

MARCH 1967 TWO SHILLINGS

tape recorder



ELTRA 1001 REVIEW — IMPROVED TAPE ERASURE — READERS' PROBLEMS
SERVICING THE OPTACORD 416 — HIGH QUALITY MIXER FOR CONSTRUCTORS

12 reasons why you will be delighted with Fidelity's sensational new Tape Recorder

1. It has three recording/playback speeds— $1\frac{7}{8}$ i.p.s. for economic speech recording, $3\frac{3}{8}$ i.p.s. for all general purposes, $7\frac{1}{2}$ i.p.s. for higher quality of music reproduction. *And* the choice of speeds permits playback of tapes recorded on most other machines.
2. It has a grouped 'keyboard' of mechanical controls for fast, sensitive, positive response to finger-tip pressure.
3. It has a pause control—invaluable when making tapes for slide synchronisation or for dubbing to magnetic stripe.
4. It has a digital tape position indicator (with instant re-set by press button) for rapid location of recorded effects, musical themes, etc.
5. A super-imposition facility allows, without any 'mixing' complications, the easy addition of a commentary to music and/or effects already recorded.
6. It has two inputs—one for optimum use of the microphone provided, and one for direct recording from radio, gramophone, second tape recorder, amplifier, etc.
7. It has an output socket for a separate loudspeaker which can be placed near the projection screen for realism. (The internal speaker is then automatically muted).
8. It has a 'monitor' socket (at high impedance) which is 'live' on both record and playback. Thus one can (a) listen (on headphones or separate amplifier) to what is being recorded, (b) record on tape whilst simultaneously 'feeding' a magnetic stripe projector or other amplifier or tape recorder, (c) dub on to magnetic stripe any material already recorded on tape, at the same time listening, so that sound/picture synchronisation is easily checked, (d) feed a playback signal to the "Synchroslide" type of synchroniser *without silencing the speaker*.
9. Electronic controls—tone, volume, superimpose—are designed and grouped for fast easy use with minimum possibility of error.
10. It has the reliability and excellent performance expected of all Fidelity Tape Recorders.
11. Whilst being particularly attractive to slide and cine enthusiasts, it also caters for all domestic purposes and can be operated simply by anybody in the family.
12. At 25 gns. for the twin-track model or 27 gns. for the four-track model (microphone, tape and jack lead included) the Fidelity PLAYTIME represents quite outstanding value for money which is possible only because FIDELITY make and sell more of any single model of tape recorder than any other U.K. manufacturer.



FIDELITY PLAYTIME

3-Speed tape recorder (Twin-track) **25 gns**
(Four-track) **27 gns**

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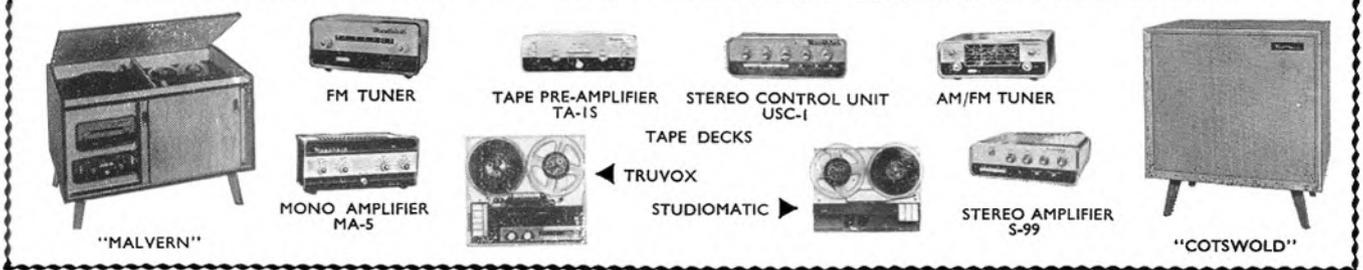
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	Kit	Assembled
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Kit £11 14 6
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DECCA ffs £18 18 0.	DECCA DERAM £9 19 6	Inc. P.T.

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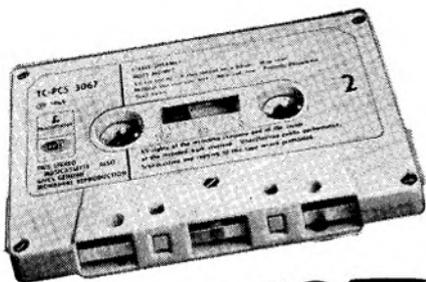
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" SP-25 " R105	£16 4 8	
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" " CONNOISSEUR, 2-speed	£17 2 11	

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BIG BEN MINSTREL SHOW
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Steenhuis**

SURFIN' WITH
WOUT STEENHUIS
Columbia TS-SCX3585

Even without its bi-directional recording and monophonic mixer, the Ampex 2100 would still be the best recorder in the world

Give it a hearing



If you were to dismantle your new Ampex 2100 (which heaven forbid), you'd find solid state electronics, four exclusive deep cut heads, bi-directional recording, a monophonic mixer, dual capstan drive, automatic threading device, solid-cast aluminium construction etc.

But it's what you get out of your Ampex 2100 that counts.

Ampex have a name to live up to. A name for the finest sound recording. And the new Ampex 2100 gives our best sound yet. There's only one way to prove the Ampex 2100 outperforms any other recorder in its price range. Listen to them all and make up your own mind.

The illustrated Ampex is the standard 2163. But there's also the Ampex 2165-3 in oiled walnut finish or an uncased deck model, the Ampex 2153.

You'd think that with all this the Ampex 2100 would cost over £250. But it doesn't.

Appetite whetter: Wow and flutter at 7½ ips, .08%

Ampex make the world's best tape recorders. 800 series, 1100 series, 2100 series. Speakers, tapes, accessories. Ask your dealer about our 4-track "Stereo Concert" bonus offer.

AMPEX

Ampex sales and service facilities are conveniently located throughout Europe and the Middle East. For more information write to: Ampex Great Britain Ltd., Acro Road, Reading, Berkshire, England. Telephone: Reading 84411. Ampex S.A., Via Berna 2, Lugano, Switzerland. Telephone: 091/3.81.12. Ampex Europa G.m.b.H., 6 Frankfurt Main, Düsseldorf Strasse 24, Germany. Telephone: 252001-5. Ampex S.A., Nivelles, Belgium. Telephone 067/249.21. Ampex, 41 Avenue Bosquet, Paris 7e, France. Telephone: 705.38.10.

The outstanding new Tandberg 6x



• The world's best stereo tape deck plus new bias head for guaranteed frequency response and unbeatable signal to noise ratio

Tandberg have taken their finest tape deck, added a Bias head and refined the circuitry. The result is the Tandberg Model 64X.

Frequency Response:

7½" per sec: 20-25,000 c/s
(± 2 dB 30-20,000 c/s).

3¾" per sec: 20-18,000 c/s
(± 2 dB 30-15,000 c/s).

1½" per sec: 30-12,000 c/s
(± 2 dB 40-8,000 c/s).

Signal to noise ratio:

7½" per sec: 62 dB. 3¾" per sec: 59 dB.

1½" per sec: 56 dB.

* Also incorporates Multiplex Filters (for stereo radio recording).

* A centre channel amplifier for simultaneous playback of two tracks into mono headphones.

* A fully transistorised oscillator circuit.

* Cathode follower outputs.

* 'On and off the tape' monitoring.

* 'Sound on sound' facilities.

* Superb teak and stove enamel finish.

The Tandberg 2 or 4 track, 3 speed Series 6X. 115 Gns.

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SERIES 6X

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STAND NO. 17
DEMONSTRATION ROOM 212

Tandberg

AUDIO '67 ANNUAL

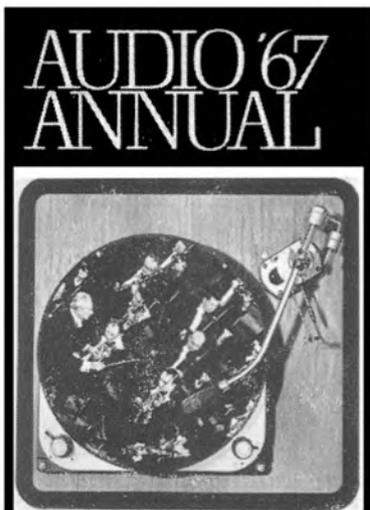
OUT FEBRUARY 17th

This new edition is packed with authoritative features written by experts for everyone interested in hi-fi sound reproduction and tape recording. Produced by HI-FI NEWS and TAPE RECORDER, it includes a selection of the more important equipment reviews that appeared in these magazines during 1966.

Other top features include
A fresh look at audio dynamics
Details of a new membrane loudspeaker
Acoustics in ancient Greek theatres
Some reflections on audio history
A look at stereo radio
Basic problems of energy conversion discussed
Listening to music in the home
Reducing background noise

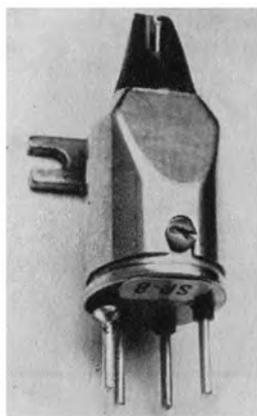
5/-

From your newsagent or bookstall
or 6/- by post from Dept. AA1,
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B & O - for those who consider design and quality before price

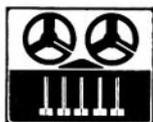
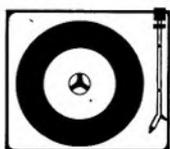


B & O—the quality angle in pickups

The B & O SP6 magnetic cartridge has been designed to provide as nearly as possible the perfect link between the gramophone record and the main amplifier. The diamond stylus is set at the B & O pioneered and now accepted standard of 15° from the vertical. It employs a symmetrical micro-cross armature for excellent stereo separation with minimum cross-talk. Push-pull design reduces harmonic distortion to a minimum. Also available with elliptical stylus (SP8). Result: A superb instrument capable of the highest fidelity.

Frequency response: 20 c/s – 20 kc/s \pm 2.5 dB. Output: 7 mv per channel at 5 cm/sec. Channel separation: better than 28 dB at 500 c/s. Stylus pressure: 1–3 gms. Compliance: 12–15 \times 10⁻⁶ cm/dyne. Moving mass: approx. 1.5 mgms. Load: 47K ohms. Mounting: standard $\frac{1}{2}$ " centres (SP6 and 8) or Plug in fitting for B & O arm (SP7 & 9). Weight: approx. 10 gms. Stylus diameter: .0007" Elliptical: .0007" \times .0002" Price: SP6 and 7 £8.8.0d. SP8 and 9 £14.14.0.

Bang & Olufsen—Danish Design—Danish Craftsmanship.



B & O also make the Beogram transcription deck, the Beocord range of Tape Recorders, Beomaster integrated Tuner amplifiers and high quality Beovox pressure chamber loudspeakers.

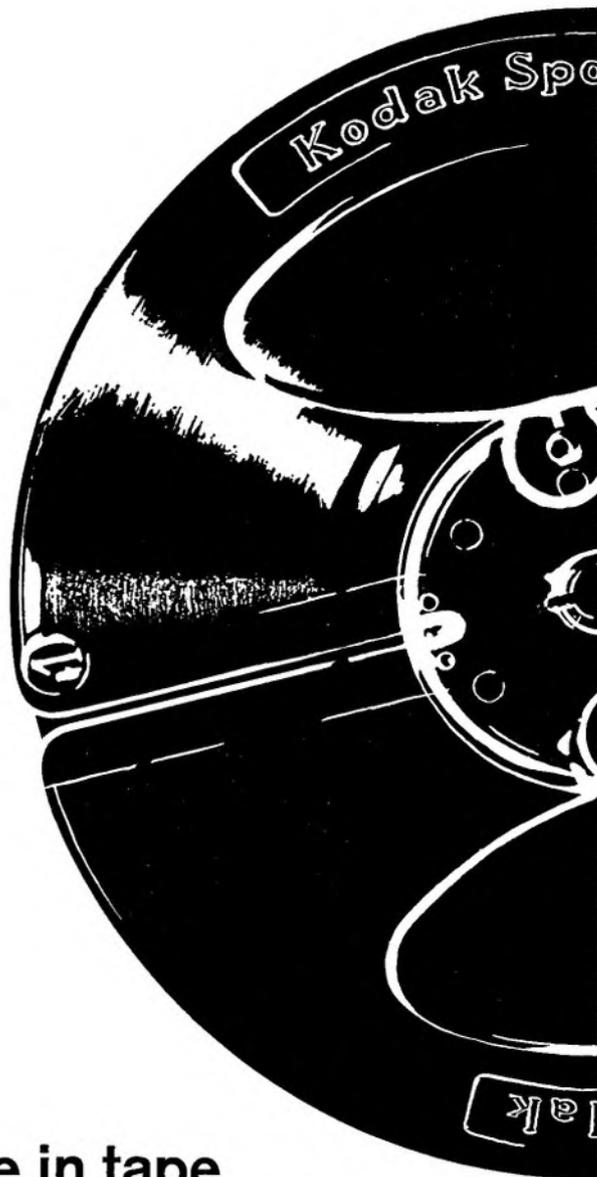
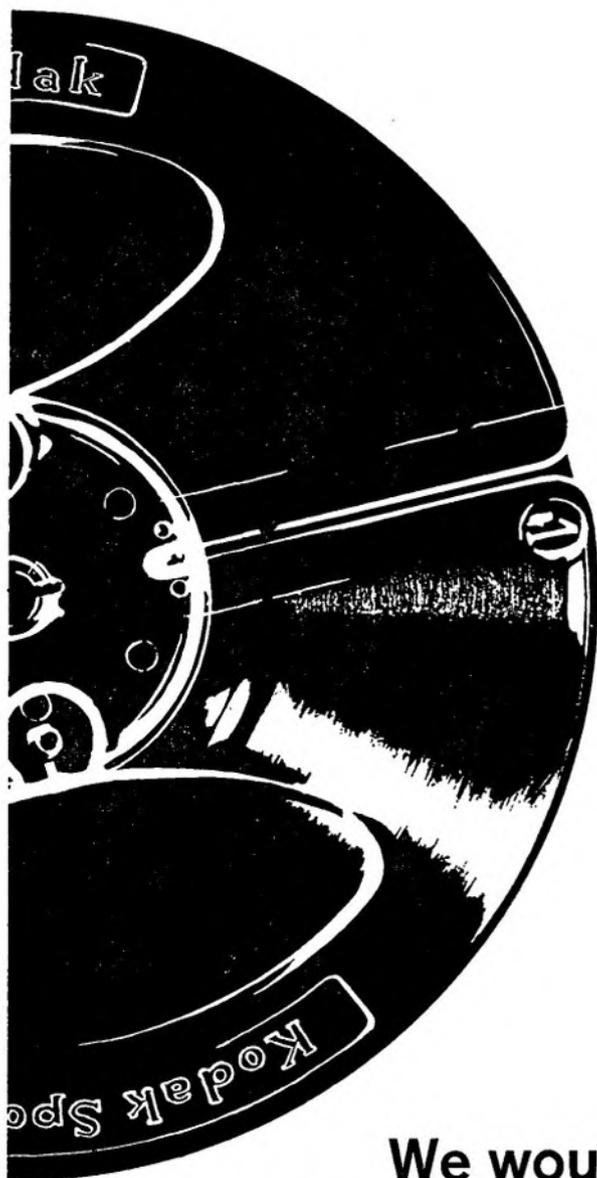
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Bang & Olufsen U.K. Sales Division

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Mercia Road, Gloucester. Telephone: Gloucester 26841

London Showrooms: 70-71 Welbeck Street, London, W.1. Telephone: HUNter 2143.



We wouldn't be in tape if we couldn't make the best

When you're a company whose products are world-famous quality leaders, you can never afford to be 'as good as' in anything.

You **have** to be best.

In entering the tape market, Kodak had to make a tape with a combination of features no other leading tape could match.

We did.

And we can prove it.

So can you, the very next time you buy tape.

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

Look for the yellow box, and ask for Kodak Tapes by name.



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Please send me literature on
Kodak Sound Recording Tapes.

Name.....

Address.....

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SONY research makes the difference

MODEL TC350 - FEATURES

4 track stereophonic and monophonic recording and playback Precision solid state circuitry comprising independent recording amplifiers and playback preamplifiers Professional 3 head system Sound on sound recording Language/music training facilities Vertical and horizontal operation All idler beltless tape driving mechanism Two tape speeds (7½ and 3¾ ips) 7" reel capacity automatic shut-off switch head-set monitor jack pause control digital tape index counter two VU meters integrated record/playback connector

SPECIFICATIONS:

Power requirements: 50W, 100, 110, 117, 125, 220, 240V, 50/60 c/s AC.

Reel: 7" or smaller.

Tape speed: 7½ and 3¾ ips. with automatic equalization change.

Recording system: 4-track stereophonic or monophonic.

Frequency response: 30–20,000 c/s at 7½ ips. ± 3 db 50–15,000 c/s at 7½ ips. 30–14,000 c/s at 3¾ ips.

Signal-to-noise ratio: Better than 50 db.

Wow and flutter: Less than 0.17% RMS at 7½ ips. Less than 0.25% RMS at 3¾ ips.

Harmonic distortion: Less than 3% at 0 db line output

Level indication: Two VU meters.

Record: NAB standard.

Playback: calibrated to 0 db line output.

Recording time:

4-track stereo 4-track monophonic
1,200' tape 7½ ips. 1 hr. 2 hrs.
3¾ ips. 2 hrs. 4 hrs.
1,800' tape 7½ ips. 1½ hrs. 3 hrs.
3¾ ips. 3 hrs. 6 hrs.

Fast forward and rewind time:

Within 4 min. (1,200' tape).

Input: Microphone

Sensitivity: -72 db (0.19mV)

Impedance: low (will accommodate any microphone from 250–1K ohm impedance).

Auxiliary

Sensitivity: -22 db (0.06 V).

Impedance: approx. 100K ohms.

Integrated record/playback connector.

Sensitivity: -42 db (6.15 mV).

Impedance: approx. 100K ohms

Output:

Line

Output level: 0 db (0.775V).

Impedance: optimum load impedance 100K ohms.

Binaural monitor

Output level: -1 db (0.692V).

Impedance: accommodates 10K ohm head-set.

Integrated record/playback connector

Output level: 0 db (0.775V).

Impedance: optimum load impedance 500K ohms.

Head: Recording RP 30—2902.

Playback PP 30—4202N.

Erase EF 18—2902H.

Transistor: 2SC402 x 18, 2SB381 x 2, 2SC291 x 1.

Diode: 1F22A x 2, 5G-D x 2.

Dimensions: 15¾(W) x 6⅞(H) x 13"(D).

Weight: Approx. 17 lbs. 3 ozs.

Accessories: Empty 7" reel. Connection cord. Capstan. Pinch roller. Reel cap.

Recommended retail price **75 Gns.**

Sony offer the finest range of tape recorders from the battery portable TC 900 to the studio quality 777.

For further details see your Sony dealer or write to:

Sony U.K. Sales Division,
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London Showrooms:
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tape recorder

MARCH 1967 VOLUME 9 NUMBER 3

INCORPORATING
SOUND AND CINE

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COVER PICTURE

The effect of bulk erasers and household magnets on magnetic tape recordings is strikingly small above distances of one or two inches. This becomes less surprising when one considers the fields set up inside the tape recorder itself by motors, transformers and loudspeakers. While advantageous in that sense, however, the phenomenon does cause some problems in efficient bulk erasing. A. J. Lowe's cure for this particular ill is published on page 105.

SUBSCRIPTION RATES

Annual subscription rates to *Tape Recorder* and its associated journal *Hi-Fi News* are 30s. and 38s. respectively. Overseas subscriptions are 32s. 6d. (U.S.A. \$4.50) for *Tape Recorder* and 38s. (U.S.A. \$5.40) for *Hi-Fi News*, from Link House Publications Ltd., Dingwall Avenue, Croydon, CR9 2TA. *Tape Recorder* is published on the 14th of the preceding month unless that date falls on a Sunday, when it appears on the Saturday.

