It can be seen that the pressure wave leads the displacement and pressure-gradient waves by one quarter of a wavelength. Another important quantity is the *velocity*, which is the rate-of-change of displacement and is obtained from the slope of the displacement curve. Since the slope of a sinusoidal curve is proportional to the frequency, it is easy to see that both the velocity and pressure-gradient are also proportional to the frequency.

Table I shows the different types of microphone available and, as indicated, they fall into two main groups, the pressure operated and the velocity operated. These two groups differ in the method employed to obtain a force from the sound wave to drive the diaphragm. In the former group, movement of the diaphragm is proportional to the pressure exerted by the sound waves impinging upon it, whereas in the latter group displacement of the diaphragm is proportional to

SOME GENERAL PRINCIPLES OF MICROPHONES BY G.T. ROGERS



the particle velocity of the sound waves. Since velocity is a vector quantity, having direction as well as magnitude, microphones of the second group, the velocity types, show important directional characteristics which will be considered in greater detail later.

It will be recalled that sound consists of variations in air pressure which are superimposed on the steady atmospheric pressure. The design of pressure-operated microphones is such that the acoustic variations are isolated from atmospheric pressure and used to drive a light diaphragm system. The basic construction of such a microphone is shown in cross-section in fig. 2, where the arrows represent the pressures of the diaphragm. Sound pressures which are superimposed on the atmospheric pressure impinge on the front of the diaphragm. The air on the other side is maintained at steady atmospheric pressure, the vent allowing air to pass in or out as the result of the comparatively slow changes in barometric pressure. The vent is so arranged that it does not transmit the acoustic pressure variation. The force available is proportional to the acoustic pressure variation and is independent of the frequency.

However the velocity u of the mechanical system in a typical moving-coil microphone is not independent of the frequency. In such a microphone the induced voltage e depends on the velocity of the coil and is given by the formula $e = Blu$, where B is the magnetic field strength, l the length of wire in the coil and u the velocity of the coil. Since the velocity of the mechanical system is inversely proportional to the mechanical impedance, there will be a pronounced peak in the velocity/or frequency curve when such a system is at resonance, and this will be reflected in the electrical output of the microphone. To overcome this difficulty, damping

elements are included in the design to oppose the high velocity of the diaphragm at resonance and achieve a reasonably flat response. However, a uniform response can only be produced at the expense of sensitivity.

In general, pressure operated microphones are non-directional (omni-directional) at low frequencies, up to 1 Kc/s, which means that they are equally sensitive to sound originating at any angle to the diaphragm. This can be shown by a polar graph where the magnitude of the output at various angles of incidence is plotted from a central origin fig. 3(a). At high frequencies, however, they tend to have a one-sided response as shown in fig. 3(b). There are two main reasons for this. Firstly, sound reaching the microphone at an oblique angle, as indicated by AB in fig. 3(b), will impinge upon different parts of the diaphragm at different times. When the wavelength is shorter than the diameter of the diaphragm, these arrivals may be out-of-phase, giving a reduced response as shown.

Secondly, there is the so called *obstacle effect*. At the higher frequencies the microphone itself is a reflector of sound waves and this tends to increase the response in front of the diaphragm. An increased response at the higher frequencies can also result from resonances of any cavity that may be in front of the diaphragm. These effects are illustrated by the response curve shown in fig. 4. Although this increased high frequency response has been used to advantage in some pressure microphones to compensate for high frequency losses, it is generally difficult to achieve a practical design over an extended frequency range.

In pressure-gradient operation both the front and rear surfaces
(continued overleaf)

of the diaphragm are exposed to the acoustic pressures as shown in fig. 5. Since the surfaces are acoustically separated by the path length d around the pole pieces, the acoustic pressure reaches the front and back at different times depending on the velocity, and consequently will be out-of-phase. Therefore, a pressure-gradient will exist between the two faces and cause the diaphragm to move from the area of high pressure to that of low pressure. This is given by the formula $P = p_1 + p_2$, where P is the pressure difference and p_1 and p_2 the pressures at the front and rear respectively.

Obviously the pressure difference between the two faces of the diaphragm depends on the path length, but it also depends on the frequency of the sound wave. Reference to fig. 6 shows that the pressure-gradient, and hence the force available to drive the diaphragm, is maximal when $d/\lambda = \frac{1}{2}$, and zero when the path length is a simple multiple of the wavelength, that is when $d/\lambda = 1, 2, 3 \dots$

At low frequencies, when the path length is small compared with the wavelength, the pressure difference P is proportional to the frequency, but as the latter increases the output falls off and is zero when $d/\lambda = 1$. In a practical design this cut-out frequency must occur outside the useful range of the microphone, and one way of achieving this is to reduce the path length, although this lowers the sensitivity also.

The mechanical design of a pressure-gradient microphone depends on the proportionality between the pressure difference and the frequency, and is such that the velocity of the diaphragm is constant and independent of the frequency provided that the system is mass controlled. (The reader is referred to textbooks on electro-acoustics for a theoretical treatment of this subject.) In a typical pressure-gradient ribbon microphone the ribbon acts both as the diaphragm and the conductor, and the voltage e generated in the latter is given by the general formula $e = Blu$, which was introduced earlier. The

TABLE 1 PRESSURE OPERATED	VELOCITY OPERATED
Carbon	Free Ribbon
Crystal	Pressure-Gradient
Moving Coil	
Capacitor (Condenser)	
Certain types of Ribbon	

voltage is therefore proportional to the velocity of the diaphragm and independent of the frequency.

In practice, certain ribbon resonances have to be controlled by damping and as a result the system is no longer mass controlled at the lower frequencies. This means that the output falls at low frequency and some degree of bass compensation is necessary. This usually takes the form of a baffle material which surrounds the pole pieces.

Whereas a pressure-operated microphone is essentially omnidirectional, pressure-gradient operation depends on the angle of incidence of the sound wave. If the normal path length is d , then for sound incident at an angle θ , the effective acoustic separation is given by $d \cos \theta$. When the angle of incidence is 90° , $\cos \theta$ is zero, and hence there is no pressure difference and no force to drive the diaphragm. A pressure-gradient microphone is therefore insensitive to sounds arriving at right angles to the axis. As θ is decreased from 90° the output reverses in phase and increases to a maximum at 180° . This is shown in fig. 7 as a figure-of-eight characteristic.

When a microphone is used on a stage it is often desirable to eliminate unwanted noises coming from the audience. In these circumstances a unidirectional or cardioid microphone, which is live on one face only, over a wide angle, is particularly useful. There are many different types of unidirectional microphone, but they all operate by combining the characteristics of an omnidirectional element and a pressure-gradient element. When two separate elements

are used their outputs will reinforce each other at the front of the microphone, but since the pressure-gradient response reverses in phase at the rear, the outputs from the latter and the omni-directional elements will be in opposition and complete cancellation will take place at 180° .

In practice, the output from two-element cardioid microphones tends to vary with frequency, and this is partly due to the difficulty of obtaining a purely omnidirectional pressure operated element.

A superior unidirectional response can be obtained by using one element to combine pressure and pressure-gradient operation. This utilises the so called phase-shift principle, which can be illustrated by a description of a cardioid capacitor microphone. Mr. Kirk's article, *Microphones and the Erase Process* (July 1965) explains in excellent terms the working of an omni-directional capacitor microphone. To introduce pressure-gradient operation in such a design, holes are bored through the back-plate to enable sound pressures to act on the back as well as the front of the diaphragm (moving plate). The microphone will then be more sensitive to sounds arriving at the front since the pressure and pressure-gradient effects will reinforce each other. Sounds arriving at the rear, however, can reach the front of the diaphragm via the external path length, and also the back of the diaphragm via the internal path length through the holes in the back plate. Now, if these two paths are made equal, complete cancellation of sounds from 180° is achieved.

Both figure of eight and unidirectional microphones rely, therefore, on pressure-gradient operation, which is appreciably independent of frequency. In addition to this, their directional characteristics favour ease of positioning in the studio, where the amount of reverberation picked up is much less than that picked up by the omni-directional pressure types. Finally, to emphasise the importance of directional characteristics, one need only draw attention to the fact that many of our advanced microphones have variable characteristics from omnidirectional through cardioid to figure-of-eight.

SYSTEMATIC SOUND CONTINUED

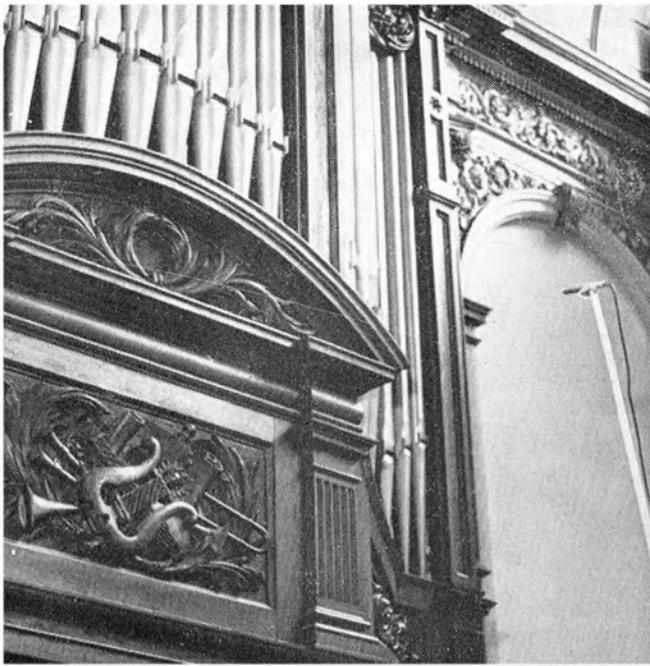
produce 0dBm from a fully modulated (2% distortion) tape, is 46dB, improving—when only one output is employed—to 55dB.

