AUGUST 1969 2s 6d

tape recorder

REPORT ON THE 1969 APRS EXHIBITION

A STEREO FI-CORD 1A

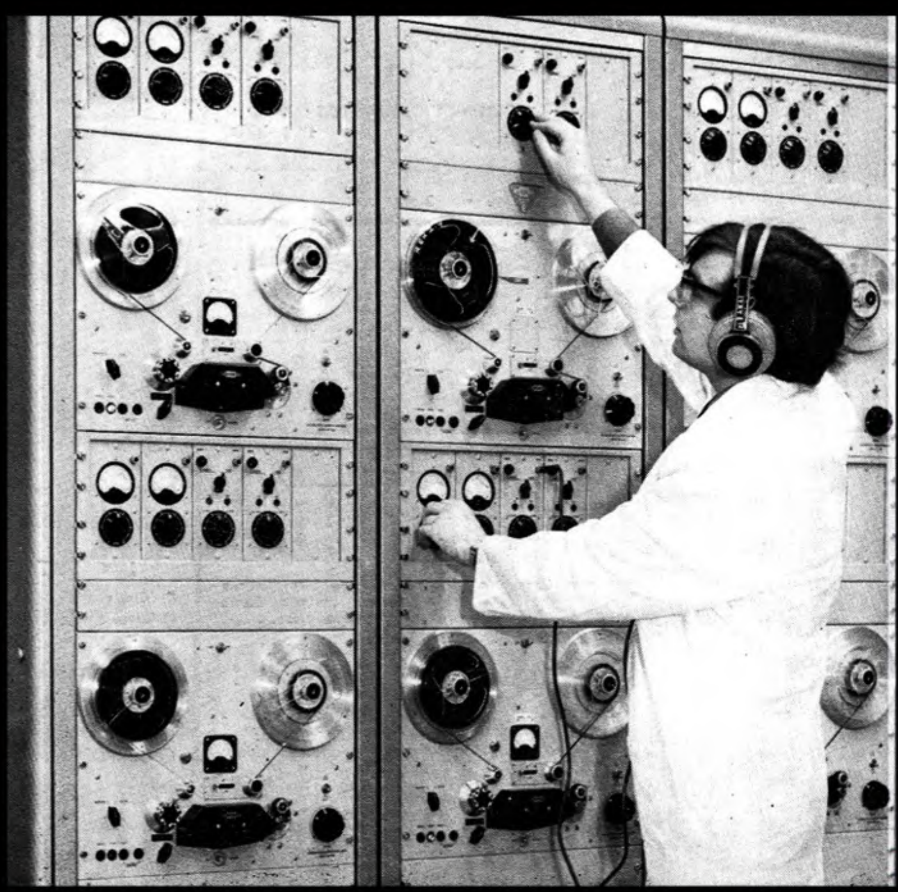
DROPOUT-AN ANALYSIS OF ITS EFFECT ON MUSIC

VTR CIRCUITRY

AURAL AND VISUAL MONITORING TECHNIQUES

AKAI X360 FIELD TRIAL

REVIEWS: DUAL TG28 AND FILM INDUSTRIES RIBBON



K. J. ENTERPRISES

BRITAIN'S PREMIER MAIL-ORDER AUDIO SPECIALISTS

Immediate despatch on Advertised Lines.

Send Cash with Order.

DISCOUNT BARGAINS ★ VAST STOCKS OF TAPE & EQUIPMENT ★ REFUND GUARANTEE.

BRANDED TAPES
20% OFF!
BASF—EMI—GRUNDIG—PHILIPS SCOTCH—AGFA

Brand new, Fully Guaranteed and in normal manufacturers pack.

STANDARD PLAY		LIST PRICE	OUR PRICE
5"	600' } Except Agfa	22/2	18/-
5¾"	900' } Except Agfa	29/5	24/-
7"	1200' } Except Agfa	36/7	29/6

LONG PLAY		LIST PRICE	OUR PRICE
3"	210' Not Scotch	9/3	7/6
3"	300' Scotch only	9/7	7/9
4"	450'	14/9	12/-
4½"	600' BASF, Agfa only	22/-	18/-
*5"	900'	29/2	23/6
*5¾"	1200'	36/5	29/6
*7"	1800'	51/7	41/6
8¼"	2400' BASF, Scotch only	74/-	58/9
10"	3280' Agfa only	85/9	68/9
10"	3600' BASF only	96/6	77/6
10½"	4200' Agfa, BASF only	113/6	89/3

SCOTCH DYNARANGE (L/P)		LIST PRICE	OUR PRICE
5"	900'	32/8	26/3
5¾"	1200'	41/-	33/-
7"	1800'	58/1	46/6
8¼"	2400' (Metal Reel)	84/3	67/6

GRUNDIG TAPE AVAILABLE ONLY WHERE MARKED WITH ASTERISK

DOUBLE PLAY		LIST PRICE	OUR PRICE
3"	300' Not Scotch	14/3	11/6
3"	400' Scotch only	16/7	13/3
4"	600'	26/-	21/-
4½"	900' Agfa, BASF only	31/-	25/-
5"	1200'	43/2	34/9
*5¾"	1800'	56/11	46/-
*7"	2400'	79/-	63/6
10"	4600' Agfa only	140/9	112/9

TRIPLE PLAY		LIST PRICE	OUR PRICE
3"	450' Not Scotch	22/3	18/-
3"	600' Scotch only	24/10	19/9
4"	900'	40/-	32/3
*4½"	1200' Agfa, BASF only	50/-	40/3
5"	1800' Not Scotch	67/2	54/-
5¾"	2400' } Agfa, BASF only	91/4	73/6
7"	3600' } Agfa, BASF only	116/6	93/6

COMPACT CASSETTES	LIST PRICE	OUR PRICE
C.60	17/6	14/3
C.90	25/-	20/3
C.120	33/6	27/-

Postage and packing 2/6. Orders over £3 post free.

AMPEX TAPE—SAVE 30%

A special offer of top quality, premium grade, mylar (Polyster) base tape with Full Leader and Stop Foil. Boxed and Fully guaranteed.

TYPE	DESCRIPTION	LIST PRICE	ONE	THREE	SIX
541-12	1150' on 5¾" reel Long Play ...	35/-	24/6	71/-	137/-
551-12	1200' on 5" reel Double Play ...	42/-	29/6	86/-	168/-
551-16	1650' on 5¾" reel Double Play ...	55/-	33/6	97/6	189/-
551-24	2400' on 7" reel Double Play ...	77/6	49/6	145/6	285/-

POST AND PACKING 2/6. ORDERS OVER £3 POST FREE.

Compact Cassettes
UP TO HALF PRICE

Standard pattern to fit Philips, Stella, Elizabethan, Dansette, Sanyo, Ferguson, Bush, HMV, Sony, etc.

Compact Cassettes with 60, 90 and 120 minutes playing time. Brand New and packed in normal plastic library box. Available at this exceptional price.

MAXELL

MC.60	MC.90	MC.120
1 for 10/6	1 for 14/-	1 for 18/6
3 for 30/-	3 for 40/6	3 for 54/-
6 for 55/6	6 for 78/-	6 for 105/-
12 for 105/-	12 for 150/-	12 for 204/-

Post and Packing 2/6. Orders over £3 post free:
Must not be confused with cheaper American Overture Cassettes advertised elsewhere.

ILFORD—ZONAL TAPE
40% OFF!

SOUND VALUE GUARANTEE

NEW KJ SPECTACULAR

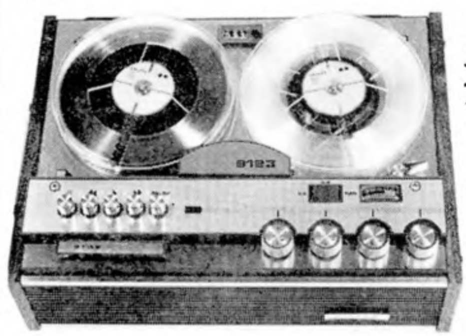
From the Motion Picture and Magnetic Products Division of **ILFORD LTD.** we are proud to present a New Stupendous **BARGAIN OFFER**! Never before have you been offered such a breathtaking opportunity. **ILFORD-ZONAL** premium grade magnetic tape (extensively used by the B.B.C.) at a terrific reduction of 40%! Brand New, Boxed, Fully Guaranteed and complete with leaders, trailers and stop foil. **UNIQUE TO KJ.**

DESCRIPTION	LIST PRICE	ONE	THREE	SIX
900' on 5" reel Long Play P.V.C. ...	29/1	17/6	50/6	96/6
1200' on 5¾" reel Long Play P.V.C. ...	36/1	22/6	65/-	125/-
1800' on 7" reel Long Play P.V.C. ...	51/4	29/6	86/-	165/-
1200' on 5" reel Double Play (Polyester)	43/1	27/9	81/-	157/6
1800' on 5¾" reel Double Play (Polyester)	56/1	36/-	105/-	204/-
2400' on 7" reel Double Play (Polyester)	78/10	49/6	145/6	285/-

Post and Packing 2/6 — Orders over £3 post free

BARGAIN OF THE MONTH
PHILIPS/STELLA 4-TRACK TAPE RECORDER

Model 9123



SPECIAL OFFER!

LIST PRICE £60-0-10

OUR PRICE £48

Carriage 10/-

An attractively priced, high quality, reel-to-reel recorder. You will find that this machine, despite its many potentialities, is very simple to operate, thanks to the clear arrangement of its controls and connection sockets alike.

LOOK AT SOME OF ITS OUTSTANDING FEATURES

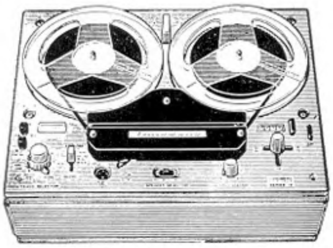
- *Mono recording and playback.*
- *Stereo playback, duoplay and multi-play with stereo amplifier and accessories.*
- *4 track, 2 speeds—3¾ and 1⅞ i.p.s. reels up to 7".*
- *Output 4 w.*
- *Tone control.*
- *Tape position indicator.*
- *All transistor amplifier.*
- *Suitable for use as amplifier.*
- *Facilities for mixing and for monitoring via its built-in loudspeaker.*
- *Supplied with omnidirectional moving coil microphone. 7" reel of tape, 7" empty spool, connecting lead and library rack.*
- *Magnificent wooden sided cabinet.*

K. J. ENTERPRISES (Dept TR7) 17 THE BRIDGE, WEALDSTONE, MIDDLESEX (Opposite Harrow and Wealdstone Station). 01-427 7758. Showroom hours: 9.30a.m. - 5.30p.m. Closed Lunch 12.30 - 1.30p.m. Close 1p.m. Saturday.

FREE Our New 100 page illustrated catalogue sent entirely FREE on request. Britain's most specialised comprehensive range of recording tape, Accessories and Audio equipment. 20,000 reels of tape always in stock with reductions ranging up to 50%

DISCOUNTS :: TERMS :: DEMONSTRATIONS

F. CAVE, Tape Recorder & Hi-Fi Specialist



CAVES

FOR

TANDBERG

Tape Recorders Available: Teleton, Standard, Philips, Akai, Ferrograph, Awia, Fidelity, Grundig, Marconiphone, Revox, Tandberg, Telefunken, Wyndsor, National, Truvox and many others.

Hi-Fi Equipment Available: Armstrong, Dual, Goodmans, Grampian, Leak, Lowther, Lux, Philips, Quad, Radon, Rogers, Jordan-Watts, K.E.F., Sanyo, Teleton, Celestion, Decca, Connoisseur, Goldring, Thorens, Transcriptor, Tannoy, Kenneth J. Elwin, Ortofon, Bowers & Wilkins and many others.

F. CAVE Tel: 01-940 0632 Up to 8 p.m.

5 BRIDGE STREET, RICHMOND, SURREY

Mail Orders: Dept. TR, 27 Hill St., Richmond.
2/6 P.O. for catalogue or S.A.E. for list

CHILTON

- ★ **Provision for microphone, radio and low output magnetic cartridge.**
- ★ **As an amplifier only with Bass and Treble controls.**
- ★ **10 watts R.M.S. per channel and fully protected by stabilised supply.**
- ★ **4 Loudspeakers in rattle free cabinet.**
- ★ **Solenoid controlled mechanism.**
- ★ **Quiet running deck, very cool even with prolonged use.**
- ★ **Fully transistorised on 10 printed circuit boards.**
- ★ **3 head system and three speeds—19, 9.5, 4.75 cm/s.**

Portable Version 146 Gns.

Chassis version from 124 Gns.

Magnetic Tapes Ltd., Chilton Works, Garden Road, Richmond, Surrey

Telephone: 01-876-7957

NuSound

THE FERROGRAPH SPECIALISTS

OFFICIALLY APPOINTED

Ferrograph

STOCKISTS

We at NuSound have been associated with Ferrograph Tape Recorders for well over ten years and our proud boast is that no one knows Ferrograph better than we do! If you value honest advice, many years experience plus personal attention, join our many hundreds of regular customers and buy your Ferrograph from NuSound.

WE ARE AUTHORISED SUPPLIERS TO EDUCATIONAL AUTHORITIES, INDUSTRIAL CONCERNS, RECORDING COMPANIES, PROFESSIONAL MUSICIANS, etc.

NEW SERIES 7

This fabulous new Ferrograph range heralds a new era in tape recording—an entirely new design—all silicon solid state electronics with FET input stages—3 motors—3 tape speeds—8¼" reel capacity—vertical or horizontal operation — two internal speakers—10 watts output—plus many other unique features and facilities for which Ferrograph users have asked.

MONO & STEREO versions available priced from £174 to £205.

ALL NEW MODELS STOCKED

plus a good selection of high quality, mint condition **Second-hand Ferrographs.** Part Exchanges welcome.

FERROGRAPH ACCESSORIES

We stock all **Ferrograph accessories** including Microphones, Defluxers, Tape spools, Splicers, etc., together with **spares for old and current models**

FERROGRAPH TAPE

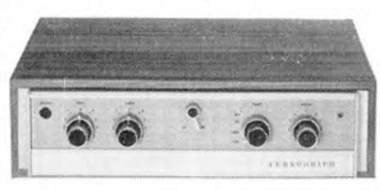
Always in stock. **Low noise-extended response.** Supplied on Hublok grey anodised spools.

BN7. 1,200ft. on 7" reel ...	**£2.10.0**	BN8. 1,800ft. on 8¼" reel	**£3.11.0**
BL7. 1,800ft. on 7" reel ...	**£3.10.0**	BL8. 2,400ft. on 8¼" reel	**£4.10.0**

P. & P. 2/6 extra.

NEW F307 STEREO AMPLIFIER

An amplifier of superlative performance built to the **Ferrograph** high standard of excellence and quality. 40 watts R.M.S. total output. Less than ·25% distortion at all levels. Inputs for magnetic and ceramic cartridges of all types. Tape record/replay facilities. Separate bass, Treble and Volume controls for each channel.



The F307 amplifier utilises the latest techniques and components and is exceptional value complete in beautifully finished teak case. **PRICE £56**

NuSound

THE FERROGRAPH SPECIALISTS

24, OXFORD STREET, LONDON, W.1.

OPEN MONDAY-SATURDAY 9-6pm. TELEPHONE: 01-580 4638/4639/5755

tape recorder

AUGUST 1969 VOLUME 11 NUMBER 8

INCORPORATING
SOUND AND CINE

EDITOR
JOHN CRABBE

DEPUTY EDITOR
DAVID KIRK

ADVERTISEMENT MANAGER
ROBIN WELLS

Editorial and Advertising Offices:
LINK HOUSE,
DINGWALL AVENUE,
CROYDON CR9 2TA
Telephone 01-686-2599

COVER PICTURE

In the space of two minutes, this Leevers-Rich installation at the University of Kent can complete five copies of a 90-minute tape. The system serves 300 students at the Canterbury Language Centre.

SUBSCRIPTION RATES

Annual home and overseas subscription rates to *Tape Recorder* and its associated journal *Hi-Fi News* are 30s. and 47s. respectively. U.S.A. $4.80 & $5.60. Six-month subscriptions are 15s. *(Tape Recorder)* and 24s. *(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.

THE SENIOR ENGINEER of a tape manufacturing plant once commented to us that, with so many interacting variables and compromises involved in magnetic recording, he was surprised the system worked at all. This contrasted with the views of another engineer, whose religious beliefs were founded on the 'remarkable order' of the physical universe.

Consider the derogatory influences acting upon a signal on its way through a magnetic recorder. It enters at a fairly low level, often to a peak of 0.775 V at 600 ohms, having already been joined by noise from an earlier microphone preamplifier. Signal and noise are normally amplified again, adding more noise and a small degree of distortion. The result is now fed to an HF pre-emphasis network which boosts the treble response to compensate partly for HF losses in the replay head. At this point a supersonic bias tone is added to lift the pre-emphasised signal-plus noise to the 'linear' portions of the oxide magnetisation curve. Although the bias tone is not itself audible, being up with the bats, it can intermodulate with harmonics of the pre-emphasised signal and produce beating on replay.

Now the signal reaches the biggest variable in the recording chain, the tape. The true shape of the 'linear' sections of the magnetisation curve, and the bias level at which those sections are reached, depend upon the formulation of oxide on the tape, which differs significantly from one brand of tape to another. Other factors which vary between tapes are the noise level and distortion for any given combination of bias amplitude, signal level and frequency response. There are five variables at this stage alone. One element may be balanced against another, but an improvement in one (say, frequency response) generally causes deterioration in others (signal-to-noise ratio and distortion). The area of compromise is not limited to adjustments within the recorder. By changing tapes, an improvement of more than 7 dB in signal-to-noise ratio can be achieved without affecting frequency response. Something for nothing? No, the reduction in tape noise is made possible by reducing the oxide grain size, and the smaller the grain, the higher the print-through. The influence of print on the recorded signal is less disturbing than tape hiss, however, and modern 'low noise' tapes can be strongly recommended for most programme material. The practice of storing tapes 'trailer-outwards' is worth following, since the pre-playback rewind process provides more than the few seconds needed for print to decay substantially. This is in any case standard studio procedure for keeping wow and flutter to a minimum.

When it eventually appears at the playback head, our signal is quite distinguishable from that fed into the recorder. Rapid fluctuations in tape speed have added a peculiar form of time distortion, the result of wow and flutter, and the frequency response has been altered by a complex series of factors, not least of which is the presence of flaked oxide at the replay head. This same flaking takes random lumps out of the image and anything left regenerates the signal in the replay head. This process tilts the LF end of the frequency band down by 6 dB per octave and a corresponding equalisation network is needed to regain the original 'flat' reponse. A certain amount of compensation for playback head gap loss is made (for a second time), but not before yet another amplifier has added its share of noise.

Not a system that reflects 'remarkable order', but nevertheless the only recording tool good enough and versatile enough for serious studio consideration. The lesson to be learned from this story (diatribe?) is that tape plays an important role in the performance of a recording system. For several years we avoided reviewing tape on the grounds that inconsistency between different production runs was often greater than that between different brands. There is such a dearth of information on the comparative merits of tape, however, that we shall shortly re-commence these reviews. If the tapes examined are still inconsistent, we shall publish and be damned.

FEATURE ARTICLES

REGULAR ITEMS

EQUIPMENT REVIEWS

Don't miss this Value For Money offer! only from R.E.W.

PHILIPS Family Tape Recorder

EL 3573 (4305)

List price £46·13·11

OUR PRICE *only* 36 gns.

One of a famous line of high quality, low-cost family tape recorders, this model is handsomely styled in black, with a grey lid and brushed aluminium control panel.

Records and plays back on four tracks at two speeds: $1\frac{7}{8}$ and $3\frac{3}{4}$ i.p.s.

Mixing, monitoring, personal listening and parallel track facilities.

All transistor for instant recording and playback.

Push-button controls for record (with safety interlock), playback, fast wind, re-wind, pause and stop. Separate controls for on-off/volume, tone microphone and radio/gramophone recording level.

8″ x 3″ loudspeaker for full, rich sound.

Excellent frequency response.

Illuminated recording level indicator. Mains on-off lamp.

Tape position indicator with push-button zero re-set.

Sockets for microphone, gramophone, radio, second recorder, external loudspeaker, headphones, amplifier and stereo pre-amplifier (for stereo playback, duoplay and multiplay).

Suitable for use under tropical conditions.

Supplied with moving coil microphone, reel of longplay tape, empty spool and direct recording/playback lead.

List price £46.13.11.

Our price only 36gns.—superb value for money!

Also from **R.E.W.** the complete **PHILIPS** range including:

ALL ON INTEREST FREE TERMS!

Philips EL 3302 Cassette Battery Tape Recorder, list price £32.1.7. **Our price only 25 gns.**
Philips EL 3575 Stereo Tape Recorder, list price £101.19.4. **Our price only 72 gns.**
Philips PRO12, professional quality Tape Recorder **£242.7.4.**
Philips Stereo 4408 £136.3.10.
Philips N4404 £80.
Philips N2500 Mains Stereo Cassette Player—hear Musicassettes through your hi-fi **£24.13.2.**
Phillips N2205 Mains/Battery Cassette Recorder, High Quality **£43.3.0.**

Always full range of Philips in stock—everything on interest free terms, one third cash price deposit, balance over 12 months.

rew **(Earlsfield) Ltd., HEADQUARTERS SHOWROOMS AND MAIL ORDER:** DEPT. TR, 266-8 UPPER TOOTING ROAD, LONDON, SW17. Tel. 01-672 4471/2 and 9175.

WEST END SHOWROOMS: 146 CHARING CROSS ROAD, LONDON, W.C.2. Telephone: 01-836 3365 (opposite Astoria Cinema).

WE SPECIALISE IN BRAND NEW

TOP QUALITY BRITISH P.V.C. MYLAR & POLYESTER RECORDING TAPES WITH FITTED LEADERS, Etc., EX 3″

Thanks to bulk purchase we can offer tensilised HI-FI tapes, manufactured by a British firm of world repute. All boxed individually (sealed if required) in polythene. Our tapes are not to be confused with imported sub-standard or used tapes. Full-money refund if not delighted.

This month :— "DRY SPLICE" (3/9) given FREE with every order.

Std.		ea.	3 for	L.P.		ea.	3 for	D.P.		ea.	3 for	Boxed empty spls	
	Length				Length				Length				
3″	150′	2/-	5/9	3″	220′	2/6	7/-	3″	400′	4/6	13/-	3″	7d.
4″	300′	4/-	10/-	4″	450′	5/-	14/-	4″	600′	6/9	19/6	4″	1/8
5″	600′	6/-	17/6	5″	900′	8/-	23/6	5″	1200′	12/6	37/-	5″	1/9
$5\frac{3}{4}$″	900′	7/-	20/6	$5\frac{3}{4}$″	1200′	10/6	30/6	$5\frac{3}{4}$″	1800′	17/-	50/-	$5\frac{3}{4}$″	1/9
7″	1200′	9/-	25/6	7″	1800′	13/-	38/6	7″	2400′	21/-	61/-	7″	2/-

All orders despatched by return. *Postage and Packing 1/9 per order.*

STARMAN TAPES, 421 Staines Road, Bedfont, Middlesex

YOU CAN HAVE GOOD SOUND EQUIPMENT

if you choose

Grampian

Grampian Reproducers Ltd. Hanworth Trading Estate, Feltham, Middlesex

---

FULLY GUARANTEED

Size Base	P.V.C. Standard		P.V.C. Long	
3″	150′	2/6	225′	3/3
4″	300′	4/3	450′	5/6
5″	600′	8/9	900′	10/3
$5\frac{3}{4}$″	900′	10/6	1200′	12/6
7″	1200′	12/6	1800′	17/9

Size Base	POLYESTER Double		POLYESTER Triple	
3″	300′	2/6	600′	9/3
4″	600′	4/6	900′	13/3
5″	1200′	18/9	1800′	23/6
$5\frac{3}{4}$″	1800′	15/9	2400′	29/9
7″	2400′	29/6	3600′	39/9

Factory Fresh. Superb Quality. Leaders, Trailers and Stop Foils on all sizes 5″ and above. We supply many local authorities and professional recording studios. May we supply you? P. & P. 2/6 per order. S.A.E. Full Lists.

LEDA TAPES (D) **17 LEIGH PARK ROAD, LEIGH-ON-SEA, ESSEX**

London Office: Tel. 01-226 7004

MORE QUALITY BARGAINS IN

EXCHANGE & MART 8d EVERY THURSDAY

if you are a RADIO, TV or TAPE enthusiast

WORLD OF TAPE

NEXT MONTH

THE FIRST OF two articles covering the theory and construction of an automatic tape transport control system will be given by R. L. White of *British Telecommunications Research*. Gerald Chevin describes the studio approach to recording pop music while Robert Wright looks at the present state of Local Radio.