MOTOR CYCLING IS NOT exactly the most frequently discussed topic in *Tape Recorder*. The magazine *Motor Cycle*, however, recently carried a feature no less suited to the spool-turning mechanism of a tape recorder as to the wheel-pushing complexity of the horseless-bicycle.

The feature in question was a *Users' Report*—a combination of readers' correspondence, field-tests and service columns. Perhaps readers would care to peruse our suggested adaptation of such a *Users' Report*.

One starts the ball rolling, some two or three months before the first report appears, by requesting owners of a certain make or model of recorder to express an opinion of their purchase on paper. Readers would be asked to describe any difficulties experienced in obtaining service, spare parts, circuit diagrams, operational information, and so on. A description of faults that had occurred in the recorder might, when the resultant letters were examined and condensed into an article, reveal certain failures to which models were particularly prone. In such cases, the advice of our specialist contributors, and of manufacturers themselves, would be sought and published.

The envisaged column holds promise of providing a meeting ground for user, manufacturer, importer and even retailer. Complaints could be aired without fear and praise offered when seemingly deserved. Readers' own operational and servicing tips could be exchanged. Are owners of the old *Sound Vogue* aware, for example, that its *Collaro Studio* deck may be removed without need of a second pair of hands to hold the cabinet? (The recorder is placed upon the floor and gripped between the feet.) Have all *Revox-owners* read about, or discovered for themselves, Peter Turner's improvised 736 pause control?

The *Users' Report* would prove a source of advice to the potential customer for a model under discussion, who may have no idea what to expect in the way of reliability and, when the thing finally does go wrong, service. To this end, of course, we would think it wise to restrict the Reports to currently available models or—in the case of the *Revox*, *Ferrograph*, *Tandberg*, *EMI* and *Akai* designs—recorders that have to some extent evolved over a period of years.

These ideas remain pure castles-in-the-air, however, until *you*, the reader, put pen to paper and submit the letters upon which reports can be based. Which brings us to the ominous question: which design do we select for Number One?

Without the slightest idea of the possible response from readers—or from *Pullin Photographic*—we must admit a considerable interest in commencing with the *Akai* range: the *X-355*, *345*, *X-300*, *X-4*, *M8*, *M7*, *910*, *1710*, *X-100D*, *ST-1*, *44S* and *707*. Perhaps we have bitten off more than we can chew in selecting so large a range at one sweep. No matter. If we are inundated with replies, the recorders

can conveniently be split to cover more than one report—the *X-355* and *345* in one, perhaps, *X-4* in another, and the not dis-similar *M8*, *M7*, *910*, *1710*, *X-100D*, *ST-1*, *44S* and *707* in a third. Our fear is not of being drowned, but being left high and dry! *Akai-owners*—it's up to you.

Habitual window-shoppers may have noticed the bombshell that fell, in the opening days of 1967, on the High-Street electrical dealers. Since BREMA withdrew their application for exemption from the Resale Prices Act, Philips, Grundig and a whole host of respected audio manufacturers have adopted a policy of 'price-recommendation'. As a result, there is much to be gained by shopping around one's hometown when purchasing anything more costly than a fuse. In a given block of shops, one may well expect retailers to offer identical prices—for obvious reasons. Over a wider area, however, greater discounts may be found. There is no difficulty, in Croydon, in obtaining a 26 gns. Philips portable at 22 gns. Since the trade price would be in the order of 19 gns. (one-third retail margin is common to most audio products), this means the retailer is now taking a profit of 3 gns. on each recorder, compared with the original 7 gns. Do read that guarantee card carefully, though, when buying a product at discount.

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Philips Cassette Recorders: excitingly easy new way to play music and record sound

Suddenly, it's fantastically easy to play music - anywhere. And to record sound. Because Philips Cassette Recorders are so simple that you can use them with your eyes shut! Their tape comes loaded in special cassettes that just snap in for instant use. And you get superb pre-recorded music on fabulous new Musicassettes - in a wide range of titles. You have three Philips Cassette Recorders to choose from.

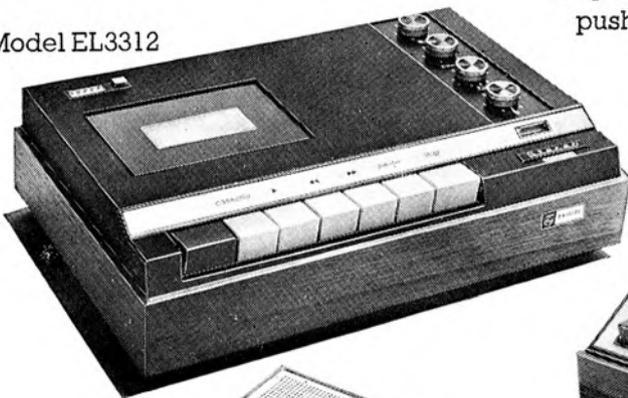
Model EL3301T is a 27 gn play-anywhere battery portable that travels in a carrying case, has simple controls including a remote stop/start switch, and can even be mounted in your car. The 35 gn Mains/Mono Model EL3310 has a teak-finished cabinet, exclusive hinged 'Sound Mirror', Automatic Recording Control

for perfect recordings, and push-button cassette ejection.

Model EL3312 is a superb

Mains/Stereo recorder at 48 gns, with two Hi-Fi speakers extra at 10 gns plus 3/1 P.T. surcharge each. All prices cover many useful accessories.

Model EL3312



Model EL3301T



Model EL3310

See your Philips Dealer or write for free brochure to Philips Electrical Ltd., Century House, Shaftesbury Avenue, London W.C.2.



PHILIPS - the friend of the family

WORLD OF TAPE

SWEET FOR RECORDER

A TAPE recorder made its debut alongside a soloist at London's Wigmore Hall recently, when *Sweet for Recorder* (correct spelling!), written by the Dutch composer Louis Andriessen in 1964, was given one of its rare airings.

In the programme note, the recorder's part was described as the emission of "white noise" which sounded, in the words of *The Times'* music critic, like "the gentle purr of an electric fan". A Dutch artist, Franz Brügger, accompanied the tape recorder with a recorder of his own—flute variety.

VTR SERVICING COURSE

FIRST of a series of two-day courses was held by Sony at the Kensington Palace early in January, to familiarise retail service engineers with the Sony domestic video tape recorder. The supply of video recorders is being undertaken through selected retailers who will be solely responsible for servicing equipment in their areas. Twenty-six engineers attended the first course, which was conducted by Mr. K. Yamakawa of the Sony design team, and Mr. P. Moger, responsible for the servicing department of Sony U.K. Sales.



PREAMPLIFIER POSTSCRIPT

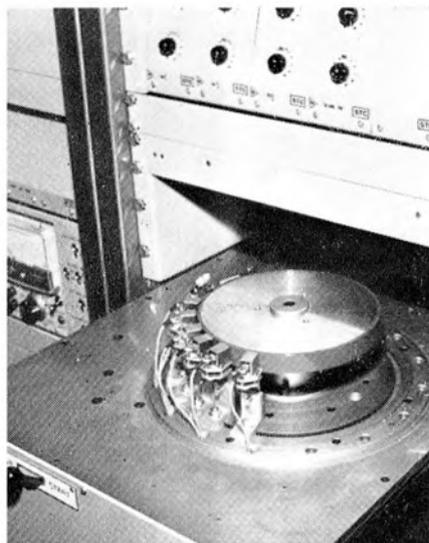
OUR attention has been brought, by Reginald Williamson, to inconsistencies between the circuit and layout illustration of his microphone preamplifier, described last month. Although the circuit diagram itself is entirely correct, the 10 μ F capacitors were given, on the constructional layout, as 1 μ F. A 5.6K resistor was given a 4.7K value in the layout but, though 5.6K is the preferred value, the difference does not alter the unit's performance.

Mr. Williamson adds, in passing, that the purpose of the optional 10K resistor added by *Walsall Timing Developments* is to keep the 10 μ F capacitor charged when feeding a valve input with a high grid resistor.

AUDIO FAIR TICKETS

THE 1967 Audio Fair will be held at the Hotel Russell, close to London's Russell Square Underground Station, from Thursday 30th March to Sunday 2nd April. As in previous years, tickets will be distributed free-of-charge through audio dealers in various parts of the country. In cases of difficulty,

readers may send requests for tickets to our editorial office, stating the number of persons involved, and enclosing a stamped addressed envelope. Under no circumstances should such requests be combined with other editorial matters. Readers should not expect immediate return of tickets, since shortages have resulted in delays in past years. Every effort will be made to pass on the tickets from the Audio Fair organisers well before the exhibition opening date.



STC AT CANTERBURY

THE Good Work being undertaken in the religious sphere by *Standard Telephones and Cables* has spread from St. Paul's in London to Canterbury Cathedral. Conventional public-address systems have been found unsuited to the building's acoustics, since listeners at the rear of the audience heard not only the loudspeaker nearest them but also apparent echoes of loudspeakers in other parts of the building. STC determined the time taken by sound to travel from one loudspeaker area to another and compensated for the delays by means of a staggered-head tape mechanism. The device, illustrated in the photograph, incorporates seven heads operating against a sleeve of magnetically-coated Neoprene on an 80 r.p.m. drum. Silicone oil lubricant in the coating contributes to an anticipated minimum lifetime of ten thousand hours. Thirty-nine loudspeakers, fed through transistor amplifiers by 25 microphone circuits, make up the rest of the network.

ELECTRONIC MUSIC LABORATORY

NOT to be confused with a laboratory equipped for the production of electronic music, a development by *Wurlitzer (USA)* is, in fact, an electronic music-teaching laboratory. The system is not unlike a conventional language-laboratory, but in this case each pupil is equipped with a semi-electronic piano instead of a tape machine. Each piano incorporates a

NEXT MONTH

TUESDAY, 14th MARCH, will see publication of the April *Tape Recorder*, containing a preview of equipment to be introduced at the Audio Fair. For constructors the issue will include full details of the *Miniflux Universal Tape Preamplifier* plus the second in John Fisher's *High Quality Mixing Unit* series. Two stereo recorders will be reviewed—the *Grundig TK340* and *Uher 724L*.

five-octave keyboard and feeds a signal to the student's headphones and to the instructor's communication unit. This arrangement has proved a practical alternative to the cacophony of two or more pupils practising in the same room on conventional pianos. The instructor is equipped to play demonstration items on his own piano, or from tape to individual pupils, or to the entire class. Disc equipment can also be connected to the system. No soundproofing is required in the teaching-room, since the lesson may proceed in total silence.

BARNET RECORDED-DRAMA COMPETITION

SOCIETIES, groups and residents of the London Borough of Barnet have been invited, by the Barnet Borough Arts Council, to enter a Tape-Recorded Drama Competition. Object of the contest is to promote tape recording as an artistic medium and to encourage work on plays hitherto given little attention, such as those requiring elaborate stage props. Provided prior permission is obtained from the publisher and author, recordings may be based on existing plays or on original scripts. (Successful original material will also be considered for publication in *Tape Recorder* at a later date.)

Recordings must be between 20 and 60 minutes in duration and completely cleared by the entrant of any copyright material included. The BBAC wish to preserve anonymity prior to judging, and entrants' names must not be announced on the tape or written on the spool or container. Name and address should be enclosed in a separate sealed envelope, with an entry fee of 10s. to cover administrative costs, made payable to the Barnet Borough Arts Council. Entries should be sent, by 30th November 1967, to the Organising Secretary, 7 Chandos Avenue, London, N.20, from whom further details are available.

TAPE AT THE APAE EXHIBITION

PUBLIC-address applications of tape recording equipment will be one of the main features at this year's *Association of Public Address Engineers Exhibition*. The exhibition is being held, as in previous years, at the King's Head Hotel, Harrow-on-the-Hill, and will include a comparative demonstration of background music, given by *Ampex, Musicord, Sound Coverage* and *Reditune*. Lectures and demonstrations on the manufacture, editing and employment of magnetic tape will be given during the three-day opening. Members and non-members in and outside the P.A. trade are invited to visit the Hotel during the exhibition hours of 2 to 8 p.m. on Tuesday 14th March, and between 10 a.m. and 5.30 p.m. on 15th and 16th.

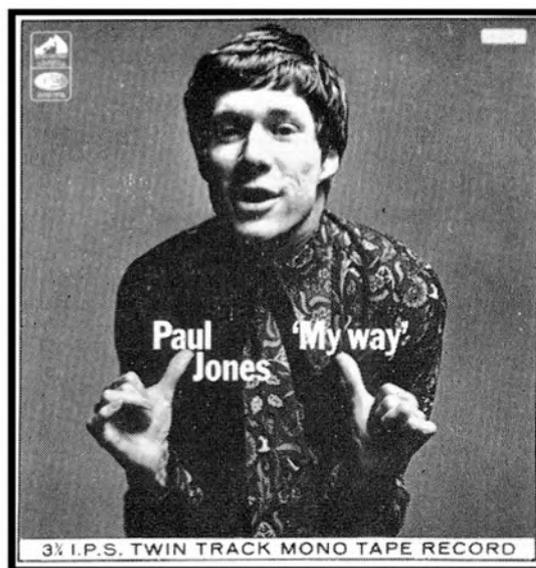
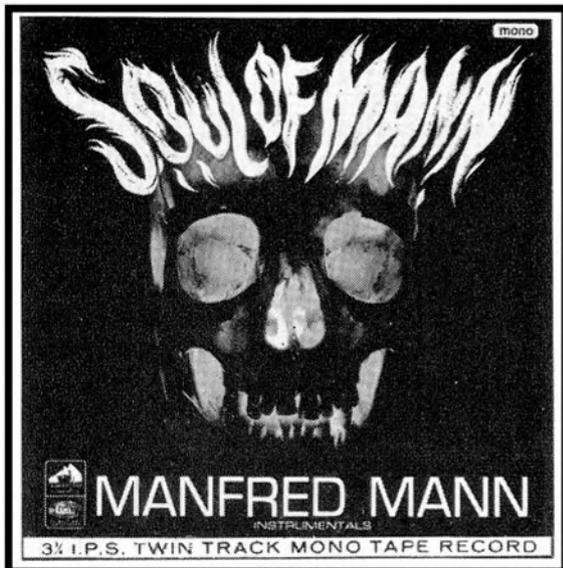
EMI TAPE THE SOUNDS OF ●●● EXCITEMENT

MANFRED MANN
The Soul of Mann H.M.V. TA—CLP3594

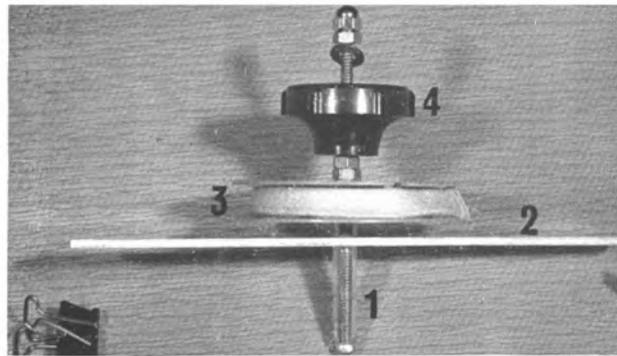
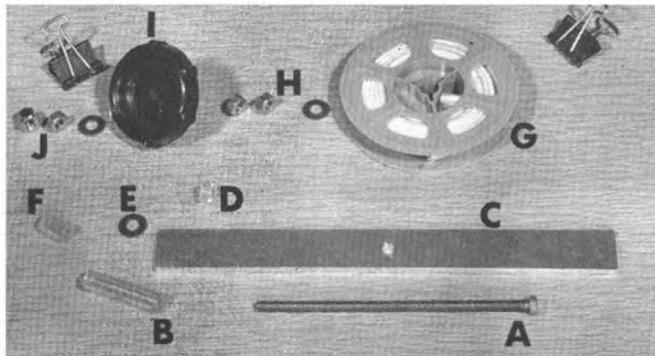
SEMPRINI
Favourite Melodies Columbia TA—SX6110

PEPE JARAMILLO
Carnival in Mexico Columbia TA—SX6111

PAUL JONES
My Way H.M.V. TA—CLP3586



THE ROTATOR



A guide to the eradication of 'bonk' □ by A. J. Lowe

REVIEWING a bulk eraser in August 1966, Mr. Tutchings referred to the problems of 'swish' and 'bonk'. These residual noises on a bulk-erased tape are caused when power is switched on while the spool is on the eraser, and when the spool is removed without being rotated at the same time.

As I have experienced these problems, I set out to devise a gadget, for use with my *Wal* bulk eraser, which would overcome them. The result is the 'Rotator' which was knocked up from what could be found around the house on a Sunday afternoon. In other words it is strictly a low-cost junk-box project.

The idea is that the eraser is switched on, the spool of tape brought to it gradually and then rotated, and then removed while still rotating. The eraser is then switched off.

Not being blessed with three hands, it was found necessary to short-circuit the push-button switch on the eraser, and use only the switch on the power point into which the eraser is plugged. As the eraser is not continuously rated, it must be switched on only when one is quite ready to operate, and must be switched off immediately after the erasure is complete.

Fig. 1 is a side view of the rotator ready for use. It consists essentially of spindle 1, aluminium cross-piece 2, 3 in. spool of cloth tape 3, and free handle 4. Everything except the handle is locked to the spindle by the nuts.

The lower end of the spindle is inserted through the hole in the centre of a spool of recording tape, and then the aluminium cross-piece is clipped at each end to the upper side of the spool by means of the two 'fold-

back' clips shown. Thus, if the handle is held in one hand and the cloth tape pulled with the other, the spindle and spool of recording tape will rotate.

In use a brass washer is placed over the spindle hole in the bulk eraser (after removing the loose spindle which is provided with the eraser), and the power is then switched on. The rotator, loaded with a spool of recording tape, is then lowered into the hole and the cloth tape slowly pulled. See front cover.

Just before all the cloth tape has been pulled off the 3 in. spool, the rotator is lifted clear of the bulk eraser and the power is switched off.

Construction is of non-ferrous material. The 'bits' are shown in Fig. 2. A 3/16 in. screwed brass rod (A), about 4 in. long, is used as the centre of the spindle. It is fitted at the lower end with a brass nut, soldered on, and filed round so that it will pass through a spool of tape. Sleeve B centralises the spindle in the hole of the bulk eraser. The sleeve may be cut from any tubing which will fit the hole in a tape spool and the hole in the bulk eraser. In this case it was found that some hard plastic tube from a ball point pen filled the bill exactly. The maximum length of the lower sleeve must be such that when the rotator is in service, the spindle does not 'bottom' in the hole in the eraser. In my case the length is 1 3/16 in., but different erasers may require different lengths.

This sleeve is fitted over the centre spindle. Next the cross piece C is fitted over the spindle. This cross-piece may be 12 gauge aluminium as illustrated, or brass or plywood, or Perspex or anything similar. It is 7 in. long (for

7 in. spools) and 1/2 in. wide. The hole in the centre just clears the 3/16 in. screwed rod.

On top of this is placed a spacer sleeve D about 3/16 in. long. The size of this spacer is not critical. Next a 3/16 in. brass washer E is added over the spacer sleeve.

Next, another short sleeve (F) is dropped over the washer. The length of this must be slightly less than the thickness of the 3 in. spool of tape. Its function is to centralise the spool of cloth tape around the spindle. Spool G of cloth tape is next fitted over the short sleeve. This spool could be a 3 in. tape spool or, as illustrated, an 8mm. film spool. Any tape could be used as long as it remains reasonably flat, and runs evenly without turns over-riding one another. The tape used happens to be a football bootlace with the metal tags cut off.

The spool of cloth tape and all the bits below it are clamped together with the washer and two nuts H. Thus the cloth tape spool and cross-piece are locked to the spindle, so the pulling tape rotates the cross-piece and any spool of recording tape attached to it.

A free running handle (I) is fitted on the spindle above the cloth tape spool. This is retained on the spindle by a 3/16 in. washer, a lock-nut and a dome nut as shown at J. The handle illustrated was a knob which happened to be available, but any piece of wood with a hole in it would do just as well.

Incidentally, there is no need to make a separate rotator for the smaller spools, because they can be held to the cross-piece with the clips applied obliquely—as a moment's trial will show.

Well, there it is, a problem solved with a home-made but nonetheless effective gadget.