The music machine employs a slightly more common form of variable speed mechanism, having a synchronous motor through which tape speed is locked to the frequency of the motor supply. Many medium-quality domestic tape recorders feature this type of drive, tape speed being locked to the 50 c/s mains supply. The Mellotron, however, incorporates a signal generator and very high power amplifier, Rotation of the speed control alters the generator frequency within fixed limits and thus provides an accurate means of controlling speed. Though a less expensive arrangement than the DC servo-drive, this system has not been employed on domestic equipment as the motor amplifier is itself very costly.

The BBC Sound-Effects Library is the source of all material used on the effects console. The machine can, however, be programmed with the user's own recordings, these being submitted to Mellotronics Ltd. on $\frac{1}{4}$ in. tape at $7\frac{1}{2}$ i/s, where they are dubbed on to $\frac{3}{8}$ in. tape for insertion into the console.

The sound-effects console is available on hire or can be purchased for £2,625. The BBC was one of the first customers and has shown great interest in its development and use. However, when one remembers that the device is not so much a piece of audio equipment as a very versatile information store, it is reasonable to expect a spate of widely differing applications to appear in the course of time. Medical authorities, for example, have expressed interest in a version of the sound-effects console, programmed with cardiac murmurs, faulty heart-beats, stomach rumbles and all ancillary noises worth memorising by the trainee surgeon.

Postscript: A Mellotron Sound-Effects System will be demonstrated at the Central Office of Information Theatre, Hercules Road, London, S.E.1., on Wednesday 9th February. Organised by the BKSTS, a lecture demonstration will commence at 7.30 p.m. and will be given by Eric Robinson (Mellotronics Ltd.) and F. C. Brooker (BBC). Interested readers who are not members of the Society should contact: The Secretary, British Kinematograph, Sound and Television Society, 164 Shaftesbury Avenue, London W.C.2.



THE HAMMOND M.100 CONDENSER MICROPHONE



FIELD-TESTED

By M. F. WOODWARD

Left : Part of the organ in Reading Town Hall, with the M.100 positioned on a simple batten.

THOSE in the market for domestic recording equipment are faced with a bewildering assortment of machines, the vast majority of which in the medium to high price range offer a remarkable performance potential. This potential is especially noticeable when the machine is fed by a good pickup or VHF tuner, and playback is by courtesy of first-rate amplifier and speaker equipment.

When, however, the recordist steps forward on to *live* recording the field is somewhat narrowed—distinctly so, in fact, when the recording is of wide-range music or sounds sensitive to delicate shades and transients, for the *smooth* range of good microphones available at a reasonable price is by no means wide.

Some manufacturers supply a microphone with their recorder, and inevitably this must be an item subject to compromise between cost and quality, for who will willingly load the overall cost with an accessory which some customers will never appreciate or use to the full?

For these reasons, the appearance of a new quality microphone is welcome, especially when it springs from the pedigree praised by Stanley Kelly in his review of the *Microkit* condenser microphone in the November 1963 *Tape Recorder*.

The new *Hammond M.100* condenser microphone is a radical development from the *Microkit*, the designer, Mr. Ratnagar, having produced a much smaller 'business end' by replacing the valve assembly of the *Microkit* by an RCA Nuvistor. The resulting shell is a mere 3½ in. long by ¾ in. diameter, anodised a discreet matt black. Herein lies one of the first attractions of the M.100, for only those 'playing at professionals' will wish for those large and impressive microphones, which succeed largely in irritating onlookers and daunting performers. Far better for the microphone to be discreet, and in this respect the M.100 is a very well mannered instrument.

The circular case officially requires a clip to adapt it for stand or boom use, and a great variety of clips, some with built-in cable connectors, are available at extra cost. I found the microphone so small and light (it only weighs a few ounces) that an elastic band fixed it to a tiny Perspex platform screwed in turn to a long slender timber batten, and this homely affair served very well (see photo of organ set-up). However, a semi-permanent clip is recommended, for if the M.100 were placed on a surface free from its cable, it could easily roll on to the floor.

This sort of catastrophe was viewed sanguinely by Mr. Ratnagar, who took the view that the case and Nuvistor were unaffected by shock and the diaphragm (protected by a deep grille) was immune to danger. I took great care however, for *had* my M.100 rolled away and nose-dived on to the floor, and *had* there been a convenient sharp object, the effect on the diaphragm could have been serious. I would have preferred to see a gauze 'thimble dome' protecting the diaphragm rather than the grille which, apart from not giving as much protection

as could be wished, might also act as a baffle to high frequency sounds at grazing incidence to the diaphragm.

The standard microphone is supplied with a length of about 15ft. of flexible cable and is connected to it by a most satisfactory 'Cannon' clip, the other end of the cable being connected directly to the power unit. Here again, extensive re-design both internally and externally has taken place, for the power unit has a transistorised smoothing and regulating device which should render it independent of normal mains voltage fluctuations. The power unit case is 12 x 4 x 4 in. and is sensibly designed to house, in addition, the microphone together with the standard cables; thus one box contains everything and one need not travel like a Christmas tree or arrive, perhaps, minus one important part. The finish is aluminium, anodised to match the microphone.

Connection from the power unit to the mains is by a 9ft. cable, and a similar length of co-ax is supplied for connection to the tape recorder. These cables are perfectly all right, but I personally would like to see more cable supplied for connection from power unit to the microphone, the 15ft. standard length being a bit tight for some occasions. The power unit can cope satisfactorily with up to 150ft. of cable (in fact the microphone was so supplied for review) and whilst this length is rather extreme, nevertheless a 30ft. length would, I feel, be useful.

So far, so good; what of the performance? Test curves supplied by the designer show a flat response on the axis from 55 c/s (-3dB) to 20 Kc/s, with a small 2dB 'hump' at 9 Kc/s. At the bottom end the response is attenuated to -12dB at 20 c/s, although those who wish can have a flat response down to 20 c/s by altering a capacitor in the power unit. Whilst apparently retrograde, the decision to attenuate the extreme bass response is an attempt to make the microphone more usable by the majority of recordists, for extreme bass can, it seems, sometimes overload the circuitry of tape recorders without the fact being shown on the level meter.

Readers of the *Microkit* review will remember a fall-off at 10 Kc/s at grazing incidence to the diaphragm, and the same effect is the case with the M.100.

(continued overleaf)

MANUFACTURER'S SPECIFICATION. Low price condenser microphone with valve preamplifier. **Polar Characteristics:** Substantially omnidirectional. **Sensitivity:** 2mV/μBar. **Frequency Response:** Effectively linear over entire audible spectrum. Bass frequency attenuator incorporated with further variable bass cut located in power supply unit. **Power Supply:** Models *SU-1* and *SU-2* power units power one or two M-100 microphones respectively. Input power is 110,135,220 or 245V, 50/60 c/s. Transistor stabilised LT and voltage regulator tube for HT supply. Battery version available. **Mains consumption:** 12W. **Finish:** Neutral anodised aluminium microphone and matt-black power unit. **Manufacturer:** C. E. Hammond Ltd., 90 High Street, Eton Windsor, Berkshire.

"WHENEVER THE DEMAND IS FOR PRECISION RELIABILITY AND NATURAL SOUND REPRODUCTION— THE CHOICE MUST BE TANDBERG"

SERIES

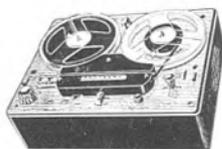
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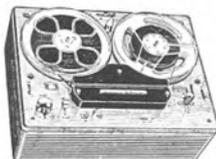


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High class monaural 3 speed (7½, 3½, 1½, I.P.S.) tape recorder, with quality comparable to the famous Stereo models. Extremely reliable machine recommended for all home and educational purposes, etc.



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Elstone Electronics Limited, Edward Street, Templar Street, Leeds 2. Telephone: Leeds 3-5111 (7 lines)

HAMMOND M.100 FIELD TEST CONTINUED

Lacking the necessary equipment to test the claimed response (*It is hoped to publish some separate measurements in a later issue. Ed.*), I did the next best thing, and loaded my tried Planet deck with Shirley Laboratories TWA.15—and also a Reflectograph recorder—into the car, and visited three comprehensive and powerful four-manual organs, also a small and brilliantly voiced two-manual organ, and tried some practical testing.