BACK BIAS ON THE SOUTH BANK

EIGHT QUAD ELECTROSTATIC loudspeakers made their debut on the South Bank in late May at a recital of classical Indian music. STC *4038* and AKG *D1000* microphones fed the speakers via two *33* control units and four *303* power amplifiers, chosen and set up by Hampstead High Fidelity. Two Electrostatics were operated from each *303*. The system provided sound amplification for Imrat Khan (sitar and surbahar) and Mahapurush Misra (tabla) in the Queen Elizabeth Hall, their May 27 and June 9 performances both being recorded on a Tandberg *6X*.

BATRC RESULTS

RESULTS OF THE 1968 British Amateur Tape Recording Contest were decided upon at Mullard House on June 9. Peter Bastin won the *Speech and Drama* class with his bi-lingual 'Have a Drink' and also the *Humour* award for 'Septimus Jones Esquire'. Robert Prizeman's 'Addington Palace (The Royal School of Church Music)' won in the *Documentary* section and was also classified as 'Tape Recording of the Year'. Winner in the *Music* section was Ken McKenzie with 'Black Velvet'. Mr. McKenzie was also first in the *Technical Experiment* section with '*On the Blaydon Beat*'. *Reportage* was won by J. and P. Douglas with 'January Storm'. The Joseph Hood Junior School, London S.W.15, won under *Schools* with 'Story of Samson'. The 1968 Set Subject 'Home Sweet Home' was won by Janet Hood aged 14 while Barrow Soundtrack Club received a Club Trophy. Dudley Kitching won the 'Handicapped' Trophy with 'Greensleeves', part of which may be broadcast in the BBC's 'Woman's Hour'. The 'Best Stereo Tape' was 'Shaftiana', composed and recorded by Michael Axtell who also participated in the performance. Copies of selected BATRC contributions may be obtained from the organiser: John Bradley, *33 Fairlawnes, Maldon Road, Wallington, Surrey*.

ELECTRONIC BROKERS EXPAND

SURPLUS DATA PROCESSING equipment, computer tape transports, chart recorders and test gear are on permanent display at the new premises of Electronic Brokers Ltd. Described as 'Britain's first electronic supermarket', the company has outgrown its premises four times since it was formed just over a year ago. In addition to selling equipment, it has launched a confidential brokerage service to liaise between buyers and sellers of electronic systems. Electronic Brokers are already in contact with over 10,000 research and educational organisations in Europe and North America. Their new address is *49-53 Pancras Road, London N.W.1* (*Tel*: *01-837 7781*).

NEW BBC APPOINTMENT

AFTER 38 YEARS with the BBC, J. P. Broadbent has retired from his post as Engineer-in-Charge of Wenvoe transmitting station, South Wales. Mr. Broadbent joined the BBC at Moorside Edge in 1931 and was transferred to Droitwich in 1935 where, four years later, he became a Senior Maintenance Engineer. In 1951 he was appointed Assistant Engineer-in-Charge at Holme Moss and moved to Wenvoe in 1952. He is succeeded by D. Thomas who joined the BBC in 1941 and was for eight years Assistant Engineer-in-Charge at Tacolneston. Since 1964 he has been Engineer-in-Charge at Sandale, Cumberland.

BACKGROUND MUSIC CALMS HOSPITAL PATIENTS

GRAPHS MAINTAINED by the staff of Farleigh Mental Hospital, Bristol, show a substantial downward trend in damage to crockery, windows and clothing since the installation of a background music system. Prior to the commencement of music therapy, some 65 200 mgm sodium amytal and phenobarbitone tablets were administered weekly in addition to the regularly prescribed doses. This has since levelled off at five.

The system being used is a Cantata *700*, produced by 3M. A single player is capable of feeding up to 30 loudspeakers and incorporates a time switch to provide continuous playing, 24 minute sequences with six minute interruptions, or 15 minute sequences with 15 minute pauses. At Farleigh, the loudspeakers are situated in dormitories, common rooms, corridors and wash areas. The loudness is adjusted according to the existing noise at each location.

NEW DEVELOPMENTS IN SOUND INSULATION

RECENT EXPERIMENTS BY Dr. K. A. Mulholland at the University of Liverpool have shown that the application of Polystyrene to a panel, with the aim of increasing sound insulation, can actually have the opposite effect. The transmission loss of a plasterboard panel with a 50 mm Polystyrene layer was found to be 5 dB poorer at 600 Hz than with plasterboard alone. By contrast, a 50 mm rockwool layer gave a 22 dB improvement in transmission loss at 4 kHz, relative to plasterboard alone, and 24 dB relative to plasterboard plus Polystyrene. This negates the common assumption that Polystyrene can be used for sound installation, probably based on confusion with its known properties as a sound absorbent. A standing-wave resonance inside the Polystyrene has been suggested as the cause of the deterioration in transmission loss.

NEW SHARPE AGENCY

CARSTON ELECTRONICS LTD., *71 Oakley Road, Chinnor, Oxfordshire* (*Tel*: *Kingston Blount 8561*) have been appointed sole agents for Sharpe Instruments, in succession to S.G. Brown. A division of Scintrex Inc., Buffalo, New York, Sharpe produce a series of studio headphones and boom headsets. Among the units being handled by Carston is a *Mk.2* version of the recently reviewed *HA10*, now selling at £23 10s.

BASF CASSETTES

IN NOVEMBER 1968 we published and replied to a letter from Mr. E. Dymock of London, N.1. This commented on squeaking problems with BASF *C120* cassettes and prompted BASF to send further samples of the *C120*. Mr. Dymock reports that they are 'a definite improvement' and free from squeaking. Our thanks to BASF for their attention to this matter.

dropout

An investigation into its effects on recorded music

BY G. DOMBURG AND B. LOPES CARDOZO*

THIS article deals with an investigation into the annoyance caused by gaps in recorded music on magnetic tape, usually called dropouts. First a rough outline will be given of the causes and physical characteristics of dropouts. Then data on the audibility of dropouts will follow. Finally a description and the results of experiments on the annoyance due to dropouts will be given.

Dropouts in magnetic recordings may result from dust on the tape or from various defects in the tape. They cause a sudden decrease in volume lasting a fraction of a second. The characteristics of dropouts depend on the recording and playback system used. In the case of the Philips cassette recorder for instance, we found very many shallow, brief dropouts (typically 1 dB, 10 mS) in a certain brand of tape, but long and deep ones (10 dB, 100 mS or so) were relatively rare. All dropouts share one common feature: the slopes are so gradual that they do not produce sharp clicks, like the notorious scratch in the gramophone record. Even more important perhaps is that dropouts do not, as a rule, recur at regular intervals.

We have examined two levels of subjective effects of dropouts, namely the audibility and the annoyance. In all experiments we used artificial dropouts made by a dropout simulator. This apparatus enabled us to vary the depth and duration of a dropout and to produce it at any moment.

Literature presents little data on the audibility of a brief pause in a continuous sound. For white noise, Plomp (JASA 1964) found that the just noticeable duration of an absolute pause is 3 mS. We started with a number of pilot experiments. Listening to white noise via Permoflux *PDR 8* headphones at 60 dB above their thresholds, two subjects adjusted the depth of dropouts so that it was just audible.

Their data show good agreement with Plomp's data. Similarly, adjustments were made for the depth of just audible dropouts in *Largo legato* music in *Vivace staccato* music. The results of these experiments are given in **fig. 1.** The abscissa represents the duration of dropouts. The relative voltage at the bottom of the dropouts is linearly plotted along the ordinate. The corresponding depths in dB are given along the right vertical scale. As might be expected, slow music is more vulnerable to dropouts than fast music. White noise is still more vulnerable. The data of Bauer and coworkers, published last year in the *Journal of the Audio Engineering Society*, have been partially replotted as small circles in this figure. The fit is not perfect, but the trends are clearly the same.

It must be kept in mind that all these data refer to regularly recurring dropouts. This is unrealistic. Informal tests showed that randomly occurring dropouts are significantly more difficult to hear.

It will be obvious that once the listener knows the rhythm of recurrence, his hearing is sharpened by anticipation.

Whereas the audibility of dropouts depends essentially on the ear itself, annoyance is a more elusive matter, into which, for one thing, the subjective appreciation of the music enters. In order to find out something about annoyance, the opinions of listeners must be sought. Two approaches seem possible. One is to try and find the annoyance value for the average listener, listening to the average type of music with the average type of playback system, loudspeakers, room, etc. This approach leads to unwieldy mass experiments. We did not do this because we have no faith in it. The average listener, the average music and the average listening conditions just do not exist. Or, if one prefers a more sophisticated argument, averaging over these sets is justified only if annoyance were a nice linear function and this certainly is not true.

So the alternative, which may be termed the worst case, approach was chosen. This means that we purposely chose very discriminating listeners, that we carefully selected music which was most sensitive to dropouts and that we experimented under playback conditions calculated for the maximum effect of dropouts.

There were two groups of subjects. One group consisted of eight amateurs rather interested in the classical repertory and extensively trained in psychoacoustic tests. The second group of subjects were professionals, that is to say, people working in the phonographic industry. These people had considerable training in close listening for minute technical flaws in musical recordings.

From pilot studies it was found that for maximum vulnerability to dropouts, one should take slow music played by a solo instrument. The music should have a small dynamic range, it should be *legato*, percussion instruments should be avoided and, finally, it should have a strong reverberation.

We easily ascertained that:

(1) Dropouts tend to be masked in double track or stereo and are most harmful in single track mono playback.
(2) Dropouts tend to be masked by room reverberation. The most sensitive listening condition proved to be by earphone.

Finally two pieces of music were chosen: an organ solo (M. E. Bossi, *Thème et variations*, Op. 115) and a violin solo (J. S. Bach, *Sonata 1 in G*, B.W.V. 1001, first movement). Both recordings have a considerable amount of reverberation, contain very few pauses and are played with small dynamic variations.

Music fragments of 20 seconds duration were formed and recorded on high quality tape. The first five seconds were left intact. In the remaining 15 seconds a dropout was introduced somewhere. Because we assumed that a dropout might escape a listener's attention when it coincided with the onset of a tone, care was taken to put the artificial dropouts in stationary parts of those sustained notes that in our opinion were most vulnerable.

The subjects were told that a dropout would occur in the last 15 seconds of every musical fragment. They did not know when it would occur nor whether it would be a heavy or a light one. They were asked to try and listen relaxedly 'as if listening at home' and to express the annoyance caused by the phenomena in a scale in which

$h = 0$ meant no dropout heard
$h = 1$ dropout heard but not annoying
$h = 2$ annoying dropout heard
$h = 3$ very annoying dropout heard.

Subjects were allowed to interpolate and to extrapolate. They were prompted to give their ratings without premeditation.

In a first experiment we thus determined the annoyance value of isolated dropouts; duration and depth of the dropouts were varied over the various fragments of music. In a second experiment the same was done for clusters of dropouts. In this case the number and recurrence rate of the dropouts were varied.

In one series of formal tests, dropouts were simulated with durations ranging from 10 mS up to half a second, and depths of 4, 8 and 16 dB.

Before discussing the result, it should be stated that, on the whole, subjects were fairly consistent: we repeated one part of the test programme after an interval of several weeks and got annoyance values that were essentially the same. Also, the rank order of dropouts of various lengths and depths in different types of music proved to be very high.

The results are shown in **fig. 2** in the same way as in **fig. 1.** This figure shows contour lines for annoyance values h=0, h=1, h=2 and h=3 as a function of duration and depth of the dropouts. These contours have the same trend as the audibility threshold curves of **fig. 1** (see curve marked **d**). The 11 types of dropouts applied have been represented by crosses along with the annoyance values,

*Philips Research Laboratories, Eindhoven

FIG. 1 AVERAGE JUST NOTICEABLE DEPTH OF RECURRENT DROPOUTS AS A FUNCTION OF DURATION FOR: WHITE NOISE (+ — +)
SLOW MUSIC (● — ●)
FAST MUSIC (■ — ■)
RESULTS OBTAINED BY BAUER ET AL ARE REPRESENTED BY (O, O), RECURRENCE RATE 1Hz.

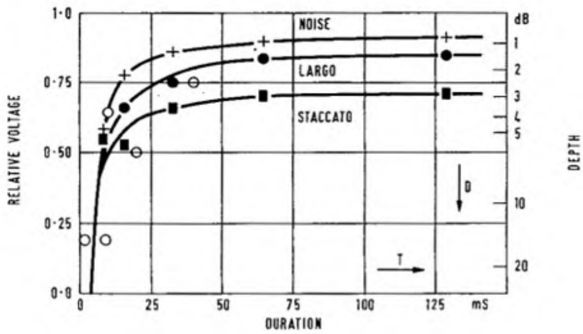


FIG. 2 ANNOYANCE h AS A FUNCTION OF DURATION T AND DEPTH D FOR ISOLATED DROPOUTS. THE LINE MARKED d REPRESENTS JUST NOTICEABLE DEPTH OF RECURRENT DROPOUTS (2Hz) IN SLOW MUSIC.

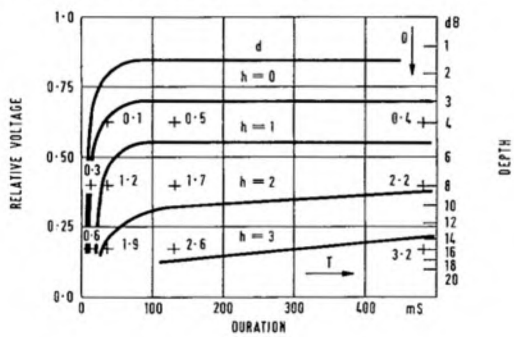


FIG. 3 ANNOYANCE h AS A FUNCTION OF THE NUMBER OF DROPOUTS (T = 31 mS, D = 8dB) IN A CLUSTER.

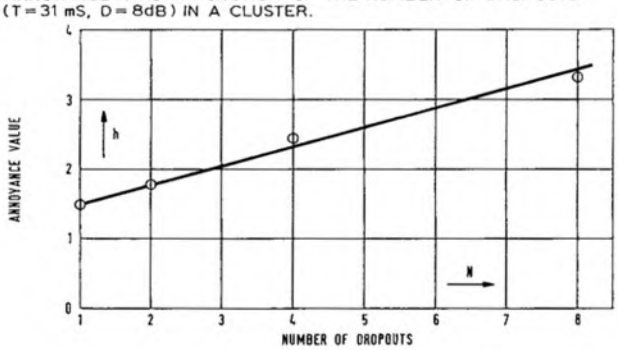
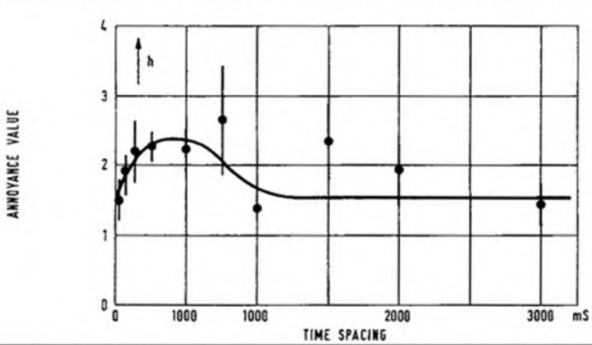


FIG. 4 ANNOYANCE h AS A FUNCTION OF THE TIME SPACING BETWEEN DROPOUTS.



averaged over all subjects and the two kinds of music. The annoyance contours have been obtained by linear interpolation between these average values.

From the **fig. 2** results we conclude that:
Single dropouts are inaudible if shallower than 3 dB (no matter how long) or if shorter than 10 mS (no matter how deep).
Single dropouts are not annoying when shallower than 5 dB (no matter how long) or when shorter than 20 mS (no matter how deep).
The line marked **d** in **fig. 2** is a replot from the audibility threshold in **fig. 1,** valid for *largo* music. Obviously the recurrency of dropouts in the previous experiments is responsible for the great discrepancy.

It is interesting, perhaps, to note that the organ music and the violin music used in the tests were about equally vulnerable, scoring $h = 1.43$ and $h = 1.22$ respectively on the average.

The professional subjects were the more rigorous judges, scoring 0.44 point higher in the annoyance scale than the amateurs. But the very light dropouts were rated exactly equally by both groups. By and large, we think that the annoyance for isolated dropouts is represented fairly well in this figure.

We have conducted fairly extensive experiments on clustered dropouts along the same lines as for isolated dropouts. On the whole, the results are not as consistent, but we feel fairly confident of having covered the main effects with two simple rules of thumb. First, let us examine **fig. 3.** It shows the annoyance value *h* as a function of the number of dropouts per fragment of music.

It is evident that the annoyance creeps up at a rate of 0.25 point per member of the cluster. For example, if there are four dropouts in a cluster (i.e., within a quarter of a minute) then the annoyance is found by taking the one with the highest rating and adding one quarter point for each additional dropout.

This rule must be corrected for dropouts in quick succession. When two or more occur within one second of time, then this seems to produce a kind of irritation, boosting the annoyance values, as given in **fig. 4.** This shows the annoyance value *h* as a function of the time interval between two successive dropouts. The dots give the measured annoyance values, averaged over subjects and music. The vertical lines through the dots give the 99% confidence intervals.

The annoyance curve bulges up in the time interval shorter than, say, one second.

If two or more dropouts occur within this time, they apparently show an emotional interaction.

SUMMARY

From a study of dropouts in magnetic tape we derived some typical features of this phenomenon. Quite often it is an isolated event.

Therefore we started listening tests with artificial, single dropouts. We purposely took the worst possible combination of conditions. For certain applications the criteria obtained in this way may prove to be too severe.

For the purpose of testing maiden tape meant for musicassettes, a dropout detector was built at the Institute for Perception Research, which automatically evaluates dropouts according to the weights described in this article.

REVOX SERIES 36

Part Two

BY H. W. HELLYER

COMMON to all the *36* range of models is the head plate and mounting assembly, shown in one or two of the illustrations published last month and again in our photo **B**. Five adjustments for each head can be seen.

The heads themselves are cylindrical, ring-core, with a central threaded suspension rod that is not itself used for adjustment, except that the limiting screws bear down on the top plate and the central rod enables the assembly to be tightened upwards by locking with the slotted nut. The central nut is slackened before other adjustments can be made and, for rotation of the head around the vertical axis, it is necessary to keep the top of the head shield plate up against the limiting screws all the time. Adjustment becomes a tricky business if the centre screw is too loose.

The height adjustment can be done with a section of transparent tape but it is possible to make a reasonably accurate initial setting with normal tape. Brass washers are used as spacers, clamped in the head assembly, and these bright strips running across the edges of the gap length form a useful datum. The height is correct when the spacer just above the gap facing is divided by the edge of the tape. This setting is best done with the rear screw as limiter, and the verticality can then be adjusted finely by the front screw. Remember, however, that incorrect adjustment of azimuth afterwards may nullify the height setting.

Azimuth setting is done with the left screw of the two in line with the tape, the right one again used as initial limiter and clamping screw only. The nut always sits low on this screw and the best way of adjusting is to cut a slot in the end of an unwanted screwdriver blade, or make a slotted-end tool especially for the job. Trying to hack the nut around with a pair of pliers, as I have seen done, makes fine adjustment impossible.

It is assumed that azimuth adjustments are being made by the 'normal' method, ie replaying a test tape, such as a steady tone or, better still, white noise, while the replay head is adjusted for a maximum reading at the cathode follower output, measured on a valve voltmeter. But a more accurate method, recommended by Revox and possible with the aid of an oscilloscope, is to adjust for minimum phase difference.

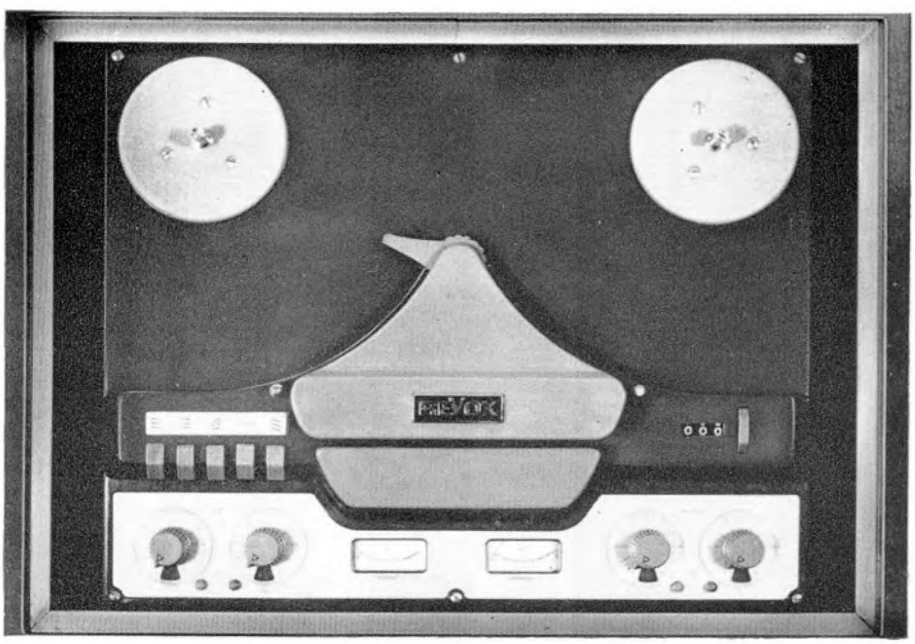
A double-beam oscilloscope is a help. The full-track test tape is played back and the outputs paralleled for VVM indication, with an HF test tone; 10 kHz is recommended but 8 kHz is a more realistic value to suit test tapes on the general market. Maximum output reading under these conditions permits a much finer adjustment. With the 'scope, each track is applied to one beam and a direct visual comparison of phase is possible. A tape with stepped frequency changes of equal modulation level gives an immediate check of phase relationship, which should be maintained at all frequencies.

When making these head adjustments, do not forget that it is possible to move the outer screen relative to the head, and deceptive hum levels can be registered. Similarly, when testing with the chassis out of the cabinet, which has inner screening, the lack of a screen at the bottom will cause hum and spurious pick-up of radiated test signals. An auxiliary test screen is used in the workshop; even a tin tray on the kitchen table is better than no screen at all.

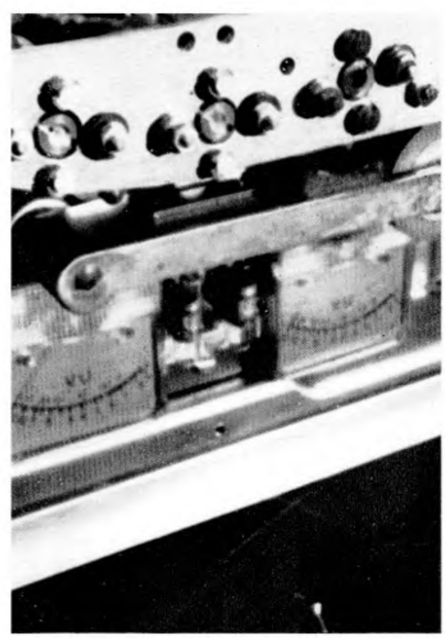
Screening for the reduction of hum is very often a compromise. No less on such an exalted performer as the Revox. With two channels in operation, it would be foolish to test for hum on one alone. The best method is again a combined output from the cathode follower terminals, measured with a valve voltmeter, and adjustment of screens for minimum hum reading. It should be superfluous to add that a much better method is the use of the oscilloscope, where the proportion of hum can be seen.

Remaining in the replay mode for the present, we find that Revox give a whole table of figures for playback response. This is most easily checked by feeding an audio generator signal across a 10 ohm resistor inserted in the

A Top plate of the 936



B View of the headplate showing alignment screws



head return lead, measuring the resultant output at the cathode follower. As a reference, a 1 kHz signal is adjusted to give a reading of 70 mV output. Other readings are related to this input, and will vary a lot, depending on the equalisation. A few spot frequencies will give some idea of the response. These figures are for the 70 µS equalisation curve: +19.5 dB at 40 Hz, +10 dB at 250 Hz, —4.5 dB at 4 kHz, —3.5 dB at 10 kHz, —2.5 dB at 10 kHz. This is with the speed selector at 19 cm/s.

Variations from these readings will lead one to investigate the circuitry and, as can be seen in our accompanying photographs, this is a simple matter. Each stage is built around the valve-base; the valves are in a row on a single metal strip, and the release of a couple of screws allows the whole circuit assembly to be moved out for immediate access to any part. Principal voltages are given on our circuit and it will be noted that cathode voltages are accorded some prominence. In this, as in many other machines which consider a stage to be more a frequency-conscious unity than a mere booster, it is often the cathode voltage that gives the first clue to any trouble. Valve ageing is possible on any equipment: substitution is the quickest and easiest test. But please be warned that the haphazard swapping of valves is not a very good idea. Tackle the job logically. Start with one good replacement valve of each kind—*ECC81* and *ECC83*—and go about the job systematically. In the playback amplifier, I have found that a weak *ECC83* will quite often show up as an early loss of bass boost. With the fairly low anode voltages, an HT rail well below 200 V, and the ample sectional smoothing, one does not get much bother with noisy stages. DC heating minimises hum in the preamp stages of both record and play amplifiers. But the price one pays for this splitting of supplies is the vulnerability of selenium contact-cooled rectifiers, one of which is indicated in one of our illustrations. Three are employed, the main one rated at 100 mA for HT supply, and the other two low voltage types (30 V, 600 and 250 mA) for solenoid operation and valve heater supply respectively.

