STUDIO SOUND

NOVEMBER 1970 3s (15p)

PROFESSIONAL RECORDING TAPES SURVEYED

THAT WAS IBC 70

CONSTRUCTING A CARDIOD CAPACITOR MICROPHONE

INSIDE TRIDENT STUDIOS

BOB AUGER: THE GENTLE ART OF BUSKING

DOLBY B REVIEW

HIGH QUALITY MIXER: PPM AND VU CIRCUITS

Poised and ready

With Sansui's new 3-motor 4-head SD-7000 stereo tape deck, you're always poised and ready to go. Because this 4-track 2-channel unit, complete with advanced relay/solenoid tape transport section, also incorporates a built-in head/capstan hold circuit.

Rarely found on even the most expensive tape equipment, the device always keeps one of the playback heads and the capstan in a "live" or stand-by state, ready for instant use when activated. And tape travel lamps indicate which direction the tape will take.

Especially convenient in rapidly locating specific selections on a tape, this circuit may not, in itself, be grounds for very much hoopla. But when you consider it in context, with all the other rare features that this deck boasts, it adds significantly to the cumulative evidence which points to the SD-7000 as the most advanced tape deck on the market.

Endowed with more tape protection devices than any comparably priced deck you can name, the SD-7000 is unrivaled for ease of operation and tonal quality.

Poised and ready, it's available now at your nearest authorized Sansui dealer.

Sansui

England: **VERNITRON (UK) LTD. Thornhill, Southampton S09 1QX Tel: Southampton 45166** / Ireland: RADIO CENTRE 122A, St. Stephen's Green, Dublin 2 / West Germany: COMPO HI-FI G.M.B.H. 6 Frankfurt am Main, Reuterweg 65 / Switzerland & Liechtenstein: EGLI, FISCHER & CO. LTD. ZURICH 8022 Zurich, Gotthardstr. 6, Claridenhof / France: HENRI COTTE & CIE 77, Rue J.-R. Thorelle, 77, 92-Bourg-la-Reine / Luxembourg: LUX Hi-Fi 3, rue Glesener, Luxembourg / Austria: THE VIENNA HIGH FIDELITY & STEREO CO. A 1070 Wien 7, Burggasse 114 / Belgium: MATELECTRIC S.P.R.L. Boulevard Léopold II, 199, 1080 Brussels / Netherlands: TEMPOFOON N.V. Tilburg, Kapitein Hatterasstraat 8, Postbus 540 / Greece: ELINA LTD. 59 & 59A Tritis Septemvriou Street, Athens 103 / Italy: GILBERTO GAUDI s.a.s. Piazza Mirabello 1, 20121 Milano / South Africa: GLENS (PTY) LTD. P.O. Box 6406 Johannesburg / Cyprus: ELFCTROACOUSTIC SUPPLY CO., LTD., P.O. Box 625, Limassol / Portugal: CENTELEC Avenida Fontes Pereira de Melo, 47, 4d., Lisboa-1 / SANSUI ELECTRIC CO., LTD. FRANKFURT OFFICE 6 Frankfurt am Main, Reuterweg 93, West Germany / SANSUI ELECTRIC CO., LTD. 14-1, 2-chome, Izumi, Suginami-ku, Tokyo, Japan

Robin Cable at Trident Studios
23 Dolby A301 units,
including 16 on two 16-track recorders

Mike Claydon at I.B.C. Recording Studios
fully Dolby equipped 16-track installation

Frank Owen at Island Studios
30 Dolby A301 units,
including 24 on three 16-track recorders

top right:
One of the Dolby installations at Olympic Studios
London's first multi-track studio to use
noise reduction throughout

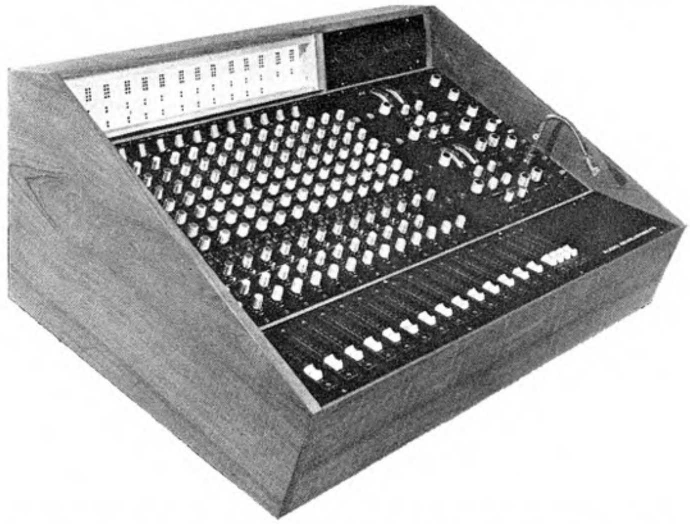
DOLBY LABORATORIES INC
333 Avenue of the Americas New York NY 10014
telephone (212) 243-2525 cables Dolylabs New York

UK and international:
346 Clapham Road London SW9 England
telephone 01-720 1111 telex 919109 cables Dolbylabs London

DOLBY SYSTEM

AUDIO DEVELOPMENTS

A PORTABLE MIXING CONSOLE BUILT ON THE MODULAR SYSTEM

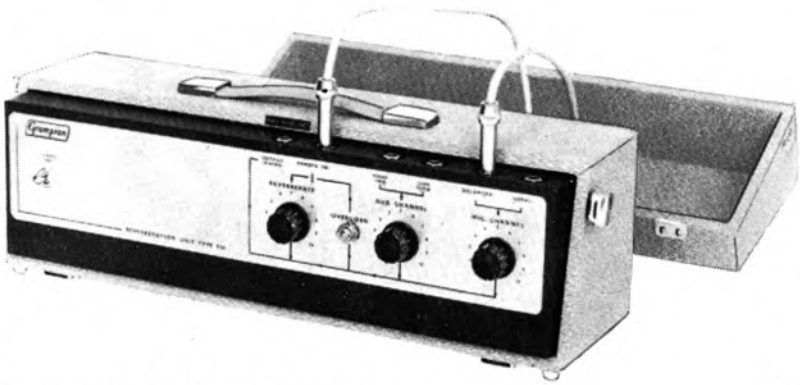


SPECIFICATION :

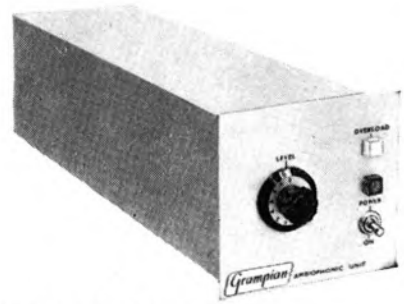
INPUTS:	12 input channels each having 600 ohm microphone input, switched attenuator and 10K ohm line input. 2 echo return channels.
EQUALISATION	All input channels have Baxendall H.F. and L.F. controls, HI and LO pass filters, and presence lift of up to 10 db. at: 150, 300 and 600 Hz 2, 3, 5 and 8 kHz
GAINS:	Maximum gain of unit in standard form 80 dB.
NOISE:	Microphone input unit with all equalisers set flat, better than −125 dB.
OUTPUT and DISTORTION:	Maximum output +20 dBm. Distortion 0.05%
MONITORING:	Built in 20w. per channel stereo amplifiers. 4 PPMs and PPM for echo send.
COMPRESSOR/ LIMITERS:	4 Compressor limiter amplifiers provided, may be inserted in any group or channel.
OUTPUTS:	4 Groups 600 ohm Balanced 2 Echo send 600 ohm Balanced 2 Fold-back 600 ohm Unbalanced 2 Monitor Speakers 8 or 15 ohm 1 Talk back Speaker 8 or 15 ohm
FADERS:	All faders are Penny & Giles slide type.
TALK-BACK:	Built-in microphone and talk-back amplifier.
ROUTING:	By unique matrix system.

PRICES AND DETAILS ON REQUEST TO

AUDIO DEVELOPMENTS, HALL LANE, WALSALL WOOD, STAFFS. BROWNHILLS 4605



Reverberation Unit Type 636



Ambiophonic Unit Type 666

After the fun of the Audio Fair, whatever amplifier equipment you have chosen, you will no doubt be interested in the added advantages of incorporating Reverberation or Ambiophonic units. May we advise you on this?

We shall be pleased to supply further details on these two units, and indeed on any Audio equipments, including mixers, microphones and mixing units etc.

AUDI/JACW/X/93

Let GRAMPIAN know your requirements

Grampian
SOUND EQUIPMENT

GRAMPIAN REPRODUCERS LTD
HANWORTH TRADING ESTATE,
FELTHAM, MIDDLESEX
TELEPHONE 01-894 9141

TELEFUNKEN
£600

BUT IT'S THE BEST

MAGNETOPHON M28A professional tape recorder by Telefunken, the company who made the world's *first* tape recorder.

● **Three-motor tape transport**
at 3¾ and 7½ ips ensuring maximum speed constancy.

Fully comprehensive mixing facilities.

● **Solid state electronics**
are used throughout. Modular construction ensures trouble-free maintenance and replacement of parts.

● **Relay operated transport control**
operated by illuminated push buttons requiring only fingertip operation.

● **Interchangeable head assembly**
comprising half-track, stereo, erase, record and playback heads, is mounted on a single rigid plate fixed to the main chassis. It is normally not necessary to replace or adjust heads during the normal life of the machine.

● **Two channel monitoring and VU-meter amplifier**
can be switched to two modes. In the 'before-tape' mode the amplifier is connected to the output of the mixer, while in the 'off-tape' mode it is connected to the output of the replay amplifier. Two large VU-meters calibrated to international standard are provided.

Broadcast-studio versions Models 28B and 28C are provided with tape speeds of 15 and 7½ ips, but have no mixing or monitoring and VU-meter amplifier. Model 28B is equipped with full-track heads. Model 28C has two-track heads and track selector switch.