It is my view that a well developed organ chorus will show up most microphone defects, for the extremes of power and frequency, plus the potential distortions and intermodulations, are approached by few other instruments. The results were eminently satisfactory, the M.100 coping smoothly and authoritatively with anything which could be thrown at it. No detectable hum or hiss superimposed themselves on the sound and the results at the extreme ends of the frequency range heard through the TWA.15 and Goodmans Axiom-Midax-Treback equipment were equal to results heard from a good disc.

REMARKABLE EFFECTS

A further recording session with a complete symphony orchestra showed excellent overall results, but with quite remarkable effects from the recorded sounds of the normally elusive cymbals, triangle and tymbrels. It is generally somewhat difficult to obtain a hint of the real effect of these instruments, but the M.100 behaved in a most exemplary manner, capturing them in an orchestral climax of great power.

The review microphone was supplied without the standard built-in bass attenuation, and some care had to be exercised with the record level initially, for heavy extreme bass notes could over-modulate the signal without the fact registering on the meters. This experience may seem to confirm the designer's policy of standardising the bass attenuation characteristic, although, as a confirmed bass response disciple, I would personally prefer to use the straight version with care rather than the doctored one with a light heart!

A high output (for a quality microphone) at low impedance is specified, and the M.100 is for this reason claimed to be suitable to all intents and purposes for any tape recorder input, a typical one being 2mV at 1M. I found the microphone gave an adequate output both for the Reflectograph and the Planet/Shirley, although the level was slightly less than that from a good moving-coil instrument. A low/high impedance transformer is available to order, and this will be a useful accessory for many of those who have high impedance inputs. If, however, a somewhat higher output could be contrived, it would nevertheless be an advantage, even up to the stage (as seen with the earlier Microkit) of having an output suitable for a GRAM input, for the quality of microphone inputs in some of the lower priced recorders leave something to be desired. If the output could be adjustable it would be even better—but I see costs rising and someone has to say stop somewhere.

FULL-TRACK RECORDING

Apart from my own recordings, I heard a full-track recording made on professional equipment of a brass/drums ensemble, and here the ability of the M.100 to deal with close placing of a solo trombone and trumpets and the sizzling transients and bass from the kitchen department was impressive indeed.

I gather that a version for stereo recording will be available, comprising two microphones and cables plus a combined power unit. The cost of this will be 44gns., and shows a worthwhile saving over the cost of two separate units (29gns. each).

In addition, a version powered by an Ever Ready 6V type 996 and a 90V type B.126 will be available at 19gns. The battery life claimed is, respectively, 14 and 28 hours, used intermittently (say, for periods of up to two hours per day). Finally, a supplementary 'battery box' is available for the mains powered version at 4gns.

Almost any tape recorder will benefit from a good microphone, and the M.100 will be a very worthwhile investment for those anxious to make top quality live recordings, offering as it does a neat and well thought-out appearance together with first-rate performance and a reasonable cost.



SOUND AND CINE

RECORDING WILD

BY ANTHONY WIGENS

THERE are three basic uses for a tape recorder on location apart from making a synchronised sound track. In each case it is unnecessary to have any physical link between the camera and the recorder, and the track recorded is said to be 'wild'. This means that there is no intention to match any part of it to a precise stretch of filmed activity—and you would find it a difficult task to do if you tried!

The track is 'wild' in two senses. In the first place no attempt is made to record a start mark on either film or tape, so there is little hope of subsequently starting or finishing them together. In the second place, the film running time will probably alter slightly on projection, as a different motor (mains instead of battery driven or clockwork) is involved—and the same kind of discrepancy may creep into the tape playback if the battery recorder has less than full power to draw on.

Within these limitations, 'wild' recording has a place in the making of a sound film, as we shall see.

The first use is in recording non-synchronous effects. Some of these will be vague atmosphere noises like the breakers on the beach with the occasional screaming of seagulls overhead. You may plan a film which takes place entirely on the beach, and require a commentary over a suitable background track.

Let us suppose that the finished film is to run for fifteen minutes, with no change in the background required during that time. To record fifteen minutes of *Desert Island Discs* type noise is totally unnecessary, and you would find it difficult to record for that length of time without some superfluous noise occurring. It might be irrelevant, such as a jet flying overhead, or it might be something totally out of script for the film, such as the voices of strangers passing by, when the film's plot called for the beach to be deserted.

You do not need to buy the BBC effects disc—just record thirty seconds or a minute of the sound, enough to ensure that repetition of recognisable groups of sounds is not apparent. If you have a cassette recorder such as the Philips EL3300 shown in the photograph, re-record on to a mains machine. Then use the $\frac{1}{4}$ in. tape spliced in a loop to dub on to the film track, prior to recording dialogue, or simultaneously.

If you are making a tape sound track, rather than a magnetic stripe one, you will need two mains recorders. If your battery recorder uses

$\frac{1}{4}$ in. tape on conventional open spools, the portable can be used to play the loop.

Other sounds may be related more closely to their origins without requiring synchronisation. The sound of an express train approaching and passing, for example, needs to start just before the first sight of the train. In fact this type of effect is used for visual cueing, in which the audience is alerted to the content of the next shot prior to the cut from the previous shot.

Effects of this kind will often be assembled in the order required for a sound track, each separated by a short length of blank tape and with a visual start mark. They can then be brought in individually on cue, with the recordist watching the film screen.

The second use of a 'wild' track is in post synchronised recording, where the actors assemble in the studio and watch the film, recreating the necessary speech to match their own lip movements on screen. Where the dialogue is formalised and every actor sticks meticulously to the script, a location recording during filming would be superfluous. But if the actors are under-rehearsed or there is any kind of ad-libbing it may be terribly difficult to establish later on what was said to match the lip movements that were filmed.

A recording made while the camera was running even if it is marred through carrying the sound of the camera motor on it—is invaluable for studio rehearsals. With a stripe projector, the film can be made into a loop for such a synchronised sequence, and run through several times after the 'wild' recording has been listened to. When the actors are sufficiently well rehearsed the film loop is run with the projector on 'record', then switched to play back for an immediate check on the degree of sync achieved by the actors.

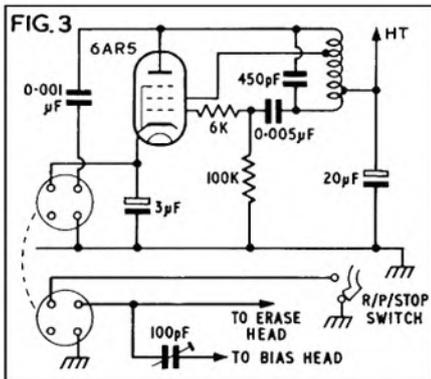
The third type of 'wild' recording is a Buzz Track. This is a tape of the acoustic atmosphere in a studio in which a synchronised recording has been made.

At a later stage it may prove necessary to edit some further shots into the scene, or more likely on the beginning or end of it. These may be cutaway shots of characters who are seen but not heard, and there is no recorded track to match the shot. In such a case a convenient length of Buzz Track is cut into the sound track, so that there is no audible end to the background hum behind the speech in the scene.

ONE of my esteemed colleagues, reviewing this model in a rival magazine, announced that he had great difficulty in tearing himself away from operating "the new toy" to settle down at his desk and write about it.

Our own pundit, A. Tutchings, Esq. (may his tapes never tangle), had a very different approach. "A recorder for the real enthusiast . . ." he announced, ". . . could form the nucleus of a hi-fi stereo system." At nearly £140 this is a toy for the pools-winning class. Yet this impecunious enthusiast cannot go all the way with Mr. T. One expects the clock in a *Rolls-Royce* not to tick too obtrusively, and for this money a machine that purports to be a semi-professional model, and whose importers would dearly like to see as a contestant for the domestic section of a *Which?* critique, should be a little more finished in design and construction. Should have, also, a few of those extra facilities that Messrs. *Grundig* and *Philips* have demonstrated can be incorporated in quite moderately priced apparatus.

I am not being deliberately awkward. At the moment we shall not concern ourselves with frequency response, signal-to-noise ratio, or even wow and flutter. These specifications can be checked by reference to the June 1964 issue. Although the cross-field biasing system will



interest us, we are not to be sidetracked by the effusive spiel of the copy-writer, who seems to imagine this is the cure for all distorting ailments. Of more immediate concern is the clutching and braking system and the inter-connected switching which has been built into the machine as a safety measure. This seems to have followed the Law of Diminishing Returns: the more complicated one makes a machine, the more complicated one has to make a machine. Yet certain other high fidelity manufacturers can produce gear of similar quality and trust the user—who is, after all, unlikely to be a ham-fisted button-puncher—to take all the usual precautions. My own experience of protective devices is that they cause more trouble than they set out to avoid!

The first of these devices we need to consider is the action of the automatic cut-off switch, which is rather more involved than the general run of such arrangements. There are two manual switch settings, 'cut-off' and 'stop'. In the former position, the complete power is cut off and in the latter, only the power to the deck is interrupted. The pin and spring method is employed, as previously described, giving protection against tape breakage.

In this case, however, the mechanism is also neutralised by an interlocking arrangement with the function switch and the pause ('instant-stop' in this instance) control. Therefore, whatever the setting of the function switch, after the autostop has done its duty the operator has to press the start button to continue. But the action of this mechanism is different for playback and record from its operation during fast-forward or rewind, and an extension to the mechanism is used to operate the microswitch, cutting off the power in the 'cut-off' position of the automatic switch.