BY H. W. HELLYER

TAPE RECORDER SERVICE

NO. 63 - LOEWE 414, 416 & 416 DIA

THE *Optacord 414* was favourably reviewed by Alec Tutchings in June 1963, the slightly modified *416* being field-tested in August 1966. David Kirk regarded the field-tested model as one of the best mains/battery portables at its price he had handled. From the servicing point of view, I can second that opinion. Certainly, we have had a couple of these machines returned to us for an overhaul after they seem to have suffered the treatment usually meted out in a kindergarten 'play session'. Despite cracked plastic cases and a few other more obvious physical ailments, they need very little refurbishing to give results almost as good as new. After the trials and tribulations of the *408*, which we discussed last month, these later machines are a great improvement.

For the purpose of this article, we can regard the circuit of *fig. 1* as common to both the 414 and 416. The differences are mainly in the second stage, where the 416 uses an AC126 and the 414 an AC125, requiring different values of emitter resistor and the collector load of the preceding stage, a change in the filter resistor in the main negative line, and alterations in the equalisation feedback networks. As the 416 circuit has been slightly simplified, the feedback over the output and driver stages being omitted, this is the given circuit, but reference to the 414 is easily made—even if the usual commendable *Loewe-Opta* practice of pasting a circuit inside the cardboard cover to the printed circuit has been too much temptation for the previous owner.

The mechanism on these models is much less prone to trouble than the earlier types. Levers are more rugged and the pivot points chosen with regard to reliability rather than expediency. Once the chassis is out in the

open (and this can be very simply achieved by removal of the base and lid, then the six screws which go through the main structure to the top plate—an excellent arrangement) all that matters can be reached. But, as with so many of these mains-battery machines, the vital part is the drive obtained directly from the light, fast-running motor. Speed regulation is most important, and the pressure of motor on flywheel plus the individual pressures of coupling wheels on carrier sections of the turntables may need attention. It is a great mistake to plunge into the adjustment procedure before a thorough test of functions when a primary drive is used, and this should always be checked first.

So we come to the motor, which is sprung to bring its single pulley into contact with the rubber tyre on the underside of the flywheel (see *fig. 2*). The secret here is to adjust the motor lift-off so that when the stop key is pressed, the flywheel does not turn. The amount by which the motor pulley stands off is limited by a tongue mounted on the motor case and easily visible from below. This should be bent for just sufficient clearance—but for a definite clearance and clean lift-off. If this is not done properly, the result may be irregular wear of the rubber tyre. In fact, those that we have had to turn down on our trusty (nay, indispensable) corner lathe, have had curious wavy indentations that may look pretty but make the music sound horrible!

Apropos this—it should hardly be necessary to remind readers of *this* publication that the stop key should always be correctly locked in position when the machine is not in use . . . so I shall not mention it (!).

As with previous models, a stroboscope marking is pasted on the upper surface of the

flywheel, and is visible without any dismantling. With a 50Hz light source shining directly on it, the marking should appear static if the speed is correct. A slower speed than normal makes the marking 'creep' clockwise; a higher speed, anti-clockwise. Again, as before, the adjustment is simply to move the motor bodily until the pulley traces a path of the correct length on the tyre, i.e., a circle of the correct diameter. This requires a longitudinal traverse of the motor in its mounting. Adjustment, provided for this, is easily seen from below.

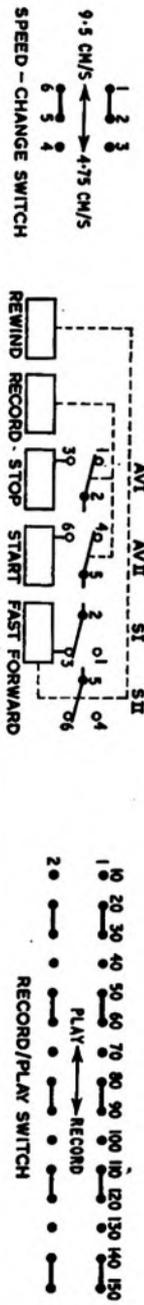
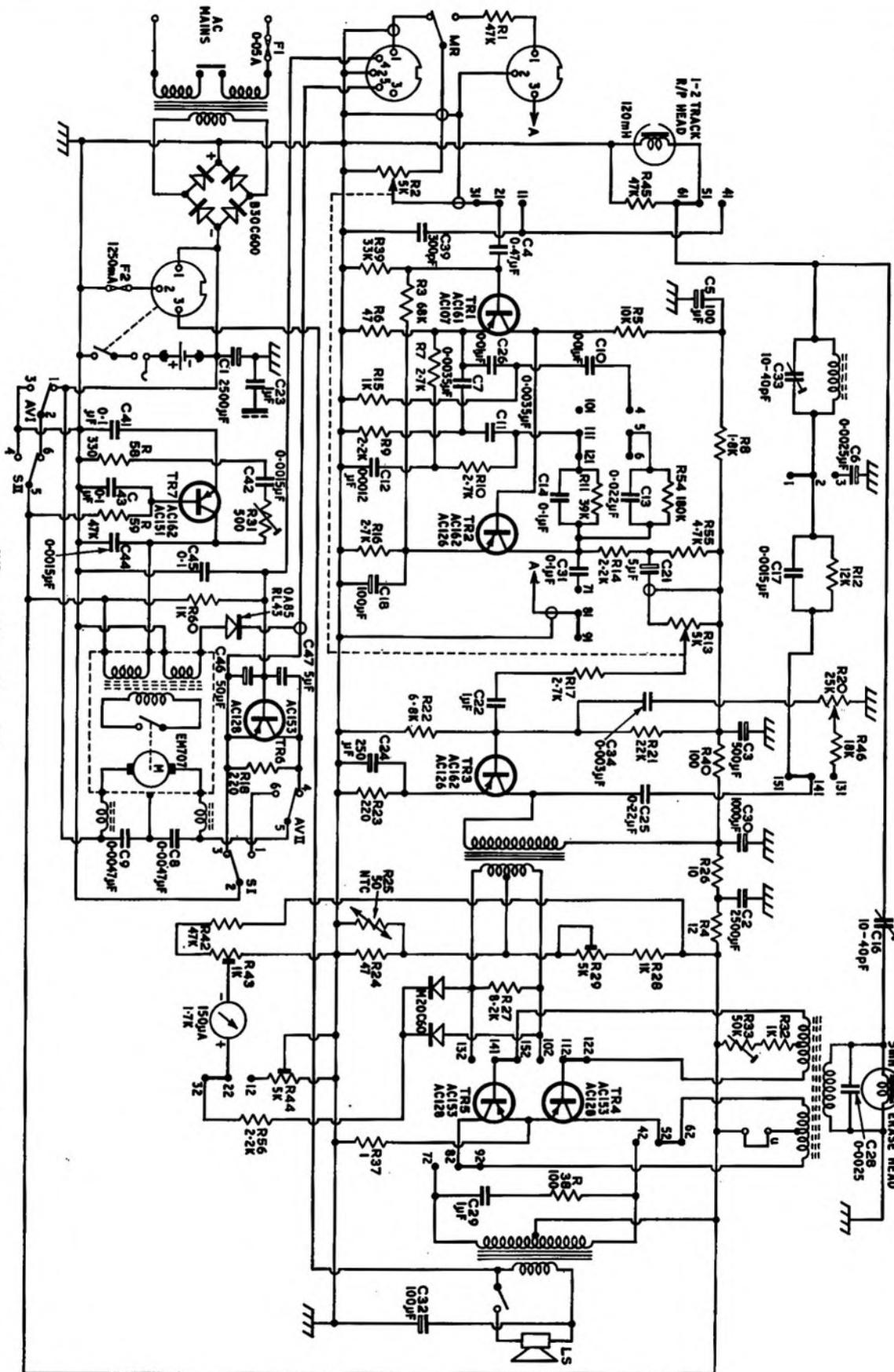
However, factors that can affect the speed, up or down, are the pressures of pinch-wheel on the capstan and of the clutch idler on the flywheel edge. And, of course, any drag caused by the spool carrier and clutch assembly.

First, to check the motor pulley pressure on the flywheel, retard either spool carrier momentarily when the machine is running in rewind or fast forward. When the turntable stops, the back pressure on the idler should immediately halt the flywheel and this in turn should bring the motor to a dead stop. Don't retard for any appreciable time, and avoid making the test too often, as an indentation can occur should the motor pressure be slack and the test repeated several times. In this case, the hold-on spring should be re-tensioned, and a screw is fitted for this purpose.

More often, and more especially on the right-hand side, the slippage is between flywheel, idler and turntable. It needs very little foreign matter on the thin idler rims to aggravate this fault and first attention should be to cleaning the edge of the flywheel, the periphery of the idler and the appropriate clutch drum section. Again, we have found

(continued on page 109)

FIG. 1 LOEWE OPTA OPTACORD 416 CIRCUIT DIAGRAM

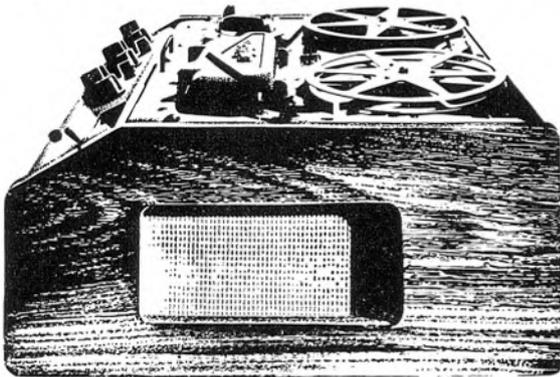


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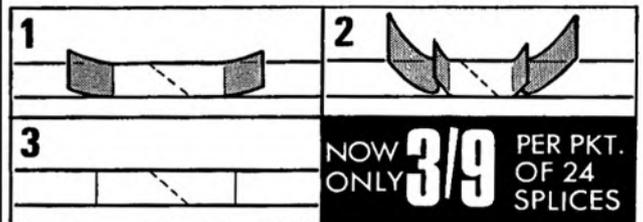
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DRY SPLICE

the lathe useful, skimming the edge of rubber wheels for a true circle. The diameter of an idler wheel, as we all know, has no bearing on speed transmission, and where there is a spring-loading device, as here, the very slight skimming is taken up readily and the smoother and more positive running is a decided improvement.

While we are on the subject, pinch-wheels are another vulnerable item. After long periods of use (disuse or even misuse!) small particles of oxide can become impregnated in the rubber. Some that we have cleaned off had surfaces like a badly laid concrete path. We find that a skim with a sharp blade, taking care that the blade is supported by being pressed at the lower end against the deck, and parallel with the pinch-wheel spindle, will clean off much flutter-causing roughness. Adjustment of the pinch-wheel is provided by a set screw in this machine. It is important to note that the shaft should have about 1mm. play for correct pressure, which is between 500 and 600 gm.

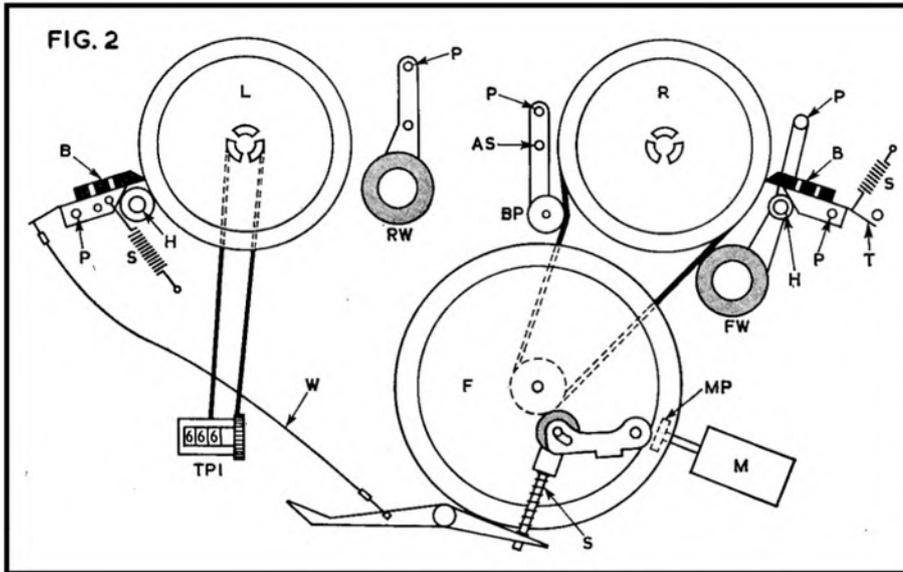
The clutch adjustment on these machines, on both sides, is again by a screw in the turntable, but great care is needed not to slacken off too much, or the nut on the inside will come adrift, and one then has to start all over again. The left clutch is straightforward enough, it only being necessary to make sure the rubber grip-ring is allowing the upper part to turn without imparting a pull to the lower part when the machine is in the play function.

The right-hand side needs a bit more finesse: whereas the feed spool only has to be dragged around by the pull of the tape, and the clutch arrangement is only to maintain sufficient back tension, the right-hand assembly is driven by a flat, soft rubber belt from the flywheel to give the necessary variation in torque for a filling reel. To smooth this out and prevent unwanted pull on the main drive system, the device of a bearing pulley is employed. This idea, used with some success in latter Grundig designs, depends very much on the free-running of the pulley wheel and exact level of the three items, flywheel, bearing pulley and clutch drum. On the 414, an adjustment for the inward throw of the pulley bracket is provided, and the drive is released from the clutch by the simple expedient of this bracket being pushed out of the way during fast forward or rewind.

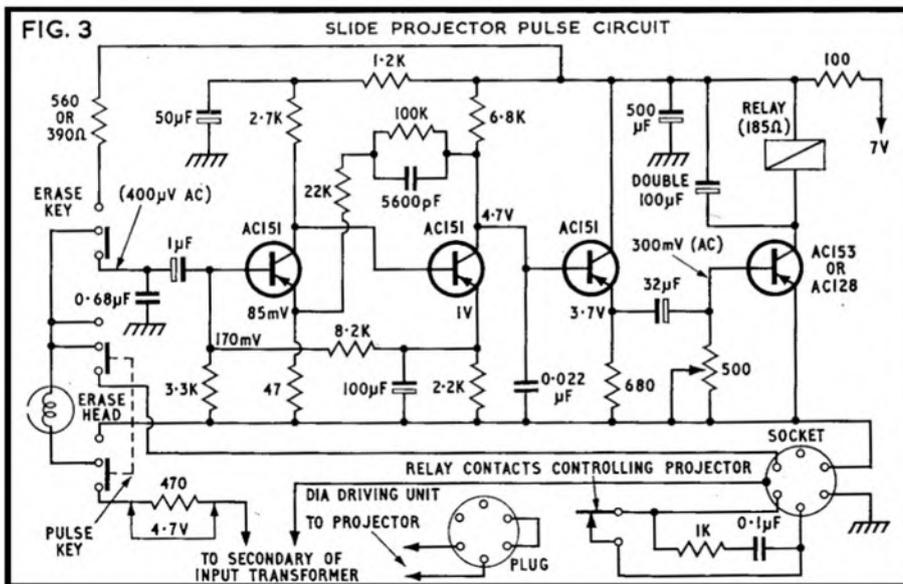
An additional tensioning device is employed. The brakes on these models, which are operated in two different ways, are soft rubber wedges. The right-hand one remains lightly engaged on the upper section of the right-hand spool carrier during take-up, i.e., when the play button is depressed. Again, spring tension engages the brake, via the pivoted bracket, and on each side, a tongue halts the travel as it reaches a stop pin. The correct position of the tongue for the right-hand brake with stop engaged is for a 2mm. clearance, and then it should remain pressing lightly on the spool carrier when start is engaged. For fast-wind, the brake is lifted quite clear. The tongues on each side should be bent to obtain about 1½mm. clearance.

In the stop position, the left brake is held on by spring tension, but there is a minor adjustment by alternative holes in the mounting bracket to which the spring is attached. This,

(continued overleaf)



Simplified layout of drive and braking system. Points discussed in text are pivot P, spring S, tongue T, forward wind idler FW, rewind idler RW, motor M, motor pulley MP, bearing pulley BP (engaging flat belt), adjusting screw AS, tape position indicator TPI, hold-off pin H, left brake wire W.



in conjunction with the tongue angle, should provide positive braking. During fast-forward and rewind, the brake is held off by a pin (with a soft rubber stabilising washer). But when play is engaged, a wire link from the pressure arm assembly of levers pulls the brake clear. The amount of clearance is determined by the length of the wire, which is secured by a clamp nipple, soldered into place. Check this security if there is snatching when the machine is switched on, or if the brake remains engaged—resulting in severe wow.

If all these things are correct, the remaining source of trouble is the right-hand clutch itself, and here it may be necessary to adjust the set-screw in the upper section of the carrier, or to dismantle, soften the felt and grease the spindle (using only a light grease). To check the clutch action, run the tape through till the right-hand spool is nearly full, then, as the machine is running, gradually raise it to an upright position from its normal site, flat on the table. If the clutch begins to chatter or the take-up grows hesitant, continue with the gentle trial-and-error adjustments.

There are a couple of small points that need mentioning before we wind up and leave room for the diagrams. First, to re-iterate, always make sure that the stop key is pressed right home every time. This really is most impor-



tant. It is quite possible to press it, neutralise the mechanism, but leave the motor pulley partly engaged. A positive action is needed.

Finally, the meter connections are perilously close to the motor housing, and although the makers always fit a strip of insulating tape along the edge of the housing, it is a wise precaution to add an inch or so of PVC tape across the back of the meter. And when re-assembling, make sure the meter bracket is not bent.

As a bonus this month, the 'Dia' circuit is enclosed. (fig. 3). Many readers have asked

about pulse circuits for slide projector operation, and the method used here on the 414 and 416 is a good example. It will be noted that the chassis return is via the shorting link on the projector plug, so although there is a permanent four-transistor circuit wired in (using a pair of connections to the mains transformer secondary and a DC source point from the negative line), with the projector not connected, the circuit is inactive.

The first two transistors are ordinary amplifiers. A combined record/erase head is fitted on the 'Dia' models, with the lower section recording the pulses on the tape and erasing previous pulses, while the upper section erases the top track. The selector key switches the head into its appropriate mode for erasure or recording of pulses.

The 50Hz mains supply, transformed down to a 7V supply for the head, and then amplified and its third harmonic selected (150Hz), provides an over-saturated pulse on the tape. Recording current is about 8mA and a drop across the 470 ohm resistor (at bottom left, as shown) should be about 4.7V under these conditions. When the pulse is picked up during replay, it is amplified, fed through the impedance transforming stage and triggers the AC128, powering the relay and switching the projector.

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THE journey was an acoustic hell. Each lurch of the ancient vehicle, as it rumbled round the airport, was accompanied by the tizz and rattle of steel and chrome, the groaning of passengers, and the shudder of loosened windows. The volume of the tinny public address system, over which the driver described the view, increased in direct relationship to the speed and noise of the engine—or was the driver simply talking louder? One way or the other, the *Sony TC-900* seemed not the least bit worried. What a pleasure it was to sit back languidly, eyes aimed out of the window, microphone directed at the loudspeaker.

The recording came over beautifully. A difficult subject had been captured with negligible effort. The day had arrived when one could simply point the microphone and press the button.

At the end of the day, of course, there was no satisfaction of a task well done: simply an immense admiration for the 'skill' of an inexpensive network of components.

The simplicity of the TC-900 is almost beyond belief. A single rotary knob controls playback, fast forward and rewind. Another, to the left of a playback volume control and tone control, interlocks with the play selector to engage the record mode. Tape speed is changed from 3 $\frac{3}{4}$ to 1 $\frac{1}{2}$ i/s by unscrewing a capstan sleeve. And that is it!

In some respects, the recorder is a very up-to-date design. Although weighing only a little over 4 lb., it incorporates a complete power pack and will accept 250V AC as an alternative to four U2-size cells. Switching from batteries to mains powering is accomplished automatically, by the simple act of plugging the mains cable into the recorder.

Insertion of batteries was a fairly straightforward matter, the battery housing being protected by a removable plastic cover in the base of the cabinet.