Turning to the recording amplifier, we find some test requirements that are more refined. In practice, of course, nothing is simpler than to bring the replay amplifier up to scratch, then record a signal and do an A-B test. But for more specific evaluation, we need to read bias, check the recording section with bias filtered, and make more detailed measurements.

This filtering at the output of the playback amplifier to remove residual bias is not needed on the later *G36*, where filters are already incorporated, but for earlier models, and indeed for other machines which have the bother of residual bias affecting output readings when record and replay amplifiers are in operation together, some method of removing bias voltages while not affecting audio output readings is needed to avoid false indications. The filters used by Revox are made up of a tuned trap circuit in series with the output from the cathode of the playback amplifier to the cathode follower output terminal, limited by a series 1.2 K resistor, and decoupled with a 3.3 kpF capacitor directly across the output. I am currently experimenting to find what external filter values of resistor and capacity can be used for optimum results, without affecting the signal—but audio bandwidth is so wide with Revox machines that an L-C filter is almost imperative to get the right slope.

Which brings me to what must surely be the tape recording joke of all time. Among the modifications Revox have brought out is one to reduce the frequency response peak at the top end in the record amplifier.

'Very laudable,' I hear you say. 'So what are the new figures?'

With an absolutely straight face, Willi Studer will tell you that they have found it necessary, because of the odd chance of interference with certain types of radio distribution system, mainly in the studios, to iron out a peak at 30 kHz, lowering the pre-emphasis peak to 23 kHz. Response throughout the normal audio band is not affected. Machines with serial numbers above 48701 are already modified. For those deprived owners who have machines below this number, the modification consists of:

(a) Addition of a 10 pF feedback capacitor between anode and grid of the first stage of the main recording amplifier (C79 of V4 and C80 of V3).

(b) Reduction of the cathode bypass capacitor, from 0.015 to 0.012 µF, of these two stages.

Such minor alterations may seem unimportant to the chap who wants to 'bung in a point one capacitor' wherever capacity is needed, but that they should even be made at all is a measure of the high standards to which these recorders are produced.

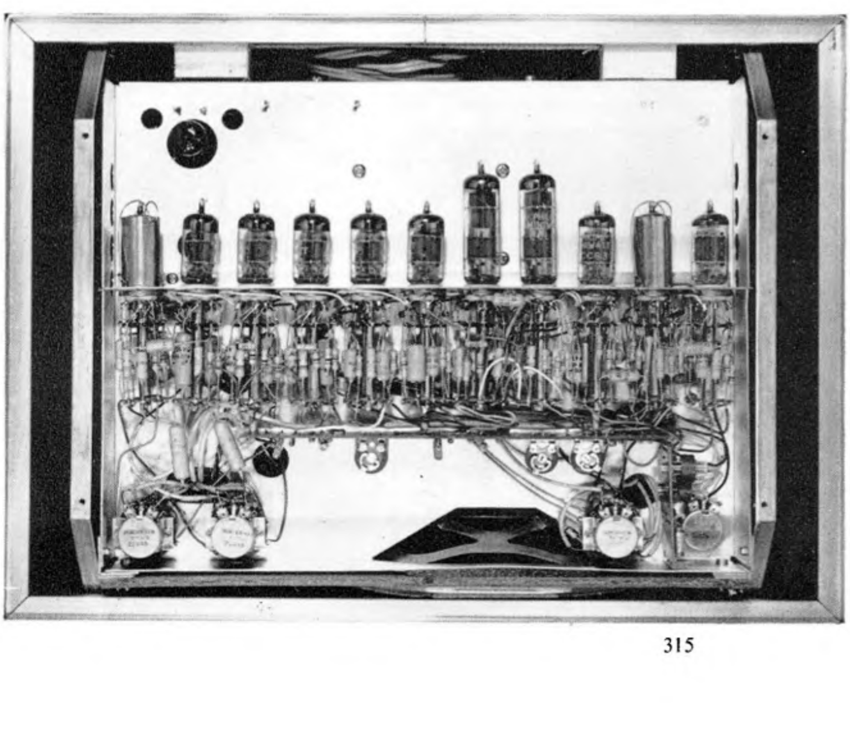
To maintain these high standards, as we all know, it is necessary to adjust your bias to the conditions under which you are working. A change of tape will demand a change of bias magnitude, to achieve correct modulation level for specified distortion and signal-to-noise ratio.

Having fitted the aforesaid bias filter, or made alternative arrangements to ensure we are measuring only the audio signal at the output, we connect our VVM to the cathode follower socket. Press the record button and, with audio input disconnected and record level turned down, adjust for minimum reading across the filter. Residual bias level should be at least 35 dB below the signal level.

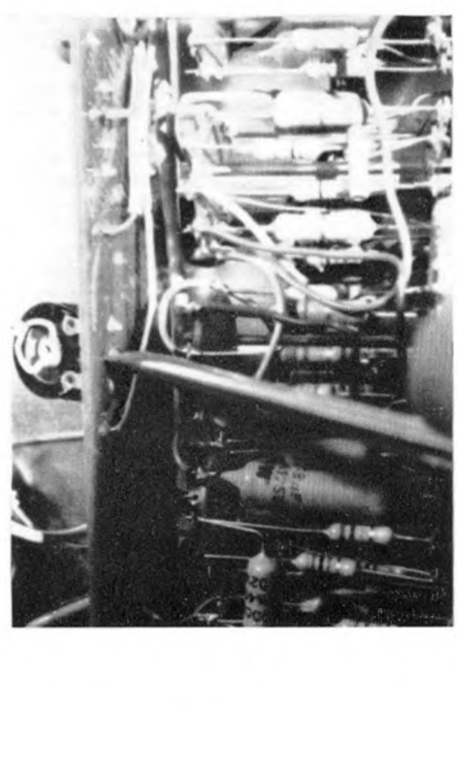
Revox make the point that bias leakage masking the signal makes it necessary to record, rewind, then replay and measure to be able to check adjustments. They also give instructions on bias adjustment that underline

(continued overleaf)

C The amplifier is constructed in a group-stage manner and can be removed *en bloc*



D VU meter preset



factors too often overlooked. I can do no better than quote from the service manual:

'Any alteration of the bias current changes the remanent tape flux and consequently affects output level, frequency response and distortion. As no two heads can be made to perform exactly alike, there is little value in measuring the bias current alone . . . the near-optimum value has to be found first before frequency response tests can be commenced.'

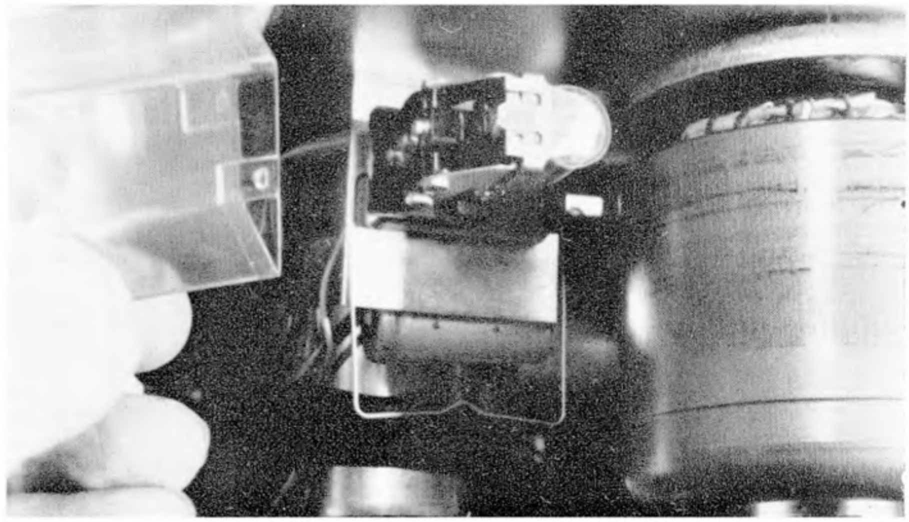
Some correspondents have taken me to task for allegedly harping on about bias adjustment. The foregoing should augment at least some of my arguments. The method recommended by Revox is to record a 1 kHz signal on a good tape, at 3 dB below full modulation and at the lower speed. Bias is adjusted for maximum audio output while this test is made (and providing the bias filters are used). Then the generator signal is reduced 20 dB and, still at 1 kHz, the output level is noted. Next, the generator is tuned to 10 kHz and the bias is readjusted to give the same output as was obtained with the 1 kHz input. This is the setting to use—and it will depend, I must again stress, on the tape with which you make the test. Differences in output level, frequency response and distortion that you would not notice with a plain adjustment of bias for maximum, or '2 dB down the curve,' or any other personal formula, will always show up with this kind of test.

The bias adjusters are easily accessible, in the bottom corner of the chassis, beneath the key section, near the *ECC82* oscillator. The two preset resistors near the bottom, on the printed circuit board, are not bias adjusters but meter setting controls (see photo C). Quite near them, to the right and at right angles, looking at the chassis upended, the new bias filter coils will be seen, but the main bias traps, common to all *G36* models, are the two coils L1 and L2 in the head feed circuit. Purpose of these is to prevent feedback of bias current into the recording amplifier circuit. They are adjusted after first switching to record, measuring the voltage at pin 1 of V5 for Channel 1 and pin 6 of V5 for Channel 2. In each case, the slug of the coil is adjusted for a minimum reading. In practice, I have found this measurement and adjustment rather touchy, and recommend the use of a good oscilloscope.

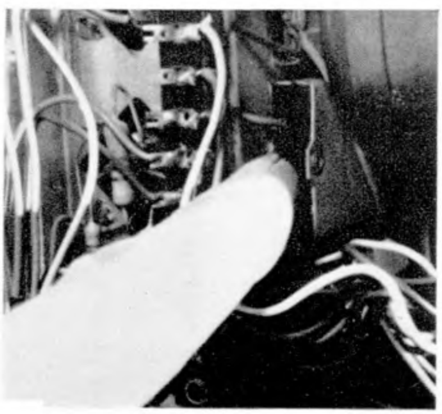
Some of the differences from earlier models that we promised to describe, and which affect servicing, are the tape-end switch and motor control circuits. On models with serial numbers above 36500 a gold-wire trip switch is used, as shown in our illustration, and the circuit is modified to provide an increased starting torque to the wind motors when the switch is made. The two-second operational delay still applies, but this time in the opposite way, ie after the circuit is made, and not between stop action and function clearance which actuates the solenoid. On still later models, an interesting change was made, whereby the relay, seen in photo **E**, is actuated by a pulse from the capacitor C68, stored while the play button is in the neutral position, then allowed to actuate the relay instantaneously when the button is pressed, opening the supply circuit from the low-voltage rectifier. The energising period is only about a third of a second and, during this time, the changeover switch feeds a higher supply voltage to the right-hand motor, keeping the take-up smooth. The reason is that trouble was experienced after all adjustments had been made to suit the normal 26.5 cm spools and then small spools, perhaps of odd diameters, were fitted. Now there should be no spillage and a smooth pull when starting, even for the sort of frequent editing use that this class of deck often experiences.

Tape tensioning is altered by the switch shown in the illustration below (photo **G**), which is operated by a lever, swung outwards for the correct back tension when small spools are in use. The main problem is refitting, against the strong blade of the spring that locates the flat side of the lever stem.

A final note, resulting from a telephoned 'Do you get much bother with worn capstans ?'. To be honest, I had not suffered much; but the lads who give these machines a prodigious beating in the studios, where they are in operation many hours each day, report that capstan wear is something of a problem. Let me stress that it only affects absolute speed, and thus compatibility. The wobble figure does not immediately deteriorate. Chromium capstans are the cure, virtually unwearable but difficult to manufacture and consequently rather expensive.

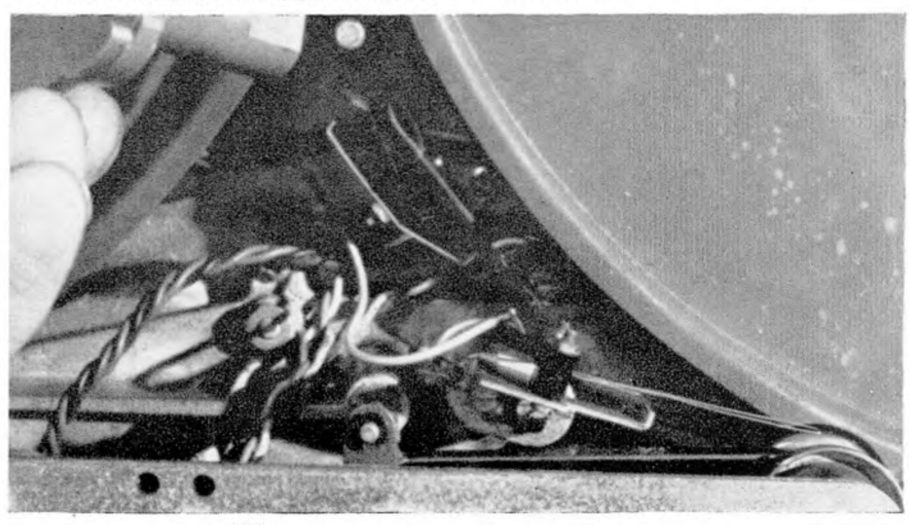


E Delayed-action relay



F Rectifiers are recessed in the deck assembly

G Spool tension lever ready for replacement. The F36 tape end switch can be seen and should be watched carefully when the top-plate is replaced



THE SOUND STUDIO

PART FIVE
AURAL AND VISUAL MONITORING

BY K. R. WICKS

VISUAL monitoring of a studio output is normally carried out using either a *volume unit meter* or a *peak programme meter*. The VU meter was developed in the USA in order to standardise programme levels in broadcast studios throughout that country. Compared with the PPM, it is relatively simple and cheap, consisting of a moving-coil meter with a full-wave copper oxide rectifier, and a series resistor. This meter is illustrated in **fig. 1a** and the sensitivity is such that the reference deflection (0 VU) is indicated when it is connected across a 600 ohm resistor dissipating 1 mW at 1 kHz (sinusoidal), which corresponds to a voltage of 0.775 V RMS. Reference volume is defined as that electrical programme signal which gives reference deflection on a standard VU meter, and volume units are used to express the level of any programme signal in decibels relative to the reference level. The term 'programme signal' infers a complex waveform with high peaks and, for this reason, only programme material should be quoted in VUs, the level of sinewave signals being referred to in dB's relative to 1 mW. The meter has a total resistance of 7.5 K which is high compared with the impedance across which it will normally be used, so that it is suitable for direct monitoring across lines, etc without risk of affecting the programme quality. The characteristics of the meter are such that, when suddenly connected to a sinusoidal voltage sufficient to give reference deflection under steady state conditions, the meter will read 80% of that deflection after 25 mS, and 99% after 300 mS, eventually overswinging by between 1% and 1.5%. This relatively long rise time causes the meter to indicate an average over a short period, which is effectively a volume indication. The great disadvantage of such a meter is that more than half the scale is occupied by the range +3 to —3 VU, leaving the low level end of the scale rather cramped, with the result that on much programme material, the meter will tend to indicate hardly at all, or else will flicker repeatedly from just above zero to full scale, causing the operator to suffer eye strain. This is a very important consideration bearing in mind that the meter may have to be watched for several hours without much of a rest.

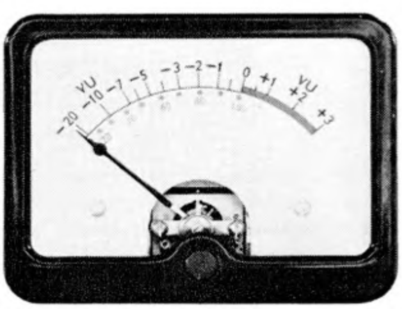


FIG. 1a
Ernest Turner VU-meter

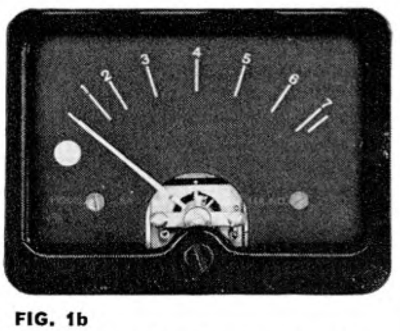


FIG. 1b
Ernest Turner Peak Programme Meter

The PPM was developed in the thirties by the BBC and is much more complicated, and therefore more expensive, than the VU meter. The essential difference is that the PPM, as its name implies, is a *peak* reading meter, which makes it very suitable for checking the programme level being fed to a transmitter or to a recorder, as both these devices will produce distortion on peaks of the signal voltage. The scale is approximately logarithmic and is calibrated from 1 to 7 as shown in **figs 1b** and **1c**, there being 4 dB between successive graduations. The PPM circuit consists of four basic parts:

(1) Input stage (high impedance).
(2) Rectifier stage.
(3) Timing circuit.
(4) Logarithmic stage.

A high input impedance is, of course, essential in order not to affect the material being monitored. The term 'high impedance' is usually taken to mean at least ten times the circuit impedance so that, for a 600 ohm line, the minimum acceptable impedance for a monitoring device would be 6 K. It is desirable to have a much higher input impedance than this, particularly when there is a possibility that several meters may be connected across the same circuit.

In the past, some confusion has been caused in the BBC when testing long lines. On one occasion, line-up tone which was being sent from Glasgow to London to establish a circuit before a broadcast was noticed to be varying slightly in level, indicating the possibility that a piece of apparatus somewhere in the chain might soon have become unserviceable. As is usually found when such a fault occurs, the sending end said that the tone was 'O.K. leaving us', and so the normal procedure of contacting intermediate stations between Glasgow and London was carried out in order to ascertain the point at which the fault was occurring. As more and more stations monitored the line, the level of tone received in London dropped until it was eventually nearly 2 dB below the line-up level ('4' on the meter), and when the fault was finally cured by the replacement of an amplifier, adjustments were made to bring the received tone up to the correct level. Everything was then apparently satisfactory, but within a few minutes, because other stations had stopped monitoring the line, it was noticed in London that the level of tone had risen by nearly 2 dB, which initiated fresh consultations with Glasgow, and led to some confusion.

At that time, most of the meters used had an input resistance of 10 K and, when it is realised that just four such meters across a 600 ohm circuit cause a drop of 1 dB, the need for much higher input impedances will be appreciated for cases like this, especially when separate loudspeaker units are used in addition to meters. Modern metering devices usually have an input impedance of 50 K or more, an input transformer with a 'floating' primary being used so that 'earth loop' problems do not arise, and balanced or unbalanced circuits may be monitored.

The rectifier stage is usually connected directly to the secondary of the input transformer, and it is essential that a full wave circuit is used if the direct voltage obtained is to be indicative of the peak signal level. This is because, with some sounds, the positive and negative peaks have different amplitudes, the ratio sometimes being greater than 2:1. If half wave rectification were used, the meter could give a reading more than 6 dB low if the smaller peaks happened to have polarity enabling them to be passed by the rectifier. With such a signal, the high undetected peak could cause distortion, and the meter reading would be dependent on the polarity of the input signal. Half-wave rectification is clearly inadequate for this application.

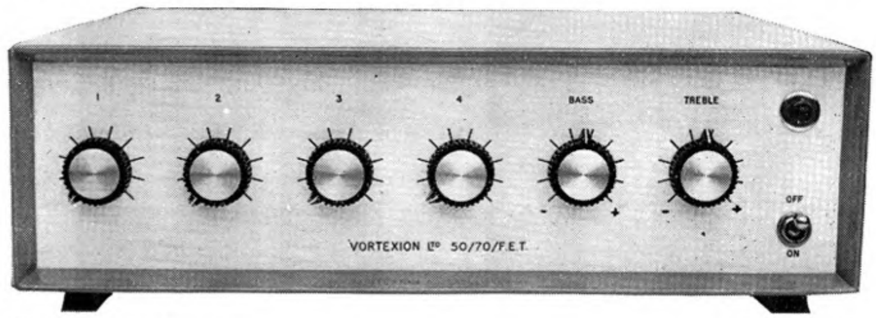
If the meter is to indicate peak signal voltages accurately, then it is necessary to store the peak voltage for a period of time sufficient to allow the pointer to reach the appropriate position, because short duration peaks of high amplitude could otherwise give rise to distortion without being indicated on the meter. The rectified signal is used to charge a capacitor, the charging time-constant (Tc) being made equal to 2.5 mS. In early PPM's, a much shorter charging time-constant was used so that the meter was capable of indicating, with a good degree of accuracy, peaks having durations as short as 10 μS, but it was later realised that the distortion caused by these peaks was not detectable by the listener, and the charging time constant was increased so that they would not be registered. This enabled signals to be safely set at a much higher level than had previously been possible without disconcerting high peaks being indicated on the meter. Distortion on high peaks starts to become noticeable when the duration is around 5 to 10 mS, and the timing circuit is usually designed so that the meter reaches within 2 dB of the steady state reading for pulses lasting 10 mS or longer. It is, therefore, necessary for the meter movement to be of

(continued on page 319)

Vortexion

This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable—100 Watt Amplifier (no failures to date) with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer amplifier, again fully protected against overload and completely free from radio breakthrough. The mixer is arranged for 3-30/60Ω balanced line microphones, and a high impedance line or gram. input followed by bass and treble controls. Since the unit is completely free from the input rectification distortion of ordinary transistors, this unit gives that clean high quality that has tended to be lost with most solid state amplifiers.

THE VORTEXION 50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4 WAY MIXER USING F.E.T.s.



Size 14″×11½″×4½″ Weight 20lb.
100 μV on 30/60 ohm mic. input
100 mV to 100 volts on gram/auxiliary input 100 KΩ

ELECTRONIC MIXERS. Various types of mixers available. 3-channel with accuracy within 1 dB Peak Programme Meter. 4-6-8-10 and 12-way mixers. Twin 2, 3, 4, and 5 channel stereo. Tropicalised controls, Built-in screened supplies. Balanced line mic. input. Outputs: 0.5 V at 20 K or alternative 1 mW at 600 ohms, balanced, unbalanced or floating.

200 WATT AMPLIFIER. Can deliver its full audio power at any frequency in the range of 30 c/s-20 Kc/s±1 dB. Less than 0.2% distortion at 1 Kc/s. Can be used to drive mechanical devices for which power is over 120 watt on continuous sine wave. Input 1 mW 600 ohms. Output 100-120 V or 200-240 V. Additional matching transformers for other impedances are available.

30/50 WATT AMPLIFIER. With 4 mixed inputs, and bass and treble tone controls. Can deliver 50 watts of speech and music or over 30 watts on continuous sine wave. Main amplifier has a response of 30 c/s-20 Kc/s±1 dB. 0.15% distortion. Outputs 4, 7.5, 15 ohms and 100 volt line. Models are available with two, three or four mixed inputs for low impedance balanced line microphones, pick-up or guitar.

CP50 AMPLIFIER. An all silicon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms-15 ohms and 100 volt line. Bass and treble controls fitted.
Models available with 1 gram and 2 low mic. inputs. 1 gram and 3 low mic. inputs or 4 low mic. inputs.

100 WATT ALL-SILICON AMPLIFIER. A high quality amplifier with 8 ohms-15 ohms and 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Input 0.4 V on 100 K ohms.

20/30 WATT MIXER AMPLIFIER. High fidelity all-silicon model with F.E.T. input stages to reduce intermodulation distortion to a fraction of normal transistor input circuits. The response is level 20 to 20,000 cps within 2 dB and over 30 times damping factor At 20 watts output there is less than 0.2% intermodulation even over the microphone stage at full gain with the treble and bass controls set level. Standard model l-low mic. balanced and Hi Z gram.

VORTEXION LIMITED, 257-263 The Broadway, Wimbledon, S.W.19

Telephone: 01-542 2814 and 01-542 6242/3/4 **Telegrams: "Vortexion London S.W.19"**

lightweight construction so that it can rise quickly, and will overshoot by a negligible amount. The timing capacitor is allowed to discharge relatively slowly with a time constant (T_D) of one second so that, for a short signal pulse, the voltage pulse across the capacitor is significantly longer, allowing sufficient time for the meter to give a fairly accurate peak indication.

A circuit showing how the required time constants are obtained is illustrated in **fig. 2.** The rise time-constant is given by $T_R = CR_R$ (neglecting the series diode resistance), and the decay time-constant is given by $T_D = CR_D$ (neglecting the shunt resistance of the converter stage, and the leakage resistance of the capacitor, which should both be very high). The effect of the storage capacitor is shown in **fig. 3** and it can be seen that, in the case of the shorter pulse, the meter reaches a peak *after* the pulse has ended. Although the indicated amplitude is slightly less than the true amplitude of the pulse, it is much nearer than the reading which would have been obtained had no storage capacitor been used.