Fig. 1 shows the basic mechanism. It can be seen that the action of the eccentric gear with its cutaway portion, is very similar to the gear wheel in the conventional autochanger disc machine. As the tape pin A is allowed to travel in the direction of the arrow by the release of tension as the tape breaks or ends, a curved spring below the crescent arm pushes the eccentric gear wheel down and it engages with the flywheel gear. This is simply a toothed portion of the spindle, accessible

to the eccentric wheel through a slot in the upper housing of the flywheel bearing assembly. As the eccentric gear is made of black Bakelite (or something very like it), there is a possibility of a broken tooth, and when this happens the assembly jams and the curved spring can suffer damage. The holding plate for this gear needs to be accurately positioned, and the pin on the plate must seat in the guide groove in the deck sub-plate. A loose screw in this assembly can cause havoc. Another fault that gives rise to erratic auto-stop action is the eccentric gear binding on the plate. Wear of the Bakelite and a deposit of foreign matter, generally caused by inadequate lubrication, will be the cause, and the remedy is obvious, if caught soon enough. This, it seems, would have been a case for the use of polystyrene or similar tough plastic rather than Bakelite, or brittle fibre.

As the flywheel continues to turn, the eccentric gear returns to its neutral position and the small pin is again in place to be depressed by the curved spring when needed. Movement of the appropriate levers B and C is by the coupling to the plate D on which the eccentric gear is mounted and the cross lever C pulls the pinch wheel bracket away to disengage from the capstan and pushes the end of the lever E to disengage the intermediate wheel F from the clutch drum G.

But during fast forward and rewind additional idlers are employed and it is necessary to neutralise these by reverting the whole mechanism to the stop position, and this is done by actually moving the control lever assembly. The function switch has a cam beneath it with a roller mounted on a separate bracket, but clamped to the cam base. The roller sits in the cut-out of the 'can-opener' lever H. When fast forward or rewind are selected, the roller is against the straight shoulders of the cut-out. The plate D pivots as the eccentric gear turns and pushes the lever H to the right. This forces the roller to a central position, which brings the function knob to the stop position and neutralises the complete mechanism as well as turning the electrical section of the switch. This lever is another possible source of trouble, and the exact movement must be ensured. If the mechanism has been forced, the lever becomes bent and the switch does not turn completely, or the roller binds against the curve of the cut-out, erratic auto-stop action

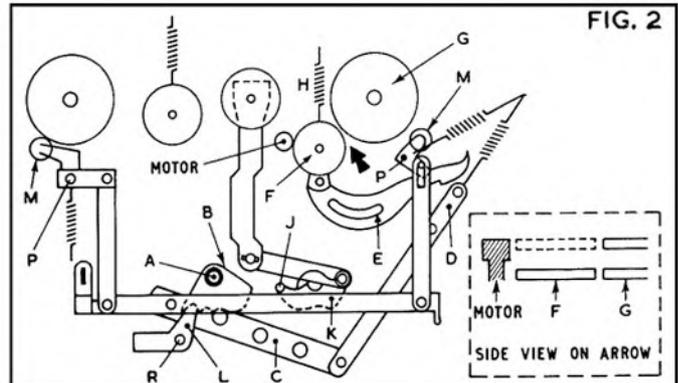
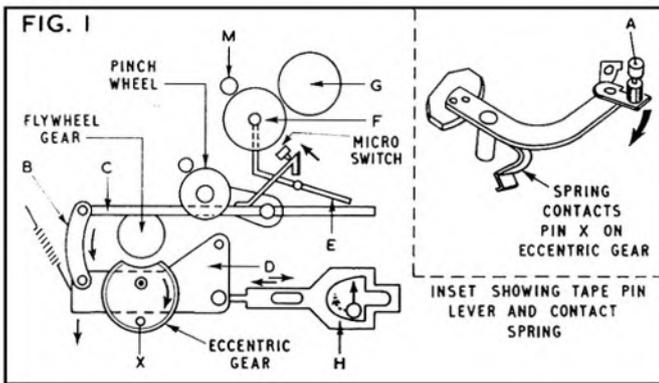
again takes place, even though the function switch can be operated normally, and the cut-out works correctly when in the record/play position.

The number of idler wheels, levers and springs on this machine, and the various cam movements, can generally be worked out by careful observation. It is when things go wrong that a knowledge of what should occur can help the investigator. Hence these notes, which may appear at times to explain the obvious. If no previous acquaintance has been made with the deck, for example, it is difficult to work out what should happen when the various functions are selected. Fig. 2 gives a rough layout, and the operation is basically as follows.

The drawing shows the mechanism in the play position. The same lettering of certain parts shown in fig. 1 is retained for reference. It is not practical to draw this to scale, as certain parts overlap, and several part section drawings would be needed to trace through all the operations in detail, which space restrictions do not allow. Reference to the machine should make matters clear. The off-play-record knob is mounted on spindle A, to which is attached the shaped cam B. The detents in this cam engage a roller on lever C, coupled to lever D, and allow the latter to withdraw, letting spring H pull the intermediate

the washers that compensate for pressures of pulleys. The pinch wheel load spring, particularly, at the inner end of the crank arm, which is pivoted on a common post with the cross-bar of the auto-stop mechanism described above, should only be tackled in the direct circumstances to regain the stipulated pressure of between 1,000 and 1,150 grams (at $7\frac{1}{2}$ i/s). Once wrongly adjusted, especially to the slack side, it can be the very devil to put right. Similarly, the take-up idler wheel, F, has to engage the motor pulley and the hard milled plastic of the spool drums, and can suffer from an excess of tension. The load spring H must be carefully tensioned, and the exact setting of the lever E relative to the cam J is important.

Reference was made above to the 'starfish' retainers. For those who have not met these little jokers, it should be pointed out that the setting of the arms (or should it be legs?) of the star provides some adjustment of tension, especially where these are used, as in the take-up spool assembly, between plastic, paper, nylon, steel and rubber washers to give the required torque by the rotating assembly. This is one of those cases when my vote goes to a three-motor deck, even though the results obtainable from the M-7 and similar models may be well up to the highest standards.



wheel F into engagement with the motor spindle and the clutch drum, by the pivoting of lever E. (Note the inset, where the alternative position of F is shown in engagement with the upper section of the spool drum assembly for fast winding. The raising of the lever arm E is initiated by the pin J on the right-hand cam, which is the one previously described, coupled to the fast wind knob and switch.)

The record safety device, a form of interlock, is seen at L, engaging in one of the detents of the cam B. Depressing the record button R releases the cam for its further arc of travel.

The brakes are peripheral types, but instead of pads, fixed rubber rollers are used, M-M, mounted on short angle arms pivoted at P-P and actuated by the main brake lever assembly. During record/play, the left-hand, supply spool has braking pressure applied to the lower part of the assembly. Both spool carriers thus have clutch assemblies, although the construction of them is different, and, in fact, the spool assembly is quite complicated, with sectional spindles, circlips, compression springs and a rubber ring in the left assembly as a clutch washer. It is a feature of this machine that torques must be exact, and any attempt to use unmatched spools results in tape spillage when the brakes are applied—and there is no easy adjustment to compensate for this. The clutch felts, on the upper surface of the lower drum in each case, require scrupulous cleaning and softening, and when adjusting or assembling spool parts it is necessary to ensure that the clearance between the lower section and the deckplate is adequate, by checking the starfish holder and the five mounting washers. The revolution counter couples to the lower part of the supply spool assembly by a pulley, held by a single grub screw, and a belt. Erratic back tension can be caused by this part of the mechanism, and if the rev counter rotates freely on fast winding but is touchy during play, with jerky tape supply, check the grub screw. Do not overlook the pulley at the other end—to the revolution counter itself, where a similar form of mounting is employed.

There is no true adjustment available for any of the usual actions, braking, reverse torque, clutch action or even pinch wheel pressure, except by tackling the springs that hold the various levers in place, or

Mention was made at the commencement of this article of the question of facilities. There are, indeed, input and output connections available from practically all the usual stages, and a little ingenuity on the part of the operator would undoubtedly enable him to patch and match to other high fidelity equipment and obtain a reasonable range of facilities. It has been found necessary, however, to safeguard the user from his own forgetfulness, and Messrs. Akai provide isolating switches all over the place. It is when these fail to operate—or, more disconcertingly, operate all the time—that misleading 'faults' can be suspected.

To begin with, the two separate amplifiers have different control switches. The left channel of the stereo set-up is used by itself for mono operation, and the right channel switched off, so the mono/stereo switch is no more than an on/off switch. Similarly, the three-position toggle switch on the upper (left), amplifier has a central 'off' position, while the 'all-on' position is used as a main control switch and the 'amp-off' position leaves only the deck in circuit. Under this condition it is possible to take a signal from the head to supply an external amplifier, at 1mV into 5K. But the point to note is that the input to each amplifier is taken to the make/break contact on the head output jack socket, so that inserting the plug mutes the deck. Similarly, inserting the jack in the preamplifier socket removes the signal from later stages. Quite straightforward—until bad contacts crop up, and then we can expect curious intermittent faults, not least of which is the elusive hum problem caused by high resistance inputs when the deck selector switches are in the 'off' position. This is because the jack connection returns through the slide switch mounted on the top portion of each amplifier chassis.