One aspect of the cabinet I did not like was

BY DAVID KIRK
field-trials of battery portables

the lid protecting the deck. This was released by pushing back against a flexible tin hinge and, although it seemed to be completely removable, was found to be a permanent feature for all practical purposes. The first TC-900 submitted for test was, in fact, supplied with a broken hinge. That model was finally replaced when a loose motor bearing caused severe 'screaming' when running. In addition, the first machine developed a fault in the recording amplifier which resulted in a continuous crackle being placed on the tape. Possibly the two troubles were connected.

The replacement TC-900 has been extensively used for some months, and the above faults have not reappeared. Wow and flutter are slightly worse on this model, however, and speed fluctuation is quite audible even on light music.

Despite its permanent-magnet erase head (which swings into operation against the uncoated side of the tape) the TC-900 has a low level of background noise, compared with the majority of low-price portables. Motor interference is well smoothed, and the 30kHz bias removes the worst of the background hiss. This technique of employing a magnet or DC-powered erase head for erasure is all too popular in Japan but seems an unforgivable thrift when AC recording bias is incorporated. How much would a slightly more powerful oscillator cost?

The dynamic microphone supplied with the recorder proved adequate for general indoor and outdoor speech recording. It is possible, however, that difficulty may be experienced if a superior microphone were substituted in the hope of obtaining improved quality. Although the AGC functioned happily with the supplied microphone, I suspect that any substantial variation in microphone output level would upset the circuit.

Which brings us to the direct connection of external equipment. The Sony AGC is designed to work (through the microphone input) from the loudspeaker output of a battery radio or recorder. In such cases, the nominal amplifier output power is usually fairly low, and a small Japanese radio, plus several Japanese portable recorders, were found suitable signal sources, when their volume controls were positioned between about the third and half-way mark. The direct recording lead, however, generally mutes the speaker in the radio or recorder from which the signal is being taken. This is no fault of Sony's, but since one cannot monitor on the TC-900 speaker either, while recording, one is left totally in the dark. Even setting the input level, for example, involves a number of test recordings at different volume settings, each sequence being assessed on replay for quality. One can, of course, monitor through an earphone in the Sony output socket, or even attach an external speaker but I fail to understand

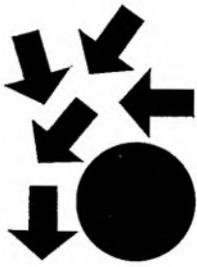
why the Sony loudspeaker is itself not left in circuit during recording.

Pre-recorded music was reproduced quite well, considering the size of the monitor speaker. The combination of speaker and cabinet produced a clean and buzz-free sound, and shows just what can be done when plastic is used carefully.

Equally impressive was the TC-900 mechanism. The recorder has a substantial flywheel and a simple but sturdy system of tape drive, fastwind and braking. Internally, the recorder resembles a rugged mains machine that has simply been scaled down to fit the 8 x 8 x 4in. case.

The Sony portable, in common with most other Japanese portables of similar price, incorporates a 'remote control' device. This takes the form of a battery cut-out switch on the microphone, connected to the machine by a separate sub-miniature jack-plug. The plug moulding supports both remote-control and microphone-signal plugs—as has become common practice in the last year-or-so. However, although the sockets themselves are standardised, the relative position of the twin prongs varies fractionally between different manufacturers' recorders. The result is that, even an experiment, one cannot normally exchange microphones from one Japanese portable to another—from Sony to *Sanyo* to *Aiwa* to *Sharp*, etc. Similarly, if one is fortunate enough to possess one of those excellent little Japanese transistor mixers, substantial plug-butcherery would be required before these microphones would enter the miniature jack sockets.

Our Far-Eastern friends remain the butt of considerable criticism. They persist in employing capstan-sleeve speed-change, even on machines costing well over £100, and put insufficient care into internal design, machining and assembly. Most Japanese manufacturers, certainly Sony, have solved the motor hash problem, and in this they are ahead of their European competitors. Since *Loewe Opta*, *Telefunken* and *Philips* have proved that accurate machining need not be expensive, I had proposed to end this field-test with the suggestion that it was time for an exchange of ideas. Having just handled the new, and admittedly more expensive, *Sony TC800* mains/battery portable, this comment now seems obsolete. Sony set high standards in the greater part of their range; the TC-900 has its good points but is not representative of that range in value for money. This does not alter my opinion, however, that Sony are very much the leader of the Japanese audio industry in production quality and originality. They are pioneering domestic television recording and, on a more mundane level, have shown that well-designed automatic gain control can be an asset to the creative recordist.



A HIGH-QUALITY MIXING UNIT

BY JOHN FISHER

FIRST OF A THREE-PART SERIES

MOST audio equipment is the result of a series of design compromises, whether because of limited budget or to cover a variety of different requirements with the minimum of adjustment or alteration, and to cater for the tastes of a variety of users. Home-built equipment can have the advantage of being tailored to one's own requirements, as well as offering

a saving of cost. The mixer to be described was designed and built around the following principles:

- (1) It should be compact, portable and rugged.
- (2) It should be of high quality, having low noise and wide bandwidth and introducing negligible distortion.
- (3) It should not be prohibitively expensive.
- (4) It should be as versatile as possible and easily convertible to stereo from its initial mono form.

- (5) It should be easily serviceable.

Compactness is rather easier to achieve with transistors than valves if components are not to be too cramped for easy servicing, and reliability is helped by the reduction of the problems of heating, and lower voltages. With currently available transistors, the requirements of high quality are easily achieved. There is probably not a lot of difference in price between a comparable valved and transistorised mixer, although valves present fewer problems when high impedance inputs are required.

On balance it seems preferable to use transistors, particularly to avoid future obsolescence.

The mixer was intended mainly for recording 'live' from microphones, but I felt that it should be possible to mix at least two high level sources, such as tape and disc recordings.

For monophonic recording of music it is often preferable to use several microphones in order to obtain clarity through good signal-to-ambient-noise ratio, and through control of the amount of echo and reverberation; also to correct the balance between sections of a choir, orchestra, etc., or between chorus, soloist and accompaniment for example. In drama recording it is, of course, essential to be able to separate characters on different microphones, move from one room to another with different acoustics, as well as mixing in sound-effects and linking music if required. Any of these situations may sometimes call for more microphones than one can afford or than one requires for most other recordings (and may indeed require the use of an auxiliary mixer) so that one is forced to borrow or hire microphones; it is an advantage therefore if the mixer will cater for a variety of microphone types, with variation in impedance and signal output, with the minimum of fuss and 'hook-ups'.

I felt that the microphone amplifier (Fig. 2) described in the *BBC Engineering Monograph No. 46* (and in David Robinson's series of mixer articles—June to December 1964 *Tape Recorder*) would form a very useful starting point, as it offers floating input impedances of 60-ohms or 600-ohms to accept balanced or unbalanced sources, and a preset control allows adjustment for differing microphone sensitivities and output.

Two amplifiers were also required to accept the output from high impedance moving-coil or ribbon microphones, with low enough noise and sufficient gain to allow low or medium impedance unbalanced microphones to be used instead. These amplifiers can also be fed from a high level source, into a higher input impedance.

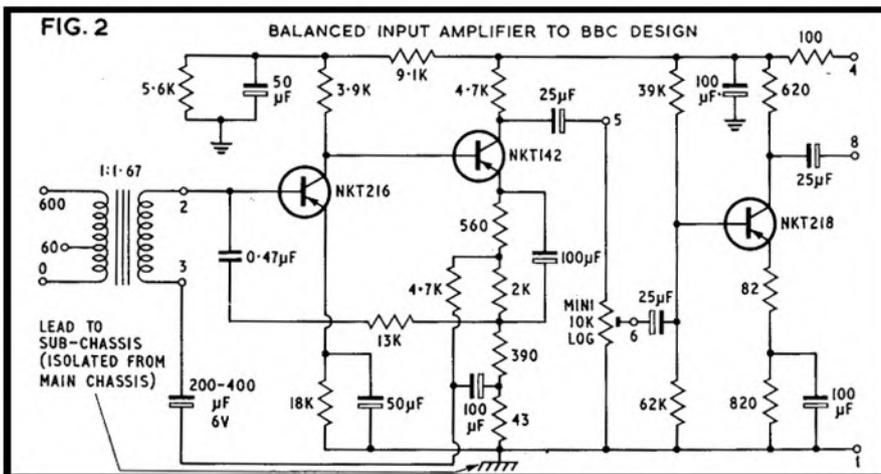
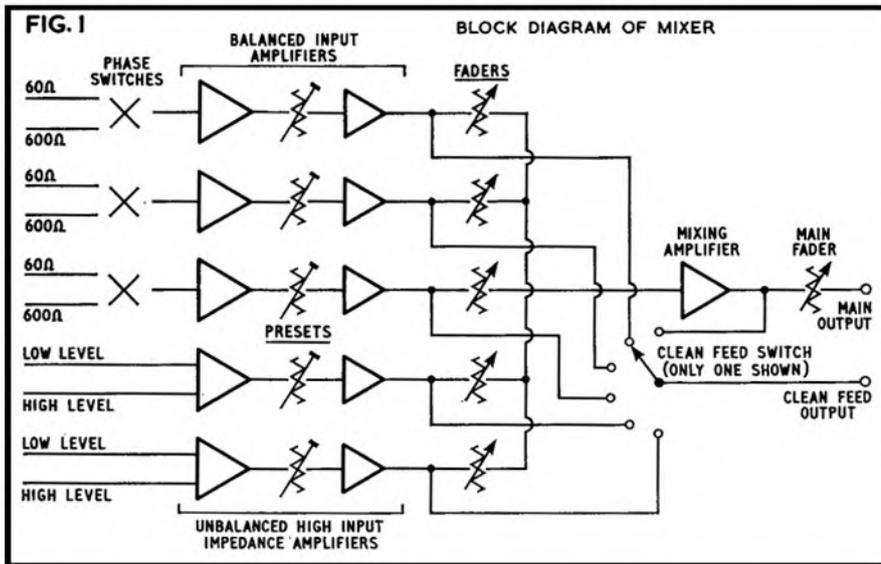
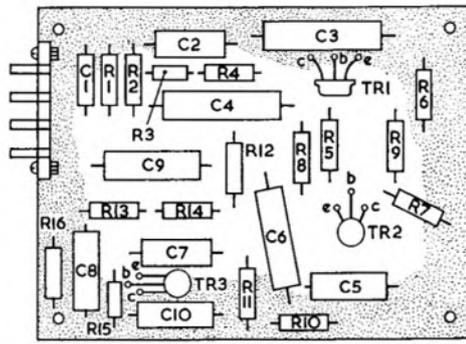


FIG. 3
LAYOUT OF UNBALANCED
INPUT HIGH IMPEDANCE AMP



Modular construction of the amplifiers (fig. 3) makes for easy servicing and allows greater freedom when experimenting, as a single amplifier can be removed and altered, or an alternative type substituted, without altering the rest of the mixer or affecting its performance.

The circuits were built on drilled paxolin sheets ("Poor-man's printed circuit" as David Robinson put it) with the component leads interconnected on one side of the board. The sheets were then bolted, with an insulating panel, to a small aluminium sub-chassis fitted with miniature eight-pin unitor plugs (fig. 4). The chassis provides screening between amplifiers, as well as supporting the circuit panel (continued overleaf)

FIG. 4 PLUG-IN MODULE SUB-CHASSIS

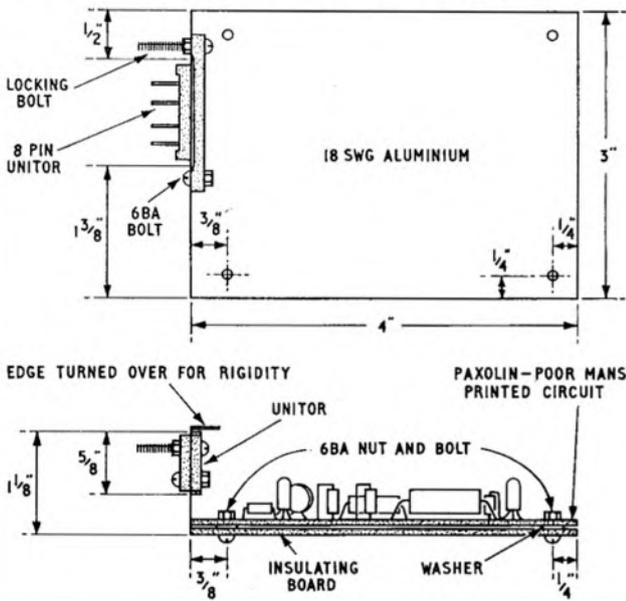


FIG. 5 BRIDGE FOR UNITOR SOCKETS CARRYING
MODULES AND TRANSFORMERS

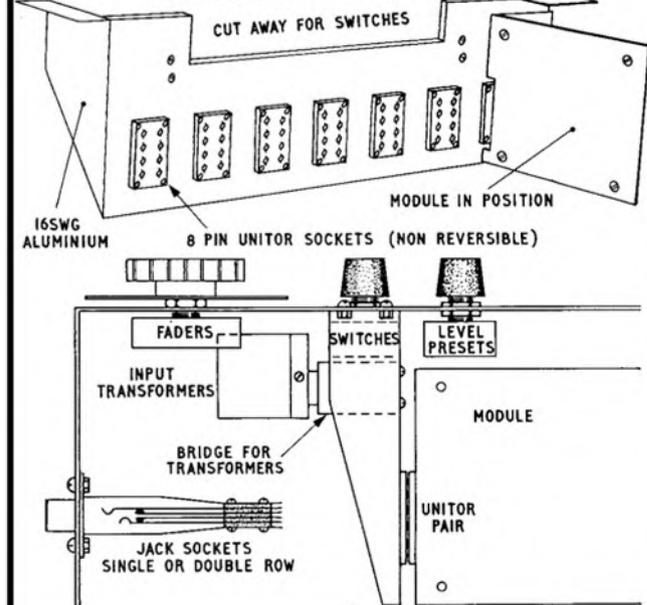


FIG. 6
PROTOTYPE MIXER
CABINET

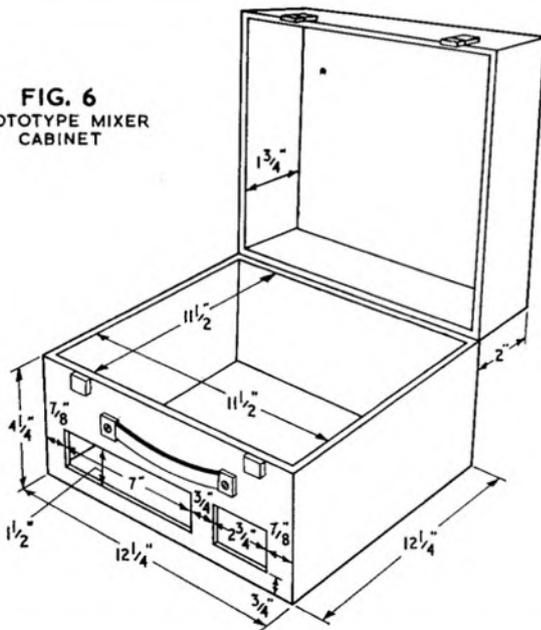
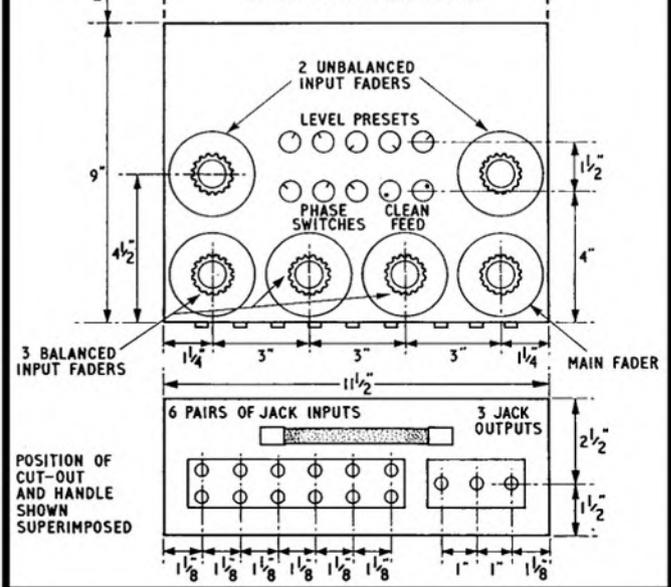
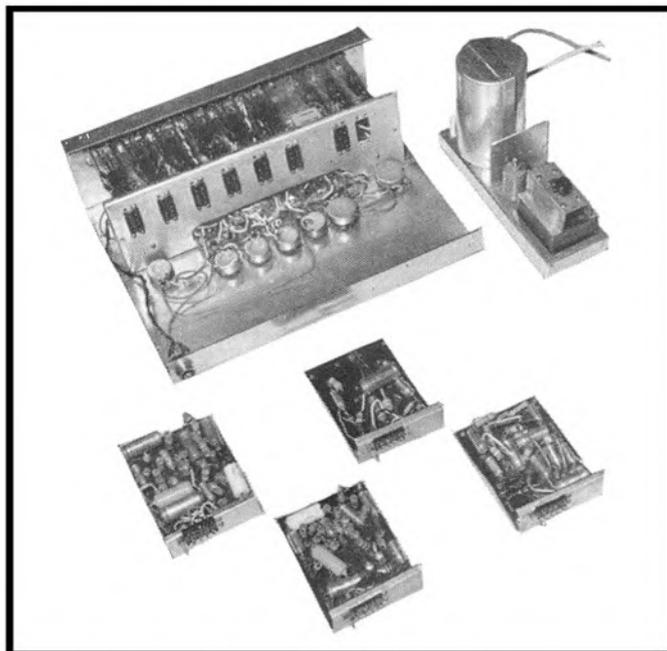
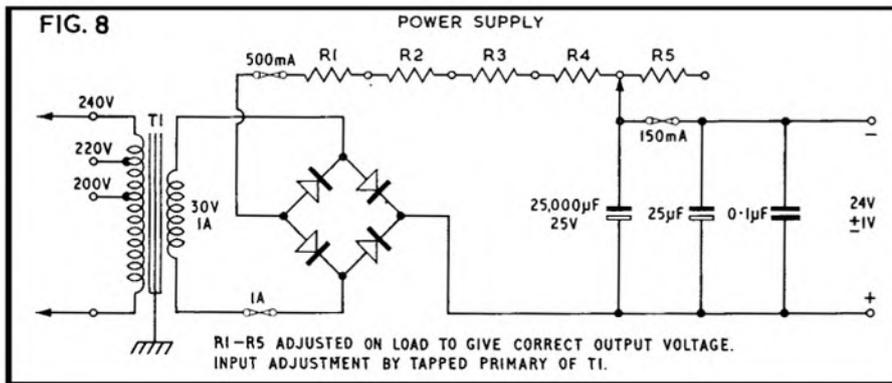


FIG. 7 SPACE INSIDE CABINET BEHIND MIXER
FOR POWER-PACK AND CABLES





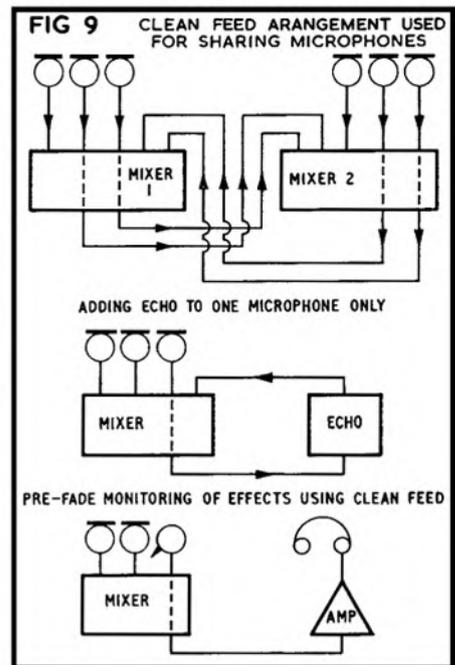
and offering some protection to the amplifier when removed from the mixer. The modules plug into sockets mounted on a 16 SWG aluminium bridge inside the mixer (fig. 5), which also supports a girder carrying the input transformers. To avoid damage, in case an amplifier is plugged into the wrong socket, non-reversible type units were used, and standard pins used throughout for input, positive and negative rails, output and return from the preset controls, and output to the amplifier fader. Isolated positive and negative rails were used to prevent hum loops, and the positive line is earthed at only one point, one of the output sockets. The input and output cable screens are earthed at the sockets which are not isolated from chassis.