As far as the registration of short duration peaks is concerned, the discharge time-constant could be made much smaller than one second, but it has been found that, with this relatively slow fall-back, eye strain on the part of the operator is substantially reduced. If, however, the decay time is increased still further, it becomes increasingly difficult to correlate what is seen on the meter with what is heard on the loudspeaker. Whilst on the subject of eye strain, it should be mentioned that the black scale with white markings and white pointer has been adopted in order to reduce this to a minimum.

The final part of the PPM amplifier is the *logarithmic law*, or *converter* stage, which should have a very high input impedance so that it does not reduce the discharge time of the storage capacitor to below the required value. In the original valve-operated units, a logarithmic response was obtained using the Ia/Vg curve of a variable-μ valve (see **fig. 4**). Linear changes in the grid voltage cause logarithmic changes in anode current which flows through the meter giving the required response. The fact that anode current decreases

FIG. 2 INPUT RECTIFIER AND TIMING CIRCUIT OF A PPM

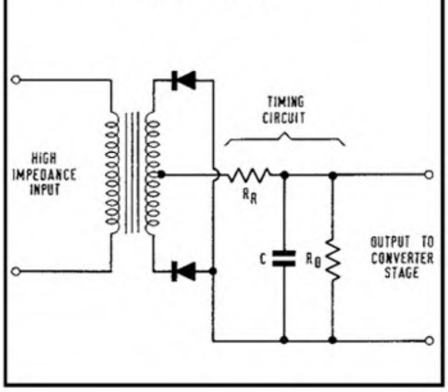
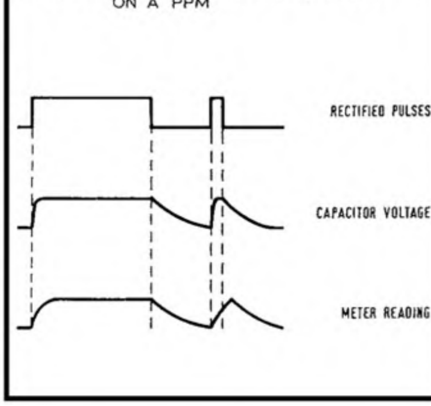


FIG. 3 INDICATION OF SHORT PULSES ON A PPM



as the negative grid voltage increases means that maximum deflection is obtained with no signal and, for this reason, the meter is constructed with a right-hand *mechanical* zero, so that when the apparatus is switched on, the meter will take maximum current and indicate the *electrical* zero on the left-hand side of the scale. Signals will cause the meter current to decrease, and a useful feature of this arrangement is the fact that it cannot be damaged by high signal levels, as these will simply reduce the meter current to zero.

Transistorised PPM amplifiers adopt a slightly more complicated method to obtain a logarithmic law, making use of the non-linear characteristics of a number of diodes in the meter circuit. The meter itself has a conventional left-hand mechanical zero, and under no-signal conditions, the meter current is zero. A current proportional to the storage capacitor voltage is applied to the meter circuit which is arranged so that, as the current increases, a larger proportion of it is shunted by the diode network, giving a law which is approximately logarithmic. A simplified diagram of such a circuit is shown in **fig. 5.**

Since the PPM was developed in England, and the VU meter in the USA, it is not particularly unreasonable to find that each country tends to favour its own type of meter, although generally, to a person who is used to a PPM, it seems incredible that anyone in their right mind would use a VU meter. I hasten to add that the popularity of the VU meter in the USA probably indicates that VU addicts have similar thoughts about the PPM, and it would seem that meter watchers prefer whichever type they are accustomed to.

The advantage of the PPM in that it indicates a *peak* reading has been explained, but this same characteristic also has a disadvantage. The waveforms shown in **fig. 6** each have the same peak value, but a sound with waveform **b** would seem noticeably louder to the listener than one with waveform **a.** In such a case, the VU meter would give a good indication of the relative loudness, whilst the PPM would simply show that the two signals had similar peak amplitudes.

The equipment used for aural quality monitoring should be capable of a very high standard of performance so that any distortion noticed can safely be attributed to the programme signal and not to the monitoring system. The input impedance to a loudspeaker amplifier should be high, and transformer coupled, for the same reasons as given for the PPM. In some systems, the loudspeaker monitoring is entirely separate from the visual monitoring, whilst in others the loudspeaker amplifier is fed from an output on the PPM amplifier, so that both meter and loudspeaker monitor the same signal.

Sometimes it is necessary to listen to the sound quality on headphones, but this should be avoided wherever possible because, for one

(continued on page 322)

FIG. 4 THE Ia/Vg CURVE OF A VARIABLE-μ VALVE

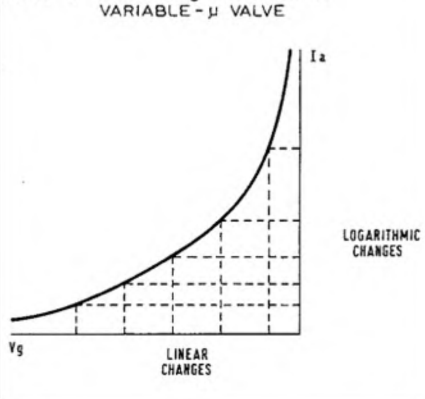


FIG. 5 SIMPLIFIED DIAGRAM OF A TRANSISTOR LOGARITHMIC STAGE

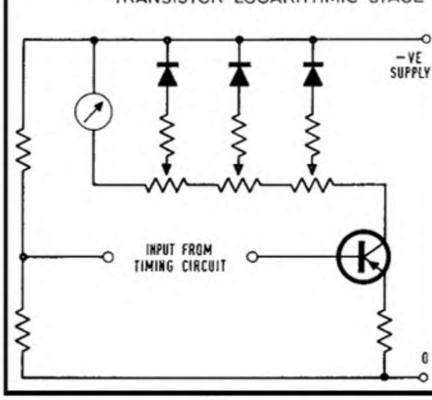
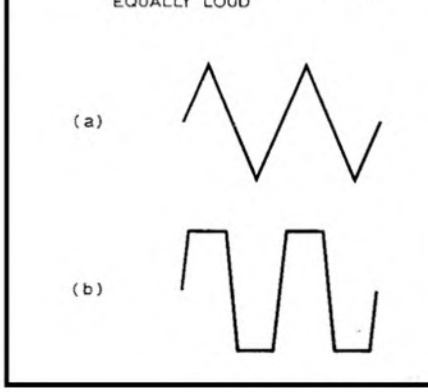
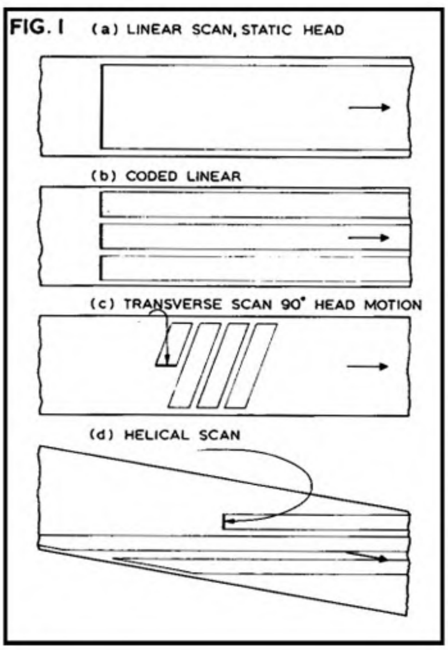


FIG. 6 SOUNDS OF SIMILAR PEAK VALUE DO NOT NECESSARILY SEEM EQUALLY LOUD



VTR CIRCUITRY PART 1

BY HENRY MAXWELL



SEVERAL interesting articles on video tape recording have appeared in the pages of *Tape Recorder* during the past couple of years, and we have been kept up to date with developments in this field, as well as its associated branch of closed-circuit television, by the assiduous Mr Golding. Correspondence on the subject has shown that an increasing number of readers wants to know what goes on inside the mysterious black boxes of the VTR system and in what specific ways the VTR differs from a conventional tape recorder.

In the following short series of articles the basic system will be discussed, with some of the underlying reasons for special circuitry. After this necessary groundwork, we can go on to dissect the individual circuits. As an example, the Sony system will be considered in some detail: partly because this is the type with which I am most familiar and partly because it is a widely used example of an inexpensive VTR or CCTV system.

From time to time alternative circuits, as used by other manufacturers, will be described, as will some of the special protection devices employed by the broadcasting authorities.

But we must start at the beginning, and this goes right the way back to the principles of magnetic recording. In many previous articles, writers have underlined the essential requirements for a recording system. The provision of an adequate bandwidth with low distortion takes pride of place. We must begin by considering how video tape recording makes special demands on the designer and, right from the outset, needs a new approach to recording techniques.

The frequency range of signals that can be successfully recorded and replayed on magnetic tape is dependent on the relationship between the width of the gaps in recording and replay heads (especially the latter) and the relative velocity of the tape to the heads.

Each cycle can be regarded as a pair of magnets of alternate polarity, when recorded on to the tape. The higher the frequency of the signal, the faster the reversal and the shorter the length of the recorded 'magnet'. For a given speed of tape travel, the HF bandwidth frequency is limited by the length of the magnet that falls near (not quite equal to) the length of the gap. That is, the 'wavelength of the recorded frequency', not to be confused with the normal wavelength in air of the signal, which is relative to the speed of light.

If we take a convenient figure, say an upper frequency limit of 15 kHz, and record at 19 cm/s, we find that each cycle of a sinewave signal at this frequency would take 15 mS to complete and would form a 'pair' of magnets 19÷150 m long.

This magnetic wavelength could be handled by a gap of just less than 50 μ, in theory. In practice, replay head gaps of 3 μ are quite common and audio signals of 12-15 kHz can be resolved at the speed of 9.5 cm/s. In fact, frequency limits of 8-10 kHz are quite often specified for cassette tape recorders running at 4.75 cm/s.

By increasing the tape transport speed we make each recorded magnet longer—i.e., more tape passes the head in a given time. Therefore, again in theory, all we have to do to increase the recording bandwidth is to increase the relative tape/head velocity.

Theory and practice are very different, and we find that there is an upper limit determined by mechanical considerations. The amount of tape to be handled by increasing the speed soon begins to assume formidable proportions. Spool size and high speed of rotation threatens tape damage, and the high peripheral velocity introduces a larger margin of speed error.

Linear recording is thus limited by physical considerations. Nevertheless, quite remarkable performances have been produced. VERA (Vision Electronic Recording Apparatus) was the darling of the BBC in 1958, and held the stage until Ampex brought along more attractive equipment. Vera operated at a tape speed of 508 cm/s, but even then the signal had to be coded on to three channels, side-by-side on a 12.5 mm wide tape to obtain a near 4 MHz bandwidth for video information. Even this is not sufficient for 625-line signals, which need more than 5 mHz if the improved vertical definition is to be maintained.

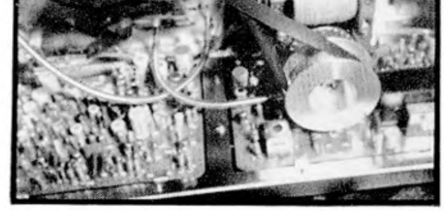
To achieve these bandwidths with conventional linear tape recording would require tape speeds too high to be practical. The answer is to increase relative tape-to-head velocity by moving the *heads* as well as the tape. There are several ways of achieving this end, and the two most popular are *transverse scan* and *helical scan*.

Transverse scan, with several video heads revolving at 90° to the direction of tape travel, is used professionally, and has been refined to a high standard by manufacturers Ampex and RCA. Transverse scan machines are complicated and costly—too expensive to be suitable for domestic or industrial use. Helical scan, though something of a compromise, has made possible the recording of television signals at least as good as the average quality of reception on the domestic TV set.

A Top deck of the Sony *CV2100E*, the dual-standard model with dubbing and editing facilities and AGC.

B Sony *CV2000B*, full-track erase head and guides to the left of the video drum.

C Crossed belt drive and electromagnetic brake.



The helical scan technique requires a revolving head, or heads, within a drum around which the tape is passed in a slow helix. The head thus scans a series of diagonal paths on the tape, the length of the diagonal determined by the slope of the helix and the relative head/tape velocity.

There are several helical scan systems, Ampex, Philips and Sony being leaders in the field. As with transverse scan, it is possible to engineer helical scan machines to a very high standard, and costs mount progressively.

The Sony system was one of the first to bring video tape recording of any acceptable quality within the pockets of smaller firms, local authorities and even the private individual, and will be considered here in greater detail. Taking the 405-line system as an example, the two heads employed rotate on a common spindle at 25 Hz. 12.5 mm tape is driven round the drum at 19 cm/s. The guides are so arranged that the tape wraps around the drum for approximately half of its circumference and each head is in contact with the tape, through a slot in the drum, 50 times per second. Direction of tape travel is conventional (left to right). A full-track erase head is located before the drum and a combination head after the drum serves to record an audio track and a servo speed control track.

The control track is at the bottom and the audio track at the top edge of the tape. Video information is recorded as a continuous succession of diagonal tracks in the space between. The dimensions of the tape and its magnetic patterns are given in **fig. 2**. The Sony *CV2000B* uses a 19 cm spool, providing one hour of playing time.

405-line television signals are made up of 50 202.5-line interlaced fields per second. In practice, the picture itself does not take up the whole 202.5 lines, several lines being blacked out during the field synchronising period of the television signal. Vertical definition, per field, can be limited to about 200 lines, without any loss of picture detail, provided arrangements are made for synchronising: Sony do this by locking the recording system to the 25 Hz incoming frame pulses (two interlaced fields), at which rate the head assembly rotates. The method of synchronising will be considered in greater detail later.

Video bandwidth, as we have considered, is limited by head structure and tape/head velocity. It is related to the number of lines, giving the balance between vertical and horizontal definition. Vertical definition is dictated by the line structure: horizontal definition for a 405-line picture demands a bandwidth of nearly 3 MHz for fine detail to be resolved. A 625-line signal requires a video bandwidth of more than 5 mHz.

To achieve a 3 MHz bandwidth at a 19 cm/s tape speed, a 25 Hz head rotation is not practicable. Sony reduce the bandwidth required by limiting the vertical definition to 200 lines, thus demanding only a 1.8 MHz bandwidth to achieve a resolution up to the quality of most domestic receivers.

This compression is achieved by recording alternate fields and playing these back twice. During recording only one of the two heads is active, tracing out diagonal paths on the tape. During replay, both heads are in circuit, the head bracket being arranged so that as one head leaves the end of a diagonal, the next takes over at the beginning. Thus the single track is replayed twice in succession. Change in picture content between one line and the next is very small, and the slight loss in overall resolution suffered by this method is more than justified by the reduction in bandwidth—and in cost of apparatus—that the system allows.

To employ a system such as this, very precise timing is needed, so that the scanning locks to the field pulses of the off-air signal or to the simulated field-pulse of the generator in the camera. On replay the heads will again scan precisely the recorded tracks, with no wander or overlap. The system must be made independent of mains frequency variations, which, despite the consistency of our National Grid, are outside the tight tolerances needed; independent, too, of variations in the synchronising pulses of the television signal which may be caused by transmission errors (!) or bad reception conditions. Interference from noise must also be minimised to prevent random triggering.

The basic drive of the Sony *CV2000B* is provided by a single-phase hysteresis synchronous motor with belt coupling to the head and servo assembly. This main spindle is arranged to run at about 23.4 Hz and is braked by an electromagnetic system something like the principle of the conventional squirrel-cage induction motor. Interaction of a stator field and the induced field in the rotor gives a braking effect proportional to the current producing the stator flux. This is derived from pulses obtained from a single coil mounted in the drum wall and a pole piece mounted on the drum assembly. Once per revolution (25 times per second) a pulse from this coil is amplified, gated, and integrated, then fed to a direct-coupled amplifier from which a control current for the stator coil is obtained.

The timing is achieved by reference to the incoming sync pulses from the television signal (or the camera generator) during recording, and by reference to the recorded control (CTL) pulses during playback. But the circuits are arranged so that the timing is not dependent completely on the individual sync or control pulses; an electronic flywheel action is employed, making the system independent of minor variations.

When recording off-air, the sync pulses are applied to a sync separator biased to be driven into conduction by the pulses. The sync pulses are thus amplified and separated from the video information. After further amplification and integration, and passing through a low-pass filter, only the 50 Hz field pulses remain and are used to trigger a delay multivibrator.

The output of the multivibrator has the same pulse-train rate and mark-space ratio, but with an adjustable delay to provide a timing reference for the monostable multivibrator. One output from this stage feeds the control recording head and another is integrated and passed to the gate, where the 25 Hz pulse signal previously mentioned has also been applied. The output from the monostable multivibrator is passed through the gate as it is opened by the 25 Hz pulse. If the speed of the rotating heads is too high, the 25 Hz pulse arrives early, the gate passes a larger part of the waveform envelope and a larger current is passed to the braking coil. Too late a pulse because of slow running causes envelope restriction, reduction of braking current and an attempt by the drive system to resume the uncontrolled running speed which, as we have noted, is slightly fast. Overall speed stability with this system is better than 0.2%.

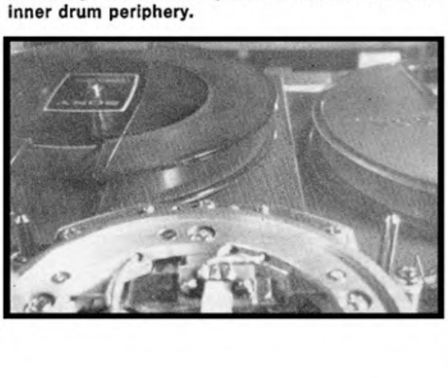
Two other sets of pulses are generated by the rotation of the main drum; it is necessary to consider these before returning to the 25 Hz pulse and its action during camera recording and replay.

A 50 Hz pulse is generated by placing two pole pieces 180° apart on the rotating assembly and using these to activate a single pickup coil. From this 50 Hz pickup a pulse is sensed, amplified and passed first to the mixer circuits of the video output section of the main VTR for synchronisation of the monitor and secondly to the camera as a trigger pulse for the vertical oscillator. Thus, the VTR, the monitor and the camera, in both off-air and closed-circuit conditions, lock to the speed of the rotating drum, which has been referred during off-air conditions to the periodicity of the incoming field pulses, but is not continuously dependent on them for its regularity. A 9 V p-p signal is available at the mixer for monitor sync, and this pulse is a good deal more stable than the average pulse from a TV receiver timebase. With all adjustments made correctly, a solid field lock is obtained.

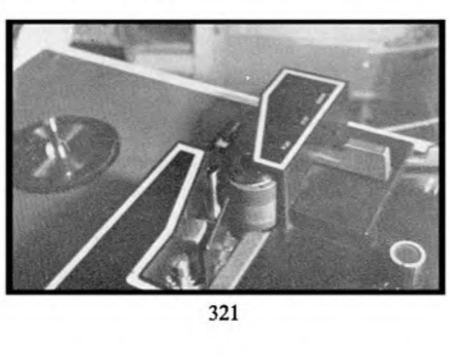
The third of the sets of pulses is the 10.125 kHz line frequency reference pulse which is employed as a trigger for the camera line timebase, again locking the complete system, independent of the incoming sync pulses. Two coils are mounted axially to give 180° out-phase signals from a toothed drum mounted on a rotating assembly. The drum has 405 grooves and, as it rotates at 25 Hz, a (405 x 25) 10.125 kHz pulse is generated in the pick-up coil. This

(*continued on page 323*)

D Inner edge of the Sony video drum. Note the mountings of the pulse generator coils around the inner drum periphery.



E Pressure roller, capstan spindle and combined control-track/audio head of the *CV2000*.



thing, the bass response will depend on the (physical) size of the operator's head, the tighter the headphones the more bass being heard, making complex balancing difficult. The treble response of headphones varies considerably between different types, which is illustrated by the fact that when, at Broadcasting House, the old-fashioned heavy headphones were replaced by a more modern lightweight type, it was found that low level induction noise, previously undetectable, was easily heard on post office lines. (This noise, incidentally, used to be heard on good quality FM receivers just before a contribution from a region, although nowadays, since most programmes are recorded, the induction is masked by tape hiss.)

MONITORING PRACTICE

The monitoring and control of the output of a sound studio is necessary at the source in order to obtain the desired quality and balance, and to restrict the dynamic range of the output.

Aural monitoring is used to determine balance, as voices or instruments which give similar readings on a meter do not necessarily sound equally loud. The need to reduce the dynamic range of a programme arises when it is greater than that which can be satisfactorily dealt with by a transmitter or recorder, the lowest acceptable level being determined by the noise in the system, and the highest level by the point at which overload distortion occurs. Thus, without control, a piece of orchestral music might well be inaudible during the quiet passages, and distorted during the loud parts. Normal BBC practice restricts maximum peaks to '6', which corresponds to 100% modulation, and requires that peaks below '2' do not occur for long periods, and so a musically educated operator with a score would be required in order to control the music successfully.

It is important to maintain as much as possible the contrast between loud and soft passages of music, and so when a loud passage is followed by a very soft one, the level should be *very gradually* increased after the change. Going from a quiet passage to a loud one, the change would have to be anticipated from the score, and the level gradually reduced just before the start of the loud passage in order to achieve a successful compromise between restricting dynamic range, and maintaining aural contrast.

The monitoring facilities provided will obviously vary from studio to studio. It is often desirable to be able to monitor any individual input to the studio mixer before the fader is opened, so that tests and level adjustments can be made prior to fading up, without affecting the mixer output. This *prefade* facility is provided in broadcast continuity studios which are used to link programmes coming from different sources, and just before the end of a programme, tests are carried out on prefade with the next contributor. It is interesting to note that the technical controllers in continuity studios rarely listen to their own output. Most of the time the PPM is across the output, but the loudspeaker is connected to an automatic switch which sequentially monitors AM and FM check receivers. Every 30 seconds, there is a substantial change in quality which can be quite alarming in the evenings when AM reception is so bad. Although the system usually confirms that at least one transmitter is working at any time, the disadvantages are great, and it is possible for a break in transmission of up to 30 seconds to go unnoticed if the other transmitter is being monitored at the time. Moreover the reception of AM is often sufficiently bad to prevent the operator being aware of any distortion or extraneous noise on the programme itself, although it is, of course, always possible to switch to the studio output if any query regarding quality arises. Many operators working with this system consider that it would be better to monitor the continuity output, and leave the public to listen to the radio.

Monitoring facilities which have not been mentioned include the jacks fitted to individual tape and disc machines to enable them, with the aid of headphones, to be set up ready for replay, and the jacks fitted inside the studio (as opposed to the control cubicle) for headphone monitoring by the artist or announcer. Loudspeaker monitoring in the studio itself is uncommon, for obvious reasons, but is necessary in continuity studios where the announcer needs to listen to the programme but does not want to wear headphones all the time. In this case, it is arranged that the loudspeaker is muted when the microphone is switched on, so that acoustic feedback is prevented.

Next month's article will cover miscellaneous studio facilities, including response selection amplifiers and reverberation plates.

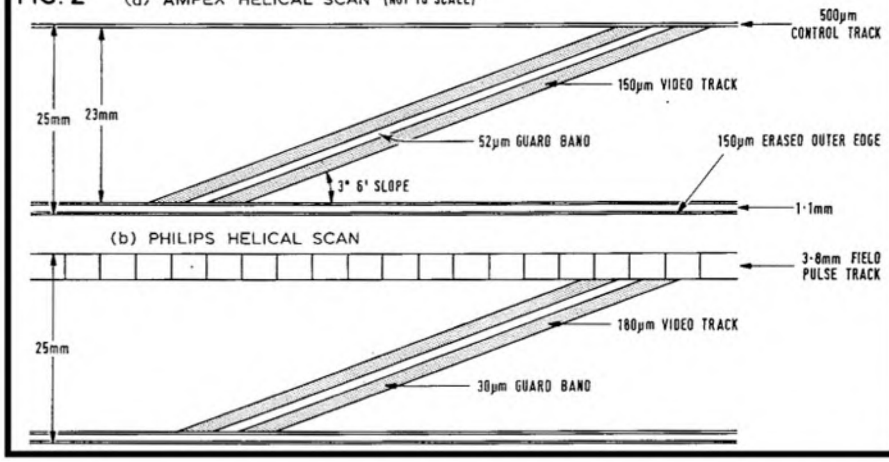
pulse is fed to a balancing circuit, then amplified and applied to the camera.

Recording from the camera requires disconnection of the separated pulses from the off-air source and application of the secondary feed from the 25 Hz pick-up coil to the pulse amplifier and delay multivibrator, and the output from the multivibrator again records control pulses on the tape. To stabilise the camera recording even more, an additional multivibrator pair is switched in to the feed line to the pulse mixer.