CONTACT: BRIAN ENGLISH

**A.E.G. Telefunken, A.E.G. House,
Chichester Rents, Chancery Lane,
London WC2
Tel: 01-242 9944**

X-200D PERFORMS BEST WITH PERFECT PARTNERS

AKAI is famous for doing more than putting together outstanding stereo models. Much, much more. How much? AKAI is also the world's foremost assembler of perfectly matching stereo systems. Starting with the X-200D three-motor automatic reverse custom deck, AKAI also offers its own unique CROSS-FIELD HEAD so the tape may be recorded over full frequency range.
Then the AA-6300 multiplex tuner amplifier has 80 watts of IHF music power along with an FET extra-sensitve FM front-end and IC in IF stages for top selectivity. Finally, the SW-155 4-way 4-speaker system produces ultra-sound clarity. This combined AKAI system can only be matched by another AKAI system.

Prove it by the sound! ·······prove it with

AKAI®

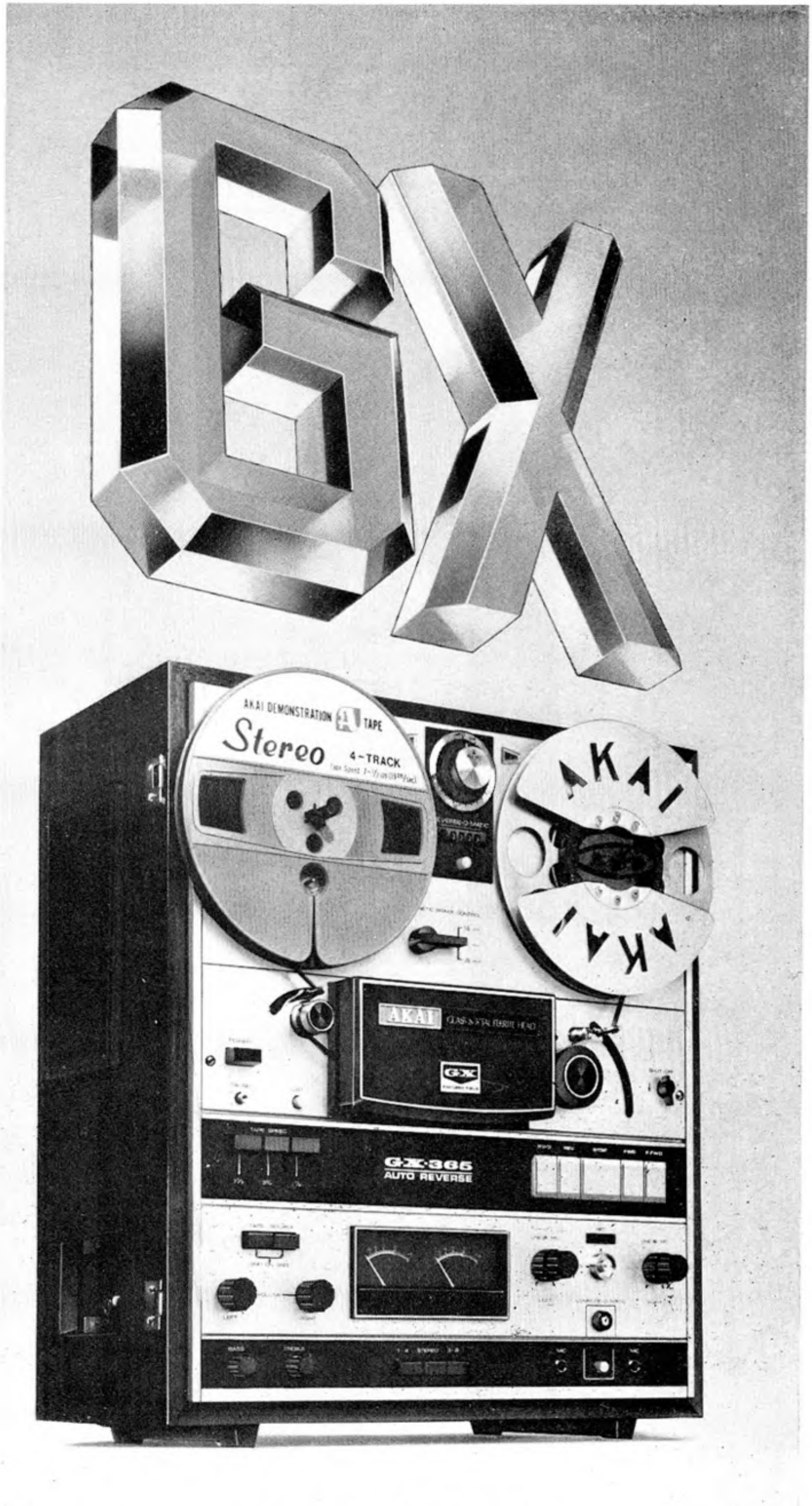
RANK ALDIS-AUDIO PRODUCTS, RANK AUDIO VISUAL LIMITED P.O. Box 70, Great West Road, Brentford, Middlesex Tel: 01 568-9222

GX-365 means "Glorious Extra" in stereo tape recorders

In AKAI's GX-365 professional stereo tape recorder, the "GX" also stands for Glass & X'tal Ferrite Head. What's in this for you? This eternally **wear free** and positively **dust free** head offers you the exclusive benefits of a "focused field" from which you can constantly record without the weakening or erasing of the signal by the bias current. There's no distortion of high frequency response in recording. But enough of that fancy engineering lingo, AKAI's GX-365 is the complete stereo tape recorder also featuring automatic continuous reverse, automatic volume control and magnetic brake. Isn't it time you had the best? AKAI is second to none in producing those "Glorious Extra" wonderful musical moments.

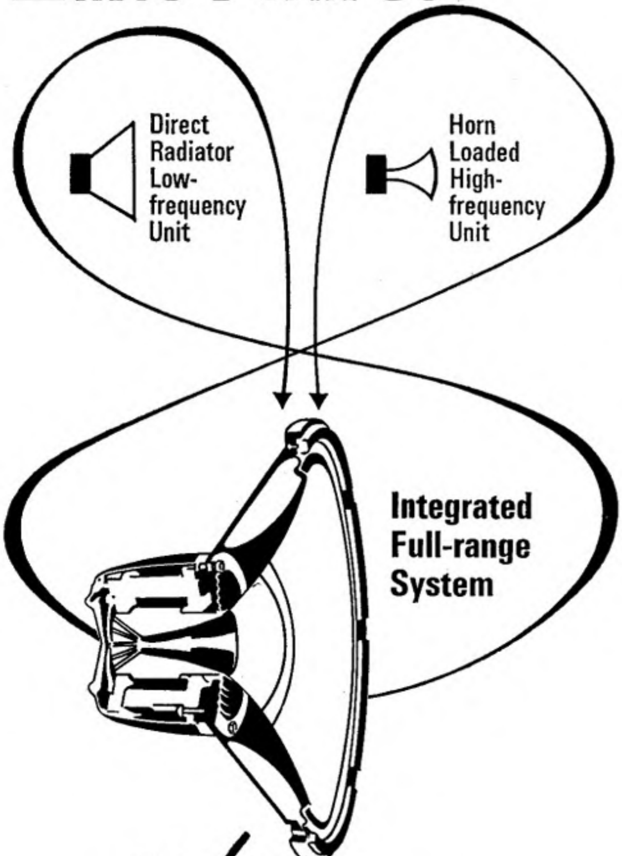
Prove it by the sound!
..........prove it with

AKAI®



Model GX-365

2 INTO 1 CAN GO!



THE *Monitor* GOLD

DUAL CONCENTRIC

. . . provides the perfect integrated source needed for stereo. The Monitor Gold is two separate transducers in a single assembly fed by a sophisticated cross-over and treble control network.

TECHNICAL SPECIFICATION

Frequency Response: 30-20,000 Hz.

Power Handling Capacity:
15″ 50 watts, 12″ 30 watts. IIILZ 15 watts.

Impedance: 8Ω nominal, 5Ω minimum.

The majority of Recording and T.V. Studios use Tannoy monitors.

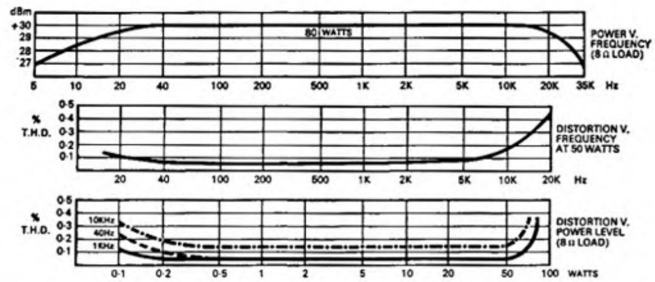
TANNOY

Norwood Road, West Norwood, London, S.E.27. 01-670 1131.

audix

"Studio 80" amplifier

POWER OUTPUT:	Max 80W into 8 ohm.
POWER BANDWIDTH:	5 Hz to 35 KHz at 80 W.
FREQUENCY RESPONSE:	+ 0 dB − .5 dB 20 Hz to 20 KHz.
TOTAL DISTORTION:	Less than 0.05 at 1 KHz.
SIGNAL TO NOISE RATIO:	Better than−95 dB below maximum output.
POWER SUPPLY:	100/120–200/250 A/C 50-60 Hz.



The "Studio 80" Power Amplifier has been produced to high performance standards for Studio and Laboratory applications.