The main body and panels of the mixer are of 16 SWG aluminium, L shaped, and carry the controls, jacks and the bridge for the transformers and amplifiers. The rest of the mixer body is of 18 SWG aluminium which encloses the 'works' and is bolted to the main panels. The whole mixer is enclosed in a small wooden cabinet, for protection, with the jacks projecting through a cut-out in the front below the handle. There is space inside the cabinet and behind the mixer for the small power pack which is on a separate small chassis and is removed during use to avoid inducing hum into the low-level circuits. There is also some room for stowing

cables inside.

The mixer cabinet (fig. 6) in the prototype is made of five-ply glued and jointed at the edges, and with a simple varnish finish. Rubber feet are fixed to the bottom and back to avoid damage to the cabinet or furniture, and the hinges on the back are miniature 'stay put' types, so that the lid can be used as a rest for a miniature score, script or libretto if required. The handle on the front is a leather covered spring type, as used on small recorders, and the jack fronts came flush with the front of the cabinet through two cut-outs below the handle. The lid is secured with miniature catches, and the mixer proper is retained in the cabinet by self-tapping chromed cross-head screws through the cabinet into the aluminium.

At the front of the panel (lower fig. 7) are fifteen standard GPO three-contact switching jacks providing six pairs of inputs and three output sockets. Two jacks on each input offer alternative input impedances. (One pair of input sockets and a unit socket on the bridge, to cater for the extra amplifier required when converting to stereo—they are otherwise available for other uses.) The main fader potentiometers are mounted above the jacks and the transformer and module-socket bridge is fastened behind the jacks to the main panel. The modules are locked in place by a retaining bolt and nut through one of the four pairs of



holes in each unit.

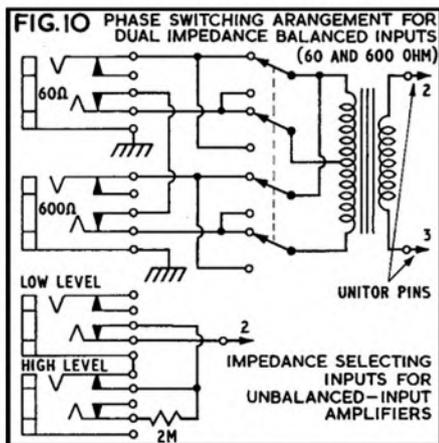
There is sufficient clearance between the bridge and main panel to accommodate the phase switches for the 60 and 600-ohm inputs, and for clean feed switches, and above the modules for the miniature variable preset level controls.

The three balanced-input microphone amplifier faders (including a stereo microphone amplifier fader, if required) and the main fader, are in the front as these are the most used controls for live recording work, and faders for the unbalanced low/high level channels are behind, either side of the bank of preset controls and switches. There is room behind for further controls to be added, as required.

The power-pack (fig. 8) is very simple, and compared with some sophisticated designs it appears crude. However, I have found it perfectly effective for the job, and its slightly greater bulk than a transistor stabilised supply is offset rather by the saving in cost, as all the components are available quite cheaply.

A tapped-primary 30V secondary transformer feeds a bridge rectifier, and the output is simply smoothed by the dropping resistor chain and the large 25 milliFarad capacitor. This system has two disadvantages, neither of which is really serious in this case. For fine control of voltage, or to allow for the addition or removal of an amplifier module, the value of dropping resistance must be altered; also, owing to the large time-constant, it takes rather more than a minute for the circuits to come up to full voltage—no 'instant sound'! One, sometimes alarming, effect of this is the crackles which can be produced if the controls are operated while the voltage is still rising appreciably and the coupling capacitors charge through the potentiometers. Also, one may not be immediately aware if the power pack becomes disconnected from the mains owing to the size of the reservoir.

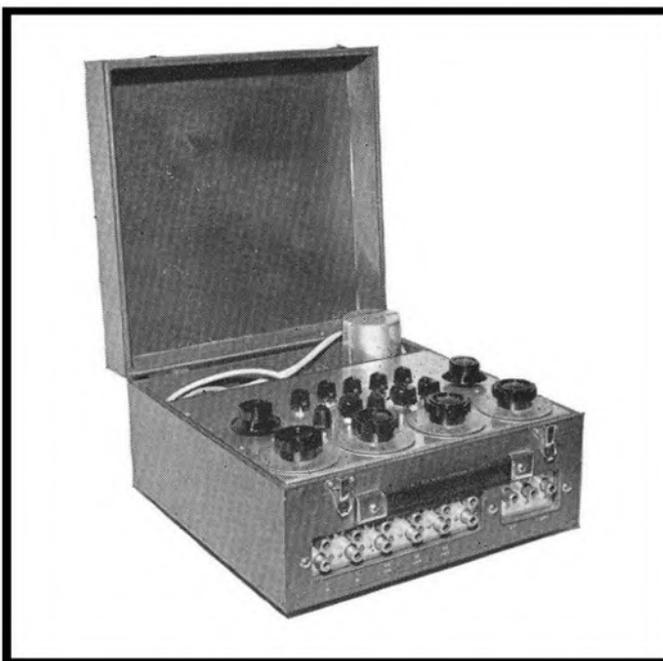
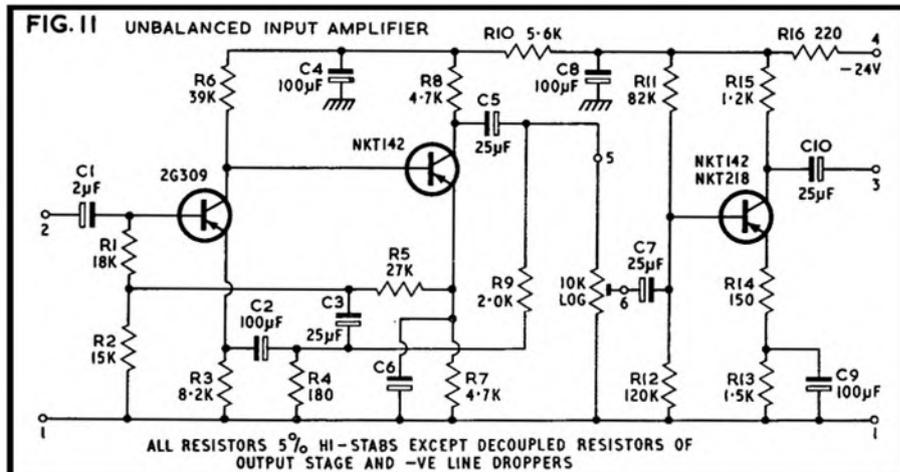
The power supply chassis is earthed, but both positive and negative supplies are 'floating', i.e., neither side is earthed, to avoid earth loops



when an earthed recorder is used. If for some reason the recorder or other amplifier in use is not earthed, it is simple to earth the mixer chassis directly.

Before going any further, perhaps it would be worthwhile giving a word of explanation about the 'clean feed', as this has been mentioned. Strictly, clean feed is the provision of a single signal, or in some cases a composite signal, which is normally passed on for mixing with other signals, tone adjustment, etc., before this treatment occurs. It means that, for example, one can monitor the signal from just one of the sources before it is mixed with the rest and continue the monitoring if this signal is faded out of the mixture. This can be useful—for instance in broadcasts, sound effects provision, etc., for checking an effect or cue before it appears in the output for fading up. It is also very useful when one is doing both a mono and stereo recording, as clean feeds from some mono microphones can be mixed into the stereo mixer as 'spot' microphones. This reduces the number of microphones 'on stage', even if one has access to more. Alternatively, it offers one the ability to produce different balances on simultaneous recordings where two or more mixers are available and where microphones are in short supply or only a few are allowed to appear (fig. 9). This is not a facility one usually comes across often in amateur equipment, but it can be very useful. Ideally one would have clean feed from each microphone amplifier or high level amplifier and from the output before the fader. However, two switched outputs selecting from any of the six sources (five microphone amplifiers and pre-fade output) is quite a reasonable compromise and the outputs, unbalanced at 600-ohms, appear on two contacts of a stereo three-contact jack. A few millivolts should normally be available to feed low-level amplifiers.

In a similar way, clean feed output from a crossed axis coincident stereo microphone can be fed out of a stereo mixer and mixed into a mono recording as a 'general' microphone, freeing one mono microphone for 'spot' use,



for picking up an individual instrument or soloist.

A further possible use for clean feed, in light music recording, is when one wishes to add echo—via a tape machine or reverberation chamber, only to individual microphones, and not the whole mixture.

The BBC microphone amplifier, which as already mentioned was the starting point of the mixer, is basically a DC feedback pair with the input transformer (tapped to give floating 60-ohm and 600-ohm inputs) in the base bias circuit of the first transistor, and both series and parallel feedback is used to linearise the frequency response, cater for transistor gain spreads and reduce distortion to a negligible level. My amplifiers used *Gilson* input transformers, Type *WO2369*, which have proved very successful; other suitable types are also available. The transformers are potted and well screened but it is as well to keep them away from stray magnetic fields from power transformers, etc. The parallel-feedback capacitor to the base of the first transistor has been changed since the circuit was first designed,

and has been reduced to introduce some lift in the extreme bass. The modified value was used (although the audible effect is very slight), as it was in David Robinson's unit.

The output from the second transistor is fed via the preset control to the third stage which provides a voltage gain of about eight times and feeds the main fader for the amplifier. The quietest transistors to hand were *NKT 216's* (similar to *NKT 226's*) by a very small amount compared with others tried—a fraction of a dB on broadband measurement. New types are constantly being produced and it may be possible to improve the noise levels of these amplifiers marginally. In practice, the *NKT 216* has proved very suitable for the first stage, giving a very low noise level. An *NKT 142* is used for the second stage, and an *NKT 218* for the third stage.

It is worth spending some effort selecting the quietest available transistors for the microphone amplifier first stage, particularly where they are likely to be used with 'domestic' or miniature ribbon microphones which, although

(continued on page 117)

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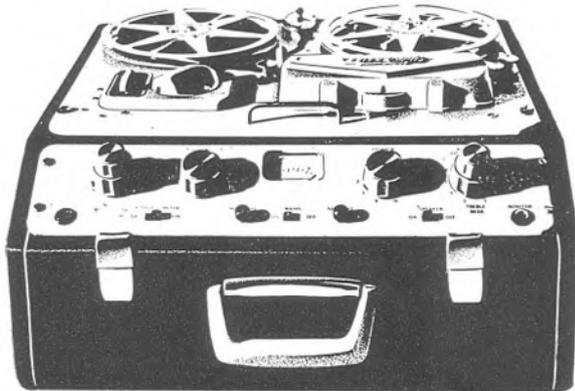
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OUR READERS WRITE . . .

. . . about the practice of earthing

From: I. A. Davies, 15 Trees View, Croft Spa, Darlington, County Durham.

DEAR SIR, Mr. Graham Balmain in the June issue invited comment on the Continental practice of supplying unearthed recorders.

I entirely agree with his remarks. I am one of the few with a sensitive skin that can distinctly feel AC of as low as 12-15V and for some years have made it a practice to earth all mains equipment that has some accessible point.

During the last two years I have acquired two recorders, a *Tandberg 62* and *Revox F36*, neither of which was provided with a third earth lead. I have had to go to some trouble to terminate the mains lead in the plug half of a three-pin cord-extender plug and socket. The socket half is then connected to a conventional three-pin mains plug. All my mains equipment is similarly provided. To open the earth lead all that is necessary is the insertion of a 6-8in. length of *twine* core, linking the live and neutral leads by means of a pair of cord extenders.

When two or more items of mains driven equipment are linked together it is a simple matter to insert one or more earth isolation links just where they can be most effective.

Yours faithfully,

. . . about five-inch boxes

From: P. D. Turner, Cotswold Tape Recording Society, 'Pike Cottage,' Frampton Mansell, Stroud, Gloucestershire.

DEAR SIR, The *Cotswold Tape Recording Society* badly needs serviceable boxes for 5in. tapes, for the circulation of tapes to the old, the blind, and the physically handicapped. Cardboard boxes, even with additional protection, do not last indefinitely; and they are surprisingly expensive to buy.

It may be that some readers have boxes they no longer require; or that some manufacturer may care to donate boxes for a good cause. If so, we should receive them with gratitude and put them to good use.

Yours faithfully,

. . . about a Luton club

From: D. D. Beswick, 63 Ashton Road, Luton, Bedfordshire.

DEAR SIR, I would like to inform your readers of a new club which has been formed in Luton. This is the *D.D.B. Sound Studio's Club*, the aim of which is to send out a sound magazine on tape to blind members once a month. Membership is free to all blind and handicapped persons who own or have access to a tape recorder. Any reader who knows of a blind person who would like to join our club is requested to contact our club secretary. We are in need of sighted members, able to get out and about, to provide us with interesting

material for our sound magazine. We charge a membership fee of 10s. per year to sighted/non-handicapped members, all money going into club funds. We are a non profit-making organisation and have made application to be accepted as a charitable organisation. Our greatest need is a 'sugar daddy' to give us a little financial support and get us under way. We have a club constitution, a copy of which would gladly be forwarded to any potential supporter.

Yours faithfully,

. . . about a service for the handicapped

From: E. G. Waters, 28 Chatsworth Road, Croydon, CRO. IHA.

DEAR SIR, I would with your help let it be known that from the 1st December 1966 I declared myself as *Studio 101, The Tape Network of Great Britain, Friends of the Blind, Aged and Infirm.*

I already supply material to various organisations but feel sure that a lot of people would like to know of, and receive, these recorded programmes. There would be a sound magazine. I have a dramatic section who are doing plays for me to record and also have a means of amplifying this at playback.

To join this network, one must be fully conversant with the use of a recorder, be able to use 15, 7½ and 3¾ i/s, and be interested enough to further the cause. There is no charge.

Yours faithfully,

HIGH QUALITY MIXER CONTINUED

they often have quite a good frequency response, give rather low output and therefore need as low an amplifier noise as possible to achieve a satisfactory signal-to-noise ratio. The low noise requirements apply equally to the unbalanced input amplifiers, although if high-output dynamic or condenser type microphones are used, the requirements are less stringent.

The input to the transformer of each amplifier is fed from the sockets via a phase switch. This allows the microphones phases to be the same, to avoid cancellation when used in pairs (or more) in mono; for stereo operation, correct phasing is, of course, essential. Where microphones are dotted around a set-up, e.g., if a multi-microphone recording is being made of an orchestra or dance band, it is sometimes preferable to adjust phase by ear when it is difficult to decide what correct phasing should be. Otherwise any two microphones can be phased by directing a low-mid frequency tone at them, from a single speaker to the front faces, metering the mixer output and switching one or other to the phase position which gives maximum output; there should be no doubt as to which way round gives in-phase signals in this way.

Fig. 10 shows the method used for feeding the signal from the alternative input sockets to the transformer. The method is slightly more cumbersome than the alternative of feeding the input signal from a single socket to a DPDT switch for phase change and then to a SPDT switch for impedance selection. However, it

does have the advantage of making impedance selection a more deliberate operation. While a 30/60-ohm microphone will not normally be seriously mismatched feeding a 600-ohm load, a 600-ohm microphone feeding into 60 ohms will generally suffer, losing top owing to the inductive component of the source impedance.

The choice of methods is a matter of personal preference, but as the space was more readily available on the front panel than on the top panel and sockets cheaper than switches, it seemed to be better to use the method I have adopted.

The unbalanced input amplifiers (fig. 11) similarly consist of a DC feedback pair followed by preset control, third stage and main fader. There is AC feedback to the undecoupled emitter resistor of the first transistor and the base bias resistor is bootstrapped to the emitter of the first transistor to maintain a high input impedance. The output from the second transistor is fed to a miniature preset potentiometer on the main panel and from there to a third stage similar to that of the BBC amplifier, from which the output is fed to the fader.

High-gain low-noise transistors were used for the first stage, *Texas 2G309's* being particularly suitable, although an *NKT216* was tried successfully. The second stage transistor is an *NKT142* high-frequency type, while either *NKT142's*, *NKT218's* or *2G302's* are suitable for the third stage. This arrangement has proved very satisfactory, the gain and noise level being adequate both for use with a 50K ribbon microphone (or 30/50-ohm type via a step-up transformer) and with 30-ohm or 200-ohm unbalanced dynamic microphones

feeding directly into the high input impedance with the preset control turned up. The high level input might be suitable for *Hammond* type capacitor microphones with cathode-follower outputs, although this has not been tried, as well as for the outputs from tape recorder replay preamplifiers, or for crystal or ceramic pickup cartridges.

No frequency selective feedback is used, although this could be tried in the feedback to make up for microphone deficiencies, provided the noise output does not suffer audibly.

If high level inputs are not required, for instance if the mixer is to be used solely and exclusively for microphone work, the series resistor from the high level socket can be omitted, and the high impedance inputs fed via a step-up transformer to provide balanced or floating low-impedance inputs in addition to the high impedance inputs, selecting input by the switching jacks.

The outputs of the amplifiers are fed in parallel to the clean-feed switches and also to conventional rotary logarithmic potentiometers, and from the sliders of these the outputs are mixed via isolating resistors into the low-impedance input of the block amplifier, whose output goes to the main fader. Large knobs with linearly calibrated metal skirts are used for the main faders, with miniature knobs for presets and switches.

I would like to express my gratitude to *Newmarket Transistors Ltd.* Applications and Measurements Department for their tremendous help with the transistors. Thanks are also due to the BBC for permission to publish the circuit of their microphone amplifier.

632

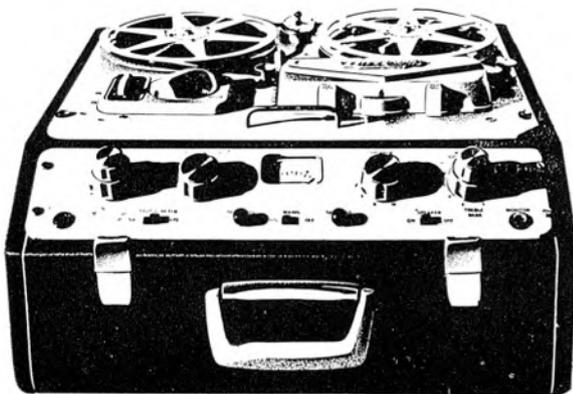
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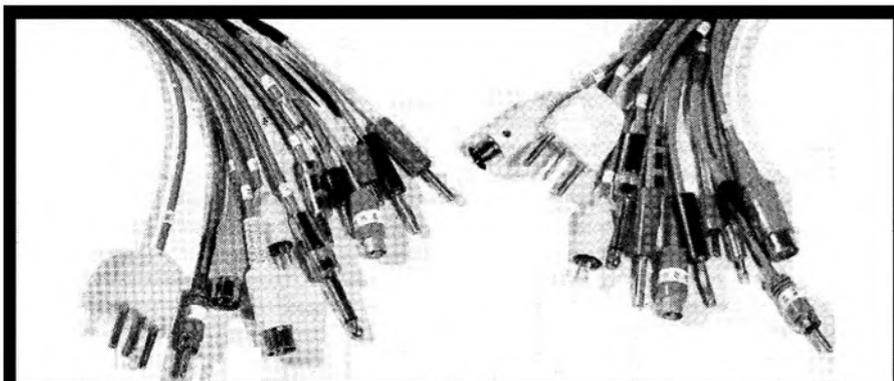
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SOME FURTHER THOUGHTS ON PLUGS AND SOCKETS

by Mike Howell

Photograph supplied by *Tape Recorder Maintenance*—one of the few bodies who actually profit from the present connector-chaos.

THE painful plug problem captured my attention recently when a friend uttered an astonished exclamation on seeing the pile of leads in one of my cupboards. This vexing situation lends itself to unanimous disapproval rather than mere tape enthusiast's angry comment, and even the housewife can work up some animosity when she finds that the plug on her vacuum cleaner will not fit the mains socket in the new house.