The switch toggles are connected by a long arm with two separate forked portions, and adjusting screws are provided for exact setting—another possible source of trouble if switches do not quite make properly. The point to watch is that switches are neutralised—or in a corresponding position—when amplifier chassis are removed and replaced, and that the slide arm and return spring for each is unimpeded

(continued on page 28)

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TAPE RECORDER SERVICE CONTINUED

by the adjacent connector cables.

One advantage of this machine, as with the 345 model described last month, is the system of interconnecting plugs and sockets. Jack-plugs are used for facing connectors (which should please our Mr. Kirk!), and the only DIN socket is the auxiliary 5-pin in and out connector on the side of the case, near the mains cable stowage compartment. Another interesting feature is the isolating switch arrangement which acts to remove input signals from this socket. When a microphone plug is inserted, the input is open-circuited, again through the jack make/break contact, but this time there is a 100K resistor in series with each input (pins 1 and 4 of the DIN socket).

At the other end there are more coupling switches. The internal loudspeaker connects, via pins 2 and 3 of the 6-pin main connector, and the left channel slide switch (pin 2 to chassis when off), and the left-hand output jack make/break contact (pin 3). This means that insertion of the jack for external speaker isolates the internal speaker when the machine is in the play or off mode, but because of the slide switch action the internal speaker is open-circuited during recording, while the external speakers are still in circuit. (The right channel requires an external speaker all the time, being employed only for stereo operation.) To safeguard the output stages, 8-ohm dummy loads are switched in during recording, and an additional one is switched across the right channel output during replay in case the machine is switched to stereo operation inadvertently.

Appropos this stereo switching. The stereo-mono switch is actually in the mains input to the lower amplifier, each having its own power supply and the common oscillator being built into the left amplifier. This means that when switching from mono to stereo sufficient warming-up time must be allowed for the added function. Quite a small modification would overcome this if frequent switching should be anticipated, by leaving the power supply in circuit and switching the h.t. Again, the internal speaker could be left in circuit as a monitor by a simple circuit bypassing the slide switch connections if this was found necessary. This would need yet another switch—but what is one among so many? (This does not overlook the fact that headphone monitoring is available all the time at the left speaker socket, using an 8-ohm headset, or at a lower level from the preamplifier output, where 800mV are available at 10K.)

The recording level indicators are VU-meters across the outputs, with a 5K series resistor switched in during playback to compensate for the difference in level—a system which will not satisfy many of the contributors to a recent controversial correspondence on this subject! The movements themselves are well damped and have an attractive, illuminated and easily read scale, which is some advantage over the edge-type horrors that some makers have inflicted upon us, but there is no means of adjustment apart from keeping some record of manual control calibration.

The oscillator in this machine is such a deceptively simple affair for an ambitious stereo set-up that it would seem at first to be beneath our notice. Experience tells us, however, to look twice at deceptively simple circuits. The oscillator frequency is a nominal 60 Kc/s, ±5 Kc/s, and the recording bias voltage should be adjusted to suit the head in use. The correct voltage, which should lie between 130 and 230V AC, will be stamped on the mounting bracket, and a preset capacitor (100 pF.) is provided for final adjustment. Measurement is made by valve voltmeter, across the recording bias head, which, in the cross-field bias system, is on the opposite side of the tape to the recording head. It is spring-loaded into place against the tape and has a fabric facing so that it acts as a form of pressure pad. When the deck is neutralised, it first lifts away, then the switch operates to 'kill' the oscillator, so there is, in effect, a dying away of flux and not a sudden cessation. The difference about this machine is the way the heads are mounted on their moving plate, whose position relative to the tape is controlled by the large track selector knob on the top of the head cover. Rotation of this knob gives track positioning for one of four positions: tracks 1-4, mono; 4-track stereo; tracks 2-3, mono; and 2-track stereo (playback only). The only adjustment is for head height, a screw being accessible through a hole in the head cover.

From this it can be seen that the oscillator has to be pretty exact, both in frequency and voltage output (and in supplying erase current), for the best performance to be obtained. The circuit in fig. 3 shows that the only adjustment is for bias voltage, by the 100 pF. preset, and that

(continued on page 36)

NEW PRODUCTS NEW PRODUCTS NEW PRODUCTS



**GRUNDIG
TK120
TWIN
TRACK**

SIMPLICITY is the emphasis of the *TK120*, latest recorder from Grundig. All trimmings have been paired down, states the manufacturer, in an effort to produce nothing more or less than a good quality recording and playback unit at low price. The *TK120* employs a single mode selector, with an interlock button located on the opposite side of the head cover. Other features are tone and combined on/off and gain controls, with electronic eye modulation indicator and a tape-graduating scale. Mains transformer is integrated in the motor windings and all electronic components are mounted on a single printed board. Connections to external equipment, for record and replay, are achieved through the microphone socket mounted on the rear left corner of the deck. Frequency range is quoted as 40 c/s—12.5Kc/s, while signal-to-noise ratio is 45dB. Wow and flutter is 0.2% and output power is 2.5W. The recorder weighs 17½lb. and measures 15½ x 11½ x 6½in. Microphone, connecting lead, and tape are included in the £30 19s. 6d. price.

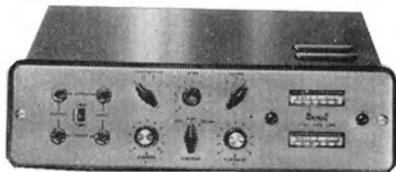
Distributor: Grundig (G.B.) Ltd., Newlands Park, Sydenham, London, S.E.26.

BIB INSTRUMENT CLEANER

MULTICORE Solders have just added an Instrument Cleaner to their range of audio accessories. Price 4s. 6d., the liquid is supplied in a polythene squirt bottle with a capacity of 4 fl. oz. Suitable for cleaning instrument panels, plastic, chrome, glass and all equipment exteriors, the fluid is non-inflammable and anti-static.

Manufacturer: Multicore Solders Ltd., Multicore Works, Maylands Avenue, Hemel Hempstead, Hertfordshire.

**BRENNELL
TAPE
AMPLIFIER**



A STEREO tape amplifier is now being marketed by Brennell for £46. Designed for use with their range of decks, the *Hi-Fi Tape Link* incorporates its own power pack and features separate record amplifiers and replay preamplifiers. A single push-pull oscillator supplies 90 Kc/s bias, the level of which may be varied to suit different tapes. Switched equalisation for 15, 7½, 3½ and 1½ i/s is incorporated, to the new CCIR standard. Modulation level is indicated on twin peak programme meters, with concentric controls giving independent record and playback gain on each channel. Claimed frequency response, using heads specified by the manufacturer, is 40 c/s—15 Kc/s ±2dB at 15 i/s, the same figures being quoted for ±3dB at 7½ i/s. At 3½ and 1½ i/s the response is 40 c/s—11 Kc/s and 40 c/s—6 Kc/s respectively, ±3dB. A signal-to-noise ratio of 50dB is quoted for ½-track heads, 45dB being obtainable with ¼-track. Dimensions are 15½ x 4½ x 8½in. including panel overlap but excluding 4 x 6½ x 4in. power unit. Overall weight is 18lb.

Manufacturer: Brennell Engineering Co. Ltd., 231-235 Liverpool Road, London, N.1.

WYNSOR VANGUARD

LATEST recorder to be announced by Wyndor is the ¼-track *Vanguard*, which costs £61 19s. A *Magnavox Studiomatic* tape deck is employed, giving speeds of 7½, 3½ and 1½ i/s. Respective frequency responses are 40 c/s to 15 Kc/s and 9 Kc/s ±3dB and to 6 Kc/s ±4dB. Signal-to-noise ratio of 50dB. The recorder may be used as a straight-through amplifier, feeding an *Axielte* loudspeaker mounted in the detachable lid.

Separate record/replay heads permit tape monitoring and artificial echo. Claimed frequency response, in this condition, is 20 c/s—20 Kc/s ±2dB. Input sensitivities are 2mV at 500K (microphone) and 0.25V at 1M (gram) with outputs of 0.5V at 10K (for external amplifier) and 4W at 15 ohms (for separate loudspeaker). The *Vanguard* is supplied with tape and two jack plugs.

Manufacturer: Wyndor Recording Company Ltd., Wyndor Works, 2 Bellevue Road, Friern Barnet, London, N.11.



ELCOM SIX-CHANNEL MIXER

SIX mono or three stereo channels may be mixed with the latest *Elcom* audio mixer. Intended for professional application, the unit will accept microphones of between 30 and 200 ohm impedance on all channels, with tone equalisation provided on two channels. Individually controlled echo-send and pre-fade listen are featured on all channels, with two echo return lines.



Headphone monitoring facilities, VU-meter and quadrant faders are featured on the mains-powered mixer. Manufacturer: Elcom (Northampton) Ltd., Weedon Road Industrial Estate, Northampton.