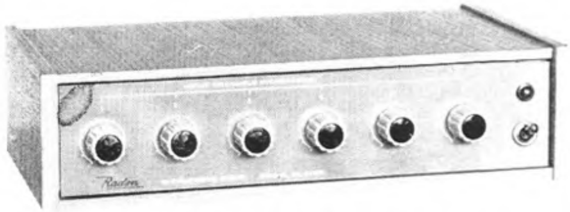
Its proven characteristics puts it in a class beyond anything yet available in power, performance, and price, and is the ultimate in economic functional engineering design – Write for full details of guaranteed performance specification.

audix SOUND SYSTEMS

AUDIX B.B. LIMITED
STANSTED · ESSEX
Tel: STANSTED 3132/3437
(STD 027-971)

RADON'S DL6CM MIXER

Designed for Professionals at unprofessional Prices



Frequency Response	10 c/s (Hz) to 35 Kc/s (kHz) Level 30 c/s (Hz) to 25 Kc/s (kHz)
Output	@6K ohms position 2.5v. max. @68 ohms position 0.025v. max.
Gain	x2 and greater than 5
Input Impedances	35 to 100 ohms (or Hi-K if required)
Hum and Noise	Better than 40 dB down
Power Supply	220 to 240 volts 50 c/s or 110 to 120 volts 50-60 c s Please state voltage required
Size	Inches: 13 x 7 x 3½ Centimetres: 32.5 wide, 17.5 deep, 10.5 high
Weight	6lb. 8oz. 3¼ kilos.

Nine transistors plus diode bridge rectifier are employed in this compact mains powered unit with the following features:

Lightweight and pleasing appearance, all controls numbered at the front to correspond with inputs at the rear, no ventilation ducting as there is no heat to dissipate, no waiting for warm-up on switching on, has high impedance output facility as well as low, with gains of x2 or x5 available at the flick of a switch, reliable standard jack sockets and a low noise level with absence of hum. The front panel is permanently engraved on grey laminate. The unit is housed in a satin polished wood cabinet.

Lo or Hi-K Standard Model	**£49.19.8** rec. retail
200 ohm Balanced Line Model	**£72.10.0** rec. retail

Also Available

Special "Audio Blocks". These are inexpensive all transistor line-matching units, to solve all those 'High and Low' problems. They are small, battery-operated units, in all-metal cases, that can take the 'treatment' and give the results you want.

Model MLA/L1 — Low to High impedance
Input 5 ohms to 1K
Output 10K to 50K Typical gain 2000—according to impedance used **£11.0.0** rec. retail

Model MLA/H2— High to Low impedance
Input 50K to 100K
Output 600 ohms Gain 20 dB @600 ohms 50 mV in for 1v. @100K out. **£11.10.0** rec. retail

Available from Dealers, or in case of difficulty, write to: **Radon Industrial Electronics Co Ltd**
Brooklands Trading Estate, Orme Rd, Worthing, Sussex Tel. Worthing 34904

Take a QUAD 50E Amplifier (a good start for any installation)

plug it into your monitor system and it bridges 600Ω lines to drive your speakers.
Take that same amplifier and, without changing it in any way, plug it into another installation to deliver 50 watts into 100 volt line * from a 0.5 volt unbalanced source. This versatility and its attendant easing of stocking and maintenance problems is one reason why large organisations use the Quad 50E.

**or indeed any other impedance from 5 to 250 ohms.*

Other advantages appropriate to users of all sizes include:

Excellent power and frequency response (—1dB).
Low distortion (0.1% at 1kHz at all power levels).
Low background (better than 83 dB referred to full output).
Pre-set level control adjustable from front panel.
Unconditionally stable with any load.
Proof against misuse including open or short circuited output.
Small size (4¾" x 6¼" x 12¾")—(120 mm x 159 mm x 324 mm).
Low price (£47.0.0 each nett for 1 off to the professional user).

QUAD
for the closest approach to the original sound

Send for details to Dept. S.S., ACOUSTICAL MANUFACTURING CO. LTD., Huntingdon, Hunts. Tel: (0480) 2561

Studio Sound

AND TAPE RECORDER

NOVEMBER 1970 VOLUME 12 NUMBER 11

INCORPORATING
SOUND AND CINE

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

COVER PICTURE

A new concept in tape/cine synchronisation, the *Crystamatic* unit mounted between tripod and Arriflex camera provides a radio link between the two recording instruments. The system was displayed at IBC 70 and is marketed here by Audio Engineering Ltd.

SUBSCRIPTION RATES

Annual UK subscription rate for *Studio Sound* is 36s. (overseas 42s., $5 or equivalent). Our associate publication *Hi-Fi News* costs 50s. (overseas 53s., $6.30 or equivalent). Six-month home subscriptions are 18s. *(Studio Sound)* and 25s. *(Hi-Fi News)*.

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

'CHRYSLER TO GIVE AWAY cartridges.' 'Decca launch cassettes and eight track cartridges.' 'Precision issuing Island cassettes.' 'Polydor pre-release tape orders doubled.' 'EMI hot up tape record drive.' Headlines such as these have become commonplace in recent months throughout the music trade press, accompanied by heavy investment in cassette and cartridge advertising. They are a reflection of the enormous promotion being given by record publishers to the packaged tape medium in general (hardly a mention of reel-to-reel) and to Musicassettes in particular.

The prime reason for this move to tape, in case you haven't guessed, is a simple human desire to make money. Tape record sales have been climbing sharply in the USA, chiefly because discs are inconvenient in American motor cars, and British producers have lost no time jumping on the bandwagon. The motorist appears to be in a remarkably powerful position. His ideal system—good enough to mask 75 dB of engine noise and take his mind off the smell—would be small, fairly cheap, unbreakable, easily loaded, and of at least 30 minutes unattended duration. In other words, any one of the several packaged tape systems currently being promoted. His position is powerful in that these systems are, for reasons of economy, also being aimed at the home-based record buyer.

Whose economy? Certainly not the consumer's. The budget conscious owner of a gramophone can obtain a wide repertoire of recorded music on LP discs costing less than 20 shillings each. Apart from a few samplers at around 30 shillings, the typical price of a cassette LP is nearly 50 shillings.

It is difficult to foresee cassette prices falling significantly unless or until radical improvements are made in their manufacture and copying. Some degree of automation has been achieved by bonding the cassette halves together, prior to which they were riveted or screwed. The actual dubbing task is at present accomplished using conventional high speed master-to-slaves transfer, with large reels of 3.8 mm triple-play tape. If the cassette really is worth heavy investment, some thought might be given to copying *before* the tape block is sliced, either using a stack of midget record heads or the elegant thermal-contact system developed by Memorex (see IBC report, page 482). It should not be beyond the ken of Philips to develop a servo-controlled slicer capable of homing between the audio tracks. An additional advantage of the Memorex system is that it relies upon the thermal characteristics of chromium dioxide tape; it has been shown that CrO_2 offers a greater bandwidth than Fe_2O_3 for a given S/N ratio and distortion level.

Our own attitude to these developments is one of sadness that the sudden application of 50% purchase tax virtually killed reel-to-reel tape records. Given the benefit of Dolby *B*, 9.5 cm/s ¼-track stereo could unquestionably hold its own against discs. Four track and eight track cartridges have three immediate disadvantages: no rewind, a tendency to wow and seize in hot weather (or when the lubricant has worn off), and an unhappy habit of tangling round the capstan when a motorist switches off his ignition. The latter was quoted to us by a leading London tape dealer, despairing of motor mechanics, who felt cartridges were more trouble than their profit margin was worth. Like us, he considered the cassette to be the most advanced packaged tape format. What did he have at home? He evaded the issue: colour television.

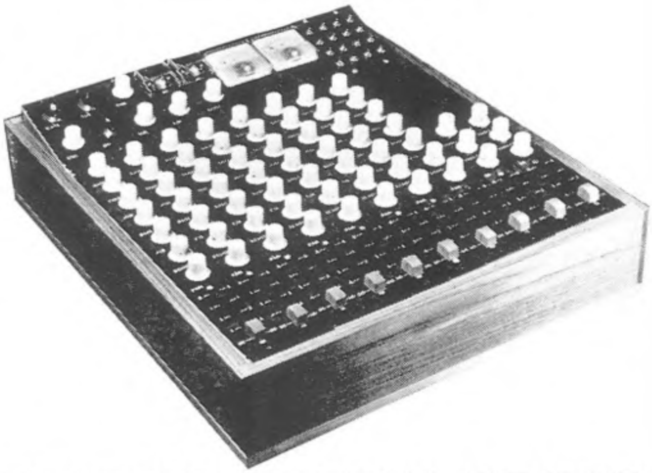
Our forecast for this decade is the phasing out of discs in favour of 4.75 cm/s cassettes, followed later—possibly encompassing quadraphonics—by a new improved cassette, probably running at another speed and, for the old economics reason, just a little wider and consequently incompatible. If the last comment seems excessively sarcastic (since a *C120* cassette would suit 9.5 cm/s without modification), remember what happened to 8 mm film.

FEATURE ARTICLES

REGULAR COLUMNS

EQUIPMENT REVIEWS

A new range of sound mixing consoles



FROM ONLY £292

Built on a modular system that allows each mixer to be assembled to customers' individual requirements, Allen & Heath sound mixing consoles have been designed to give compactness, versatility and quality at reasonable cost.

There are two standard units, the smaller accommodates up to 20 modules (10 large and 10 small) and the larger up to 40 (20 large and 20 small).

In either case the basis of the customised unit incorporates the following equipment:

* Jackfield, employing two-way jacking system
* Twin metering module
* Oscillator or talkback module
* Metered echo and foldback send modules
* Voltage stabiliser and cue module
* Monitor control module
* Two output modules incorporating echo return and equalisation

Modules available for inclusion in the mixers are:

MIC/LINE INPUT MODULE
EFFECTS EQUALISER
LIMITER
STEREO HEADPHONE AMPLIFIER

Units are supplied in attractive teakwood cabinets or portable vinyl cases with GPO Jack sockets on rear, or, if required, in chassis form with tag strip connectors.