The Electricity Board must be given hearty praise for the installation of what they term "a standard thirteen amp socket" in all new premises. The electrical war caused some brutal bombing and the debris will not be cleared for many years. Though the truce can be appreciated, the Battle of the Standards cannot be overlooked by those who make regular trips with electrical equipment. The fighting took place between the North and South of England (my investigations cannot uncover the part played by the Midlands) and was the refusal to accept one of what each side dared to term: "Our Standard Plug". In the singular, the word 'plug' can only be viewed as outrageous, for, even in the various regions we have inherited a large number of mains connectors. For instance, my own residence gives employment to a past relic which is known in its very limited circle of use as a crab-pin. For the uninitiated, the body of this plug is round and consists of three connections, the two outer pins being flat with the central one being round. The crab-pin's advantage is its own downfall: as a form of adaptor, a smaller version can be inserted into the larger plug, but the trouble starts when you try to fit the larger adaptation into the smaller wall socket. I am also given a nasty shock when reflecting that the more up-to-date (?) version has just enough difference in the angling of the points to render its use in the older socket impossible. The Treaty of Ring-Main was supposed to put an end to these petty differences and the problem can only be counteracted by the construction of a plug board (which does not altogether eliminate the

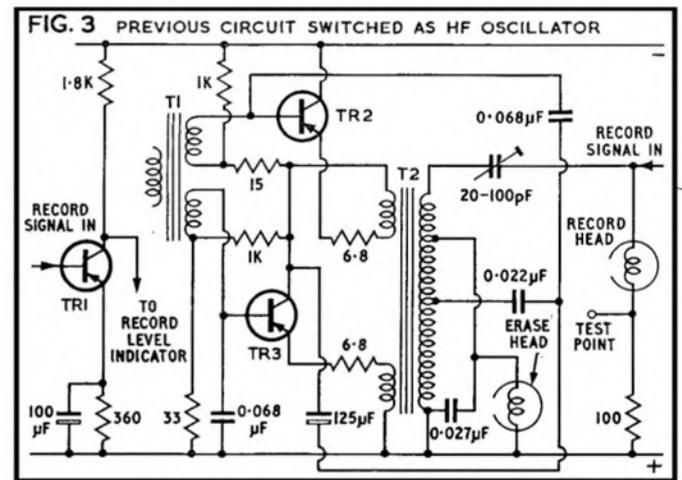
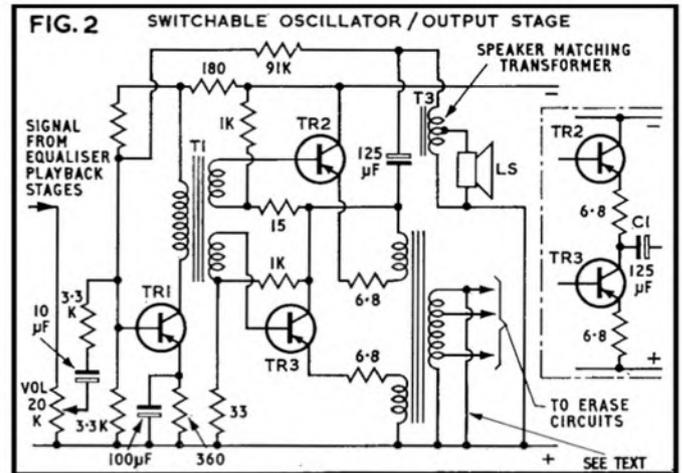
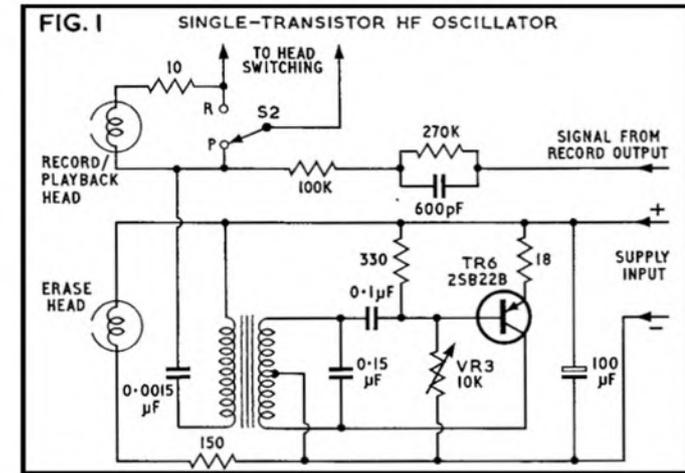
main snag), the use of the light socket (which does not permit the earthing of appliances), or, preferably, the use of a readily available gadget, little different than the present standard plug, which can provide connection to all the most widely used sockets in Britain.

One despairing glance at the recording lead matter shows that everything is in a dreadful tangle. There are so many plugs which have been used in this sphere—some in favour, some out of favour—that our tape journals could print an annual "Plug Top Twenty". One fitting which now seems to have fallen from even rarified use is a miniature jack utilised by Philips some years ago. On attempting to obtain one, I was told that the plug was now deleted and that I would just have to suffer the manufacturer's change. I would have been compelled to expedite the writing of this article had it not been for the fact that my dealer was willing to change the socket to accommodate a standard jack plug. The order of popularity is hard to determine, but the three main connectors in vogue at present are the phono and standard jack and the DIN connector (the fact that the latter can have three, five or six pins does not deter manufacturers but certainly baffles the public). The former two seem to be engaged in furious competition and I fear that within a few years the phono will reign supreme over its bigger brother. My preference for the older plug is because the appearance and size present something more practical and substantial. Soldered plugs have little advantage, especially if your lead gives up the ghost when a soldering kit is not available. The argument which manufacturers offer for their extensive use of the difficult-to-solder phono is that this insert costs approximately 1s. 3d. where as the standard jack may cost twice as much. Such a trifling matter would not influence my choice of plug were I asked to draw up a good tape recorder specification. The DIN socket can be accepted a little more graciously because, whatever you think about the differing number of pins and the necessity for solder, this is the

favoured connector on the Continent, the only resistance to standardisation being resistors, resistors, resistors! In moments of extreme good will, the Continental maker will use a phono and the British manufacturer will reciprocate the action by using the occasional DIN socket. However annoying this sub-standardisation may be, a wide variety of plugs will have to be accepted for a long time and perhaps even for ever for the main reason that, unlike the mains connectors, the tape recording manufacturers do not fall under the dictates of one central governing body. The humiliation could perhaps be alleviated by the CCIR who have succeeded in keeping many aspects of recording to very reasonable uniformity. This dream is unlikely to materialise, but my own choice of universal plug would be the wander as this is cheap, easy to replace, does not require solder and is simple to connect and use.

Having excused the use of a variety of connectors, I cannot be at all lenient about the current Continental all-purpose lead craze. These are supposed to provide input and output facilities without the addition of a second socket on the recorder, but the first difficulty experienced with such a lead is the fitting of the plug(s) as the radio-gram end is divided into three separate wirings, one for earth and the others serving input and output respectively. There is a risk of snapping the lead at the third branch wire, for, the lead is supplied with some strange wiring which, so rumour has it, is actually acceptable as a 'plug' on the Continent. The choice of plugs usable with such leads is limited and when I acquired a recorder which incorporated the one-socket system, my input-output lead snapped while in the wiring process. My intention had been to use wander plugs but on realising the difficulty a friend was having in selecting which plug provided which function, I was pleased to think that I had been spared all the frustration. The public are powerless against this tragic introduction and though I am left speechless by manufacturers who persist with what they call "handy simplification", the only practical suggestion I can make in the hope of reducing the pain for fellow-sufferers is the making up of separate input and output leads. This works very satisfactorily and allows the use of all plugs at the radio-gram end, the only disadvantage now being that machines employing this system do not give a muted speaker when the output lead is inserted and are only capable of external reproduction via an amplifier and speaker.

Being one who desired to copy from many different sources, I had to decide whether to invest in a tremendous number of leads and plugs or look for some other alternative. Eventually I had what is plainly known in the trade as a 'junction board' constructed but my own preference is to allude to this piece of apparatus as 'a magic box'. This contains two of every socket in use today and has saved my tape worries on many occasions. Such an aid is simple to construct, no extra power is required and the cost is relatively small. If you are prepared to suffer slight losses when many plugs are connected, then the "magic box" is the answer. The friend who constructed mine added the extra facilities of two cut-throat razor blades lest I became too socket-depressed—and that's no 'plug'.



battery powered tape recorders

WE have now investigated almost all aspects of battery-powered recorders, from batteries to transistor circuits and from drive motors and their control to power supply units for battery models. In this final article of the series it is proposed to clear up one or two outstanding points, starting with the circuits used for generating the erase and bias current.

Last month we discussed the prime recording and playback circuits of a battery model, including the manner of switching from record and playback, but no material information was given about the HF generator. This can prove an embarrassment in models deriving their power solely from batteries of cells, for although it is not difficult to obtain adequate HF power for biasing, the much greater power needed for creating an HF erase field of sufficient magnitude to give low-noise tape erase is not all that easily obtained from a limited-voltage power supply.

Early battery models overcame this problem by using a small power oscillator for HF bias and the field from a small permanent magnet for erasure. In the record position this magnet was pushed against the tape oxide prior to the tape passing the record-replay head. In fact, the magnet occupied the same position

as the erase head in machines using HF erase.

While a permanent magnet can certainly clear a tape of previous recordings, it does orientate the oxide particles, as it were, into a regular pattern and a small magnetic component is imparted upon the tape which, when the tape is recorded, adds noise to the reproduction. This problem is overcome by the use of AC/HF erase, since the changing magnetic field has the effect of putting the oxide into complete random deflux and (*in theory at least!*—Ed.) no residual magnetism remains on the tape. Thus, with the exception of other factors, the replay of a subsequent recording is as noise-free as the purity of the erase signal allows.

This correctly implies that the tape noise is influenced by the waveform of the erase and HF bias. If the HF generator produces a distorted signal, the effect can be of a DC component on the HF signal producing a field and a consequent residual magnetism on the tape. It is thus important that the HF generator delivers a signal containing the least possible distortion (i.e., a pure sine-wave). Now, a pure signal is not difficult to obtain at low power, when the power of the supply is limited, but it becomes progressively more difficult as the HF signal power demands are

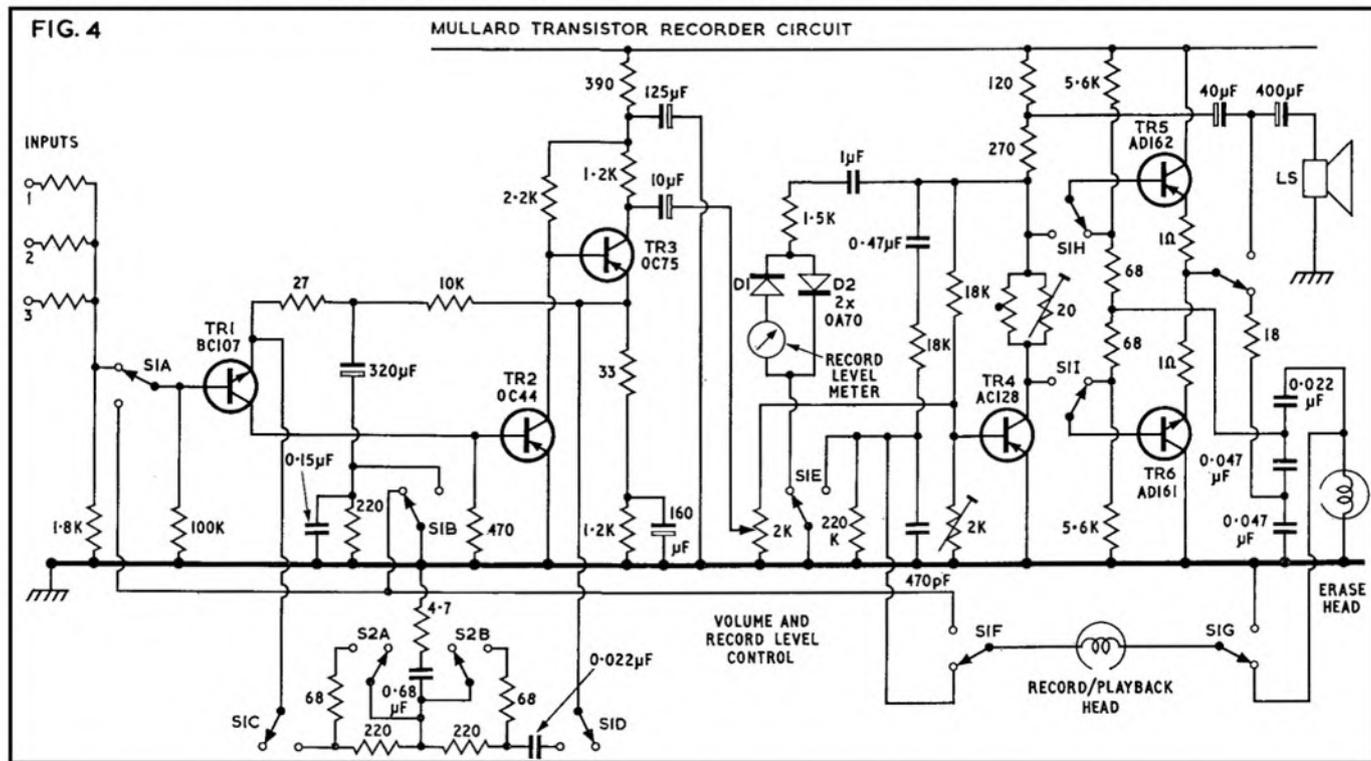
increased. Harmonic distortion (more specifically *odd* harmonics) occurs on the waveform which, so far as the heads are concerned, can be analysed into pure signal *plus* a DC component.

Fortunately, transistor development has made it less difficult to obtain a fair waveform at battery voltages, and even in the cases where the waveform is not absolutely pure, a slightly distorted erase and bias signal produces less noise (and has less impairment on the overall signal-to-noise ratio) than a machine opting for permanent magnetic erase. It should be noted here that the real professional 'field' models deliver a signal of purity equal to the best mains-powered recorders.

Although single-transistor oscillators can produce sufficient erase flux, greater power—ensuring a good erase—is more easily obtained from a push-pull oscillator, using a pair of transistors. A popular way of deriving this signal push-pull-wise is by switching the push-pull replay output stage from an amplifier to an oscillator. However, semi- and fully-professional machines often employ a completely separate push-pull oscillator with the design focused towards waveform purity.

Another idea, incidentally, in less-exacting

PART 16 — OSCILLATORS AND AGC □ BY MICHAEL GORDON



machines is to arrange the erase head itself to act as the tuned circuits of the HF oscillator. In that way maximum current is assured in the erase head winding.

Fig. 1 shows the oscillator circuit—using a single transistor—of the *Sanyo MR200* (other parts of this circuit were discussed last month). Here Tr6 is used solely as the oscillator, with feedback taking place through the tapped winding of T1 from collector to base. The other winding of the transformer is for coupling the HF signal to the erase head and to the record/playback head, via the 0.0015µF capacitor. A variable resistor in the base potential-divider of the transistor is used to set the base current for the correct signal amplitude and waveshape. The oscillator is tuned by the inductance of the transformer in conjunction with the 0.15µF capacitor in shunt with its tapped winding. The frequency in this case is 35kHz.

Fig. 1 also shows the feed path for the recorded signal to the head. The 100K resistor gives a constant-current characteristic (see later), while the 270K in parallel with 600pF capacitor gives a degree of treble boost due to the high-pass characteristics of the network. The oscillator is switched on by a section of the record/playback switching in

the recording position, and to avoid a transitory collapse of oscillatory signal when the oscillator is switched off, which could modulate the tape, the 100µF electrolytic capacitor stores sufficient energy to cause a gradual decay in signal amplitude when the main supply is switched from the transistor. This is a common feature of oscillator switching techniques.

Fig. 2 shows a push-pull class-B playback output stage (transistors Tr2 and Tr3) and its driver (Tr1). This kind of circuit is not uncommon in battery models, and the DC connections of the push-pull output pair are shown in the small diagram on the right of the main circuit.

Fig. 3 shows how this circuit is switched to function as a push-pull HF oscillator in the recording position. It should be noted that transformer T2 comes into action only when the circuit is switched to oscillate. In the playback condition (fig. 2) the transformer is effectively isolated since its two windings in the emitters of the output transistors simply act as a bit of additional resistance.

In fig. 3, however, T2 back-couples both transistors to give a push-pull oscillator condition. The driver transistor Tr1, not required for the oscillator action, is switched to serve as a recording level amplifier. Power

coupling to the erase head is from a tapping on the secondary of T2, while the correct frequency for maximum power is tuned by the 0.027µF capacitor across the head. HF signal is fed to the recording head through the 20-100pF preset capacitor, and a 'test point' is made available for measuring the head current by the 100-ohm resistor being connected in series at the bottom end. The head current produces a voltage across the resistor which represents the test voltage.

Incidentally, it is interesting to note the use of a small speaker matching transformer in the playback condition (fig. 2). This permits the full power of the output transistors to be delivered to a speaker whose impedance is below that of the transistors themselves.

A transistor circuit by *Mullard* in which the erase head inductance is used as the oscillator tank is shown in fig. 4. Here the playback output stage uses a pair of complementary transistors (Tr5 *p-n-p* and Tr6 *n-p-n*) DC-coupled to a *p-n-p* driver Tr4. This sort of circuit is now common in small and large audio amplifiers, and versions are being made in the form of printed circuit modules by *Mullard* and others.

The circuit is drawn in the recording position
(continued on page 123)

633

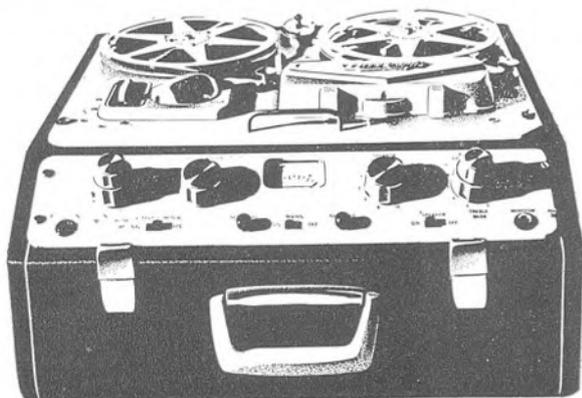
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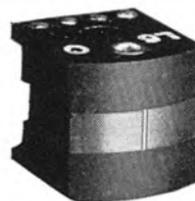
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BATTERY TAPE RECORDERS CONTINUED

and the push-pull complementaries are switched from their driver by S1H and S1I, while the inductive element of the erase head is coupled in through S1J to give the oscillator action, with the feedback being from the emitters of Tr5 and Tr6 to their bases, via the coupling from the junction of the 0.022 μ F and 0.047 μ F capacitors in the head circuit.

The head signal during recording is extracted from Tr4 collector, via the 0.47 μ F capacitor and the 18K resistor. The signal amplitude here with about 22V on the supply rail is relatively high, permitting the use of a conventional constant-current feed resistor. The same signal is metered by the moving-coil movement and the two OA70 diodes, forming the recording level indicator.

Tr1, Tr2, Tr3 and Tr4 are thus used for recording and replay with the usual switching (see Part 15). Playback equalisation is

done because of the remarkable flatness of level indicators (non-weighted type) over the whole of the audio spectrum.

We have seen that the recording head can be energised either from a transformer winding or via a resistor in series with the signal source and the head. The requirement is to attain a fairly constant induction on the tape over the frequency spectrum. To do this, a signal current of constant amplitude (at all frequencies) is needed. Because the head is substantially inductive, the current through it will try to fall as the inductive reactance of the head increases with increase in frequency.

This is commonly avoided by feeding the head current through a relatively high value resistor, the value of which is substantially greater than the head reactance at any frequency. In that way, therefore, the head current is controlled essentially by the resistance, and because this is non-reactive it fails to be influenced by frequency.