TRUVOX SERIES 40

EXCEPTIONALLY high input sensitivity is a feature of the new *Truvox Series 40*, which features a built-in microphone transformer. Based on the *Magnavox Studiomatic* tape deck, the new range comprise ½-track *R42* and ¼-track *R44*, both selling for £46 4s. and both being fully transistorised. A moving-coil microphone is included in the price, feeding a 50µV, 25K input. Low (50µV) and high (100mV at 100K) level input signals can be mixed and monitored during recording, the tone control doubling as high level fader. Spool capacity is 7in. and speeds are 7½, 3½ and 1½ i/s with respective wow and flutter of 0.15%, 0.25% and 35%. Frequency response is from 40 c/s to 15 Kc/s at 7½ i/s, to 10 Kc/s at the middle speed, and to 5 Kc/s at the lower, within 3dB. Signal to noise ratio is 46dB, hum and noise being quoted as —42dB. Two outputs are provided: variable up to 1V at 10K for external amplifier and 3W at 15 ohms for external speaker. An 8 x 5in. forward facing drive unit is incorporated in the wooden cabinet. Modulation level is indicated on a VU-meter and dimensions are 16½ x 14 x 8in. Weight is 22lb.

Manufacturer: Truvox Ltd., Neasden Lane, London, N.W.10.



REPS R10 MkII VERSION

AN IMPROVED MODEL IS NOW
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 $3\frac{3}{4}$ i.p.s. 40—10,000 C.P.S. ± 2 dB 200 μ S } to C.C.I.R.
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5 ECC83. 2 EL84. 1 ECC82. 2 Contact Rectifiers.

Pre-amp Signal/Noise > —55dB at all speeds.



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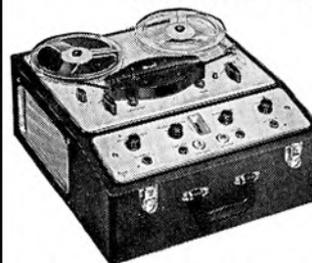
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equipment reviews



AMPEX
863
STEREO

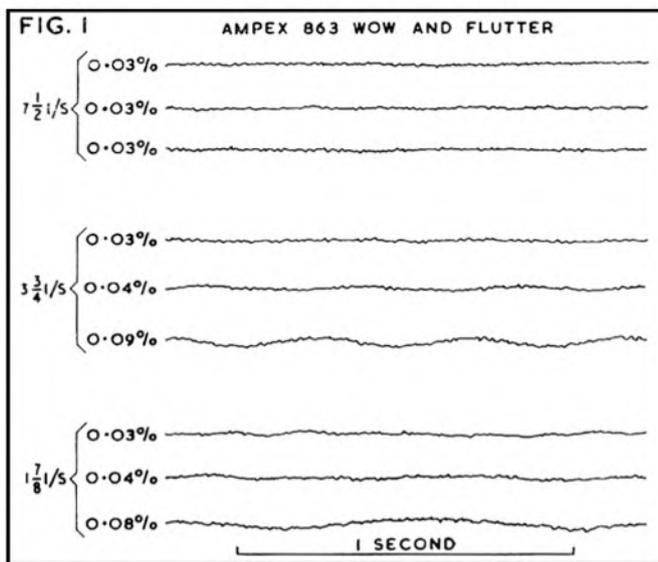
MANUFACTURER'S SPECIFICATION: Quarter-track solenoid-controlled recorder with internal power amplifiers. **Tape Speeds:** $7\frac{1}{2}$, $3\frac{3}{4}$ and $1\frac{7}{8}$ i/s. **Wow and flutter:** 0.15% at $7\frac{1}{2}$ and 0.25% at $3\frac{3}{4}$ i/s. **Frequency Responses** (respective): 50 c/s—15 Kc/s and 50 c/s—7.5 Kc/s, ± 4 dB. **Signal-to-noise ratios** (respective): 46dB and 43dB. **Output Power:** 6W per channel. **Fast Wind:** 2 minutes 40 seconds per 1,200ft. **Microphone Input:** High impedance, 1mV—30mV maximum. **Dimensions:** 19 x 13 $\frac{1}{2}$ x 7 $\frac{1}{2}$ in. **Weight:** 37lb. **Price:** £127 10s. **Distributor:** Ampex (G.B.) Ltd., Acre Road, Reading.

The Ampex model 863 is one of the 800 Series based on the deck design used in the model 2073 reviewed last month. The 850 is the deck and electronics, up to one output only, for incorporation in a hi-fi installation. The 860 (present review) includes power amplifiers and cabinet, but no loudspeakers. The 865 is identical to the 860 but is fitted to a walnut cabinet. With this choice, the customer can have the best features of the 2073 at a much lower price. The coding '3', incidentally, refers to the power supply: 250V 50 c/s.

The model 863 is fully transistorised and uses robust silicon n-p-n transistors throughout, except for the power output stages which are heavy duty p-n-p power transistors. Dual capstans are used to keep wow and flutter to the lowest possible levels and to provide instant reversal when playing pre-recorded tapes. VU-meters are fitted for accurate monitoring of recorded level. The tone control is really a variable time-constant in the playback equalisation circuit which enables any recording characteristic to be matched exactly: the scale is marked with the settings for the three speeds and recording characteristics used on this machine. When the tone control knob is depressed, a fixed bass lift is introduced which is useful when using the smaller type of external speakers.

Fig. 1 shows that the wow and flutter performance is at least up to the standard of the 2073, indeed the $7\frac{1}{2}$ i/s readings of 0.03% rms are the lowest encountered on any machine tested to date. The $3\frac{3}{4}$ and $1\frac{7}{8}$ i/s traces show the same smoothness and lack of high frequency flutter, with only an occasional wow at capstan frequency of $2\frac{1}{2}$ and $1\frac{1}{4}$ c/s respectively; even so the integrated RMS readings were well under 0.1% at each of the lower speeds.

Test-tapes recorded to 70, 140 and 280 μ S time-constants were



played at the three speeds with the tone control set to the relevant speed calibrations to give the solid curves of fig. 2. This shows that the recorded characteristic at $7\frac{1}{2}$ i/s is to the NAB 50 μ S characteristic. A slight clockwise rotation of the control altered the playback time constant to that of the test-tape (70 μ S) to give the level response shown by the dotted line.

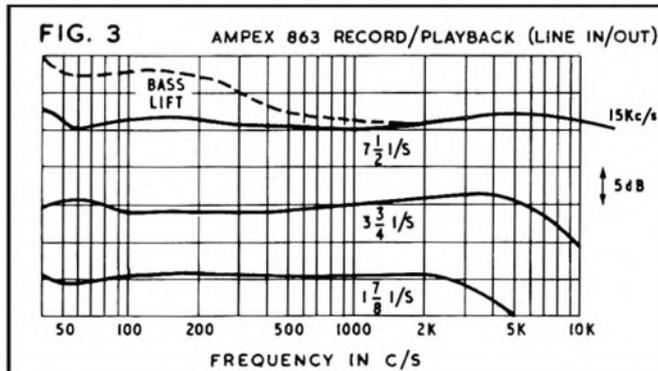
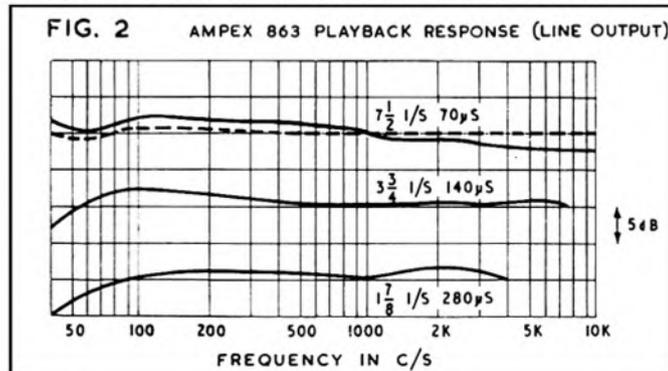
System noise and hum with no tape passing the heads was very low at 40dB below test-tape level.

Recording tests from line input to line output produced the curves of fig. 3. The responses at the two higher speeds are to specification, but the $1\frac{7}{8}$ i/s response seems disappointing when compared with that of many cheaper recorders. I thought I would look into this a bit further and try to find out why. The first hint was that the specification gives no figures for either frequency response or wow and flutter at this speed, and the instruction book dismisses $1\frac{7}{8}$ i/s as only being suitable for speech. Further investigation of the circuit showed that recording pre-emphasis was fixed, and not even switched between $7\frac{1}{2}$ i/s and $3\frac{3}{4}$ i/s, so there is little wonder that, with no extra recording pre-emphasis, the $1\frac{7}{8}$ i/s overall response should be so poor. This perhaps reflects Ampex's professional background and says in effect "If you are going to buy a machine in this class you should be prepared to use a bit more tape and only employ $1\frac{7}{8}$ i/s for speech recording".

The dotted curve on the $7\frac{1}{2}$ i/s response shows the effect of switching in the fixed bass lift.