Because there are no 50 Hz sync pulses available as reference when recording via camera, a different arrangement has to be made for brake stabilisation, and this is done by first setting the brake retard with an off-air signal, then adjusting a preset in the brake stator return line to obtain the same pulse lock for camera recording. In setting up, this means that an oscilloscope has to be connected to the video output test point (vertical plates) and synchronised by the 50 Hz sync pulse from the separated signal. It is preferable to take off this sync after the low-pass filter. The 50 Hz pulses of the composite video signal prior to application to the monitor, will be those obtained from the pulse sensing and reference circuits. These are then made to overlap those from the sync separator. In practice, the pull-in range of the multivibrator circuits gives a lock when the overlap is within 1/25th of the pulse interval. This represents an error of some 4 μS.

On playback, the pulses recorded on the lower track of the tape are picked up in the control head, fed to a preamplifier and thence to the sync/control amplifier of the main video pulse control chain, with the sync separator amplifier now switched out of circuit. The integrator is bypassed and the amplified control pulses amplified, delayed and fed to the monostable multivibrator, where they are shaped prior to input to the integrator and gate chain. Here they are compared with the 25 Hz reference pulse, as before. The output from the gate is again integrated, as for recording, and used to control the braking circuit. The 50 Hz pulse

FIG. 2 (a) AMPEX HELICAL SCAN (NOT TO SCALE)



Ampex single-head helical scan using 25 mm tape gives a trace speed 2200 cm/s, increasing to 25,400 cm/s on 60 Hz mains.

is again applied to the monitor for vertical sync, providing an additional reference for a stable lock. Adjustment for overlap of the vertical fields on playback is obtained by physical adjustment of the 50 Hz coil.

Video signals from the monitor are used to provide modulation, but require a good deal of processing before they can be applied to the transducer. The characteristics of magnetic recording are well-known and need no underlining. Because of the non-linear transfer characteristic of the recording head and the magnetising process of the tape oxide, some form of high frequency bias is required for normal audio tape recording. This has to be several times the highest frequency of the signal to be recorded. In the audio chain of the Sony *CV2000*, the HF bias is 90 kHz. For video recording, where the highest frequencies are several megacycles, such a method is not feasible, and instead, the video signal is used to modulate a frequency modulated carrier which then provides the recording current.

Individual circuits in this system will be given and described in later articles.

The 1 V p-p video signals from the TV or camera, with negative-going sync, modulate a double sideband FM generator operating at 1.7 mHz. Other advantages that accrue from the use of this method are preservation of the DC component, i.e. zero deviation, and a protection against amplitude variations which are inevitable with tape to head contact, unless (as in the transverse-scan Ampex) a suction pump is used to maintain intimate contact of the tape with the heads.

A white clipper precedes the modulator, and clamping has already set the DC reference level. A record amplifier feeds recording current to the head, with pre-emphasis to allow for the non-linearity of the recording system. Part of the signal is fed to the playback stages at a preset level and, in fact, a video signal plus pulse mixing and sync lock are available from the playback output during recording—a facility that can be useful for cascade operation of a combined system.

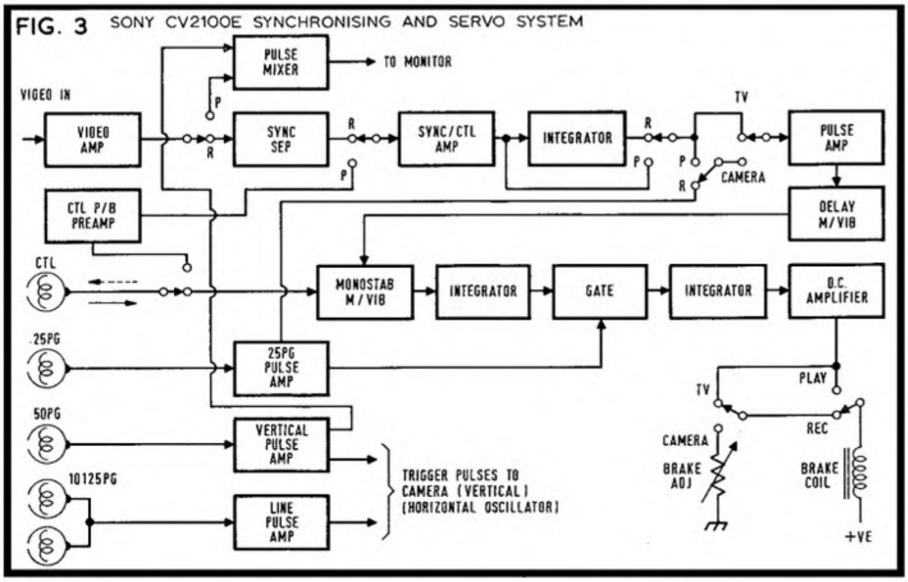
Playback requires much more complicated processing, both to maintain the original signal after demodulation and to eliminate noise and other undesirable interference effects. The frequency characteristic of the reproduced signal has the usual 6 dB-per-octave characteristic, familiar to tape recording enthusiasts. Because of the frequencies involved, the losses are greater than with audio recording, and the curve droops at the upper end, so that equalisation is not a simple affair of series RC feedback.

A pair of amplifiers boosts the small signal from the heads, one handling each output, and the combined output is balanced before application to a mixer-amplifier, where they reform the complete carrier signal—still at FM. Several limiting and amplifying stages follow and control of the signal to prevent limiter saturation (a familiar cause of signal degradation in FM amplifiers) is carefully adjusted.

The amplified, limited signal is applied to a differential transformer and the resultant square-wave feeds a push-pull demodulator, the combined pulse output from the pair of opposing diodes being at twice 1.7 mHz. The signal is now a series of sharp spikes and, passing through a low-pass filter with integra-

(*continued on page 336*)

FIG. 3 SONY CV2100E SYNCHRONISING AND SERVO SYSTEM



APRS 69

David Kirk reports on the 1969 APRS Exhibition

AT 10.30 in the morning of Saturday 17 May, the doors of the Woburn Room at London's Hotel Russell opened on the second annual APRS Exhibition. Thirty companies displayed studio equipment from manufacturers in Britain, Denmark, Italy, Norway, Switzerland, the USA, and West Germany.

APRS 69 was dominated by stacked-head multi-track recorders, reflecting a major trend in studio demand which stems from an increased public appetite for pop music.

The largest and prettiest multi-track machine (it won an APRS award) was the Ampex *Master Maker 1000*, a two-speed console with rapid-conversion facilities for eight tracks on 25 mm tape and 16 or 24 on 50 mm. The basic *MM1000* is an eight-track system operating at 38 and 19 cm/s. Eight reasons for its prettiness, perhaps, are the multi-coloured illuminated channel mode selectors. These switch from a red record position, through yellow to green playback. Self-synchronisation enables an artist to monitor earlier performances from the record head stack while recording his own offerings on one or more free tracks.

Ampex have based the *MM1000* tape transport on their VTR mechanism. In common with Leevers-Rich, Scully and 3 M multi-track models, it is solenoid-operated, capable of full remote control, and operates at 38 and 19 cm/s. 38 cm/s specification with Ampex *404* tape is 30 Hz-18 kHz ±2 dB frequency response for 1.1% distortion and 60 dB signal-to-noise ratio. Crosstalk at 500 Hz is —50 dB on eight- and 16-channel systems. Playback wow and flutter on an 0.03% Ampex test-tape totals 0.08% RMS. Basic price of the eight-channel unit is £8,534.

Another new Ampex, replacing the *AG-440*, was the *AG-440B*. This provides multi-track facilities on a smaller scale: one or two channels on 6.25 mm tape or four channels on 12.5 mm. The four-track model costs £2,439 basic.

Feldon Recording displayed two multi-track recorders manufactured by another American manufacturer, Scully. One of these, an eight-track machine (see photo) could just be defined as portable. The *280* series comprises eight versions, of which the most elaborate is the 12-channel *284-12*. This takes 25 mm tape and has a 38 cm/s specification of 30 Hz-18 kHz ±2 dB frequency response for 56 dB signal-to-noise ratio (+6 VU to noise). Total harmonic distortion of the playback amplifier is 0.5% at +18 dBm and peak unweighted wow and flutter totals 0.08%. The model illustrated (bottom, far right) is the transportable *284-8*.

Leevers-Rich, now the only important British manufacturer of studio recorders, exhibited an eight-track 25 mm *G 858*. Crosstalk is better than —50 dB at 1 kHz (46 dB at 10 kHz), signal-to-noise ratio being 60 dB below peak (32 mM/mm). Frequency response is described simply as 'to B.S. 1568:1960' while 38 cm/s wow and flutter total 0.06%.

The danger of accidental erasure can be eight times greater with an eight-track recorder than with a 'one-run' stereo or mono unit. Hence the adoption of an uncluttered 'penthouse display' meter panel and illuminated track and mode selectors.

A multi-track recorder with a difference was shown by 3M. Their *Mincom* range employs an *Isoloop* system to reduce spool tension effects at the heads. The transport was originally designed for telemetry and is currently being used by the NASA.

Whether future multi-track recorders will imitate the *Isoloop* is open to conjecture. Several manufacturers are rumoured to be developing multi-channel recorders employing pulse code modulation instead of stacked heads. This could return the industry to 6.25 mm tape but might also create standardisation problems as great as those in the industrial VTR field.

Other recorders at APRS 69 included a new model from Tape Recorder Developments, the *600/P*. Solenoid controls, variable speed spooling, and plug-in silicon-planar electronics are among the features. The *600/P* is a single-channel machine and costs £365.

Hayden Laboratories displayed the *Nagra 4* battery portable and confirmed that a stereo model was still many months into the future. Six mono versions are available to meet the requirements of sound and film industries. Also on show was a Sondor 16 and 35 mm sprocketed tape recorder. A 5 mS start-up period is claimed, with 0.1% wow and flutter. Hayden now represent the Italian Appel company, manufacturers of 19 cm/s studio cartridge players. Wow and flutter are specified as approximately 0.4% p-p with BASF *PES 45* tape. Frequency response is ±1 dB from 50 Hz-10 kHz for 1.5% overall distortion at +15 dBm, 1 kHz. Unweighted noise level, without tape, is —55 dB. Maximum loop duration is 7 minutes 30 seconds, the minimum recom-

Tape Recorder Developments *600P*.

Ampex *MM1000* sixteen-channel.

Leevers-Rich *G 858* eight-channel.

APRS 69

David Kirk reports on the 1969 APRS Exhibition

mended duration being one minute.

A four-channel 6.25 mm Crown International recorder was to be shown by Carston but failed to arrive in time. The new £115 *DC 40* amplifier was displayed. In addition to representing Crown, Carston run a hire division and can supply professional sound equipment on short term or contract rental. Carston's own product was a new wow and flutter meter, the *1301*, believed to be the only battery-powered model currently available.

John Bauch, Michael Bauch and Werner Wahl manned the F.W.O. Bauch stand, displaying and discussing the products of Studer, EMT, Neumann, Albrecht, Danner, Klein & Hummel, Europa Film and Universal Audio. The three Studer exhibits were two studio recorders and the transportable mixing console introduced at the 1968 International Broadcasting Convention.

Several Uher domestic recorders on the Bosch stand provided a curious contrast with the rest of the exhibition. Centrepiece of their display was a new version of the Uher *1000* professional battery portable.

The EMI emphasis was on tape rather than recorders, though a *BTR4* rubbed shoulders with a Ferrograph *7*; Mr Griffiths using his influence? Test equipment on the stand enabled the EMI team to demonstrate the performance of *815* and *825* professional low-noise tape and their existing *811* and *812* brands. *Afonic 99* is their contribution to low-speed narrow-track recording and EMI claim to have improved the signal-to-noise ratio without the usual increase in print-through.

AKG featured the *D224E* dynamic and FET *C451* capacitor microphones. The former is the most elaborate of several twin-coil microphones produced by AKG and employs a cross-over system to achieve a useful frequency range of 20 Hz-20 kHz.

Audio & Design displayed a new addition to their *F600* series of limiter/compressors. The *F700* has a range of compression ratios from 2:1 to 20:1.

In addition to importing Sennheiser microphones and mixers, Audio Engineering announced that they were acting as a sub-agency for Tandberg *11*, the main agents being Elstone Electronics. Since the APRS Exhibition, the company has been made UK representative of Stellavox. The *SP7* is a stereo battery portable operating at 38 and 19 cm/s and starting in price at £364.

BASF offered specifications and samples of their *LR56*, *LGR*, *LGR30* and *PES40* professional tapes.

The Bruel & Kjaer exhibit comprised a *4712* frequency response tracer, *SMG1* stereo generator, *4910* strobescope and a *Peekel TF824* bandpass filter. The latter incorporates 11 filters between 5 Hz and 18 kHz with individual attenuation of up to 55 dB.

Dr Ray Dolby, aided by his wife Dagmar, David Robinson and Ioan Allen demonstrated the Dolby *A301* noise reduction system, using examples played on a Studer console recorder. The system provides a 10-15 dB reduction in tape hiss, print-through and crosstalk, and 10 dB increase in dynamic range. It can now be leased for less than £3 10s (tax relief lowers this to £2) per week or purchased outright for £560. A very much simpler version is incorporated in the KLH *40* stereo tape unit, on sale in the USA, to give 66 dB signal-to-noise ratio at 9.5 cm/s compared with 58 dB when the circuit is switched off. Scotch *202* tape adds a 3 dB improvement.

A compressor/limiter designed by Peter Levesley was exhibited on the Audio Developments stand. This recently-formed company specialises in the manufacture of modular studio electronics. Existing designs include microphone preamplifiers, line, mixing and power amplifiers, and PPM units. Complete mixing systems using A.D. modules can be supplied to individual order.

British Homophone displayed items from their range of disc-pressing machinery, including an 18 cm record die.

The spring reverberation and ambiophonic units produced and exhibited by Grampian are now widely used in studios and provide an inexpensive alternative to the EMT plate. Also displayed was the *16/6* six-channel microphone mixer. Rotary level controls on each input can be preset and cut in with separate switches, if desired, a master fader operating on all channels (unless otherwise specified). Six basic versions are available with 200 µV at 25 ohms, 450 µV at 200 ohms, or 500 µV at 600 ohms inputs, balanced or unbalanced. Output level is 0.775 V at 600 ohms with under 1% distortion and —65 dB noise. Tone controls are mounted on the rear panel giving —10 dB at 100 Hz and —12 to +6 dB at 10 kHz; 'level' frequency response is 100 Hz-15 kHz ±2 dB. A damped-movement 1 V output meter is incorporated to prevent accidental overload.

(continued overleaf)

Studer *C37*.

3M *Mincom*.

Scully *284-8* eight-channel transportable.

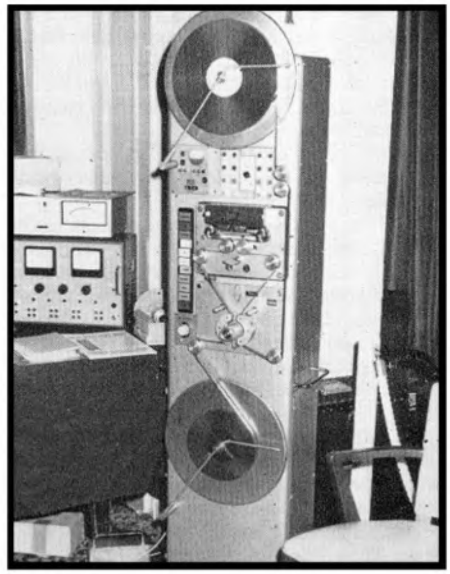
A range of studio amplifiers, preamplifiers, tone controls and metering units were shown by J. Richardson Electronics.

Electrovoice microphones were displayed by the importer, KEF, alongside KEF's own *LS5/1A BBC Monitor* loudspeaker and its intended successor, the *LS5/5*.

E. G. Lennard and Stanley Kelly manned the Lennard Developments stand, showing the new *ME104* wow and flutter meter and *ME301* wave analyzer. The *ME104*, manufactured in Germany by the Bruno Woelke Technisch-Physikalisches Laboratorium, succeeds the *ME101* reviewed in September 1966. It employs a 3.15 kHz oscillator and features $\pm 0.3\%$, $\pm 1\%$ and $\pm 3\%$ peak measuring ranges.

Transco master disc recording blanks, an inexpensive 18 cm Allied Recording blank, and Standard elapsed time indicators occupied the Leonard Wadsworth stand. Among the Standard products was a 25 cm diameter wall mounting ETI.

Lockwood provided the only organised demonstration at APRS 69, in conjunction with Tape Recorder Developments and Richardson Electronics. The new *LE/1 Universal* was among the Lockwood monitor speakers operating in the first floor demonstration room.



Sandor sprocketed tape transport

Rupert Neve and Company, one of the most respected studio mixer manufacturers in the world, waved their flag from Stand 23. Neve produce systems ranging from a portable ten-channel unit to a 48-channel console.

The Scopetronics display centred on the new *1151* transport. This is a solenoid-controlled version of the *1150*, also shown, and incorporates optical autostop and remote control facilities.

A five-channel mains/battery mixer with four low-impedance and one line inputs, the *M67-2E*, was exhibited by Shure. Among the Shure microphones displayed were the *SM5* unidirectional boom and SM33 unidirectional ribbon.

In conclusion, our congratulations to John Borwick and his colleagues for a well-managed and civilised exhibition. We wish every success, and a few more live demonstrations, to APRS '70.

... about discs and cassettes

From: Robert Auger, Halfacre, Bix, Henley-on-Thames, Oxfordshire, RG9 6DB.

Dear Sir, Your editorial in the May issue is most refreshing, but I would like to comment upon one or two minor points.

Firstly, I think you have misunderstood the section of my [*Amateur Photographer*] article wherein I mentioned the problem of record companies not planning new releases in view of the vast amount of material which is already available on disc. The point I endeavoured to make was that every time a major industry finds itself in a quandary as to how to attract further public interest, it invariably turns towards some new technical innovation, and of course this was my point in drawing a parallel with the film industry. When the mono LP catalogues were choc-a-bloc with duplicated versions of the classics along came stereo, and once again the companies had an excuse for re-recording the whole standard classical repertoire. I believe that the next excuse, if you like, will probably come from an advance in the tape medium and the cassette seems to me to be the logical development in this field.

Also, it was never my intention to suggest that the tape cartridge *as it stands at present* is good enough to take over, from a technical quality point of view, from disc, but we should consider the enormous strides made in developing slow speed tape recording over the last ten years. Once we stop to think about these advances, then I am confident that there will be even faster development in tape recording and high speed duplication in the very near future. I am personally unable to see any similar major strides in disc recording on the horizon.

Yours faithfully

... about measuring wobble

From: W. H. Myall, 35 Villiers Road, Watford, WD1-4AL.

Dear Sir, For several months now I have had a small bee in my bonnet over a comment in one of your editorials, attributed to Messrs. Dolby and Terence Long.

The gist of the comment was that it is not possible with present techniques to measure wobble much below 0.03% (presumably RMS). To find a similar view expressed yet again in your May issue is really too much of a challenge not to be taken up.

The repetition appears in the article by Arturo Stosberg ('A Capstan Servo System for Studio and Home Tape Recorders'). The figure given in this case is 0.04% and is described as 'nearly unmeasurable'. I am wondering if there is any significance in the fact that the claimed limitation is appended only to the figure according to American standards (again presumably meaning RMS). If so I can see no foundation for this either. It would stand up if the error signal was far from sinusoidal (the RMS value of an occasional 'pip' being very low). The figures given in the article, however, rule this out.

It must be assumed that these views stem from experience with a particular measuring instrument, in which case the limitations may well be those imposed by the instrument itself rather than by the technique employed, and could result from economic considerations allied to the needs of the best tape transports the industry can provide today. To my mind, the impression created by these statements is that wow and flutter meters in general are not capable of doing any more than confirming a mediocre tape transport as being just that.

I can only speak from experience with my own instrument and in this instance a wobble of 0.03% is a long way from being unmeasurable. I am not overstating my case when I say it would plainly differentiate between 0.01% and no wobble at all. An error in the reading there certainly would be, but this is mainly due to the non-linearity which creeps in at the lower end of the scale and is common to most, if not all, AC measuring instruments incorporating meter rectifiers. By comparison, noise at this level of wobble has barely reached significance.

The wobble waveform, before becoming distorted by the meter rectifiers, is of sufficient fidelity to suggest that, should the need arise, a quite accurate reading of 0.01% could, in fact, be achieved.

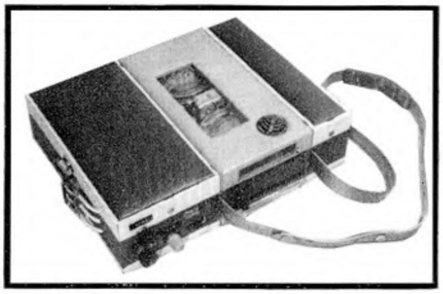
The non-linearity can be minimised in several ways but beyond a certain point it becomes easier to introduce a more sensitive range whereupon the smallest reading required is no longer near the bottom of the scale. Easier, but not economically sound whilst there is no call for it. *Yours faithfully*

... about printed leader

From: C. Champney, Speedwell, 20 Bellevue Road, Southampton, SO1 2AY.

Dear Sir, I wonder if through the columns of your magazine it would be possible to find the name of a supplier of printed leader tape. As a supplier of recorded tapes, we wish to trace a firm able to print our name on leader but have been unable to find anyone. *Yours faithfully*

A STEREO FI·CORD



M.G. Skeet* describes the conversion of a Fi-Cord 1A

PART 1

IN the tape recording field, surely the Fi-Cord *1A* of the late '50s is as revered as Brough Superiors and 'Moggy' Morgans are in motorcycling and motoring circles. Here was a small, two-speed battery portable tape recorder with a sensible faster speed of 19 cm/s which, despite its lack of powered rewind, has in its day been enthused over. The writer's first acquaintance came at an Audio Fair in London. The first thought, 'gimmick,' was quickly replaced by disbelief when a recording made on an outboard powered boat was played back on a Ferrograph via a large speaker enclosure. Ownership was not long delayed.

Some years passed and, with the adoption of stereo equipment, the Fi-Cord fell into disuse. The idea of conversion to stereo was born; the desired facilities being as follows:

Half-track stereo record. No fancy track switching; that is for mains machines at base.

Headphone monitoring on record. Although not done on the conversion to be described, it is possible to fit separate record and playback heads for off-tape monitoring. This comes about if the secondary cells are no longer used and the extra deck space is available for the resulting head rearrangement.

Headphone playback listening.

Full-track tape erasure.

Separate record and playback amplifiers. This eases switching problems and would be essential if separate record and playback heads were used to provide off-tape monitoring.

Meter level indication—one meter for both channels.

Input mixing, enabling three microphone inputs to be used. A stereo pair feeding, conventionally, the left and right record amplifiers. The third microphone input to be arranged so that both channels receive its signals equally.

Use of as much existing circuitry as possible, which would imply re-use of many existing components.

The replacement of the (excellent in their day) secondary cells by two sets of primary cells, as the original type are no longer available; one set being used for the motor drive and the other, of twice the capacity, for the electronics.

So, with the aims set out above, development work proceeded. Ideas tried and ideas discarded. For example—silicon planar transistors tried for the preamps but unaccountably severe pickup of radiated motor noise resulted. Equally curiously, it is entirely absent on record with the germanium types so no changes were made. Playback on the converted Fi-Cord is marred by this motor interference but, as the playback is only required as a check on headphones when out and about, no attempt has been made at trying to cure it. Thoughts of 'the devil you know' come to mind. As the recordings made are 'clean' that is how it stands.

After a description of the circuitry decided upon, a list of suppliers of major components will be given so that readers wishing to proceed with conversion may muster resources. Next month details of performance, head changing problems and case construction will conclude the series.

The full circuit is shown in **fig. 1** in semi-block form. The dotted boxes indicate the plug-in printed circuit boards PC1 to PC5. These are used for the majority of the components and, by being plug-in, allow the size of the finished conversion to be kept as small as possible. The circuitry of the boards is shown in **figs 2** to **8**. Anything not shown within a dotted box is fitted as appropriate to the machine's physical layout.

Consider initially the circuitry without the optional centre fed channel. The LH and RH microphone preamps as shown in **fig. 2** are specially tailored to suit the *LM200* microphone, a pair of which were used in the recently described stereo windshield. The published response curve for this microphone indicates a fall in response below 500 Hz. The output is —8 dB at 100 Hz. The circuit corrects for this in the feedback path given by the 38 K resistor and 10 kpF capacitor. Should microphones not requiring this correction be used, then the preamps can be to the **fig. 4** circuit. The first transistor is a low-noise type. The resistors should be also high-stability, low-noise. A great contribution to low noise is made by the *LM200*, whose output is higher than average.

The ganged record gain control follows the preamps. Mixing in the signals from the optional centre channel takes place after this gain control. Interaction as a result of mixing is very small. Also the crosstalk introduced by adding the centre channel is negligible. Should the centre channel not be provided, then the 22 K resistors following the ganged gain control should be omitted. Greater sensitivity results. Emitter-followers come next. These are the biggest departure from the original circuitry. They provide a far more efficient matching between the preamp and the low impedance of the record amp feedback pair. Here the resonant circuit (10 m Hand 12 kpF) gives treble boost peaking at 14 kHz. The head matching transformer is the existing type (one channel has the actual original). After the transformer, the head is fed via a 22 K resistor. This arrangement allows a bias filter to be provided across the transformer secondary.