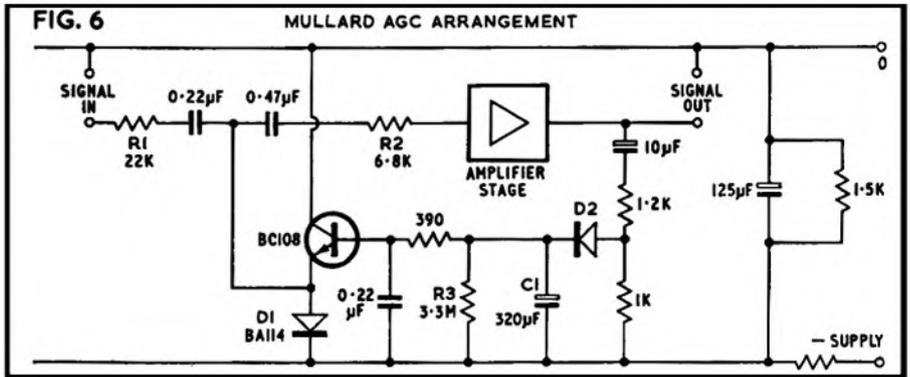
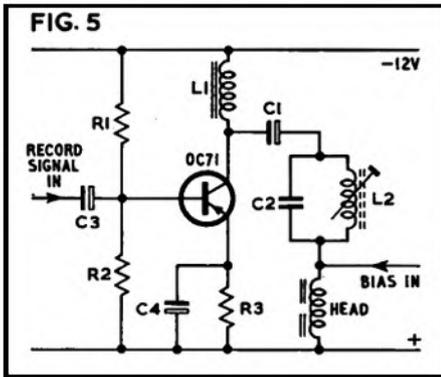
The bug here, though, is that the value of the resistance often needs to be quite large to

stantial deterioration in signal-to-noise ratio.

The tuned circuit L2 and C2 in fig. 5 acts as a rejector for the HF bias signal applied to the head. If this signal gets to the transistor collector it could cause non-linearity and intermodulation troubles. In all battery models some form of rejector is employed to prevent the HF signal from arriving at high level at the recording output transistor. If a tuned circuit, as in fig. 5, is not used, then a low-pass RC configuration is adopted. This is arranged to pass the audio signals to the head while severely attenuating the HF bias signal from the head to the driver transistor.

Transistor automatic gain control has been adequately pursued in recent issues by friend "William Henry" and it is not proposed to enlarge upon the basic principles and circuits expounded. However, a series on battery-powered recorders would be incomplete without some reference to the technique.

Audio AGC is by no means new and it has been used in certain dictation machines for almost a decade (by *Grundig* and others).



switched in by S1C and S1D, while S1B gives some treble boost on record.

Equalisation is handled in battery models, often in a similar manner to valve circuits, whereby frequency-selective feedback, using RC elements corresponding to the tape velocity time-constant, is switched over the first two stages, from collector to base or emitter, depending on the actual circuit configuration. Sometimes the feedback is applied over just one stage. The effect is the same, however, that the feedback increases, at a given rate with increase in frequency, thereby progressively decreasing the stage gain, which is the requirement for tape replay equalisation.

The signal current in the head is often caused to rise with frequency as a means of extending the overall treble response. This is perfectly satisfactory in moderation, but when excessive treble boost is applied in the recording circuits there is a tendency for an impairment in recording signal-to-noise ratio owing to the rising gain of the amplifier. The effect of this boost can often be revealed by feeding a constant amplitude signal into the microphone (or other) input over a number of spot frequencies within the spectrum and observing the deflection of the recording level indicator. In many models it will be seen to increase towards the top end, often commencing at about 7-8kHz and peaking at about 16kHz, depending on the tape speed. This can be

mask the changing reactance effect of the head, and a large resistance calls for a large signal voltage to drive a suitable signal current through the head winding. In some transistor equipment a signal voltage of sufficient amplitude cannot be obtained. This means the use of a smaller value resistor and compensation elsewhere in the recording channel or some other method of feeding. A transformer can be utilised in conjunction with a resistor (lower value one), as was shown in Part 15, but another idea is shown in fig. 5. Here the collector of the recording output stage is loaded by a choke (inductor) L1. At low frequencies this has a low reactance and the signal voltage at the collector is low. As the signal frequency rises, however, the reactance increases, thereby giving a rising signal voltage.

As we have seen, at low frequencies the head also has a low reactance but the current through it is limited because the signal at the collector is relatively low. At increasing frequencies the reactance rises, but so does the signal at the choke-loaded collector, and the current remains fairly constant over the frequency spectrum provided the L values are chosen correctly. The signal is coupled through a large value electrolytic capacitor which does not affect the signal current much. However, this must have a very good insulation resistance to avoid the presence of DC in the head winding, which could cause a sub-

The basic idea is also adopted in volume compression circuits, whereby the signal voltage is rectified and the resultant DC used to control the gain of one or more amplifier stages in the recording (or programme) channel. For volume compression, the circuits have to be fast-acting. That is, peak signals above a pre-determined amplitude only have to incite the rectifier action and almost immediately this has to be reflected to the amplifiers as reduced gain.

The basic idea is to arrange the connection of the signal rectifier so that a negative-going DC output is obtained. This is then fed as additional grid bias to an amplifier valve (or more than one) of variable- μ characteristics. As the stage gain of such an amplifier reduces as the negative grid bias is increased, the overall gain of the programme amplifier can thus be controlled by the amplitude of the signal in the channel. The greater the signal amplitude, the greater the negative bias and the less the gain. Clearly, by this means one can limit the dynamic expansion of the signal to virtually any range.

The converse of this technique, where the gain is caused to increase with increasing signal amplitude, is called *volume expansion*. and this was at one time very popular with hi-fi types to open the dynamic range of, say, a radio programme or disc recording, over that provided at the studio and by necessary

(continued on page 131)

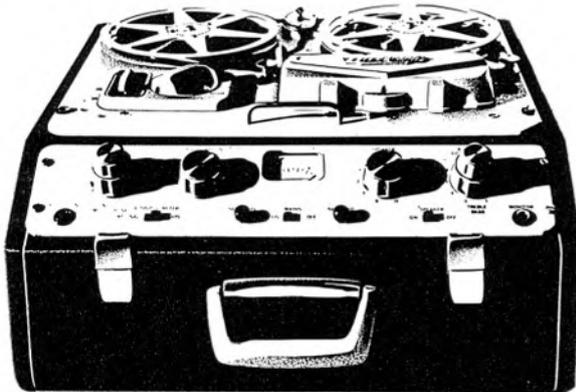
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AMPEX 2100 SERIES

NEWLY introduced by Ampex is the 2100 Series, comprising three bi-directional stereo recorders. Unlike the 2000 Series, which offered automatic reverse playback in addition to conventional recording facilities, the 2163 will both record and reproduce in either direction. Automatic reversal is achieved electronically, by means of an inaudible recorded pulse. Four heads are incorporated, and three speeds of 7½, 3¼ and 1½ i/s. Standard Jack sockets are incorporated at the microphone inputs and headphone outlet, all other connectors being

NEW PRODUCTS

Phono. The Model 2163 is solenoid-controlled and has twin capstan mechanisms. No pressure-pads or pins are employed against the tape heads. Modulation indication is by means of twin VU-meters, mixing of two high, high and low, or two low-level inputs being possible on mono recordings. The 2163 is supplied with transportable cabinet at £227 10s. and incorporates stereo preamplifiers and replay power amplifiers. The price includes one Ampex 2001 dynamic microphone. A version with record and replay preamplifiers only, *Model 2153*, is available in chassis form at £184 10s. Third member of the Series is the *Model 2165-3*, identical to the 2163 but with an oiled walnut cabinet.

Manufacturer: Ampex International, 72 Berkeley Avenue, Reading, Berkshire.

LAVALIER CAPACITOR MICROPHONE

NEUMANN are now producing a lavalier capacitor microphone, the *KML 65*, with built-in field-effect transistor preamplifier, to sell at £60 10s. A cardioid characteristic and 40Hz-16kHz frequency range are featured, output level being in the region of 0.5mV/ μ Bar with 18V supply. Signal-to-noise ratio is 36dB.

Distributor: F. W. O. Bauch Ltd., Holbrook House, Cockfosters, Barnet, Hertfordshire.

SHARP RD504 MAINS/BATTERY PORTABLE

LOW-price mains/battery portable with relatively large spool capacity is the *Sharp RD504*, taking 5in. reels and selling at £27 6s. The recorder operates at 1¼ i/s and (with screw-on capstan sleeve) 3¼ i/s, and has quoted output of 1W. AC recording bias and DC erase are featured, along with fast-forward and rewind facilities. The fast-forward lever and record button interlock with the main mode selector. Separate inputs are provided for microphone and radio, record and replay gain being governed by a single control. A switched treble control is incorporated close to the recording-level/battery-voltage meter. Included in the price is a dynamic microphone with integrated battery cut-out switch.

Distributor: Sharp Sales and Service, Wholesale Supplies (Swinton) Ltd., 16/18 Worsley Road, Swinton, Manchester.

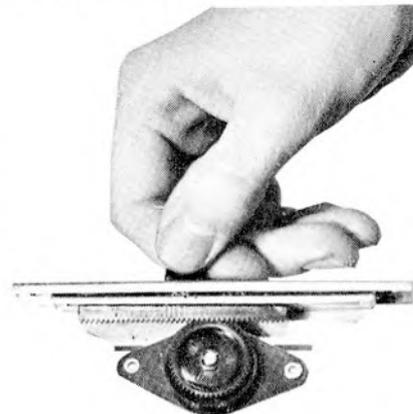
LOW-PRICE SLIDE-FADER

READERS of the not-so-recent *Studio-Quality Mixer* series may recall the trouble taken by the author, D. P. Robinson, to construct a quadrant-fader from a rotary potentiometer. A flat-fader of sensible dimensions is at last commercially available at 12s. 6d. Of simple construction, the component is 5in. long, effective slide length being 2¾in. Approximate width is ¾in. The fader, designated *Potentiometer 62 ZW*, incorporates a rack-and-pinion driven high-stability carbon-track potentiometer, with low-noise carbon-tipped wiper. Power ratings are 0.15W (Log.) and 0.25W (Lin.). Values of 1K, 5K and 10K

NEW PRODUCTS

(Log.) are normally supplied ex-stock, other values being available on request.

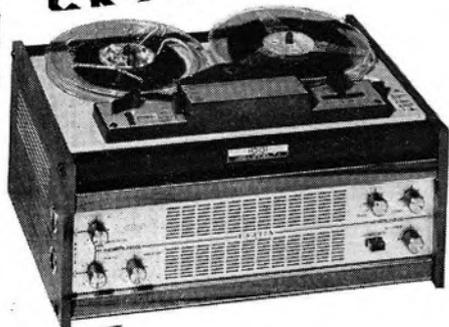
Distributor: F. W. O. Bauch Ltd., Holbrook House, Cockfosters, Barnet, Hertfordshire.



THORN TAPE ACCESSORIES

SEVENTEEN accessories for *Ferguson, Ultra* and *Marconiphone* tape recorders have been introduced by the *British Radio Corporation*. The *TA/01 Synchro-Amp* permits precise synchronisation of a ¼-track tape recorder with an automatic (solenoid-controlled) slide projector. Synchronisation is by means of a recorded pulse. Also possible with the unit is preamplification of stereo tapes, one channel of which may be reproduced through the recorder's internal amplifier and speaker, the other passing via the *TA/01* to a headphone or external power amplifier. Price is 9 gns. Two remote-pause switches are also now available, taking advantage of the solenoid pause mechanism employed in the two-speed and three-speed Thorn recorders. A 20ft. lead is fitted to the *TA/12* hand-operated control, which costs 10s. 6d. The *TA/03* foot-switch retails at £3. Other accessories comprise a range of audio connectors, including the *TA/06* 20ft. microphone extension lead, price £1 1s., a low-price cardioid dynamic microphone, foam spool-retention pads and monitoring stethosets. **Distributor: British Radio Corporation Ltd., 284 Southbury Road, Enfield, Middlesex.**

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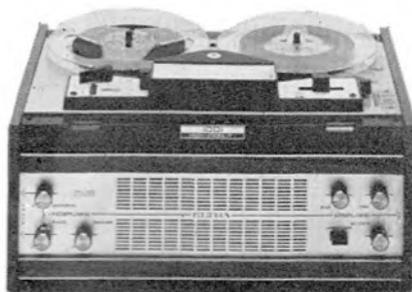
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equipment reviews

ELTRA
1001



THIS Danish tape recorder contains many original features; one obvious one is that the recorder is built around a *BSR TD.10* deck which is imported from this country, modified slightly around the controls, and exported back to us in a nicely styled cabinet with carefully designed electronics which make full use of the capabilities of this excellent deck.

The control modifications include a micro-switch to cut the power to the motor when using the recorder as an amplifier only, a latch which allows the record lever to be locked in the record mode for setting levels or listening without recording, and a pause control for instant stop and start of the tape.

SEPARATE AMPLIFIERS

The electronics are unusual in providing completely separate record and play amplifiers, with the record/play head switched to one or the other as required. This ensures that pre- and post-equalisation can be carefully tailored without complicated switching circuits.

The wide range bass and treble tone controls are a distinctive feature of this recorder, and are unusual in being simple passive networks instead of the more usual feedback circuit. I have reproduced this part of the circuit diagram for two reasons: to show that a non-feedback tone control is capable of excellent performance (see fig. 4), and to introduce the very interesting circuit symbols used in the *Eltra* factory. Note that the main circuit lines go right through each

FIG. 1
ELTRA 1001
WOW AND FLUTTER

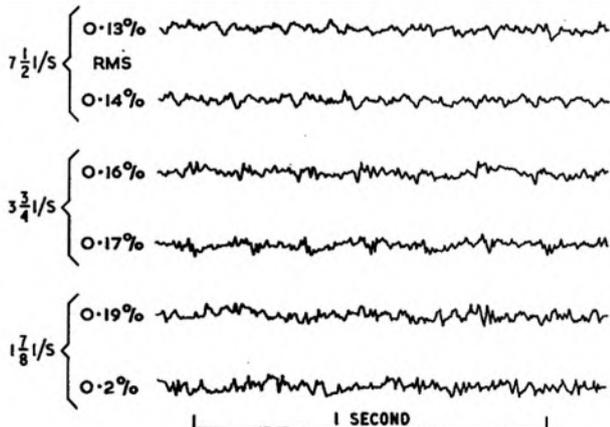


FIG. 2 ELTRA 1001 PLAY-ONLY RESPONSE (TEST-TAPE TAPE TO LINE OUT)

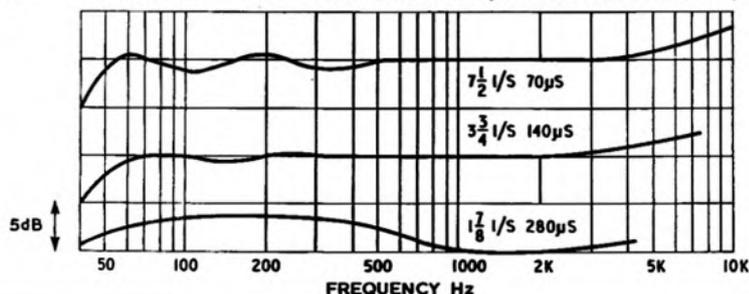
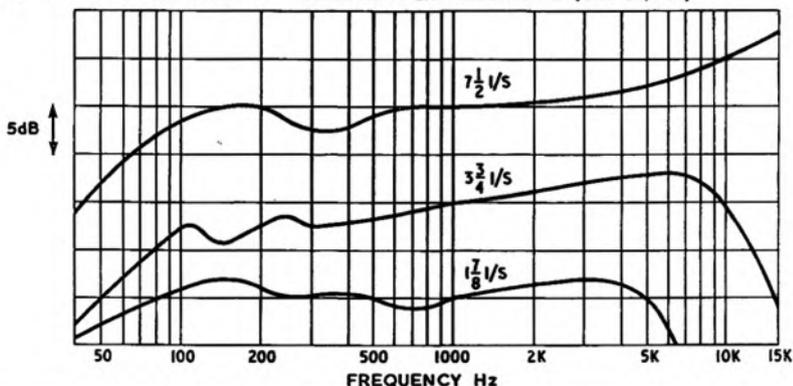


FIG. 3 ELTRA 1001 RECORD-PLAY RESPONSE (LINE IN/OUT)



MANUFACTURER'S SPECIFICATION. Half-track mono tape recorder with modified *BSR TD.10* deck. **Tape Speeds:** $7\frac{1}{2}$, $3\frac{3}{4}$ and $1\frac{7}{8}$ i/s. **Signal-to-Noise Ratio:** (respective) 54dB, 50dB and 45dB weighted. **Wow and flutter** (respective): 0.2%, 0.25% and 0.35%. **Output Power:** 6W at 5% harmonic distortion. **Frequency Response** (playback of DIN 45513 test-tape): 50 Hz—18 kHz at $7\frac{1}{2}$ i/s and 50Hz—12.5kHz at $3\frac{3}{4}$ i/s, +3dB. **Erasure:** 70dB. **Bias Frequency:** 55 kHz +2kHz. **Tape Head Life:** Over 2,000 hours. **Inputs:** Radio—5mV across 100K, Microphone—300 μ V across 1M. **Dimensions:** 8 x 11 $\frac{1}{2}$ x 16in. **Weight:** 25 lb. **Price:** £51 9s. **Distributor:** C. E. Hammond & Co. Ltd., 90 High Street, Eton, Windsor, Berkshire.

component and that the component symbols are simply drawn against this line. A capacitor is a little tick at right-angles to the line, an electrolytic capacitor is hooked, and valve diagrams have no dotted or wavy lines.

WOW AND FLUTTER

Fig. 1 shows the fluttergrams for the three tape speeds. It will be seen that there are almost equal proportions of capstan wow and high frequency tape and drive motor flutter. The HF speed disturbances are not very audible and impart only a slight roughness to a reproduced pure tone; the wow frequencies of 12, 6 and 3Hz at the three tape speeds are audible on a sustained tone, but not at all obvious on normal programme material.

(continued on page 129)

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Ferguson 3224 ...	15 8 0	2 11 4	44	
Wyndor Vanguard ...	20 13 0	3 8 10	59	
Philips EL3556 ...	21 14 0	3 12 4	62	

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Grundig TK120 ...	10 6 6	1 14 5	29½
Tandberg 823 ...	18 18 0	3 3 0	54
Brenell Mk. 5/3 ...	25 18 0	4 6 4	74
Brenell Mk. 5/3 'M' ...	32 11 0	5 8 6	93
Ferroglyph 631 ...	33 5 0	5 10 10	95
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Sony TC260 ...	33 19 0	5 13 2	97
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Beocord 2000K De Luxe ...	43 15 0	7 5 10	125
Revox 736 ...	44 9 0	7 8 2	127
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Philips EL3301 ...	9 9 0	1 11 6	27
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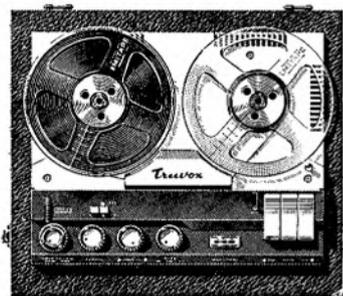
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5"	600' 6/-	17/6	5"	900' 8/-	23/6	5"	1200' 12/6	37/-	5"	1/9
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Playback equalisation is to the standard DIN/CCIR characteristics at $7\frac{1}{2}$ and $3\frac{3}{4}$ i/s, as will be seen from the play-only responses from 70, 140 and 280 μ S test-tapes in fig. 2. The step in the $1\frac{1}{4}$ i/s curve indicates that the playback equalisation is nearer 100 μ S at this speed. System noise, with no tape passing the head, was 33dB below standard test-tape level.

Overload recording tests at 500Hz showed that the magic-eye beams clashed at 11dB above test-tape level, but that the level could be increased by a further 3dB before serious waveform distortion became visible on the CRO.