Write or phone for full details

ALLEN & HEATH LIMITED

Drummond House, 203-209 North Gower Street, London N.W.1.
Telephone 01-387-9611

CALREC TRANSISTORISED CAPACITOR MICROPHONES

CM 1050

STUDIO CARDIOID £54-8-0

ANGUS McKENZIE says:—

. . . I compared the performance of this mike very carefully with a professional capacitor costing much more and, surprisingly, the Calrec consistently had a better noise level.

The lack of distortion was very noticeable and the sound was exceptionally smooth, with an excellent bass response. Although the *1050* is the most expensive in the range, it is still appreciably cheaper than almost every other professional capacitor and yet audibly sounds as good . . .

The price quoted is recommended retail. Generous trade and professional discounts are available. For further details of the 1000 series, 800 series (miniature) and 600 series (unbalanced) please contact:—

CALDER RECORDINGS LIMITED

REGENT STREET, HEBDEN BRIDGE, YORKSHIRE
PHONE 2159

JACKFIELDS, JACKCORDS, PLUGS AND JACKS

XLR IN-LINE ATTENUATORS, 4mm BANANA PLUGS, TEST PROBES AND CLIPS BY HIRSCHMANN.

Write or phone for full details and prices :

FUTURE FILM DEVELOPMENTS LTD.

38 HEREFORD ROAD, LONDON W.2.

01 - 220 8054

High-speed Compact Cassette Copying

Runs from 25 upwards

Fraser Peacock Associates Ltd.
94 High Street Wimbledon Village London SW19
01-947 2233 sole UK distributors of infonics

fpa

studio diary

LWT STUDIO FOR HIRE

THE SPARE capacity of London Weekend Television's studio is now being hired through Intersound, a division formed with Intertel Colour Television Ltd, at The Television Studios, Wembley Park, Middlesex. An eight track Scully master recorder is supported by a pair of two track Scullys, all with remote control and variable speed facilities.

Mixing is through a 24 channel eight group Neve, other equipment including two stereo and four mono EMT plates, a stock of Neumann and AKG microphones, and four Lockwood monitor speakers. Hourly rates (inclusive of Bosendorfer grand piano) are £22 multitrack, £12 two track, £10 mono, £15 reduction and £5 telecine. A comprehensive array of VTR equipment is additionally available. 35 and 16 mm film sound transcription is 3½d per foot. Ten per cent overtime surcharges apply from 6 to 12 pm, 25% from midnight to 8 am. The studio can handle up to 50 musicians (including their cars and stomachs.

BBC ORDER AMPEX AVR-1

THE FIRST EUROPEAN delivery of an AVR-1 automated VTR was made to the BBC TV centre at White City following the International Broadcasting Convention in September. Among other orders placed for the third-generation Ampex colour video recorder is one for 10 units going to broadcasting stations in Germany. Deliveries commence this month.

BASF TO ISSUE PRERECORDED CASSETTES

BASF HAVE confirmed their intention to enter the prerecorded music market, initially distributing light music on compact cassettes and on discs. Recording commenced in September, directed by a team working in Hamburg under Werner Cyprys, and first issues are scheduled for spring 1971.

NO MUSIC ON RADIO BRISTOL

THE FIRST OF 12 new BBC local radio stations to commence operation this autumn, Radio Bristol, has failed to reach agreement with the Musicians Union and Phonographic Performance Ltd over the broadcasting of commercial records. The ban, imposed on Radio Bristol since its opening on September 4, is still being discussed by the parties involved and unless lifted will affect all the proposed stations.

WESSEX EXTEND

THREE MULTITRACK Ampex recorders have been delivered to Wessex Sound for their newly extended studios in Highbury, North London. Two *MM-1000* 16 track and an *AGB-440B* eight track are being employed alongside the company's existing eight track *AG-440*, in conjunction with a 28 channel Neve desk. The latter has 24 output groups to meet any future demand for 24 track recording, for which the *MM-1000* may be adapted. Quadraphonic monitoring facilities, 20 Dolbys and four reverberation plates are accommodated, studio 'A' having air conditioning and room for 70 performers.

THIRD LEEVERS-RICH FOR SOUTH AFRICA

AN ORDER for a third eight track recorder has been placed with Leevers-Rich by a South African studio. Additional orders for these machines have been received from Studio Madeleine, Brussels, from Studio 10, Paris, and from the leading Swiss music and record publishers, Soundcraft, Bienne.

T. A. WALLER JOINS LUSTRAPHONE

THE APPOINTMENT of Mr T. A. Waller as sales manager is announced by Lustraphone Ltd. Mr Waller was previously sales manager, communication products, with S. G. Brown Ltd.

TRD MERGE

WE ARE asked to point out that Tape Recorder Developments has merged with Walsall Timing Developments and not, as quoted in the September APRS report, Audio Developments. The latter company is a subsidiary of WTD.

STUDIO MIXER

READERS REQUIRING *MSC 1829* transformers, recommended recently in David Robinson's *High Quality Mixer* series, are requested by Parmeko to address orders for small quantities to Home Radio Ltd, 234 London Road, Mitcham, Surrey. Reference of this transformer is *TR58* and the retail price is currently 44s 6d. The 30s price quoted earlier is applicable only to large quantities.

CUEMASTER AGENCY

FELDON RECORDING LTD, 126 Great Portland Street, London W.1, have been appointed UK agents for Cuemaster professional cartridge tape equipment. These units are manufactured in Victoria, Australia, by Consolidated Electronics (Sales) Pty and were detailed in last month's *New Products* column.

GARDNERS BROCHURE

THE FULL range of Gardners audio frequency transformers is described in the company's latest brochure, *GT.5*, available free from Gardners Transformers Ltd, Christchurch, Hampshire BH23 3PN. The current range includes line-matching transformers meeting PO requirements for high voltage working, and exceptionally wide bandwidth types capable of handling steep transients without overshoot and with low phase shift.

NEXT MONTH

DAVID KIRK field tests the Sony *CV-2100ACE* helical VTR and visits the EVR (Electronic Video Recording) plant at Basildon. John Fisher discusses FET building bricks while David Robinson details a PPM arrangement reading the greater of two signals. Trevor Attewell visits the Calrec capacitor microphone factory.

'Radio One Club' mobile disc jockeys' control desk used on outside broadcasts. The desk separates into three parts and includes Eagle cans, Plessey cartridge players and an AKG D202 on an Anglepoise stand.

We want you to get the best of us.

To get the best of us, you'd have to buy our Four Track Stereo Recorder – the N4404. Specialists consider it to be the best reel-to-reel recorder, for the price, in a range which already contains some of the finest machines on the market.

And no wonder when it has everything the most discerning user could wish for.

Mono or stereo recording and playback at 7½ and 3¾ ips. Four tracks with facilities for mono or stereo playback of parallel tracks. A built-in stereo interference filter which gives crystal clear recordings from stereo broadcasts.

And an illuminated VU type meter for control of recording level. The machine can be used in a vertical or horizontal position and has its own two loudspeakers and moving coil mono microphone.

What's more, there are separate inputs for radio, pick-up, stereo or twin mono microphones.

All for only £87. At that price you can certainly afford to get the best of us.

We want you to have the best.

PHILIPS

PHILIPS

RECORDING STUDIO TECHNIQUES

PART ELEVEN REVERBERATION

BY ANGUS McKENZIE (Roundabout Records)

ONE of the most useful aids for the recording and broadcast engineer is the facility of adding echo or reverberation to the direct mixed output of the control desk, simulating the acoustics of a much larger studio, concert hall, or even a church, in a studio which may have a comparatively short reverberation time. Reverberation devices can also be used to create special effects, as will be described later. Methods for producing artificial reverberation fall into three main categories: natural reverberation rooms or chambers, devices relying on the effect of spring or plate vibration, and thirdly some form of magnetic tape loop.

Echo chambers almost always give the most effective and natural reverberation. They are usually rooms in the basement of a studio building with specially constructed walls to give the maximum reverberation time in the room. Many have a domed ceiling. Walls, floor and ceiling have a surface highly reflective to sound, often being cemented and then painted with several coats of high gloss or varnish. The door must also be similarly treated and this can be done by fixing a thick glass panel on the inside. It is usually not sufficient to paint the wood. Although normally only one loudspeaker is used in an echo chamber, two microphones are often placed in different positions to get a stereo reverberation from a mono source. Since the reverberation pick-up is always much greater than the direct sound pick-up in such a chamber, the phase of the reverberation will be found to be very random. In order to break up echo chamber resonances, small wooden tables or chairs are sometimes randomly left around. Quite frequently an L-shaped room is used in which no direct path exists between the speaker and mikes, A word of warning should be given here about the type of loudspeaker that should be employed. If an ordinary loudspeaker is installed in a newly constructed echo chamber, after a few months of use the sound heard from the microphones deteriorates rapidly. The most usual cause is that moisture from the cement, as it dries out, attacks the loudspeaker cone and suspension and also the moving parts of the microphones. For this reason it is advisable to leave an echo chamber, when built, with an electric fire on day and night for some considerable time until the room is completely dry. The loudspeaker and microphones should also be examined every three months or so. It is best to employ units that are recommended for use in the tropics, as these will have been treated to withstand greater humidity than is usually found in Great Britain. I have actually known of a case where green fungus appeared on the loudspeaker cone after 18 months of use.

In mobile locations, back stair-cases and toilets are often extremely useful as echo chambers. I trust engineers will be luckier than the one who was shaken rigid by the toilet being flushed while being employed on a broadcast.

The reverberation plate is patented and made by EMT (agents in the UK being F. W. O. Bauch & Sons) and consists basically of a large fairly thin steel plate approximately 2.5 × 1.5 m, suspended in a tubular steel framework. Connected to one end of the plate is a moving coil actuator driven by the output of an amplifier. At the opposite end of the plate are two ceramic transducers which pick up the vibrations and feed equalised amplifiers. It is thus possible, as with a chamber, to get stereo reverberation from a mono source. The reverberation time can be controlled by moving a large damping sheet, of sound absorbent material. The reverberation time may be varied from about 1 to 4.5 seconds, also depending on the tensioning of the main steel plate. A remote control accessory can be fitted so that the engineer can alter the reverberation time by turning a knob on the control desk; this activates a motor which moves the damper sheet. Although the EMT plate costs £1 500 for a complete installation, it is very widely used in studios and in broadcasting. Not quite as good as an echo chamber, it nevertheless performs very well.