The bias is brought from the oscillator feed to the erase head. The magnitude of the oscillator output and the bias levels needed are discussed later. The 220 pF capacitors might appear to couple the two channels together. However, even at the upper audio frequencies, their impedance is too high for this to affect inter-channel crosstalk. It will be noticed that on playback the bias capacitors are still connected to the heads. When a switch off is made from the record mode, the bias through the head will die away just as the erase head current dies away. The oscillator's 100 μF capacitor ensures this. A sudden removal of bias current could magnetise the record head. This is widely considered the cause of 'hissy' recordings (or 'hissy' playback for that matter). Beware though, for it was found that lumpy low frequency noises were being produced when the heads became magnetised during experimental work.

The oscillator is as originally provided and shows excellent waveform shape. The 15-ohm resistor controls the output level.

Monitoring on headphones whilst recording is effected by the use of emitter-followers to feed the headphones via the ganged potentiometer, giving control of the level. STC phones of 300 ohms impedance are used. Actually the monitoring facility whilst recording is something of a misnomer if you are standing near to the sound source and it is loud. However it is very useful when employing the mixed microphone technique for bird song recording where the mono microphone is some distance away or is used with a parabolic reflector. Employing an emitter-follower to take the signal to the phones has the advantage that the record circuit is not loaded at the point of connection.

The record level meter also makes use of this feature and the signals of both channels are rectified by the two pairs of *OA81* diodes. SW1c is arranged to short circuit the meter on switch off from record. This prevents a switch-off surge, from the 100 μF capacitors after the emitter-followers, passing through the meter. The short circuit is maintained in the playback mode to avoid the meter responding to the playback signal.

The capacitors at the input to the emitter-followers are an attempt to remove the treble-boost that has previously been applied in the record amplifiers. It cannot fully 'de-equalise' as the boost was applied by a resonant circuit which has a steeper slope than a CR circuit.

SW1a and SW1b switch the head to the playback amplifier. Because of the previously mentioned motor noise on playback, and because recordings are intended for playback on mains machines, no attempt at perfecting the playback amplifier has been made. It does not give full equalisation or sufficient level to make it worth controlling via the ganged potentiometer. However the circuit has a hiss level lower than tape hiss.

An important detail of the playback amplifier

*GPO

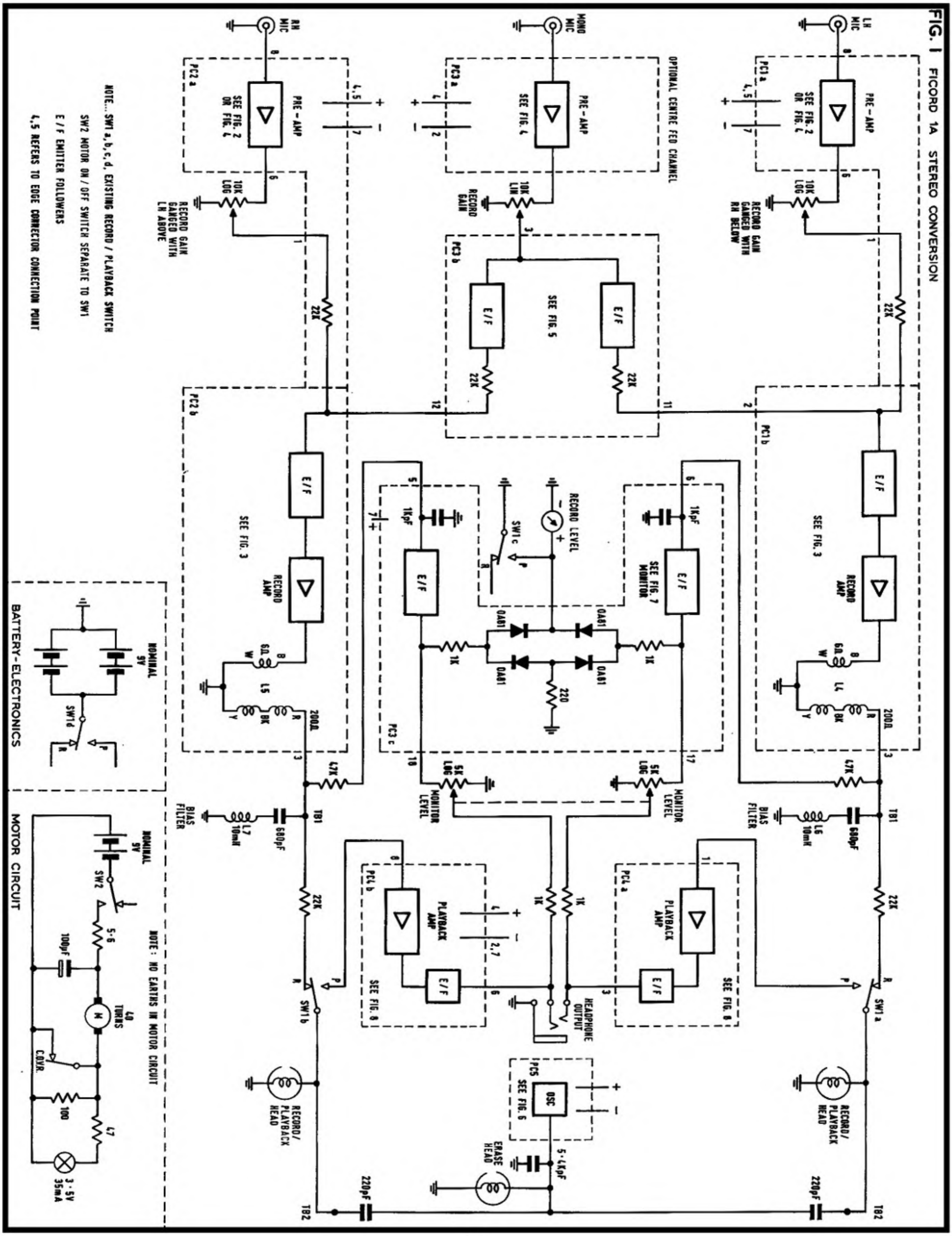


FIG. 1 FICORD 1A STEREO CONVERSION
LH MIC
MONO MIC
RH MIC
PRE-AMP
SEE FIG. 2 OR FIG. 4
SEE FIG. 4
OPTIONAL CENTRE FED CHANNEL
PC1 a
PC2 a
PC3 a
10K LOG
10K LIN
RECORD GAIN GANGED WITH RH BELOW
RECORD GAIN GANGED WITH LH ABOVE
RECORD GAIN
PC3 b
SEE FIG. 5
E/F
22K
PC1 b
PC2 b
SEE FIG. 3
RECORD AMP
RECORD LEVEL
SW1 c
SEE FIG. 7 MONITOR
1KpF
OA81
1K
220
PC3 c
L4
L5
200Ω
6Ω
8K
4.7K
5K LOG
MONITOR LEVEL
TB1
BIAS FILTER
L6 10mH
L7 10mH
680pF
PLAYBACK AMP
PC4 a
PC4 b
SEE FIG. 8
HEADPHONE OUTPUT
SW1 a
SW1 b
RECORD/ PLAYBACK HEAD
PC5 SEE FIG. 6
OSC
ERASE HEAD
5·6KpF
220pF
TB2
NOTE... SW1 a,b,c,d, EXISTING RECORD / PLAYBACK SWITCH
SW2 MOTOR ON / OFF SWITCH SEPARATE TO SW1
E/F EMITTER FOLLOWERS
4,5 REFERS TO EDGE CONNECTOR CONNECTION POINT
NOMINAL 9V
SW1 d
BATTERY-ELECTRONICS
NOTE : NO EARTHS IN MOTOR CIRCUIT
SW2
5·6
100μF
40 TURNS
C.O.V.R.
100
47
3·5V 35mA
MOTOR CIRCUIT

is the 10 K resistor across the input. This eliminates the production of a surge through the head when switching to playback. This surge really did magnetise the head and made noisy a pre-recorded tape.

The mono microphone has a preamp circuit which gives linear amplification and the level is controlled by the use of the existing 10 K linear potentiometer. Twin emitter-followers couple the signal to both the left and right record amplifiers. The 22 K resistors reduce the loading on the circuits at the points of connection.

The circuitry of **figs 2-7** show negative 9 V, coming in via the edge-connector contacts. Supply de-coupling resistors and capacitors will be noticed. These are important in that it is possible to get a low frequency coupling between the different parts of the circuit. During development this sometimes occurred at low gain settings, sometimes at high gain, and sometimes depended on whether certain screens were earthed or not!

COMPONENTS

RESISTORS. High stability 5% were used throughout—especially required in the preamps and equalisation.

CAPACITORS. Electrolytics require to be of no more than 12 V working. The many existing capacitors were used. Non-electrolytic—silver mica 1% type used.

TRANSISTORS. Oscillator uses existing *GET3A*. Emitter-followers use *OC82* or existing *GET114* or *GET3*. Others comprise Texas *2G308* for early stages and *OC82* elsewhere.

DIODES. Mullard *OA81*.

PRINTED CIRCUIT PANELS

PC1 a and b. Radiospares printed circuit panel (Transistor).

PC2 a and b. PC3 a, b and c. PC4 a and b. Six required altogether as *PC3* is equipped with the plug part of another to double the number of connections. Also *PC5* has a plug part fitted to it.

PC5. Part of the existing printed circuit.

EDGE CONNECTORS. Radiospares eight-way edge connectors.

BIAS FILTER COILS L6 and L7. RECORD EQUALISATION COILS L1 and L2. Repanco 10 mH non - adjustable type *CH4* from Henrys Radio.

RECORD TRANSFORMER L4 and L5. Existing one used in one channel. Fi-Cord are able to supply another (Type *10207*).

POTENTIOMETERS. 10 K lin for centre channel —existing pot used. Others are ganged Radiospares log types matched to 2 dB.

SW.1. Existing record/playback switch.

SW.2. Bulgin microswitch.

TAG BOARDS TB1, TB2. Radiospares standard six-way group panel.

LEVEL METER. 170 µA Radicator *V103* (Japanese) from Henrys Radio. Far better looking than catalogue photograph.

BATTERIES. Ever Ready *1289*. Four for the electronics in series/parallel arrangement. Two in series for the motor.

RECORD/PLAYBACK HEAD. Miniflux *SKN4* ¼-track stereo record/playback. This has electrical characteristics closely approaching the existing Miniflux head. Supplied by *Lee Electronics, 400 Edgware Road, London, W.2.*

ERASE HEAD. Miniflux *LF4V* full-track. This is unfortunately no longer available from the above source. A substitute *LF4VS* is understood to be obtainable from *Miniflux Electronics Ltd., 8 Hale Lane, London, N.W.7.*

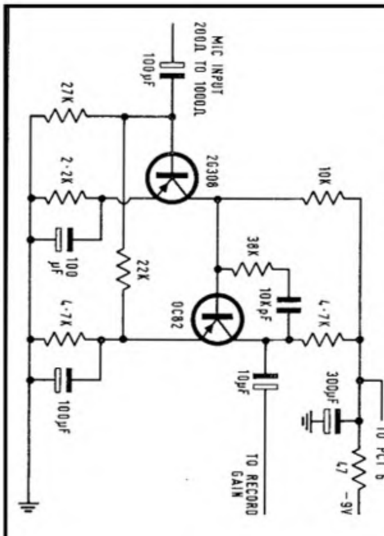


FIG. 2 PC1 a (PC2 a) MIC INPUT—WITH BASS BOOST TO SUIT LM200

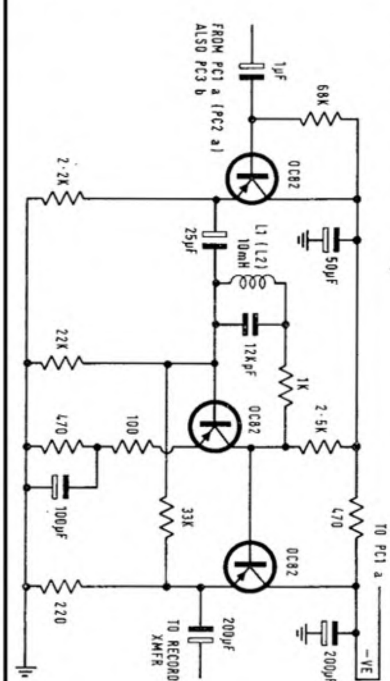


FIG. 3 PC1 b (PC2 b) RECORD AMP

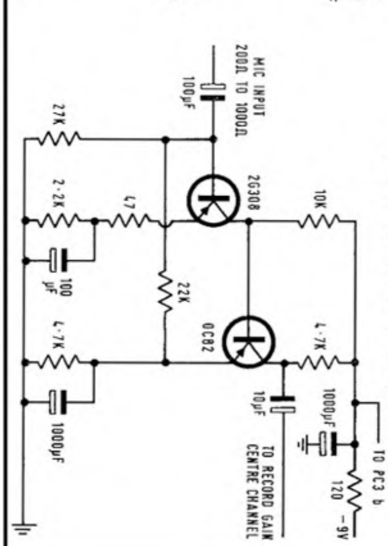


FIG. 4 PC3 a MIC INPUT—AS USED FOR CENTRE CHANNEL

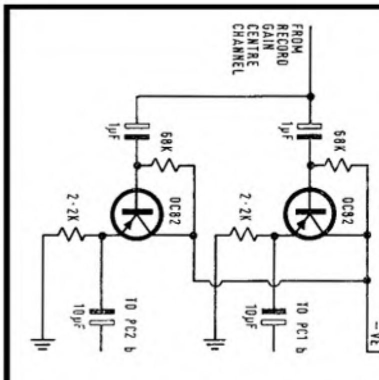


FIG. 5 EMITTER FOLLOWERS

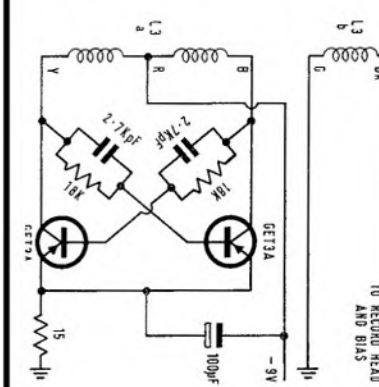


FIG. 6 OSCILLATOR (EXISTING)

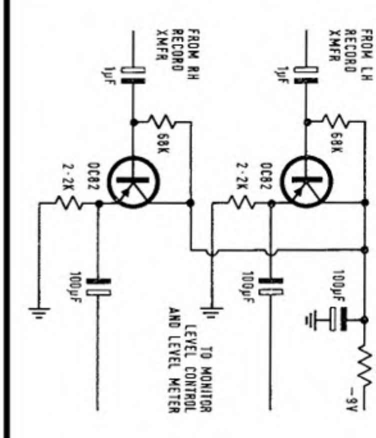


FIG. 7 PC3 c RECORD MONITOR AND LEVEL METER E/FS

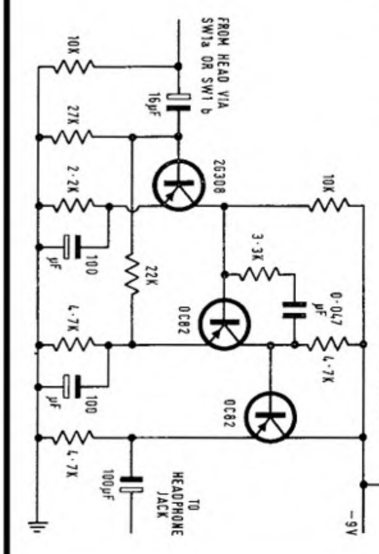


FIG. 8 PC4 a (PC4 b) PLAYBACK AMPLIFIER

AKAI X360

BY DAVID KIRK

INTRODUCED in the summer of 1968, the *X360* is the most expensive of Akai's domestic tape recorders. It is also the most elaborate. Separate ¼-track erase, record, bias and play heads, solenoid controls, automatic (time-switched) reverse, AGC, an electronic head-cleaning indicator, stereo headphone and side-facing loudspeaker monitoring, AB comparison, a 3-speed hysteresis-synchronous capstan motor, magnetic braking with variable left-to-right supply tension, multiplay and four-channel input mixing all come in this 444 x 406 x 254 mm package.

The *X360* is a £359 development of the £250 *X355* of pre-purchase-tax days and has suffered heavily at the hands of the chancellor. It makes no attempt to meet studio demands (how many studios want ¼-track?) but offers the amateur almost every facility he could conceive. The only desirable features he would miss are a couple of handles to support its 25 kg weight.

All controls are sensibly positioned, the rewind, reverse, stop, forward and fast-forward mode selectors falling beneath the right hand. These selectors, like those on the *X355*, are feather-light and traverse barely 3 mm from rest to 'on'. The controls are sprung and do not stay down once the operator's finger is removed. Interlocking is completely foolproof. The record button, a circular control beneath the stop tab (considering things vertically), will select record during play without the usual 'both down' interlocking. A rotary lock is fitted to the record button, providing some degree of safeguard against accidental erasure.

Pressing the reverse tab causes the transport to halt in a neutral position while the motor changes direction and the play head moves down (another solenoid) to scan tracks 4 and 2. Once the motor is up to speed, the solenoids engage again and the tape moves off at minus 19 cm/s, or whatever. This system works very well but has the incidental effect of reversing the right and left channels.

I have many unhappy memories of snapping tapes on the *X355*, but found the *X360* mechanism consistently gentle. Fast-wind speed has been reduced and a non-mechanical magnetic brake incorporated, with very good results.

Three buttons on the left of the head channel select 19, 9.5 or 4.75 cm/s drive and equalisation. The capstan motor is a switched six-pole device, separate motors being used for forward and reverse fast-wind. A 38 cm/s capstan sleeve and smaller pinch wheel are provided, stored under the hinged head cover.

The track selectors are situated below the meters, three buttons marked *1-4*, *stereo* and *3-2*. Akai appear to assume that the *X360* will not be used for serious single-track mono recording and only leave the left-hand monitor amplifier in circuit. Mono monitoring is therefore limited to only one internal or external loudspeaker or one headphone earpiece. This makes life difficult when the multiplay facility is employed but emphasises the obvious fact that two recorders should be used for such work.

Coaxial input level controls permit the four-channel input mixing mentioned in the first paragraph. I tried this facility in a four-microphone stereo recording session, a crossed pair feeding the microphone input via low-to-medium impedance transformers. A pair of Foster dynamic cardioids with built-in transistor preamps fed the line inputs. Results were very satisfactory, for ¼-track.

AGC could be selected at the touch of a button and was operative on all inputs. Variations in gain were displayed by an arrow at the protruding tip of a motorised ganged potentiometer spindle. The motor belches softly when it varies the gain. My first reaction was to blow raspberries back but I develcped a healthy respect for the speed and levels at which it worked. If one disagrees with the average level setting, this can be altered by twisting a preset potentiometer in the AGC circuit board. The eight-transistor circuit employed to control the AGC motor (plus another eight for the electronic 'dust minder') may seem extravagant for comparatively minor features but one must remember that circuit components today are cheaper than ever. (The *X360* circuits will shortly be published with Alec Tutchings' review.)

MANUFACTURER'S SPECIFICATION (19 cm/s). Quarter-track stereo tape recorder with side-facing loudspeakers. **Wow and flutter:** 0.04% RMS. **Frequency response:** 30 Hz - 18 kHz ± 3dB (9.5 cm/s). **Signal-to-noise ratio:** 50 dB. **Distortion:** 1.5% at 1 kHz (O VU). **Bias frequency:** 100 kHz. **Spool capacity:** 18 cm. **Tape speeds:** 38 (with sleeve), 19, 9.5 and 4.75 cm/s. **Modulation indicators:** Twin meter. **Microphone input:** 0.5 mV at unspecified impedance. **Line input:** 50 mV at unspecified impedance. Line output: 0.4 V or 1.23 V at unspecified impedance. **Headphone output:** Not specified. **Sockets:** Unbalanced jack (microphone); phono and DIN (line); GPO jack (headphone). **Tape heads:** Erase, record, bias and play. **Dimensions:** 444 x 406 x 254 mm. **Weight:** 25 kg. **Price:** £359 (£287 2s. 10d. plus p.t.). **Manufacturer:** Akai Electric Co. Ltd., 12, 2-chome, Higashi-Kojiya, Ohta-ku, Tokyo, Japan. **Distributor: Pullin Photographic Ltd., 11 Aintree Road, Perivale, Greenford, Middlesex.**

Input and equalised playback signals may be compared while recording, using the tape/source buttons on the left-hand side of the meters. They can be switched quietly, using two fingers, but leave an electrical 'plop' on the tape. It is therefore best to stay on off-tape monitoring when recording. The meters show the signals leaving the playback preamplifiers and consequently are also affected by the tape/source switch. Ideally the meters should be in the recording amplifier, registering the signal feeding the record pre-emphasis network. The only meter calibration is a white on black O VU mark at which one presumes to get 1.5% distortion and 50 dB signal-to-noise ratio at 19 cm/s with the Scotch *202* tape specified by Pullin. Akai recorders are usually under-biased, to meet the 'hi-fi' brigade's demand for wide frequency range: a figure of 30 Hz — 18 kHz ±3 dB is quoted for the *X360* at 9.5 cm/s. Increased bias (record and erase presets are accessible in the oscillator card) can pull this back to a respectable 12 kHz, reducing hiss and distortion. The *X300* used by Gilbert Briggs at the 1968 Northern Audio Fair was modified in this manner.

Headphone and loudspeaker monitor levels were governed by the volume controls beneath the tape/source switch. Bass and treble controls are incorporated. For headphone work, the internal speakers or power outputs can be muted.

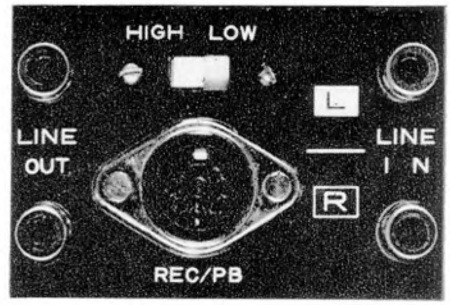
An amber lamp just above the meters illuminates when the erase, record or playback heads (it is difficult to know which) become dirty. This highly original device employs a frequency-selective circuit to detect signals above 7.5 kHz. The lamp illuminates (after ten seconds, I am told) when no signals above 7.5 kHz reach the detector. This meant hardly ever with the 19 cm/s speed at which the record was normally used.

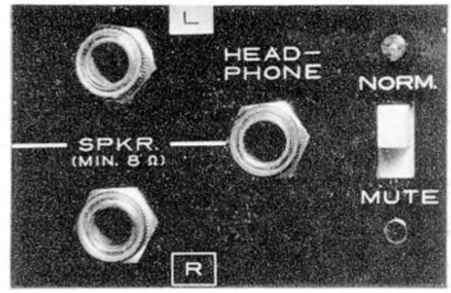
(continued overleaf)

The *Reverse-o-Matic* facility did not interest me but might sell the *X360* to a retailer or restauranteur. By pressing a button and positioning the pointers of a spool-driven counter, a tape can be played in a practically endless cycle between predetermined points. The system is fairly simple and takes advantage of the solenoid controls and bi-directional facilities. It is actually simpler than the version on the *X355*, being confined to the playback mode. The *X355* was also capable of fast-winding during its automatic cycle.

Unbalanced microphone input jacks are mounted on the front panel. A strong hum field is radiated beneath the recorder, in the region of these inputs. If the *X360* is used with the deck horizontal, many microphone impedance transformers will fall naturally into the hum field. A pile of *Tape Recorder* back-numbers placed against the front of the machine supports transformers and unbalanced leads away from this field. The *X360* is supplied with a Christian three-core mains cable, making earthing a convenient proposition. Many Continental recorders are supplied with two-core mains leads; their makers overlooking the fact that low noise recording depends on a good earth.