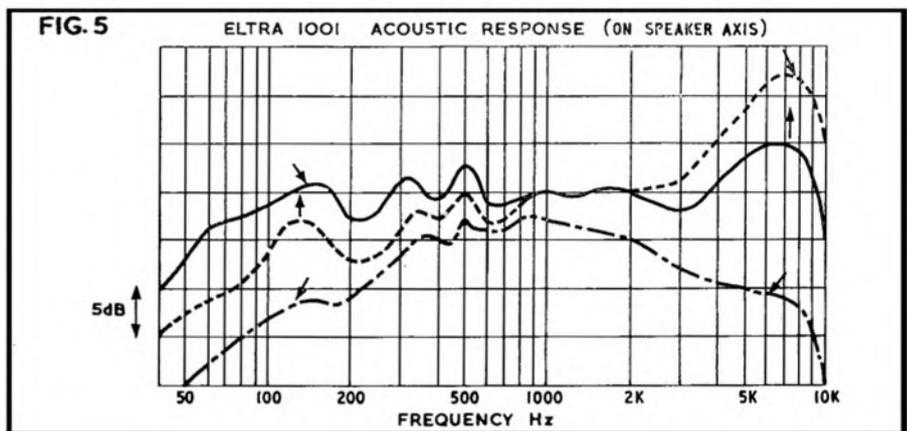
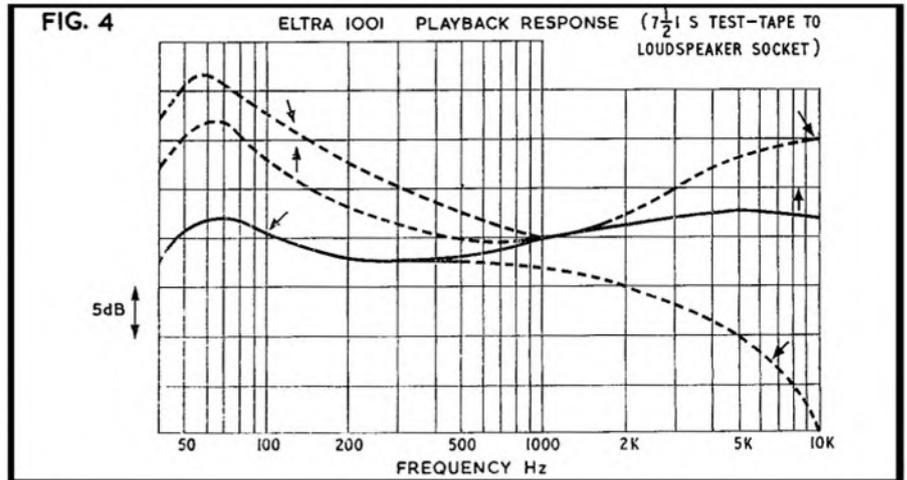
Erase and bias recorded noise, with all input controls at zero, was 30dB below test-tape level unweighted, improving to 36dB when the mains hum was almost eliminated by a filter simulating the ear's response at low listening levels. Thus the weighted signal-to-noise ratio, from peak undistorted recording level to erase and bias noise, was just 50dB.

RECORD-PLAY RESPONSE

Record-play tests gave the responses shown in fig. 3. The low frequency 'wiggles' are a symptom of head contour effects which occur when the pole face is short compared to the recorded wavelength and when the leading and trailing edges of the pole face fall away quickly from contact with the tape. Recording pre-emphasis would seem to be very close to CCIR requirements, but there is a bass loss in recording of 6-8dB at 60Hz.

Fig. 4 shows the effect of the tone controls at the speaker terminals when playing a $7\frac{1}{2}$ i/s 70 μ S test tape. The arrows show the settings of the bass and treble tone controls. A nearly level electrical response to the speaker is obtained with the bass control nearly anti-clockwise and the treble control in the midway position.

The overall electro-acoustic response of fig. 5 was obtained by playing a $7\frac{1}{2}$ i/s 70 μ S white-noise test-tape containing 25 one-third-



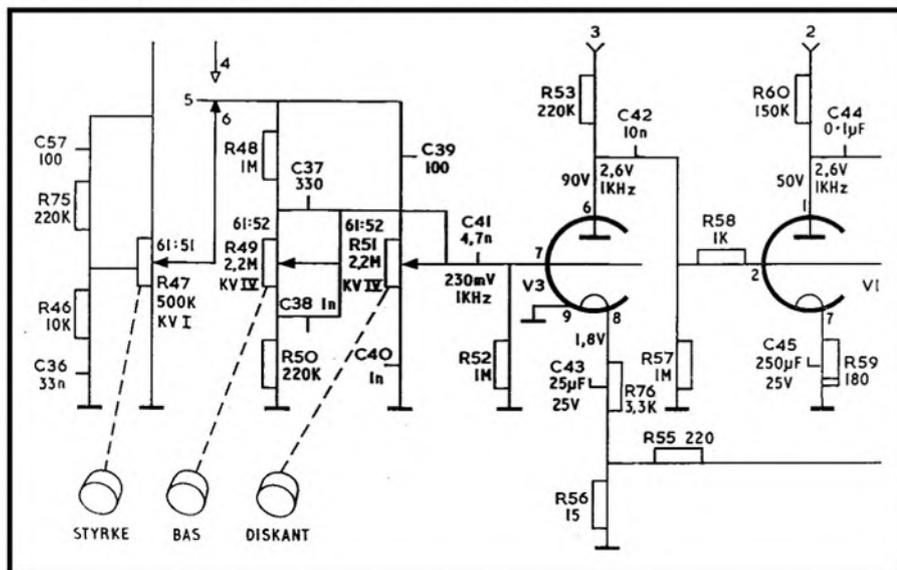
octave bands of filtered white-noise and measuring the sound output of the speaker at a distance of 1ft. on axis with a calibrated microphone at the same tone control settings. It will be seen that the most level acoustic response is obtained with the bass boost fully advanced and with the treble control at the midway setting.

The internal speaker showed some distress and frequency doubling on the noise bands below its cone resonance of 140Hz, but only a very slight trace of thickening of the mid-bass response was evident on normal programme material with the control fully advanced. When this happened, the bass control was turned back to the halfway setting with little loss of balance and rather cleaner sound quality. The high note peak started above the sibilant range of 2-3kHz so that turning the tone control fully clockwise only altered the 'wetness' of the reproduced voice and made listening 'off axis' very pleasant indeed.

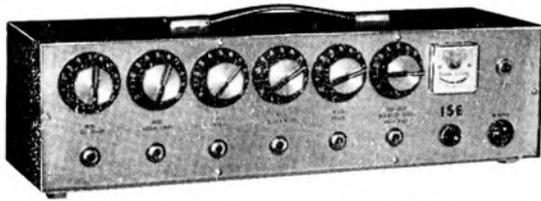
COMMENT

I have gone into my subjective impressions of the operation of the tone controls because I think the beginning and end of the listening appeal of this recorder is in the accurate matching of the speaker, cabinet and tone control responses to give a balanced wide-range response on the internal speaker. On a good external speaker, also, one could alter the balance to suit the room or recording with a precision and satisfaction unusual in machines in this price range. One bonus of the split circuit was that the recording pre-emphasis did not upset the balance whilst monitoring a recorded programme, and the tone controls could be set to give the desired balance with the assurance that the settings would have to be altered very little when listening to the recorded signal.

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BATTERY TAPE RECORDERS CONTINUED

compression. These days, however, we can reproduce a dynamic range of 60dB, since good quality recordings fail to inhibit the expansion to the same extent as occurred a few decades ago.

Now, to change volume compression to AGC, the time-constant of the control circuits needs to be arranged so that it responds very rapidly to the overload signal (ensuring that the inevitable distortion is recorded for the very small time period), and then once the gain has been pulled down to suit the signal amplitude, for the recovery time to be relatively longer. Should the recovery time be short, then one would be back with volume compression and the ear would detect the increase in gain of the channel.

FAST-ACTING DIODE

It is not a difficult problem to satisfy these requirements. The quick rise is achieved by the use of a fast-acting rectifier diode fed from a low impedance whilst the delayed decay is provided by a capacitor, charged by the first rise in signal amplitude, discharging relatively slowly through a resistor. The DC voltage across the capacitor is fed to the controlled valve(s) through filter circuits designed to delete most traces of audio signal.

All this is very well so far as variable-mu valves are concerned, but with transistors more problems are involved in holding the distortion down to a reasonable level. It is possible, of course, to subject the amplifier transistor(s) to reverse or forward bias by arranging for the control DC across the capacitor to change the base current and hence the amplification, but this can incite harmonic distortion and noise, and whilst it would be permissible to a fair extent in dictation-type recorders, it is not nice to have around in machines designed for reasonable or high-quality applications.

ONE SOLUTION

Mullard engineers have come up with one solution to the problem, as shown in fig. 6. Here the block enclosing a triangle is the symbol of an amplifier, and this represents the signal amplifier existing in the recording channel of the recorder.

The method of gain control is by variable attenuation, as distinct from variable gain of a transistor stage proper, and the factor giving variable attenuation in the circuit is the diode D1 in the emitter of the *n-p-n* transistor. It is the slope resistance of this which controls the attenuation and, as we have seen in the article dealing with the diode, this varies with the amount of DC flowing through it.

The characteristic curve of the slope resistance is singularly non-linear, and a single diode by itself would provoke considerable harmonic distortion. This is overcome, however, by the emitter junction of the transistor being in parallel with the diode in such a polarity that the slope curvature is cancelled.

Now, the input signal fed to the amplifier in the recording channel is also fed to the

emitter of the transistor. Thus, the amount of signal reaching the amplifier input is basically governed by the effective ratio of R1/R2 and D1 slope resistance. If the diode is biased so that its slope resistance is high, then the attenuation will be least and the amplifier will receive towards maximum input signal.

The output of the amplifier is signal-coupled to the control diode D2, and when D2 conducts on signal overloads, C1 charges, making the transistor base positive with respect to its emitter. This causes an increase in base current and an amplified increase in transistor emitter current, and since this flows through D1, its slope resistance falls and less signal is applied to the amplifier input, thereby removing the overload.

The attack time is determined by the value of C1 in conjunction with the impedance as 'seen' by the D2's 'anode'. This is the source impedance and is about equal to the 1.2K resistor in parallel with its partnering 1K resistor. The attack time in the circuit drawn is about 150mS.

It should be noted, though, that for small signals the charge in C1 will be insufficient to bring the transistor sufficiently into conduction to alter significantly D1's slope resistance. This delay which takes place before the auto control occurs is fixed by the circuit parameters, and there must be a delay for the circuit to work properly. When the amplifier output signal rises to control level, the voltage across C1 is then swiftly increased to make the transistor conduct.

MAIN DECAY

The main decay time is determined by C1 discharging through R3 and (possibly) the transistor. This relatively slowly pulls the transistor away from conduction, thereby decreasing the attenuation due to the rising slope resistance of D1.

A correctly designed circuit of this kind, tailored to the recording amplifier, will yield an attenuation factor in the order of 40dB, while holding the rate of attenuation increase (due to C1 discharging) down to about 6dB per minute. The harmonic distortion introduced by the control should not exceed 2% at controlled signal levels approaching 2mV RMS.

With this very interesting Mullard circuit, we bring this series to a close, and hope in the future to disclose in these pages details of the new developments occurring in the very popular battery-powered recorder.



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READERS' PROBLEMS

Readers encountering trouble with their tape equipment are invited to write to the editorial office for advice, marking their envelopes "Readers' Problems — Tape". Replies will be sent by post and items of general interest may also be published in this column at a later date. This service does not, however, include requests for information about manufacturers' products when this is obviously obtainable from the makers themselves. Queries must be reasonably short and to the point, limited to one subject whenever possible. In no circumstances should such letters be confused with references to matters requiring attention from other departments at this address. We cannot undertake to answer readers' queries by telephone.

FIDELITY ARGYLL OSCILLATOR FAULTS

Dear Sir, I have a Fidelity Argyll tape recorder (the model with separate EL84 output and bias-oscillator valves), which is now giving only partial erasure. Playback of material recorded on the machine has a tremble about it, very noticeable with a girl singing. Playback of similar material recorded on another recorder is quite acceptable, so I do not suspect the deck mechanism.

Recording on the Argyll produces a heavy interference pattern on our television receiver, consisting of vertical bars about ¼ in. wide and some 2 in. apart. I have replaced the bias oscillator valve without any improvement.

Yours faithfully, C.G.W., Thornton Heath.

The problem originates in the oscillator circuit, as you have deduced, and the most likely cause is the 2,000pF capacitor from the anode of the EL84 to the return end of the coil primary.

But this could be caused, especially as it is setting up the interference on the television, by any section of the oscillator, and as the radiation is quite severe and erasure most badly affected, the trouble could be the erase head itself. To prove this, shunt the head with a low-value resistor, from 100 ohms to 1K, and note whether the radiation ceases, and whether the recordings, made on a clean tape (new or previously erased) re any better. If so, suspect either the erase head or its feed circuit. Check the superimpose switch to make sure that the 200pF 'killing' capacitor is being shorted, and check the 0.02µF series feed by substitution. Make absolutely sure the earth returns, on the amplifier end of the connecting lead, are quite secure.

ADDING A METER

Dear Sir, I have a tape recorder fitted with a miniature VU-meter which is about 1¼ in. long. However, this is really only good enough to avoid overload distortion, as the needle deflection at normal sound levels is so small as to be quite useless.

Can I use the line output rated at 0.75V ±4dB, 47K, to feed a large diameter meter? If so, what type and rating of meter would be necessary to magnify the lower range of my present meter, and would it be necessary to protect the meter in some way when the volume level exceeds the range?

I would prefer to use the line output rather than the speaker socket as my tape recorder is

fitted with separate input and output volume controls. I will then be able to record at a standard volume level while leaving the speaker volume setting untouched.

Yours faithfully, J.E.S., London, S.W.20.
The necessary circuits to operate a meter such as you describe can be taken from the 'Studio Mixer' series of articles in October and November 1964. It is not simply a matter of connecting a meter to the line output socket, but also of rectifying the signal and applying correctly averaged voltage to the meter. The type of meter stipulated is the Ernest Turner 100µA unit, available for about £1. If you cannot get this directly from a local retailer, write to Ernest Turner Instruments Ltd., High Wycombe, Bucks.

AN OBSTINATE R.94

Dear Sir, I have a Truvox R.94 tape recorder which refuses to do anything when in the play position, although rewind and fast-forward work happily. I suspect the drive motor. Before the tape drive cut out, there was some intermittent speed variation.

Yours faithfully, A.L.G., Birmingham 31.

The problem with your Truvox R.94 may well be the drive motor, but we are more inclined to suspect the drive mechanism. You should check the motor with the idler held off manually. If it runs freely, check the position of the idler, which can jam between capstan steps, and also the locating plate, which gives inward movement when the start key is pressed.

There is a hooked return spring on the level which moves the idler bracket, and if this comes adrift, as it can sometimes when the machine is up-ended and carried, the idler does not engage. Intermittent speed variations would also point to the idler, if the periodicity of variation was fairly rapid.

LONG MICROPHONE LEADS

Dear Sir, I should be most grateful if you could advise me on cable lengths and impedance. I shall be working with a 75ft. microphone cable for which, my dealer informs me, a 200-ohm microphone will be satisfactory. I was thinking of using a 25-ohm balanced-to-earth set-up. Which would you recommend?

Could I then feed a common-base pre-amplifier with a high output impedance into a lower impedance mixer input by loading the pre-amplifier with a suitable resistor and taking the signal off this?

It appears very involved, but I find that, feeding my present microphone through a Grundig mixer into a Uher, all controls are near maximum—and so is the noise!

Yours faithfully, J.A.N., London, S.W.1.

A fairly long microphone line in the order of 200 ohms impedance is perfectly satisfactory (the BBC use 600 ohms). For minimum noise and hum pick-up, any long line should be balanced, but this can only be achieved by a balanced output from the signal source and a balanced input at the amplifier programme circuit. For many ordinary applications an unbalanced line is suitable. The lower impedance (i.e., 25 ohms) would not contribute much to signal coupling. In either case, however, the source and amplifier input impedances must (or should) be matched for the best results.

The output of a common-base amplifier could be connected pretty well direct to the mixer input without trouble.

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Replies to Box Nos. should be addressed to the Advertisement Manager, Tape Recorder, Link House, Dingwall Avenue, Croydon, CR9 2TA, and the Box quoted on the outside of the envelope. The district after Box No. indicates its locality.

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Engineer (Tape Recorder) required. Must be conversant with all top quality machines, including continental. Top rates of pay. R.E.W. (Earlsfield) Ltd., 266-268 Upper Tooting Road, S.W.17. Tel. 672 8267 and BAL 9175.

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For Sale Ferrograph 5AN £55 and Ferrograph 4AN £45 or £95 the two. G. S. Clark, 23 The Grove, Walton-on-Thames, Surrey. WT 25627.

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Microphones by S.T.C. £3 13 6 to £49 10 0. Hammond Condenser 29gns., Grampian £8 5 0 and £10 10 0, Reslo £11 12 6. Others. Accessories. Free plugs, leads and fitting. State type. Microphone Services, 51 Stubbington Avenue, Portsmouth 62569, Hants.

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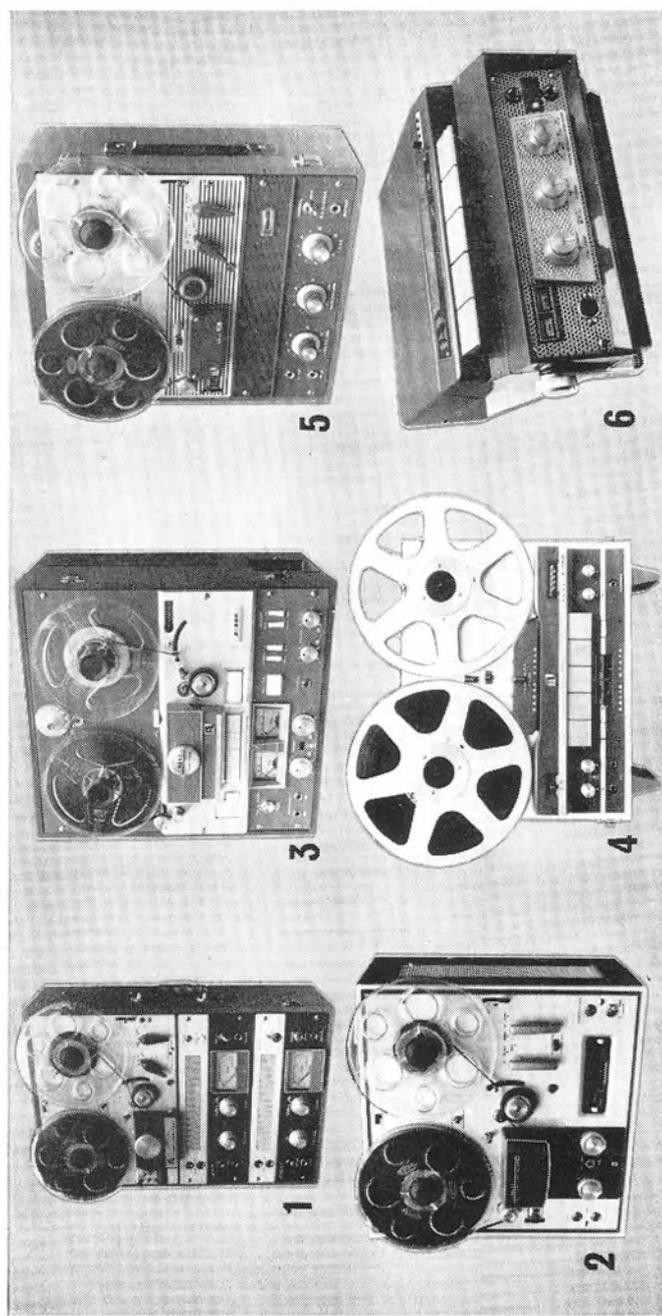
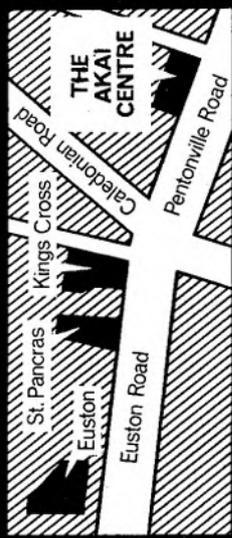
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