Spring reverberation was first patented in the late 1920s but was little, if at all, used until the late 1950s by which time the Hammond Organ Company had designed a practicable system and patented it. I used a crude form of spring echo in early 1956, and I will describe it for the amusement of readers. An old 2 K MSS cutter head was solidly mounted horizontally on a frame work about 1.3 m high and the end of a 1 m coiled spring was screwed tightly into the stylus holder. The spring hung down vertically and at its other end was screwed into a pre-war Rothermer crystal pickup, whose output was connected to a tape recorder replay amplifier. An elaborate system of laterally placed elastic bands, pulled the spring in various directions in order to damp it. Although the whole apparatus was extremely crude, it was fairly successful, and I still have one or two recordings made with it. The Hammond organisation uses four 20 cm long springs arranged in longitudinal pairs, having unit delay characteristics of approximately 29 and 37 mS. The reverberation time of the Hammond *Type 4* unit described is approximately two seconds at 300 Hz and 1.5 seconds above 1 kHz, with a cutoff at 6 kHz caused mainly by the thickness of the spring material. The bass cut-off is approximately 100 Hz, introduced in the accompanying amplifiers. The springs are driven torsionally by small ceramic magnets at one end, these acting as armatures of an electric motor. When the fixed drive coils are energised, the magnets rotate and twist the springs. The pickup transducer is the same with minor differences of construction. The whole unit gives a fairly exponential reverberation, and one excellent example using the Hammond *Type 4*, is available in two different versions from Grampian Reproducers Ltd of Feltham. One of their units, known as type *636*, normally supplied as a battery operated device but available with a mains power supply, includes a two-channel mixer and independent control on direct and reverberant sound paths. Therefore this is particularly useful where no echo send and return mixing facilities are available. The alternative unit, *Type 666*, is much simpler and only includes a reverberation path. It is important to note that a constant current direct to the transmitting transducer is essential to the proper working of the device and the Grampian

(continued on page 481)

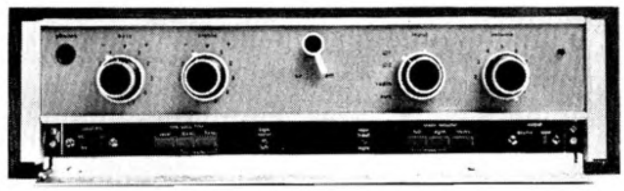
Ferrograph stereo amplifier F307

Ferrograph's F307 is one of the finest stereo amplifiers in the world. It has been designed to make the heart of great hi-fi systems.

It is an integrated stereo amplifier, built in the Ferrograph tradition to provide a unique combination of performance and facilities. Power output is 20 watts RMS per channel into a load of 8 ohms. Total harmonic distortion is less than 0.25% at 1 kHz at all levels up to its rated output. Silicon solid state devices are used throughout, with F.E.T.'s in certain input stages to provide high input impedances and large overload margins and thus to accommodate a wide range of input sources, including tape, ceramic and magnetic pick-ups, radio and auxiliary inputs, at their optimum levels. The signal-to-noise ratio, measured with volume control at maximum, is better than 65 dB. Controls include four-input selector switch, switched mains outlets, press-button HF filter, comprehensive mono/stereo input and output switching. The main controls are readily to hand on the front panels; all others are conveniently placed under a hinged flap.

In appearance, the F307 amplifier continues the uncluttered lines of the Ferrograph Series 7 recorder, the two making an ideal combination which is matched both visually and technically. But the amplifier is equally compatible with most other good recorders and hi-fi installations, suits innumerable amateur and professional uses, blends with any decor, stands attractively on any bookshelf or room-divider.

When planning your hi-fi system the F307 deserves your serious consideration. Your local Ferrograph specialist will be pleased to demonstrate it to you. Alternatively, please write or ring for details and address of nearest stockist. The Ferrograph Co. Ltd, The Hyde, Edgware Road, Colindale, London NW9
Tel: 01-205 2241, Telex: 27774



International Distributors:
Leroya Industries Pty, 266 Hay Street, Subiaco, Western Australia 6008, Australia;
Matelectric, Boulevard Leopold II, 199, 1080 Brussels, Belgium;
H Roy Gray Ltd, 14 Laidlaw Boulevard, Markham, Ontario, Canada;
Cineco, 72 Avenue des Champs Elysees, Paris 8e, France;
Henry Wells & Co. KG, 1040 Wien 4, Danhausergasse 3, Austria
Ferropilot GmbH & Co., KG, Hamburg 39, Sierichstrasse 43, West Germany;
Hi-Fi Installations, P.O. Box 2430, 276 Andries Street, Pretoria, South Africa;
Elpa Marketing Industries Inc, New York Park, New York 11040, New York, U.S.A.
There are Ferrograph Distributors also in most other countries. Please obtain details from the London office.

Ferrograph

units are provided with such a drive.

It is understood that AKG in Vienna are working on a very much modified form of spring reverberation unit with many additional features but this is not likely to be available for some considerable time. More details will be given when they come to hand.

Many other forms of mechanical reverberation have been attempted over the years, possibly one of the most ingenious being made by an engineer who bought an old grand piano and built a 20 cm loudspeaker into the wooden frame underneath the middle strings. He built a microphone into the same base board, took out all the dampers and tuned the strings so that, in the case of three strings normally of one note, the two outside ones were offset to slightly higher and lower than the centre string. The device worked quite well as long as the piano lid was not slammed! Another enterprising device was made in which a large tank of liquid housed the transmitter and receiver transducers. The input audio signal was transponded to a supersonic frequency centred around approximately 60 kHz, transmitted through the liquid, and the received signal transponded back to audio again. I understand it worked well but was rather impracticable and needed a large rack of equipment.

The third type of reverberation device is available in many forms, possibly the most comprehensive being the *Echorec* made by Binson. A magnetic drum system includes one record head and up to four replay heads which are staggered to allow several different echoes of the original signal to be picked up. The outputs from all these are controllable and can also be fed back to the original record head to obtain tape flutter echo. Such devices always produce slow isolated echoes rather than a continuous reverberation, unless modified to operate at very high speed. Many studios have a tape recorder with PPM set up in the control room, using a tape loop to give a delayed signal to a reverberation device or to obtain normal flutter echo. 38 and 19 cm/s are frequently used, some studios even fitting a variable speed drive.

A most interesting example of the use of delayed tape echo is to be found in the PA system at St Paul's Cathedral, delaying the public address sound to each loudspeaker by the same amount as the natural time delay that a listener would hear from a preacher in the pulpit. This greatly improves the clarity of amplified speech.

BBC drama

Echo devices can be used in a number of ways which may not be immediately obvious, one way being used frequently by the BBC in drama. The difference channel output of a crossed bi-directional mike such as the AKG *C24* is fed to the echo device, usually a plate, and the stereo return fed normally to left and right. As the performer enters the stage from the left, reverberation will be heard on his footsteps and voice and, as he arrives at the centre, the reverberation will decrease and then increase again as he moves over to the right, thus giving the impression of being in a large room. Alternatively the output of only one capsule can be reverberated, giving the effect of a large corridor at one side of the stage. The BBC frequently use spring echo devices such as the Grampian for mobile locations because of its portability, and often delay the sound of the spring with a tape loop. It is important to watch carefully the levels being sent to both the tape and any other device to work the equipment at the best level. Very different effects can be achieved with echo chambers by adjusting the dynamic level at which the chamber is used. Engineers should always bear in mind, when using a reverberation device, that too little is often better than too much, as the latter becomes too obvious and can be very nasty on string instruments. When using EMT plates, incidentally, it is always better to use a stereo pickup from one plate covering the entire stage. Two individual plates, of course, give two distinct points of reverberation which makes their use very obvious.

Many engineers find that compression and/or limiting with equalisation is very useful in both the send and return paths to control the characteristics of the reverberant sound. Compression in the transmission path will give more reverberation effectively to quieter instruments, whereas in the return path it will give an overall increase in reverberation time. By equalising, more reverberation can be applied to particular frequency bands which can be used to good effect, particularly in popular music recordings. I would like to refer readers to the previous article in this series in which I described the different methods of connecting echo devices into the studio mixer.

When recording or broadcasting in concert halls, it is sometimes considered necessary to use additional microphones to pick up extra reverberation. I would like to give a word of warning that in such circumstances each pair of mikes used for this, with one capsule feeding the left channel and the other the right, should be as coincidental as possible, with at least 90° between their axes. This will give a spread of reverberation across the sound stage whereas, if two mikes are used several metres apart, two discrete reverberation sounds appear on extreme left and right with little in the centre. This latter technique would be particularly ineffective for mono compatibility since there would be less echo noticeable in mono than in stereo. I also deprecate the use of two microphones pointing in the same direction, or even just one mike centre injected, since this gives a reverberation as if from a corridor in the centre of the stage. When pure cardioid microphones are in use for recording a group of musicians, the necessity for adding reverberant sound is of course greater. It is often considered better to use a crossed bi-directional technique, allowing reverberation to enter the back of the microphone more naturally.

OBITUARY

TERENCE LONG

TERENCE LONG will be remembered, by all who knew him, as a man of outstanding character, charm and accomplishments.

One of Terry's most remarkable attributes was the manner in which he overcame his misfortunes. As a boy and young man, he suffered illness which left him physically handicapped; this in no way reduced the success he achieved in his work as an analytical chemist and as a precision engineer. This strength of character remained with him throughout his life, sustaining him in a two-year fight against his last and often painful illness. Throughout this final phase, he continued to work to his accustomed high standards and, as a true professional, he insisted on finishing all outstanding commitments.