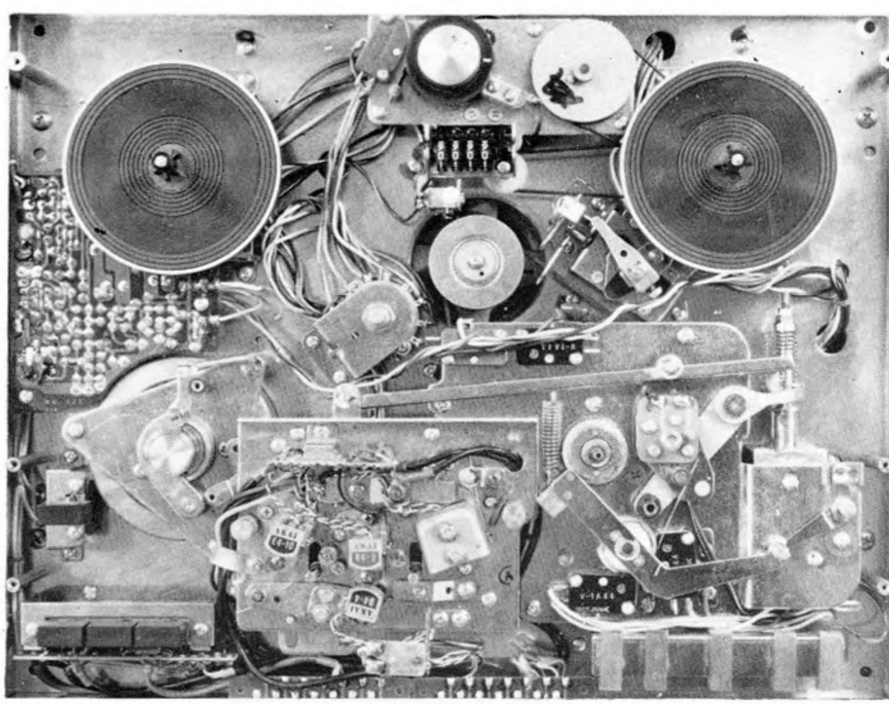
Performance of the tape transport was good at 19 cm/s, wow and flutter being low enough for reasonable piano recordings. Adding the 38 cm/s capstan sleeve and pinch wheel generated a distressing capstan-frequency wow, however, and I am forced to make the old complaint that removable capstan sleeves represent vulgar engineering. There is no 38 cm/s equalisation and the *X360* would be a very much better recorder if the 4.75 cm/s speed was abandoned in favour of switched 38, 19 and 9.5 cm/s.





The tape amplifier was good by domestic standards and, as mentioned before, could give excellent results if extreme HF is sacrificed in favour of lower noise and distortion by increasing the bias level. The power amplifiers and speakers provided enough rattle-free sound to satisfy a jazz band in a small hall but were too boxy for reasonable monitoring of live choral material. A couple of tweeters might improve matters, or even the metal forward-reflectors on the old *X355*.

Is it worth £359? Not in my opinion. Would it have been worth the pre-tax £287 2s? By present price standards, yes. But present standards dictate that a Marantz amplifier alone can cost £250, and a tuner over £470.



auditory training

OVERCOMING DEAFNESS WITH MAGNETIC TAPE

By Francis Cook and Edward Bowden

STC photo

A LITTLE-KNOWN facet of education which at first sight seems to be a paradox is the teaching of deaf children through their ears. Most people consider that all deaf children can have no hearing at all and must therefore be taught visually. This is a very serious misconception, since very few children are totally deaf and the teacher's main aim is always to exploit all the child's residual hearing to its utmost potential. This entails increasing the child's listening power to a degree where the child discovers for the first time that it can actually hear for itself, and make full use of that hearing, with, of course, the assistance of a hearing-aid. This in time will enable the child to play a fuller part in its adult life than would have been thought possible even 30 years ago.

This system of teaching is known as auditory training. If any one of our faculties or abilities is defective, we tend not to use it whenever we can manage without it. For example, when recovering from a broken arm, when the limb is out of plaster, and still weak and painful, we naturally try not to use it, whereas the doctor will insist that we use it as much as possible short of straining it since the longer we delay in giving it a fair amount of exercise, the longer it will remain in its weakened state. We must exercise the limb to get as much use as possible out of it.

DEPENDENCE ON LIPREADING

Defective hearing is very much like this. Children born with a hearing loss tend to depend on lipreading, gestures and other clues to get the meaning out of life. They tend to use their hearing less and less, according to the degree of deafness. We cannot cure their deafness but we can make them *appear* to hear more by teaching them to make more use of what they can hear.

This, then is auditory training, and it is surprising just how much benefit a child can obtain from this method. Children with small hearing-loss are the obvious ones to gain from auditory training, but even severely deaf children gain far more from this exercise than would have been thought possible a generation ago.

The tape recorder enables auditory training to proceed whilst the teacher is giving his attention to individual speech tuition. A series of exercises is recorded on tape, preferably in the teacher's own voice in the earlier stages, and this tape is played back through an amplifier known as an Auditory Training Unit. This instrument, generally an Amplivox, feeds a pair of headphones. Each headphone can be individually set at the optimum level of hearing for each of the child's ears. This optimum level is ascertained by referring to the child's pure tone audiogram (test of hearing) and his level of hearing for each ear averaged over the range of 500 Hz, 1 kHz and 2 kHz. The Auditory Training Unit is then set at 30-40 dB above this level for this ear. The Audiogram is again referred to and a similar calculation made for the other ear. A child suffering from a severe high frequency hearing loss may have the calculations made over the range of 0.25, 0.5 and 1 kHz with the auditory trainer tone controls set to give maximum treble boost or maximum bass cut.

One exercise that the children thoroughly enjoy is as follows. Early reading books that they have already read are recorded in a steady, deliberate voice on tape at a minimum speed of 9.5 cm/s. The machine used is a Telefunken *M.70* and the unamplified signal is taken direct into the auditory training unit, where tone and volume are monitored and adjusted. A slower tape speed is not practicable, since it would not replay the higher elements of consonants. The child follows the spoken word by reference to the reader. This exercise gives him experience in the following ways. He is listening to something that he has previously only read himself. He is listening especially for words and phrases with which he is already familiar from previous reading and from lipreading. He is revising a previous reading lesson whilst improving his listening power.

Whilst this lesson is going on the teacher is usually dealing with another child, using yet another auditory trainer with a microphone and giving this second child individual speech correction. The loudspeaker of the tape recorder is turned down to be only just audible to the teacher, which means that it will not disturb any of the other children in the room, as it will be below their threshold of hearing. The teacher keeps half an eye on the child doing auditory training and when this child has finished the two children change places. When they have both had a session of auditory training they return to the other exercises that are taking place in the room

UNFAMILIAR LANGUAGE

Another exercise consists of pure vocabulary drill. The earliest forms of this are built up from the vocabulary that is already well-known to the child. We must only teach one thing at a time, and if we are teaching the child to use his listening powers then we must not confuse the issue by using unfamiliar language. The appropriate words are in illustrated form and are mounted on cards. There are four words on each card, with the picture above each word. Sixteen of these cards are used in one exercise, giving a vocabulary of 64 words. The first stage of the exercise is for the teacher to record in a firm steady voice on the tape and in correct order the words so illustrated, using the phrase 'turn over' after each group of four has been said. This first stage asks for no discrimination, and is the teaching stage, as it would be called in programmed learning. The child must be trained to turn each card face downwards on to the fresh pile as it is used. Then at the end of this stage he turns the whole pile over, thus restoring them to their original

(continued overleaf)

order. The second stage again names the four words on the first card and then the voice says 'show me the cat', choosing one of the words on the card. The child then points to the word or illustration asked for. Thus he is asked to discriminate one of the four words which he has listened to on two occasions. He is then told to 'turn over' and the next four words are named. Again he is asked 'show me the . . . ' and again he is thus asked to discriminate one of the four words. This is repeated with each card. The next stage is without a repetition of the four words. The child is merely asked to 'show me the . . . turn over'. And so on right through the pack. Stage four on the same pack consists of being asked to discriminate two out of the four words without any preliminary phrase. The tape simply says 'Cat. House. Turn over'. until the 16 cards are used up. The fifth stage is the same as the fourth, but using the other two words on each card. The sixth and last stage asks for the four words on the card, in random order, with only the phrase 'turn over' between each four.

When a child is using this auditory training procedure, as has already been said, the teacher sitting nearby is keeping half an eye on the child for the following reasons: To make sure that he is able to follow the exercises and to turn up his auditory training unit 5 or 10 dB when he is floundering. To take him off the equipment when he has finished so the next child can take over. To watch for improvement in his power to discriminate and as soon as he is able to follow at his optimum level to cut him down by steps of 5 dB in each ear. This must be done very carefully and very gradually, but it is the ultimate aim of the exercise. When the child has regained his discriminatory powers at this lower level of hearing and has had time to feel confidence in it, he can be cut by a further 5 decibels. Many children can be cut by 20 dB from their calculated optimum level during the course of a few months of auditory training. Lower than this, many of them flounder, and the teacher has to be content with a 20 dB improvement in the child's discriminatory ability. Some children can be taken down and down until they are listening at a level which at their original assessment of deafness appeared impossible.

Another obvious use of the tape recorder is to enable the teacher to follow the child's progress in the acquisition and improvement of his speech. It also guards against the teacher's natural error in thinking that the child's speech has improved when really what has happened is that the teacher has become more accustomed to it. Children with rather better hearing may listen to their own efforts as compared with the teacher's.

All auditory training techniques have a definite and direct effect upon the clarity of a child's speech. It makes the child more alert, and above all nearer to normal in all respects. It is the 20th Century approach to overcoming the handicap of deafness, but only the marvels of electronic equipment have made it a possibility.

MORRIS IMPORTING TEAC

SEVERAL MODELS in the Teac range are now being imported from Japan by B. H. Morris. The *7030* takes 27 cm NAB spools and operates at 38 and 19 cm/s. A two-speed hysteresis synchronous motor drives the capstan and eddy current motors power each reel. Four heads are incorporated giving ½-track stereo erase, record and playback, and ¼-track playback. The 38 cm/s specification includes 0.06% RMS wobble, 30 Hz-20 kHz ±2 dB frequency response and 55 dB signal-to-noise ratio. Crosstalk is −45 dB at 1 kHz (interchannel) and −40 dB at 100 Hz (adjacent tracks). Input sensitivity is 0.5 mV at 10 K (microphone) and 0.1 V minimum at 10 K. The *7030* is essentially a tape unit (record amplifiers and replay pre-amplifiers only) but incorporates an 8 ohm stereo headphone jack with variable output level. Microphone inputs are unbalanced jack. Cost is £387 9s. (All current Teac prices are provisional.)

At £283 15s., the *4010* is a ¼-track three-motor stereo unit operating at 19 and 9.5 cm/s, forwards and backwards. Source and off-tape monitoring are incorporated. The £199 *2050* is a 19, 9.5 and 4.75 cm/s bi-directional ¼-track stereo unit. Model *A-20* is a stereo cassette unit designed to feed external amplifiers. Price is £78.

Distributor: B. H. Morris & Co. (Radio) Ltd., 84-88 Nelson Street, London E.1.

MILLBANK AUDIO MODULES

FIVE ADDITIONS have been made to the Millbank range of silicon transistor audio modules, two of which feature integrated circuits. The £7 14s. *062* provides +15 dBm maximum output at 600 ohms line, from a balanced transformer. Module *063* is a £7 2s. power amplifier feeding 2 W at 1% maximum distortion into 15 ohms. The £4 4s. *064* and £3 5s. *065* are extensions of the Millbank series of power supplies while the £9 9s. *066* is a two-tone cuckoo oscillator alarm with variable timing.

Manufacturer: Millbank Electronics, Hartfield, East Sussex.

NEW MODELS FROM PHILIPS

A STEREO TUNER/AMPLIFIER with integrated cassette recorder, the *RU881*, has been introduced by Philips to retail at £94 19s. 6d. The tuner features two-band AM and stereo FM reception. AGC is incorporated in the recorder. Amplifier output power is 6.5 W continuous per channel.

The ½-track mono *N4302* is a development of the *N4304*. Wow and flutter at the 9.5 cm/s single speed is 0.25% p-p, frequency response being 80 Hz-10 kHz ±3 dB for a 45 dB signal-to-noise ratio. Pins 1 and 4 of a five-pole 180° DIN socket accept 0.2 mV at 2 K (microphone, pin 2 earth). Pins 3 and 5 accept 100 mV at 1 M (auxiliary input) and supply, on playback, 750 mV at 20 K. Output power is 1.5 W at 8 ohms from a two-pole DIN loudspeaker socket. A 102 mm speaker is incorporated in the cabinet. Spool capacity is 14.5 cm and overall dimensions are 369 x 255 x 127 mm. Unlike its predecessor, the *N4302* employs transistors throughout and an illuminated moving-coil meter. Price is £35 17s. 6d.

Distributor: Philips Electrical Ltd., Century House, Shaftesbury Avenue, London W.C.2.

DIRECT READOUT MICROMETER

FASTER MEASUREMENT and fewer errors than with conventional micrometers are claimed by GKN for their *Speedread* range. Two versions were introduced in June, reading .01-25 mm and .0001-1 inch. The direct readout feature will be extended progressively through the company's measuring instruments. GKN are prepared to convert Imperial Speedread micrometers to metric for a small charge.

Manufacturer: GKN Shardlow Metrology Ltd., P.O. Box 62, Petre Street, Sheffield S4 8L7.

TAPE/FILM SYNCHRONISER

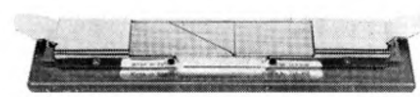
BASED ON THE *CS/1* introduced in 1964, the Contronics *CS/2* employs an electronic pulse system of tape/film synchronisation. Retailing at £46 13s. 6d., it incorporates several new features including a motor speed control which eliminates the need for heavy ballast resistors.

Manufacturer: Contronics Ltd., Deepcut, Camberley, Surrey.

25MM TAPE SPLICER

A SPLICER FOR 25 mm tape is now being manufactured by Multicore Solders, based on the existing 12.5 and 6.25 mm *Bib* units. *Model 22* includes razor guides for diagonal and butt joins, the tape being held in place by two swinging clamps. The splicer costs £7 18s. including eight cutters, six fluff-free cleaning cloths, and a bottle of anti-static instrument cleaner. Discounts are available for quantity orders.

Manufacturer: Multicore Solders Ltd., Hemel Hempstead, Hertfordshire.



PYE MARKET PHILIPS DESIGNS

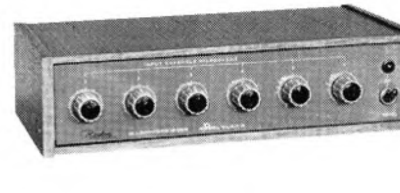
FIVE PHILIPS recorders are now being marketed under the Pye label at prices between £32 and £103. Cheapest is the *9104*, employing cassettes and selling at £32 0s. 7d. Model *9106* is a 9.5 cm/s ½-track recorder taking up to 14.5 cm/s reels. This incorporates AGC and costs £37 13s. 1d. The £43 3s. *9115* is a mains/battery cassette recorder. At £60 0s. 10d., the *9123* takes 18 cm spools and features a two-speed mechanism, ¼-track heads and a 4 W power amplifier. A stereo playback preamplifier is available. Most elaborate of the range is the £103 15s. 4d. *9137*, a three-speed ¼-track stereo recorder with 4 W per channel output to side-facing 154 x 102 mm loudspeakers. Mixing and headphone monitoring are among the features.

Distributor: Pye Group (Radio & TV) Ltd., P.O. Box 49, Cambridge CB4 1DS.

SIX-CHANNEL MICROPHONE MIXER

A SIX-CHANNEL microphone mixer with silicon transistor amplification before each gain control has been developed by Radon. The *DL6CM* accepts 1 mV at 35-100 ohms and supplies 0.25 V p-p at 68 ohms and 1 V p-p at 6 K. The mixer is powered from 50 or 60 Hz mains and gives −80 dB hum and noise without earthing. Versions with high impedance inputs are available to order. Dimensions are 355 x 175 x 105 mm and the weight is 3.25 kg.

Manufacturer: Radon Industrial Electronic Co. Ltd., Orme Road, Worthing, Sussex.



tion, the video information is obtained, amplified and then de-emphasised.

Part of the reason for retaining the pre-emphasis to this point is to have available the high frequency components of the signal, where the greatest noise will be present. The rather clever system of noise removal employed by Sony deserves a deeper explanation than there is time for at present. Briefly, the 'grass' in the high frequency spectrum is picked off, amplified, processed and fed back in antiphase to the delayed main signal to cancel out the original noise, and, incidentally, provide additional limiting.

A clamp circuit adjusts the sync tip for correct DC level, and the simulated sync from the 50 Hz pulse circuitry is then mixed in an emitter-follower stage and matched via another emitter-follower to the monitor output. At this point, a signal is tapped off for metering.

Audio circuits are conventional, and only the switching complicates matters. The meter is switched to provide audio, video and supply line indication, and is active during recording and replay to enable exact setting up to be performed.

The preceding notes apply to the *CV2000B*, the 405 - line machine. Coming to the *CV2100CE*, the 625-line version, we find several additional facilities, as well as the differences dictated by the system.

The *CV2100CE* is actually a dual-standard model. Vertical scanning is again 25 fields per second with 2:1 interlace and horizontal resolution better than 240 lines on 625-line recording. With a signal-to-noise ratio better than 40 dB, 625-line video operation is normal. Tape speed is increased to 29 cm/s and 12.5 mm tape is again used, giving approximately 40 minutes playing time with the usual 18 cm spools. Sync is again negative-going and any normal 50-field camera can be used.

The differences are largely operational. Dubbing, editing, stop motion and automatic recording level were all features suggested by the original users, and now incorporated.

Sound dub and edit buttons beneath a sliding panel near the function control permit insertion of new material, the break before and after dubbing showing as short-term (about one second) stripes as the synchronism locks. As the tape is being replayed, with the camera connected and the TV/cam switch to camera, the edit button is first pressed, and then the recording button. New recordings do not begin until the record button locks. Pressing the edit button the second time unlocks the record system—and this should be timed at a couple of seconds before the end of the insert, the main function control then being returned to its neutral position.

To add sound, the edit button is used in conjunction with the sound dub button, but this time we do not need to neutralise by pressing the edit button. A separate light in the level meter indicates when the dub button is pressed to warn the operator that a new recording is taking place over playback.

Standby operation allows rotation of the heads while the tape is at standstill but with manual spool movement possible, so that the pulses can be moved 'out of the way' and the portion of the recorded picture to be viewed can be centred on the monitor screen. About five minutes is the maximum time preferable for this facility, before there is a danger of visible tape wear (after all, there is a dual-head assembly passing the tape coating at 1500 RPM). To obtain longer periods of static picture would require such refinements as air pumps to keep the tape at a small and regular distance from the heads, with the consequence of increased cost.

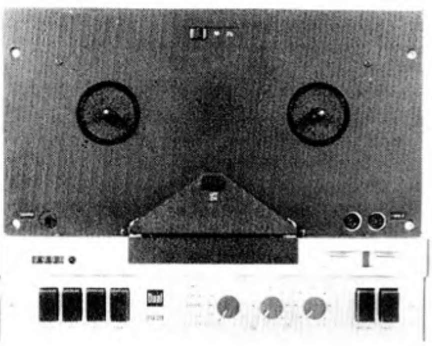
AGC is now a familiar function and needs no great detail in this explanation. An additional five-stage amplifier is inserted for automatic video recording with preset input, clamping and individual voltage regulation, operating at full gain on a low signal and biased back on signals greater than the predetermined threshold.

The audio AGC circuit is similar to many audio tape recorder systems, with a rectified feedback signal controlling early stages, part of the control being tapped off and fed to an intermediate stage to allow a slow 'follow' of the incoming signal.

One of the advantages of AGC has been the ease of copying it affords. With a master video tape recorder and several slaves, a monitor and a link unit, a pre-recorded tape can be copied directly, with the minimum of adjustment. In addition, an off-air signal fed to the master can be recorded and fed out to the slave unit giving duplication.

equipment reviews

DUAL TG28



MANUFACTURER'S SPECIFICATION (19 cm/s). ¼-track stereo tape unit with stereo headphone output. **Wow and flutter:** 0.1% RMS. **Frequency response:** 20 Hz - 21 kHz ±3 dB. **Signal-to-noise ratio:** 54 dB. **Harmonic distortion:** 1.5% at —6 dB level. **Spool capacity:** 18 cm. **Tape speeds:** 19 and 9.5 cm/s. **Modulation indicators:** Calibrated VU-meters. **Equalisation:** NAB. **Microphone input:** 0.15 mV at 200-700 ohms. **Phono input:** 50 mV at 1 M. **Line input:** 0.15 mV at 1 K. **Output:** 0.775V at 600 ohms. **Dimensions:** 383 x 298 x 134 mm. **Weight:** 6 kg. **Price:** £99 15s. 0d. **Manufacturer:** Dual Gebrüder Steidinger, 7742 St. Georgen/Schwarzwald, West Germany. **Distributor: Dual Electronics Ltd., Radnor House, London Road, Norbury, London S.W.16.**

FIG. 2 DUAL TG28 RECORD/PLAY WOW AND FLUTTER

I REVIEWED the *TG27* in February 1968, and had to admit that the technical performance was excellent despite the lightness of the deck mechanics.

The *TG28* is rather more robust, with the electronics and underside of the deck decently shrouded in a gauze cover, so that the unit can be used free standing or mounted in a cabinet as desired.

The circuit diagram of **fig. 1** shows that the motor acts as a mains transformer to feed a voltage doubler rectifier and smoothing system to supply the 30 V HT to the silicon n-p-n transistor circuits.

Three transistors are used in each of the stereo record/play amplifiers. The gain control on each channel acts to reduce both the input level and gain of the preamplifier so that there is no possibility of input transistor overload, even with very high level input signals. Both DC and AC feedback are applied to the DC-coupled amplifiers for stability and record/play frequency correction. A single transistor bias/erase oscillator provides power to all heads; this is made possible by using low-loss ferrite erase heads and efficient record/play heads.

The central function control knob allows for stereo recording and playback at its mid position, mono top and bottom tracks in the two anti-clockwise positions, and track-to-track transfer with added signals at the two clockwise settings. The top and bottom channel gain controls can be locked together for stereo use, or uncoupled for balance or individual gain setting as required. The record key can be locked down by pressing the stop key at the same time; the start key will then set the tape into motion without unlocking the record key. Use of the wind, rewind or stop keys automatically switches the circuits to play.

The tape position indicator is driven from the left-hand supply reel and ten revolutions of the spool clock up 17 digits on the counter.

Wind or rewind of 600 m of LP tape is completed in just under three minutes in either direction.

The long-term tape speeds were within ±1% limits at all parts of an 18 cm reel, showing that the constant tension servo brakes are a good design feature.

Short-term speed deviations were small at 19 cm/s with combined wow and flutter not exceeding 0.11% RMS. Wow was completely negligible at this speed, and the fluttergrams of **fig. 2** show that the higher frequency flutter is random in character and is probably mainly due to tape friction effects. At 9.5 cm/s, a 4 Hz wow builds up from time to time as the record and play wows come into step to give a total RMS reading of 0.19%. During cancelling periods the wow almost disappears, leaving only a random friction flutter at 0.16% RMS.

Fig. 3 shows the responses obtained by playing NAB 50 and 90 μS test tapes. The responses are within 1 dB limits from 100 Hz to 10 kHz at 19 cm/s, and 150 Hz to 10 kHz at 9.5 cm/s.

The record/play responses, using BASF *LGS35* reference tape, are shown in **fig. 4.** The 19 cm/s response is within ±3 dB limits from 60 Hz to 18 kHz; the 3 dB limits for the 9.5 cm/s speed are 70 Hz and 13 kHz. The responses are smooth and free of head contour effects.