Peak recording level tests showed no visible waveform distortion at 12dB above test tape level, with the VU-meters well off scale. The full dynamic range of the tape was used when the pointers were

(continued on page 33)



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allowed to kick into the grey sector of the scale only occasionally. On steady tone, a level 6dB above test tape level was recorded with the needles just entering the grey sector.

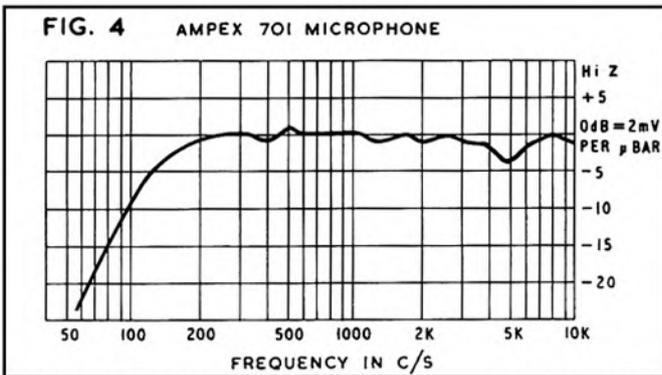
Peak recording level was erased and the wide band signal-to-noise ratio measured as 50dB. Weighting the measuring circuit to match the ear's response at low listening levels improved the reading to 55dB.

The above frequency responses and signal-to-noise ratios were exactly repeated at the external speaker sockets and on each of the four tracks.

The microphones provided with the 863 are tiny units barely four inches long and less than three quarters of an inch in diameter. Because of the small internal volume of the case, the extreme bass response falls below 200 c/s, but the response above this frequency is remarkably smooth as will be seen by the response of fig. 4. The polar response is non-directional, so that spaced microphones will have to be used for stereo recording.

COMMENT

Sound quality on a pair of wide range speakers was superlatively good, and a pair of cheaper smaller units gave a pleasant balanced response with the bass rise switched in. I would suggest that speaker plugs be inserted before the machine is switched on. If they are plugged in with the amplifiers 'live' there is a very nasty 'crack' due to a pulse of DC through the speakers as the feed condenser from the transformerless output stage is charged. With an HT line of 40V the far side of the condenser rests at 20V so that, with an 8-ohm



speaker, there will be a momentary charging current of 2.5A, enough to make some sensitive speakers jump out of their cabinets!

Recorded quality from microphone or radio had that silky professional smoothness which is a subtle blend of low distortion, low wow and flutter, low noise, low drop outs, and a frequency response which is level, but not necessarily super wide range. And I would place these virtues in *that order*. The design of the machine is a distillation of Ampex professional experience over 20 years or more and is an object lesson in putting 'first things first' and not pandering to the advertising copy writer. Just have another look at the conservative specification of this machine and see if you would have considered it against that of some of the more 'popular' machines!

A. Tutchings.



PHILIPS
EL3552
AUTOMATIC

MANUFACTURER'S SPECIFICATION. Half-track domestic tape recorder employing automatic and manual gain control. **Tape Speed:** 3 3/4 i/s. **Wow and flutter:** better than 0.6% peak-to-peak. **Spool Capacity:** 5 1/2 in. **Frequency Response:** 80 c/s—12 Kc/s ±3dB. **Signal-to-noise ratio:** better than 45dB. **Amplifier Power:** 1.5W. **Inputs:** Microphone, diode and gram, through combined socket. **Output:** 750mV at 20K for external amplifier. **Rewind:** 1,200ft. in three minutes. **Dimensions:** 14 1/2 x 10 x 5 in. **Weight:** 12lb. **Price:** £25 4s. **Manufacturer:** Philips Electrical Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

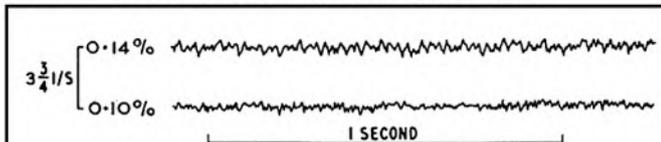


FIG. 1 PHILIPS EL3552 WOW AND FLUTTER

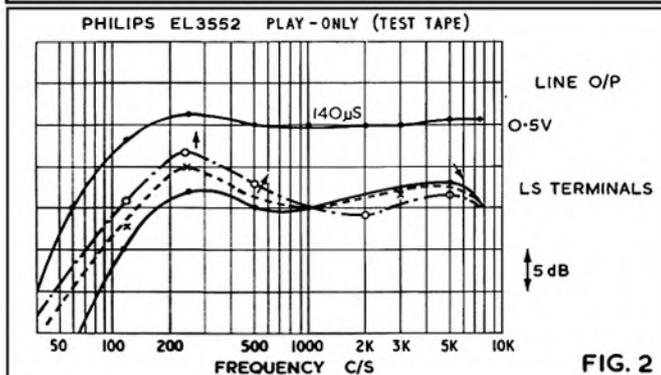


FIG. 2

AFTER a surfeit of self-contained stereophonic recording and reproducing systems weighing up to 50lb., replete with every conceivable gimmick and gadget, it is a welcome relief to come down out of the clouds and deal with a homely little domestic recorder where everything has been made as simple as possible for the operator, but which, nevertheless, contains enough novel design features to make an interesting review.

This is another 'automatic' recorder which produces excellent recordings from microphone or radio without critical setting of the controls or constant monitoring of the magic-eye record level indicator. It is rather analogous to an automatic camera where you simply point it at the subject to be recorded and press the button.

There is only one socket, of the standard 3 pin DIN type, for the microphone or a combined input/output lead for recording from radio or feeding an external amplifier. The recording level is automatically set to suit the input signal unless the central button between the volume and tone controls is pressed to give manual control. On playback the volume and tone controls operate in the normal way.

As the very long time-constant required for automatic level control involves an inherently high impedance device, valves are used for most of the amplifier and control circuits. A transistor is used in the first stage to keep hum and noise to minimum level.

The deck mechanics are a dream of absolute simplicity: a single flat plate carries a motor at the rear R.H. corner driving a square cross-section belt which meanders around a number of idler wheels mounted on flat strips which are moved directly by the control keys; on the way the belt also drives the flywheel and capstan at a constant speed. For fast wind or rewind, the appropriate idlers are brought into contact with the reel hubs and the pressure roller moved away from the capstan. The stop bar, below the keys, releases all controls and applies simple servo-brakes to the reels.

The electronics are on another flat plate below the deck, with all parts and switches on a large printed circuit. The deck keys operate the switches by downward projections which engage with the printed circuit switches.

The wow and flutter performance is remarkably good considering the very long belt path. Fig. 1 shows that the RMS readings average 0.2%, with top and bottom limits of 0.14% and 0.10%. Wow is negligible, and the flutter is mainly at 25 c/s motor shaft rotation frequency which adds and subtracts to give the above mentioned flutter limits.

The play-only response of a recorder is important if it is to be used for playing pre-recorded tapes, which are recorded to a standard recording characteristic of 140μS for a tape speed of 3 3/4 i/s. Accordingly,

(continued on page 35)

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a 140 μ s test-tape was used to obtain the responses shown in fig. 2. The line output (white lead on record/playback lead provided with the recorder) remained at 0.5V within limits of ± 3 dB over the range 100 c/s to 7.5 Kc/s, which was the top frequency on the test-tape. The play response was also measured across the speaker terminals as the tone control only operates on the output stage. It will be seen that the voltage feed to the speaker is most constant with the tone control fully advanced.

The record-play response of fig. 3 was obtained by switching to manual control and applying constant tone levels to the red recording lead, and measuring the line output at the white lead on replay. The rise in high note response compared with the 140 μ s test-tape response of fig. 2 indicates that the recording characteristic is nearer 100 μ s on this machine.

A 500 c/s tone was recorded with the magic-eye beams just touching and the recording level was found to be only 7dB above test-tape level. Higher recording levels showed waveform distortion, which indicates that the tape was somewhat under-biased. (A properly biased tape should accept a level 12dB above test-tape level without distortion.) The undistorted peak recording level was erased on the machine and the peak signal-to-noise and hum ratio was found to be 45dB, which agrees exactly with the specification.

Loud speech tests on microphone, with the automatic record level control in action, showed only momentary overload on the first syllable, with the rest of the test recorded perfectly. In the same way, signals recorded from radio via the recording lead were free of overload after the very first transient. The operating time of the circuit was much faster than the reaction time of a human control engineer. Recovery time to full sensitivity seemed to be in the region of one minute, but switching to play automatically discharges the time-constant to give full initial sensitivity on the next recording. No overload or evidence of automatic control was noticed if the radio signal was faded up over a period of 1-2 seconds. On microphone, even the first word overload can be prevented if the sentence is started with the microphone about 18 inches away and the microphone is brought nearer gradually.