His involvement in sound recording began around 1951 when, in his early forties, he purchased his first tape recorder and found himself dissatisfied with its engineering quality. He modified the machine and, progressing to more expensive designs, found that these too benefited from his attention. The studios which in later years relied upon his engineering skill will miss his unique services.

Terry will also be remembered and greatly missed by a large circle of recording enthusiasts —amateur and professional—for whom his home, West Lodge, was open house. There they had the opportunity of listening to superb master tapes, of meeting performers, and of participating in stimulating discussion and experiments often extending far into the night.

Those of us who came into contact with Terry through our audio interests were inclined to forget that this was only one aspect of his expertise. His engineering company was concerned primarily with producing surgical instruments. This was formed in 1930 and during its first two years supplied 30 000 electric polishers to the medical profession.

His love of mechanical devices is perhaps best reflected in his comment that tape recorders are like human beings, each one displaying individual behaviour. This attitude extended to railway transport, of which he compiled a considerable photographic record.

Terry's achievements in life were those of a man who made full use of his many gifts, not only for himself but for the benefit and enjoyment of others. We extend our deepest sympathy to his wife Mary.

THAT WAS IBC 70

Haydec, this one ordered by EMI Film Productions for installation at Elstree Studios

David Kirk recalls highlights of the international broadcasting convention

IVC-871 helical VTR

IT takes an IBC to remind me, every couple of years, that audio is only one aspect of the broadcasting industry. While the APRS Exhibition is almost entirely devoted to sound processing, the International Broadcasting Convention has its five feet entrenched in audio, television, cinematography, signal distribution and automation. It has been sponsored over a six-year period by the Electronic Engineering Association, Institute of Electrical Engineers, Institution of Electronic & Radio Engineers, and The Royal Television Society (UK), also the (US) Institute of Electrical & Electronics Engineers, and the Society of Motion Picture & Television Engineers. With this support, not to mention substantial fees from visiting delegates, the Convention enjoyed the space and comfort of Grosvenor House, Park Lane.

In his introductory address, James Redmond (BBC Director of Engineering) expressed his disappointment that very few papers in the lecture sessions were related to sound broadcasting or, in view of recent developments, to the distribution of television programmes by wire. 'One wonders . . . whether there is a demand for a choice of 10 or 20 or even more television programmes. Obviously if they could be provided cheaply enough, the viewer would not object to having them available. However, if the programmes are to be worthwhile, they must be of good quality in terms either of entertainment, information or education, in which case they will be costly. Even if they have been broadcast before, the cost of repeating them would be high. To repeat all 26 episodes of the Forsyte Saga, for example, on one of these channels would cost well over £100 000 in repeat fees alone to the artists whose performances have been recorded.'

D. J. Bryan (Thames Television) described a digital servo system permitting the synchronisation of VTRs and multitrack audio recorders, extending the flexibility of television sound. Quadruplex, helical and audio recorders may be locked, using the helical scan recorder as the controlled element to prevent wow.

Thermal contact duplication

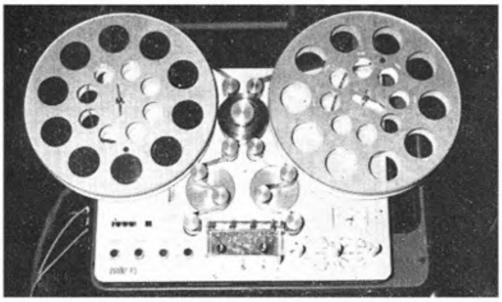
The thermal contact duplication of videotape was outlined by W. B. Hendershot (Memorex). High-speed copying in the conventional sense is mechanically, if not electronically, out of the question and one-to-one copying was described by Mr Hendershot as a 'brute force' approach, a large amount of capital equipment being tied up (at least two VTRs) to copy a single tape. Mr Hendershot first explained the disadvantages of recently developed AC transfer systems. These were inefficient at long wavelengths, requiring separate heads to copy audio and control tracks. They incurred a loss of 3 to 8 dB below the potential level of a conventional one-to-one copy. The Memorex thermal system, on the other hand, exploited the low (compared with ferrous oxide) Curie point of chromium dioxide tape. If an iron-oxide master is placed in contact (coating to coating) with a CrO_2 slave in a thermal environment which passes very rapidly down through the CrO_2 Curie temperature (125°C), the master signal coerces the CrO_2 into magnetisation. The resultant duplicate can actually have a higher output than the original iron master.

David Robinson, at the end of an erudite paper upon applications of the Dolby noise reduction system, mentioned that the record unit can be used alone for special effects, when it behaves as a low-level frequency dependent compressor. Popular recordings have been issued with the signal in its compressed form and Austrian Radio is currently conducting tests to determine the benefit this technique offers to AM radio transmissions.

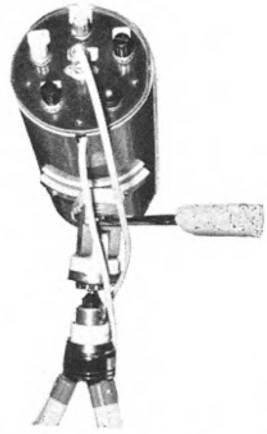
Radio link

Audio Engineering Ltd, in the exhibition hall, displayed the *Crystamatic* radio link which permits cable-free synchronisation of camera and sound recorder. At £850, it also incorporates radio talkback facilities. As may be seen from the cover, the unit is designed to sit between camera and tripod. Other features include automatic scene counting, automatic alarm, and 24 or 25 f/s speeds. Audio Engineering are planning the introduction of a wireless microphone series, the *Micron*, to sell at about £195. The UK model will operate at 174 MHz, crystal controlled to GPO requirements. Receiver sensitivity is 3 μV for 40 dB signal-to-noise.

A range of new video tapes for helical-scan recorders was demonstrated by EMI. Emitape *626* is intended for quadruplex VTRs, *627* for IVC and Bell & Howell models, while

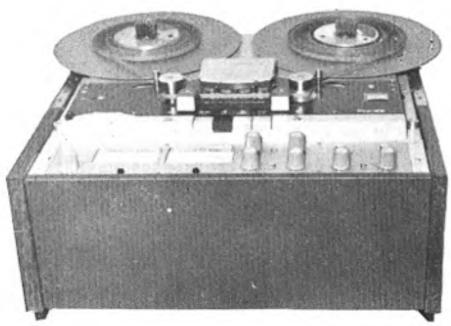


Sondor **M3** sprocketed film sound recorder



Low cost do-it-yourself TV camera from Mullard

Ampex **AVR-1** automated colour VTR



Philips **Pro 36**

825 is an LP version of *815*, intended for low-tension portable audio recorders. Co-operation between EMI and Thames Television has resulted in equipment systems providing automatic control of many routine operations involved in the day-to-day running of a television station. Thames TV is the first British company to employ computer devices for this purpose.

Four *A361* units on the Dolby stand were sold during the exhibition to EMI for use in the Hayes tape duplicating plant. An order for five *A301* units came during the week from the White House in Washington, where it will be part of an 8-track recording system.

Two new additions to International Video Corporation television equipment were shown, the *IVC-871* VTR and *IVC-311* Plumbicon colour camera. The recorder has a 5 MHz bandwidth (PAL, SECAM or NTSC to order), two audio channels and internal audio monitoring.

Leevers-Rich have introduced a new version of their bulk eraser, a low-price unit handling spools of up to 21 cm diameter. Provisional price is £21 (including tax). A larger version handling spools of up to 30 cm diameter will be in production before the end of 1970. An audible warning device prevents accidental erasure. Also introduced were a range of full, half and two track audio heads for 6.25 mm tape, two and four track 12.5 mm, and four and eight track 25 mm.

The Nagra *4* was seen in the unique guise of a 27 cm spool studio recorder, dwarfed by the add-on assembly developed for EMI Film Productions. This assembly converts the portable Nagra into a full studio machine and can be supplied to any Nagra owners requiring such facilities.

The Philips *Pro 36* made its anticipated UK debut, succeeding the *Pro 35* as a transportable recorder intended for location recording. Ferroxcube heads are incorporated (full track 6.25 mm, stereo 2.75 mm or two channel 2.20 mm to order), with a three-speed servo-controlled drive giving a claimed 0.05% RMS maximum wow and flutter at 38 cm/s. Overall frequency response is 40 Hz to 18 kHz ± 2 dB (CCIR equalised) with 60 dB signal-to-noise ratio ref 32 mM/mm, unweighted. Other speeds are 19 and 9.5 cm/s. The recorder was demonstrated as part of a complete broadcasting studio installation.

Chrome dioxide VTR

On the VTR front, Philips displayed the *LDL 1250* colour helical recorder designed for 25 mm chrome dioxide tape. Video bandwidth reaches 5 MHz with 45 dB signal-to-noise at a scanning speed of 23.5 m/s and 26.7 cm/s tape speed. The unit records 625 line PAL and includes sound dubbing facilities.

A comprehensive series of mixer modules was announced, including the *MDR2* spring reverberation unit, *7021* VU meter, *7020* equalisation amplifier, *5752*, *5753* and *4060* compressors, *5714* PPM with amplifier, *5711* talkback amplifier, *4020* audio amplifier, *4047* five-frequency tone generator, and *4067* 25 W (for +4 dBm input) power amplifier. Complete mixers are available in the form of *MD* and *SSM 14* desks, *2669* and *5744* portable and *MP4*, *5740* and *5741* table-top units.

A 38 cm/s version of the *Pro 12* recorder is the basis of the *CTD 4* cassette duplicator. A 9.5 cm/s master reproduces at four times nominal speed into up to four slave cassettes (19 cm/s) simultaneously. Philips claim a production capacity of 35 000 cassettes per year. Extra slave units can be paralleled with the *Pro 12*.