System noise, with no tape passing the heads, was 50 dB below peak recording level on the top track and —48 dB on the bottom track, unweighted. Weighting the response to that of the ear at low listening levels improved the readings to —55 dB and —53 dB respectively. The hum field from the motor has been reduced

(continued overleaf)

FIG. 3 DUAL TG28 PLAY-ONLY RESPONSE (TEST TAPE TO LINE OUT)

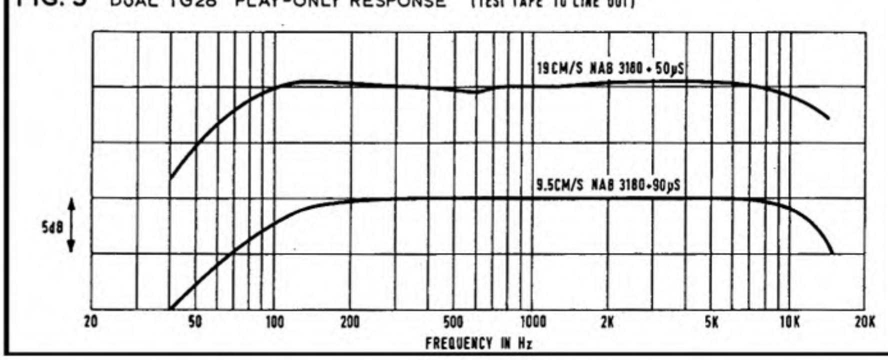
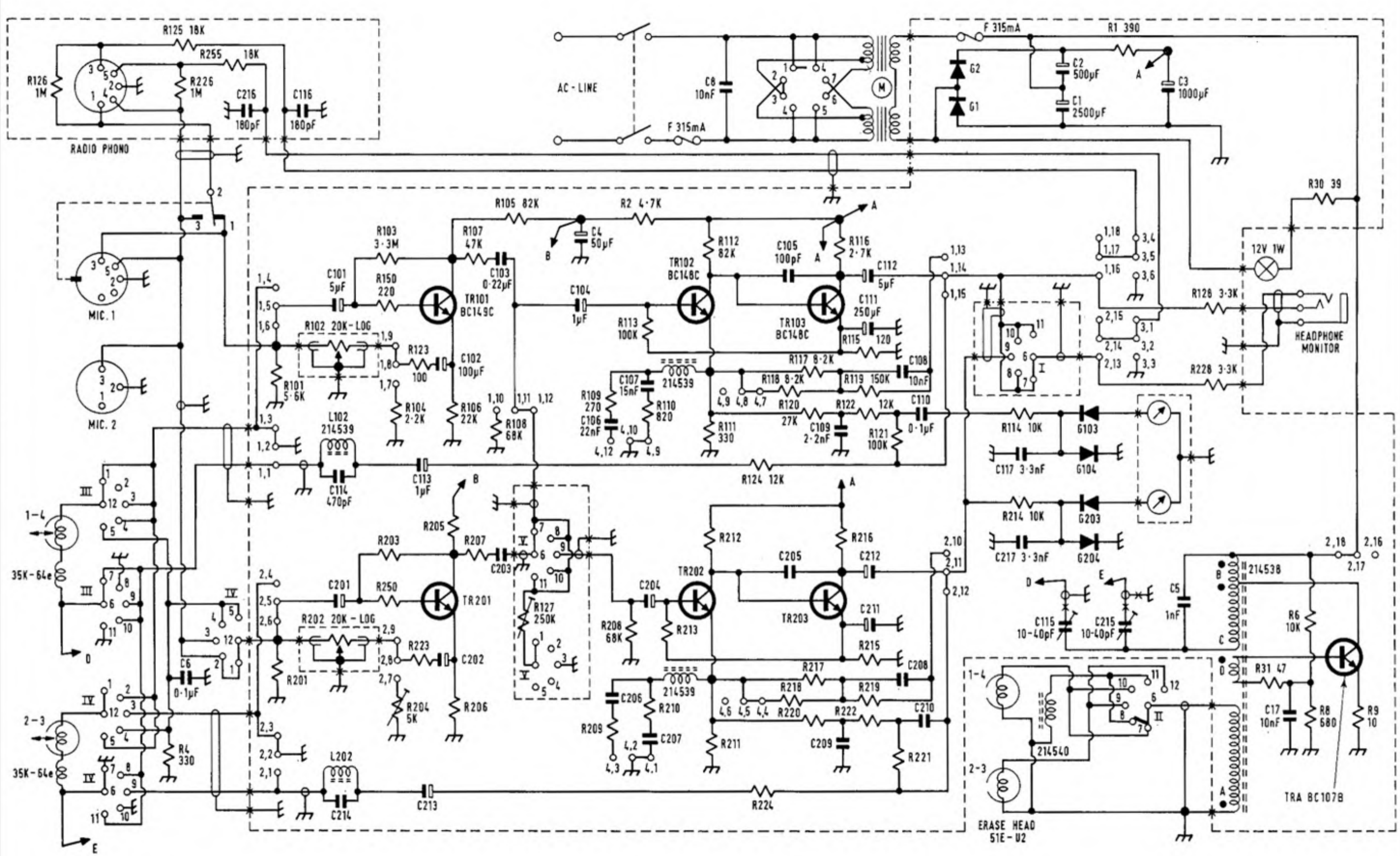


FIG. 1 DUAL TG28 CIRCUIT DIAGRAM



and the shielding of the heads much improved compared with the earlier *TG27*, so that the hum bucking coils are not called upon to do an impossible task but only to reduce the slight hum almost to vanishing level.

Peak recording level of 32 mM/mm was obtained with the VU meter reading 0 dB. Distortion at 1 kHz peak recording level (19 cm/s) was 3.5% and erase and bias noise on *LGS35* was 52 dB below peak recording level.

The apparent simplicity of this tape unit tends to hide a multitude of very clever, and far from simple, design features. The constant tape tension servo brake for example is an old idea but I have never seen it exploited so cleverly as on the *TG27* and *28*. The use of a roller between the erase and record heads instead of a fixed guide has been done before but, in combination with other refinements, it leads to faster wind and rewind times as well as reduced tape flutter. The cunning scheme of using the kinetic energy in the flywheel to operate the stop key when the tape runs out, instead of a complex system of insulated guides, tinfoil leaders, elaborate relays and solenoids, really appeals to my simple nature.

The electronics also are basically very simple, and this is reflected in the circuit diagram where all earth points are marked by individual earth symbols instead of by a multiplicity of connecting lines which would obscure the essential signal carrying circuits.

The bias setting follows domestic practice of aiming for the widest possible frequency range at the expense of higher harmonic distortion at peak recording level (3.5% instead of the Tandberg and Revox 1.5%).

The Dual *TG28* can be unreservedly recommended for playing commercial recorded stereo tapes installation and for recording stereo and mono tapes to a standard only slightly below that of much more expensive semi-professional equipment. A. Tutchings

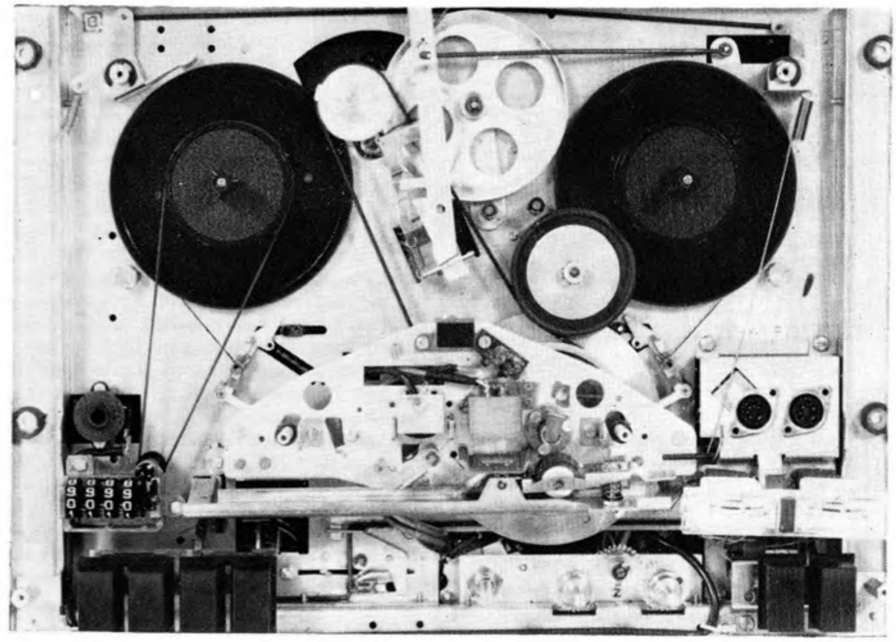
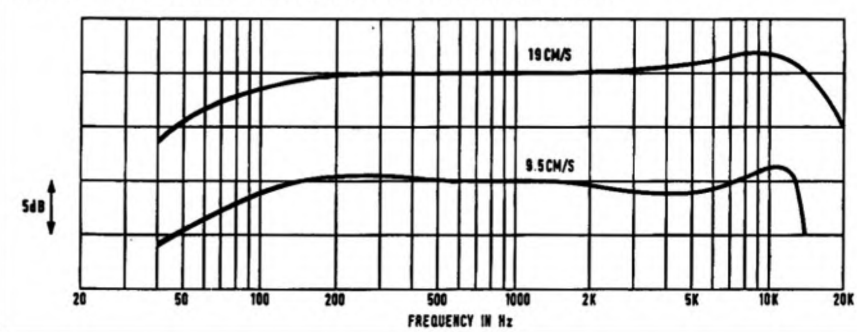


FIG. 4 DUAL TG28 RECORD/PLAY RESPONSE (LINE IN TO LINE OUT)



FILM INDUSTRIES M8 RIBBON MICROPHONE

MANUFACTURER'S SPECIFICATION. Figure-of-eight ribbon microphone. **Frequency range:** 35 Hz - 13 kHz. **Impedance:** 30 ohms (medium and high impedances available to order). **Sensitivity:** -85 dB ref 10V/N/m² at 1 kHz. **Price:** £9. **Manufacturer: Film Industries Ltd., Beacham Hydraulic Pump Works, Station Avenue, Kew Gardens, Surrey.**

I FIRST reviewed the *M8* microphone in November 1960 and since that time production has remained virtually unchanged, apart from small manufacturing modifications. After our group microphone reviews last year, Film Industries decided to submit a current model for review to see if there were any measurable changes in performance.

This was a challenge indeed as my test equipment has been changed in many small ways over the intervening eight years, although the basic test procedure has remained the same. A glance ahead to **fig. 1** will show that the old and new microphones, on the old and new test gear, are reassuringly similar, in fact the differences in response are no more than would be expected between different microphones from the same production batch. Having disposed of that, this would seem to be a good time to discuss these acoustic tests in detail for the edification of those readers who are interested in the method of test rather than the test figures.

To measure the response and sensitivity of an unknown microphone, one must know the sound level at a certain point in space over enough points in the sound spectrum to plot a meaningful response curve. The prime requirement is a reference microphone whose response and sensitivity is known to an accuracy of plus or minus 1 dB. My original reference microphone was an old STC 'ball and biscuit' moving coil microphone which had been accurately calibrated in an anechoic chamber against a standard capacitor microphone. Corrections had to be applied at frequencies below 100 Hz and around 8 kHz with doubtful calibration above 10 kHz. I am now the proud possessor of a B & K *2203* sound level meter fitted with a *4131* capacitor microphone with a free-field calibration like a ruler line up to 18 kHz and down only 2 dB at 20 kHz.

The second requirement is a sound source which will generate equal sound levels at 25 to

(continued overleaf)

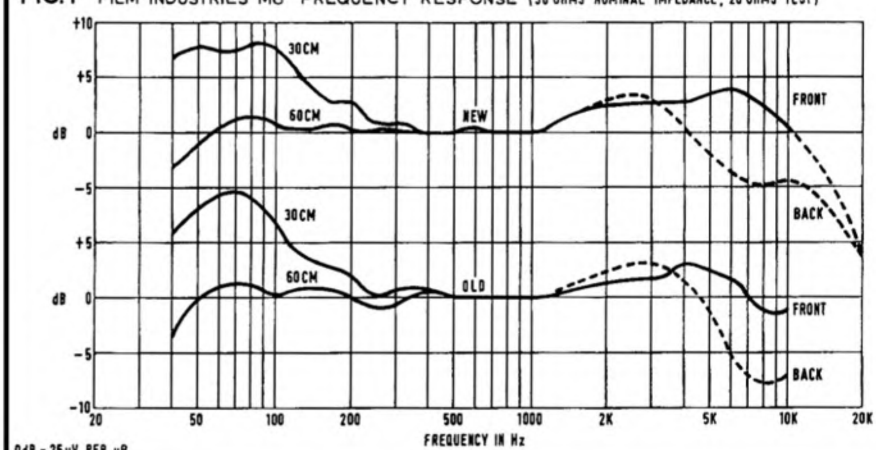
30 points in the sound spectrum without interference by sound reflections from the room bounderies. To avoid reflection effects we use one-third octave bands of filtered white noise so that each test 'frequency' consists of a continuous spectrum of completely random noise peaks covering a bandwidth of one-third of an octave. To make sure that the sound energy in each one-third octave band is equal, we use a tape recorder to 'remember' the different signal levels required to compensate exactly for peaks and dips in the response of the actual sound source. It is also helpful if the sound source or 'artificial voice' has about the same dimensions as a human head. We now use a Goodmans *Maxim* speaker fed from a Revox *736/HS* recorder where one-third octave bands of filtered white noise are fed to the recorder and reproduced a fraction of a second later from the tape. The input level on each band is quickly adjusted so that the sound level meter indicates equal sound levels on each band. When the recorded tape is replayed, each noise band is reproduced at a constant sound level and it is only necessary to replace the sound level meter with the microphone under test and plot the open circuit voltage on each noise band as it is reproduced from the tape.

With the improved speaker and sound level meter, we have been able to extend the tests to 20 kHz and the top curve of **fig. 1** shows that the front response of the *M8* is only 5 dB down at 16 kHz. As before, the rear response is some 7-8 dB down over the 6-8 kHz region due to the lack of standing wave reinforcement within the semi-circular magnets which cup the rear of the pole piece assembly.

COMMENT

The *M8* stands the test of time very well and the manufacturers are wise to leave the design as it is. As with the original sample, the impedance of this microphone is nearer 20 ohms than the specified 30 ohms and it might be worthwhile increasing the secondary turns on the internal transformer to raise the impedance, and output voltage, very slightly. **A. Tutchings**

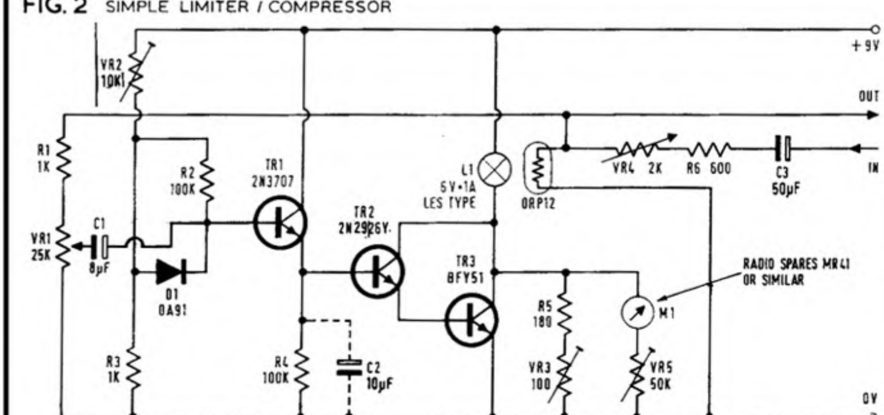
FIG. 1 FILM INDUSTRIES M8 FREQUENCY RESPONSE (30 OHMS NOMINAL IMPEDANCE, 20 OHMS TEST)



LIMITER-COMPRESSOR POSTSCRIPT

We apologise for a series of errors in the Transistor Limiter-Compressor circuit published last month. A corrected version appears below from which it will be seen that R2 and D1 are in parallel and C1 is not connected to R3. Tr2 is a 2N2926Y, VR2 is 10 K and L1 is 0.1 A. Apart from that it was fine!

FIG. 2 SIMPLE LIMITER / COMPRESSOR



IMPRESSIONS

JOHN SHUTTLEWORTH LOOKS AT SPECIFICATIONS

DURING the past few years I have been involved in testing tape recorders to see if they meet the manufacturers' specifications and also to test the quality of the recorder, these two being by no means the same thing.

After long experience, I have divided manufacturers into three basic groups:

(1) Those whose specifications seem to have been written by the service department, who do not want to get landed with too many adjustments under guarantee. They claim a performance likely to be given by one of their poorer machines after it has been dropped 3 m on to a concrete floor. In this way the worst machine they produce in any batch, operating under adverse conditions, is still likely to meet its conservative specification and the customer cannot complain. In this group I would place the top professional tape recorder manufacturers like EMI, Leevers Rich, Ampex and, certainly with their older models, Ferrograph.

(2) Those whose specifications seem to have been written by the design team. This means that a good sample should meet its specification when it leaves the factory, provided all has gone well along the production line and the inspection at the end has been rigorous enough. I would place most of the well known British and Continental manufacturers of the highest quality domestic and semi-professional recorders (whatever that may mean) in this group.

(3) Those where specifications seem to have been written by the advertising agency, ranging from optimistic figures that a particularly good example might meet on a fine day with the wind behind it, to flights of fancy that can only be described as highly improbable fiction.

The problem with tape recorder design is the old business of swings and roundabouts; every improvement in one sphere has to be paid for, either by the customer's hard-earned cash or by degradation in another sphere.

For a given sum of money one can either have, for instance, a wide frequency response with high distortion, a more restricted frequency response with less distortion, or an even more restricted response with even less distortion. You pays your money and you takes your choice or, to be more accurate, the manufacturer takes your choice for you.

Because of this interplay of gains and losses in different spheres of measurement, one has to be very careful in judging a machine by its specification unless the manufacturer makes quite clear the way the measurements are taken. A statement like 'frequency response: 20 Hz-20 kHz' is quite meaningless and could mean that the cabinet rattled at 20 Hz and the fuses blow at 20 kHz. In both cases the machine could be claimed to respond to the frequencies concerned.

The other difficulty I meet, even with the most reputable manufacturers, is that some recorders will meet the manufacturer's specifications but not if operated according to the manufacturer's own instruction manual.

For example, one well known and highly respected machine is claimed to have a 58 dB s/n ratio. I tested this by recording a 1 kHz signal at 0 dB on the machine's meter, replaying the tape and measuring the output from the recorder. Then, after erasing the tape on the machine, replaying this and measuring the new output. The difference between these two readings should, to my mind, be the signal-to-noise ratio at 1 kHz, and the figure I determined was only 40 dB.

I took this up with the importers who informed me that the meter on the recorder should be ignored when measuring the signal-to-noise ratio, and the signal should be recorded on the tape to give 3% distortion instead. This sent the record level meter off the end of the scale and made me wonder what use the meter is in practice. It certainly accounts for the fact that all tapes I have heard recorded on these particular machines seemed to me to be under modulated.

The point is that this particular machine would give a 52 dB signal-to-noise at 2% distortion, 40 dB with 1½% distortion, but the specification of 58 dB at 3% distortion was not met using the recorder's meter for obtaining full recorded level on the tape.

The following specifications are for two recorders, one a highly respected professional model costing over £1000, extensively used by the BBC, the other a domestic recorder in the £90 price range. The professional recorder will, of course, run at 38 cm/s, but I have given the specifications at 19 cm/s for both recorders.

	Studio Machine	*Domestic Machine*
W+F	0.2% RMS	0.1% RMS
S/N ratio	54 dB	55 dB
Frequency response	40 Hz-12 kHz ±2 dB	30 Hz-18 kHz±3 dB

Anyone choosing a recorder from its specification would be tempted to buy the domestic machine, though there is no comparison between the quality of the two recorders or the quality of recordings they make.

What can the average enthusiast do about this? Firstly he can read the reviews of machines in this magazine, though remembering that review models can be specially selected by the manufacturer.

Secondly, some dealers offer honest advice, though anyone selling a machine is prone to some degree of bias. Knowledgeable friends will be reluctant to admit they have made a mistake in buying an *X* recorder that is not entirely satisfactory, and so will tell of its good points while forgetting its faults.

Thirdly, and I may incur the Editor's displeasure in saying this, a letter to *Tape Recorder* will obtain expert and unbiased advice.

CLASSIFIED ADVERTISEMENTS

Advertisements for this section must be pre-paid. The rate is 6d. per word (private), minimum 7s. 6d. Box Nos. 1s. 6d. extra. Trade rates 1s. per word, minimum 15s., Box Nos. 2s. extra. Copy and remittance for advertisements in SEPTEMBER 1969 issue must reach these offices by 21st JULY addressed to: The Advertisement Manager, Tape Recorder, Link House, Dingwall Avenue, Croydon CR9 2TA.

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

FOR SALE—PRIVATE

Tandberg 64 and series 12. 4-track stereo, £75 each o.v.n.o. Tony Apple, 46 Ridgmount Gardens, London, W.C.1. 01-636 2502 evenings.

Akai X-4 portable stereo tape recorder, earphones and tapes, £75. Allen, Globe Inn, West Camel, Yeovil, Somerset.

Pre-recorded stereo tapes, Sinatra, Basie, Kenton, Mancini, Bennett, Herman, Peterson, Riddle, Gillespie, sent approval against deposit, £2 each. Hind, 29 Brybur Close, Reading.

FOR SALE—TRADE

Pre-recorded stereo American tapes $7\frac{1}{2}$, cheap as records; Bernstein's Mahler, Maazles Sibelius, Karajan's Beethoven Nine Symphonies £15, £3 cheaper: also pop, jazz, all stocked: catalogue 5/-. Postereo Tapes, 9 Darley Street, Harold's Cross, Dublin, Ireland.

Ferrographs, ex-Govt. models, from £17.10. S.A.E. details: Wright, 10 Church Street, Dowlais, Glamorgan.

Blackburn has Lancashire's leading Hi-Fidelity/Tape Recorder stockists and Electronic Engineers at Holdings Audio Centre, Mincing Lane/Darwent Street, Blackburn (Tel. 59595).

Battery, mains, portable Sharp RD504 $3\frac{3}{4}/1\frac{7}{8}$ 5in. spools rec. Price £35.5.3, our price £27.5.0. Write Tapecraft, 1 Sherwood Street, London W.1.

Continental music tapes, marches, light dances and folk music, send 1s 6d for brochure to: Hartley, 41 Swanmore Road, Bournemouth.

STUDIO FACILITIES

Studio Sound Recording Studios. Recording and disc transcription service. Latest high-level cutting techniques. Mono and stereo records. Exceptional quality obtained from amateur recordings. Members A.P.R.S., 31-36 Hermitage Road, Hitchin, Herts. Telephone Hitchin 4537.

Your tapes to disc. 7in. 45—25/-, 10in. L.P.—55/-, 12in. L.P.—65/-. 4-day postal service. Masters and Vinylite pressings. Top professional quality. S.A.E. photo leaflet: Deroy Studios, High Bank, Hawk Street, Carnforth, Lancs.

Your own tapes transferred on to discs. Send for details: R. J. Foley Tape to Disc Service, 112 Beach Road, Scratby, Great Yarmouth, Norfolk.

J & B Recordings. Tape to disc—latest high level disc cutting, all speeds. Mastering pressings, studio, mobile. 14 Willows Avenue, Morden, Surrey. MITcham 9952.

Graham Clark Records. Tape to disc pressings. 23 The Grove, Walton-on-Thames, Surrey. Tel. Walton 25627.

Pressing Specialists. Stereo/mono discs manufactured from your tapes, e.g. 99 off 7" EP Mono 10/4 each. 99 off 12" LP Mono 15/- each. Mobile recording service available. Please send for full particulars. North Surrey Recording Co., 59 Hillfield Ave., Morden, Surrey. 01-648-6345.

Rapid Recording Service. Records made from your own tapes (48-hour service). Master Discs and pressings. Recording Studio—Demo Discs. Mobile Recordings, any distance. Brochure from 21 Bishops Close, E.17.

Ring Guildford 61684 for Tape-Disc and mobile recordings. EP and LP pressings. S.a.e. brochure. Fanfare Records, 1 Broomfield Close, Rydes Hill, Guildford.

MISCELLANEOUS

Skilled tape recorder repairs carried out by expert personnel of many years' experience backed by extensive test equipment: Wow and flutter meter, audio valve voltmeter, audio generator, oscilloscope, etc., with final test performance figures quoted if required—Ferrograph specialists. Tape Recorder Centre, Tel-Lee-Radio, 220 The Broadway, Wimbledon, S.W.19. 01-542-4946.

Tape Recorder Repairs. Executed expertly, efficiently, economically by the Tape Recorder Centre. See page 343 for branch address.

WANTED

Lee Electronics. The Tape Recorder and Hi-Fi Specialists wish to purchase good quality Tape and Hi-Fi Equipment for cash. 400 Edgware Road, W.2. Phone PAD 5521.

Highest prices offered for good quality Tape Recorders and Hi-Fi. R.E.W., 266 Upper Tooting Road, London, S.W.17.

GOOD QUALITY TAPE RECORDERS PURCHASED FOR CASH. TELEPHONE 01-472 2185.

STC 4038 ribbon microphones wanted urgently. Box No. 552 (London).

STOP PRESS

FOR SALE — PRIVATE

Truvox R.84 Four track 3 speed mono tape recorder—perfect. £33. Sterns Mullard Type 'C' Tape pre-amp, with power supply unit, as new, £10. Magnavox 363 Deck, less heads some mods. £5. Collaro Studio 3 motor deck. No head. Assembly o.k. for spares, £2. 8 Victoria Crescent, Burton-on-Trent, Staffs.

CLASSIFIED ADVERTISEMENTS ORDER FORM

To: TAPE RECORDER, Classified Advertisements Dept., Link House, Dingwall Ave., Croydon CR9 2TA

Please insert the advertisement indicated below. (Please write in BLOCK LETTERS to avoid errors.)

NAME.. NUMBER OF INSERTIONS............

ADDRESS.. CHEQUE/P.O. ENCLOSED £ : :

Neve designed and built it for **THAMES** TELEVISION LTD

24 Channel
free grouping TV Sound
Control Console with two
plug-in 12 Channel
auxiliaries to provide
maximum flexibility.
This is the first stage of
a complete re-equipment
programme entrusted to
Rupert Neve & Co. Ltd. by
THAMES TELEVISION LTD

Rupert Neve & Co. Ltd. **Cambridge House, Melbourn, Royston, Herts.** Telephone MELBOURN 776 (STD: 0223-975) Telex 81381