The combined response of recorder and loudspeaker was measured by recording bands of filtered white noise on manual control and measuring the sound level on the axis of the speaker on replay. Fig. 4

(continued overleaf)

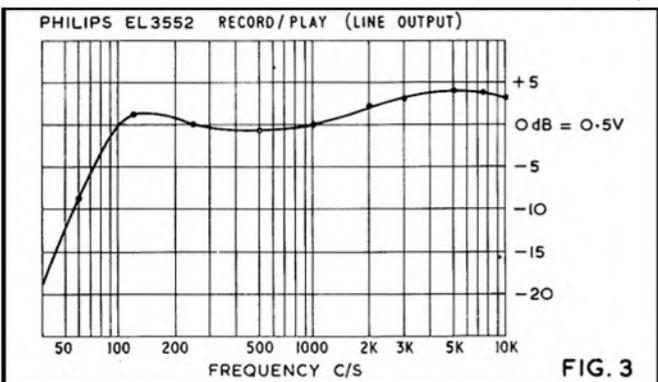


FIG. 3

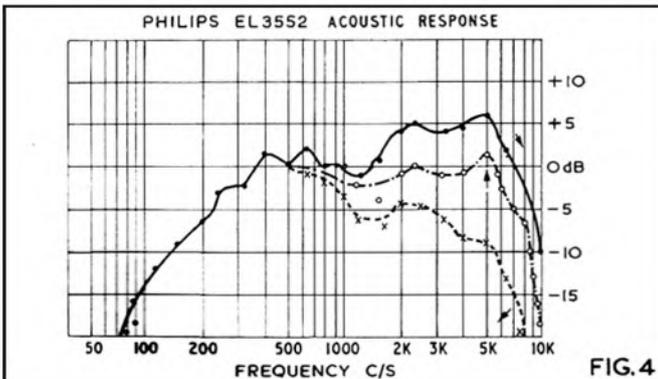


FIG. 4

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PHILIPS EL3552 REVIEW CONTINUED

shows that the electro-acoustic response is most nearest to level with the tone control at the half-way setting.

The microphone response was also measured in a white noise sound field to give the response of fig. 5. The response matches that of the recorder acoustic response over the range 200 c/s to 5 Kc/s.

COMMENT

Nowadays everything is automatic, from the gear change on your car and the light setting of your camera to the landing of a jet plane with a hundred passengers aboard. The apparent simplicity of the operation should not hide the fact that tremendous amounts of research and development have gone into the perfection of such devices.

In the case of the recorder, it was not a matter of developing the circuit—this was done many years ago for dictation recorders and for certain types of sound-on-film recorders. Rather it was a case of reducing production tolerances on certain components used for tape recorders: the tape itself had to be of known and constant sensitivity; magnetic heads had to be improved so that not only were the playback sensitivities more consistent but the recording sensitivity and bias requirements were constant from sample to sample. Production techniques had to be evolved to set the point at which the AVC came into action to exactly the right level, and to ensure that the controlled recording level corresponded to the overload point of the tape, having due regard to the bias setting used to give the best compromise between wide frequency response and harmonic distortion.

This, then, is the triumph of the EL3552: to achieve all this at a selling price of 24 gns.

My only complaint: no extension speaker socket. But perhaps after all it is not required by the type of customer for which this machine was designed. We boffins tend to assume that many recorders play into wide-range speakers to overcome limitations of the tiny speaker and cabinet of the average tape recorder, but we should probably be shocked to find how few in fact are used in this way. A. Tutchings.

PHILIPS EL 3552 MICROPHONE RESPONSE

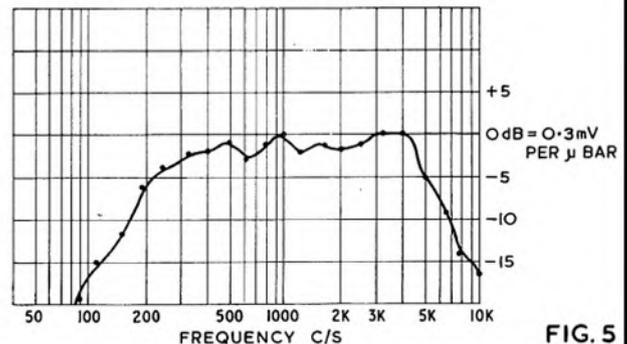


FIG. 5

TAPE RECORDER SERVICE CONTINUED

the frequency is determined by the coil and its associated capacitors, especially the 450 pF. across the coil. There is no tuned adjustment. The method of switching off the oscillator is by effectively open-circuiting the cathode to DC, but leaving a capacitance in series to allow the necessary AC decrement. Valve used is the powerful 6AR5. This circuit takes away some of the complications of normal practice: namely, preventing bias voltage from re-entering the amplifier circuits via the head feed, while still retaining constant current recording, a procedure which often leads to design compromises and servicing worries, but it is important that cable routing, screening where applicable, and circuit values are maintained as the makers have originally produced them, to keep up the good performance of which this machine is capable.

Incidentally, when testing performance, always judge the Akai with its correctly matched speakers. Using only the internal speaker is hardly fair, considering the set-up is designed to work into a pair of ten-inch woofers with 2½ inch tweeters, capable of handling 10W. With the inbuilt 5 x 7in. elliptical speaker, the tone controls and gain can be set to give the sort of distressing distortion one would expect from a single pentode output.

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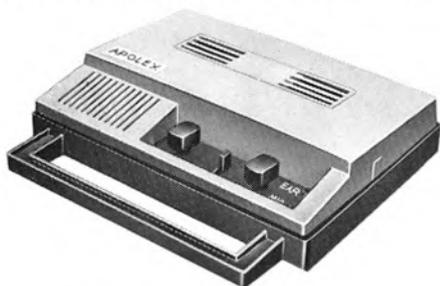
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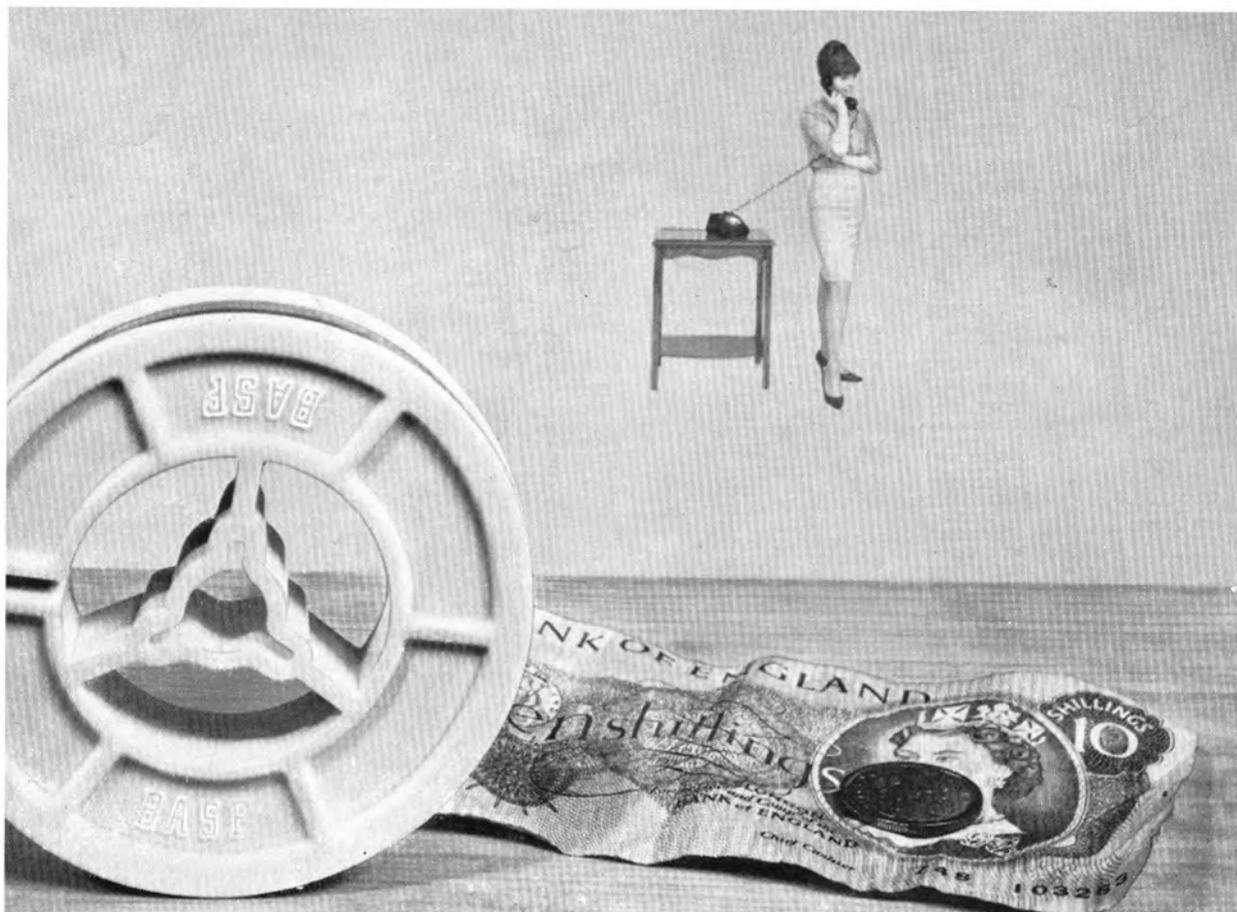
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