RCA demonstrated a new quadruplex VTR, the *TR-70C*. Extensive use of ICs in the transport servo system give a claimed improvement in reliability comparable with the early progression from valves to transistors. Also shown were the compact *TR-60* and an automated editing system. The most interesting piece of engineering at the convention was the RCA *TCR-100* television cartridge recorder. This can be loaded with up to 22 quadruplex video cartridges and was conceived as a means of automating advertising breaks.

Sondor, sharing the Hayden Laboratories stand with Kudelski, have developed a new sprocketed magnetic film recorder, the *M3*. Powered from a 12 V car battery, it permits location recording on 16 or 35 mm stock in synchronism with a cine camera. This 'Mini Sondor' (420 x 280 x 250 mm, 16 kg) operates at 24 and 25 f/s, giving 58 dB signal-to-noise ratio and 0.1% wow and flutter. Current consumption during normal running is 2 A and the anticipated price is around £1 500. A mixer is being developed by Sondor to suit the recorder.

A HIGH QUALITY MIXER

David Robinson

PART SIX

VISUAL MONITORING

THE VU meter originated in the United States when there was a need for standardisation between the many radio stations which were springing up at the start of sound broadcasting. There was, of course, much programme interchange between studios, and some system had to be devised for measuring levels at various points in the transmission chain. The method of measurement had to be simple and easily added to various points in a chain. It had to be cheap so that even small concerns could afford to invest in it—and this is still true today. The system finally adopted uses an ordinary moving coil meter incorporating a metal oxide rectifier but with a tight specification laid down to ensure that all VUs have the same characteristics.

Bell Telephone Laboratories drew up the first specification for the VU in 1940, and readers interested in the original document can find it in either the Bell System Technical Journal, January 1940, or in the Proc. IRE 28, 1940. This document specified the most important features of the instrument; the most significant are the sensitivity and dynamics. The dynamic properties must be such that when a step input is applied to the meter of an amplitude which causes full scale deflection, the overshoot is between 1 and 1½%. The needle must arrive within 90% of full scale in 300 mS. It should have a well defined impedance of 3.9 K and a controlled sensitivity. With a series resistor of 3.6 K (making a total of 7.5K) and input signal of + 4 dBm (1.228 V in 600 ohms), the needle should be within 70 to 80% of full scale, that is on the 0 VU mark.

FIG. 39
Ernest Turner 1027 PPM

There had, of course, been similar meters up to this time, but this was the first attempt at standardisation. A meter built to these exacting specifications is not cheap and, from a well-known manufacturer who guarantees the performance, the price is about £9. Other versions are available at lower cost but these should be treated with extreme caution if an accurate VU is required—in particular, the overshoot characteristics may suffer in low cost instruments.

The main advantage is that for this price the instrument is complete—there are no further amplifiers to add to the unit. This implies that there is a suitable point in the circuit or output point where the signal is correct in amplitude and impedance, or larger in amplitude so that it can be attenuated and still give the correct impedance. It is possible to reduce the external 3.6 K resistor to increase the sensitivity, but this allows the non-linearity of the meter rectifier to reflect back into the main circuit and adds more distortion there; also the ballistic properties can be affected.

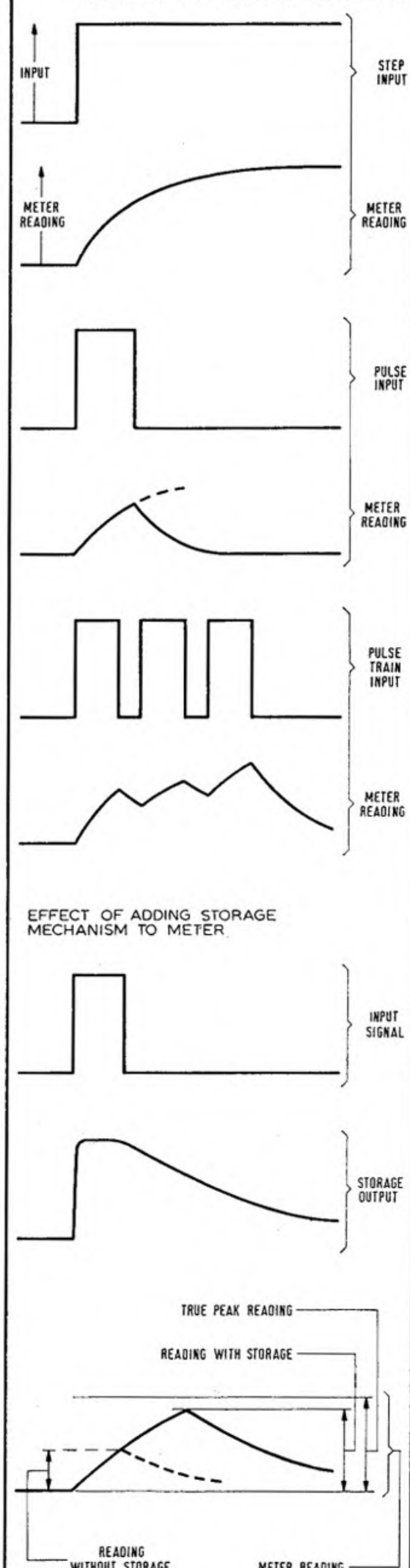
Since it takes a full 300 mS to respond to a step input, the VU meter will not respond accurately to short sharp pulses such as occur in harpsichord or guitar music. By the time the meter has started to respond to the pulse, the pulse has finished; as there is no storage mechanism the meter never moves to the full scale. **Fig. 40** explains this in more detail. The longer the input pulse, the more chance there is of reaching the true reading of the peak. Alternatively, the more rapid the sequence of pulses, the more accurate the reading. This corresponds closely to the auditory sensation of loudness or volume—short sharp pulses do not sound nearly as loud as longer lasting sounds of the same amplitude—and hence the term Volume Unit meter.

The peak programme meter was initially developed about 1936 by the BBC and in its modern form used by broadcasting organisations in this and many other European countries. It was designed with the express purpose of reading the peak level of the incoming signal. The term PPM has become the accepted name for both the meter and the special logarithmic amplifier that is nearly always used with it, and throughout this article PPM will refer to the two, except for a few obvious exceptions.

The price of a good PPM is about £8 but on top of this is the cost of the amplifier which must go with it, making it much more expensive than the VU meter. The amplifier requires quite a few components since it must include the storage mechanism, and also provide the

(*continued on page 487*)

FIG. 40 GENERALISED RESPONSE OF METERS TO VARIOUS INPUT WAVEFORMS



The Grundig TK147 is a hush-hush job

The TK 147, a four-track, fully automatic stereo machine, is one of Grundig's silent breed of tape recorders. The one sound we don't want you to hear out of the TK 147 is the TK 147. So we've designed it with that in mind. Because at Grundig we like to be at least several jumps ahead of the rest of the crowd. The TK 147 is built to an exclusive Grundig design with an elaborate electronic circuit that keeps noise to a minimum.

But that's just the start. This superior design also keeps the distortion level low and frequency response and dynamic range high, whatever the conditions, the composition or the volume of the recording.

And how d'you like the sound of that? You can get superb stereo playback results by connecting it to a Grundig Stereogram or external stereo power amplifier and loudspeaker.

Wherever you look, you'll find clear evidence of Grundig's superb craftsmanship and attention to detail which results in a sound quality that is unmistakably better.

Listen to the hush-hush TK 147 soon - it's something to make a noise about. TK 147 - £96.4.0.

GRUNDIG

Made Better to Sound Better

Grundig (Great Britain) Ltd., London, S.E.26.

logarithmic indication which needs to be both accurate and stable.

Both the PPM and the VU are arranged to read positive and negative peaks by using full rectifier techniques, since it has been shown that differences of up to 8 dB occur in musical sounds.

So much for the specification of the units. We must now discuss the relative merits of each system. Firstly, in broadcasting in general and tape recording in particular, we are especially interested in the peak signal since distortion in amplifiers and on tape is linked to the amplitude of the signal and not to its duration. If we are to avoid this overload distortion we must be able to measure peaks correctly. We have seen that the VU cannot do this on all types of music. The PPM on the other hand is very good at registering peaks but tape overloads slowly so that it can lead to under-recording.

This brief explanation outlines the main differences between the two meters, and shows that there must be careful interpretation of the meter readings. If the VU is treated as a peak meter and the recording gain altered to give always a nominal peak level, then the amount of instantaneous distortion alters depending on the type of music being recorded. Some skill or experience is required here; the PPM always gives the peak reading so that, by following it carefully, there is much less likelihood of any distortion through over-recording. However, it can lead to over-cautiousness instead. The important factor to remember is that tape hiss is the most annoying factor in a recording. If the recording sounds clean and free from distortion, even though the meter is pegged firmly at the right-hand side, then this is surely satisfactory, although the theoretical distortion may be astronomical.

It is interesting to note that the two major recording companies in this country differ over their meters, one using VUs and the other PPMs. Both receive favourable reviews, so it is evidently possible to produce identical results with the two systems. For interest, it is worth nothing that the PPM in question has different time constants to those used by the BBC. There are many opinions both here and on the Continent as to the correct values to use. A new British standard BS 4297/1968 has been written which ties in with the German DIN except for scale markings, and it is to be hoped that the industry will gradually accept this.

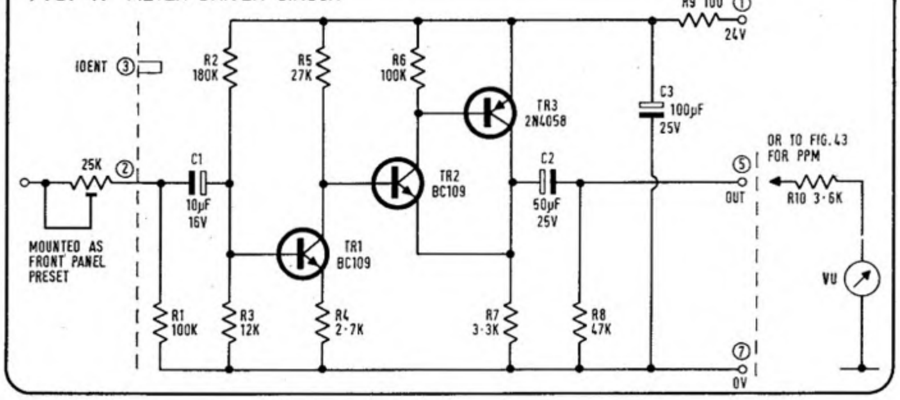
A disadvantage of the VU meter is the scale compression. It is very useful to have a system which covers as much of the range as possible; low signal levels on the VU give a very small deflection and the first meaningful reading is at about –15 dB. The PPM on the other hand has a corresponding lowest reading of about –22 dB.

Turning to the high end, VU ballistics can lead to a rather unfortunate state of affairs during line-up conditions. Most organisations record tapes so that the peak level corresponds to about 2% tape distortion. With many tapes this distortion is produced with a flux of 32 mM/mm per tape width, and the current DIN test tapes have this level recorded as a reference. This will give a reading of 6 on the PPM but, taking into account the VU ballistics, must be set for + 4 on that instrument—which is of course off the scale. The Ampex test tapes are recorded to a lower level, to give 0 VU or PPM 5; this corresponds to a distortion of 1% on a particular piece of tape used in the early days of setting standards. Using the Ampex tapes, to the NAB standards, the user must remember that peak recording level is 4 dB above test tape level. And it is extremely difficult to use the DIN tape on a machine with VUs! This apparently simple difference has led to a great deal of confusion, particularly with devices which need to be set up and operated at peak recording levels.

And so to the actual circuits. Both the PPM and VU meters need a preamplifier, since the monitoring point is taken at the mixer output rather than the actual output. (The reasons for this were explained in last month's article.) The level at the monitoring point is -6 dB (see fig. 36), so the amplifier of **fig. 41** is used to raise this to a suitable level. This amplifier has one stage of amplification (Tr1, approximately 20 dB or 10 times). The input level control has a maximum of 10 dB, so that the input of -6 dB will be amplified to + 4 dB with this control fully in. This is the level for direct connection of a VU meter. Tr2 and Tr3 form a low impedance unity gain amplifier to drive the VU; the connection method is also shown in **fig. 42.** Some VU meters have the 3.6 K resistor built in, and therefore R 10 is not needed. This can be checked in two ways; 1.23 V applied to the meter/resistor combination should produce 0 VU, or the impedance can be measured. Feed in a 1 kHz signal to give 0 VU reading, and add a series resistor of 3.9 K. If the meter lacks the added resistor internally, it will indicate half scale; if it has, the indication is about 65% of full scale.

To be continued

FIG. 41 METER DRIVER CIRCUIT



Component suppliers:

Components: Henry's Radio Ltd, 303 Edgware Road, London, W.2.

Printed Circuit Cards: From the author, c/o *Studio Sound* (cheques made out to the author, not Link House).

Ref. *217* Meter drive amplifier 6s.
218 PPM circuit 6s.

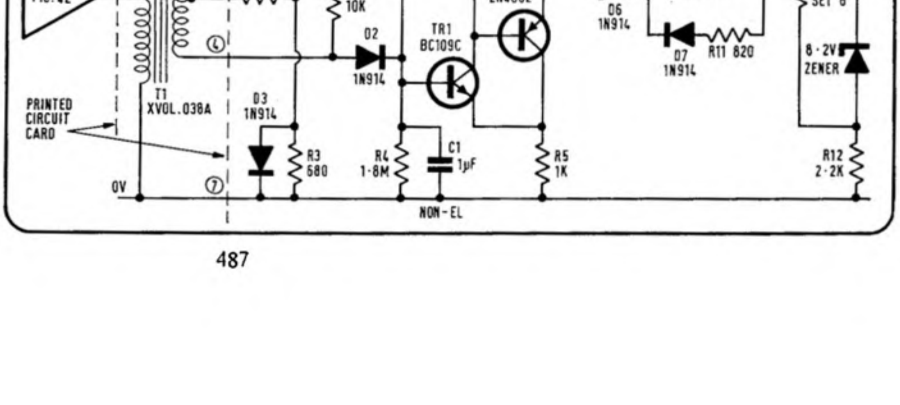
PPM transformer: Type *XUOL.038A* from Transformer Equipment Ltd, Railway Place, Wimbledon, London, S.W.19. Price 33s.

PPM movements: Type 642 (replaces the 702 used on prototype) £7 15s., 1 mA to BBC spec.
Type 643 (larger size) £9 5s. 1 mA to BBC spec.

VU meters: 642 £8 15s.
643 £9 5s.

All meters from Ernest Turner Ltd, Chiltern Works, Totteridge Avenue, High Wycombe, Bucks. (PPM delivery is at present 16 weeks)

FIG. 42 PPM CIRCUIT



ANGUS McKENZIE TESTS NINE CURRENT TAPES, COMPARING THESE WITH THE BEST OF 1948.

OVER the last decade there have been significant improvements in the standard of magnetic recording tape manufacture. Since the professional recording engineer has very little time at his disposal to test tape adequately, engineers are very loth to change from one tape to another since it means changing all the bias and equalisation settings of the record amplifiers on their machines. Some tape manufacturers, for this reason, are still making tapes virtually the same as those made over 12 years ago, at the same time as having greatly improved tapes in their catalogues.

In evaluating the tapes mentioned in the table, I had to make quite sure that the tape recorder on which they were examined was beyond criticism. For this reason a Telefunken *M10*, with interchangeable head blocks for mono and stereo, was used. The distortion characteristics of the record and replay amplifiers are referred to in the September *Studio Sound* review, and will be seen to be very low. The evaluation took many days since very considerable care had to be taken to ensure precise alignment on all the record and playback heads, including not only their height and azimuth, but the accurate setting of their wrap-round characteristics. After considerable adjustments had been made, a gain of some 0.5 dB in the tape path over what had previously been considered satisfactory was obtained, and this is considered most important in the measurement of distortion and 10 kHz squash point measurements, as the differences between several tapes were very marginal.

Professional recording tapes fall into several different categories and, before analysing the actual tapes, these types will be considered. Compared with tapes produced a decade ago most modern tapes have a lower basic noise figure and in general the lower this is the poorer the print-through figure becomes. Many tapes capable of being recorded to a very high flux density at mid frequencies are now produced, these normally being referred to as 'high output'. It appears to be a characteristic of these tapes that the squash point at very high frequencies is in most cases inferior to that on medium and low output tapes. A very important conclusion must therefore be drawn with the use of these high output tapes, and that is a strong recommendation for the use of the NAB 50/3180 μS characteristic for playback at 38 cm/s, this requiring less treble pre-emphasis on recording.

Whereas with the 35 μS DIN characteristic it is dangerous to adopt a peak studio recording level of more than 6 dB above 32 mM/mm for *LR56*, a peak recording level of +8 dB can be used with the NAB curve, provided that the music recorded does not have an excessive amount of HF present. In general the high output tapes have a thicker layer of oxide, with a subsequent requirement, usually, of more bias. Such an increase in bias unfortunately tends to decrease HF amplitude thus limiting the peak level that can be recorded. Considerable variations in the amount of modulation noise were also apparent, this being noticed as a shushing noise behind music and tones recorded at high level. Tapes having a low modulation noise sound considerably cleaner at high levels, and this is a factor which is unfortunately often overlooked. It is perhaps ironical that some of the best tapes suitable for use with machines having a DIN 35 μS curve are made by American companies or their subsidiaries, whilst several European tapes more frequently used with such a characteristic are more suitable for the American NAB one.

The most important consideration for ordinary use, apart from modulation noise and print-through, is the ratio between a tape's weighted noise figure and its recommended peak recording level. For use with the Dolby *A301* noise reduction system one of the most important considerations is the harmonic distortion figure for a tape recorded flux of 32 mM/mm, or to be strictly correct, using the latest recommended units, 320 pW/mm (pico Weber per mm).

From the table it will be seen that distortion at 320 pW/mm varied from 0.5% to 1.25%, this variation being considered quite high. The two tapes capable of the highest output at 1 kHz had the lowest distortion at lower levels, whereas the tapes with the lowest output capability corresponded to the highest levels of distortion, and this added to the appearance at first sight that the highest output tapes would be the most suitable for use with the *A301* system. Although this system tends to reduce the effect of modulation noise it certainly does not eliminate it and, because the high frequency output is limited from these tapes they will begin to overload noticeably at a slightly lower level than others, since engineers using the *A301* will frequently balance with more HF present since such a balance recorded without a noise reduction system will either tend to suffer distortion or have audible tape noise present.

The biasing for each tape was adjusted with a 1 kHz sine wave recorded to give a playback of 20 dB below 320 pW/mm as it was felt after considerable experiment that such a method gave more reliable information about the tape than the now more usual biasing at very high frequencies. After engineers have decided on the tapes they are going to use in the studio it is nevertheless better to bias at the higher frequency after measuring the overdrop corresponding to the biasing at 1 kHz. The size of the recording head gap also to a degree determines the bias requirement at very high frequencies for a given overdrop, whereas the size of this gap does not materially affect the results obtained when 1 kHz is used. Several independent organisations that have also been testing tape recently agree with these comments. The amount of bias required was measured by connecting a high frequency probe to the live terminal of the record head, the output from the probe being connected to the Y input of an oscilloscope having its time base switched off, the vertical height in cm of the display being measured using a constant gain. The figures are represented in the table as centimetres, the height being proportional to the required bias current. The equalisation of the record amplifier was extremely carefully set for BASF *LR56* tape after the replay amplifiers had been set to an accuracy of ±0.5 dB using a BASF DIN 38 cm/s test tape which had been very carefully compared with a reference 320 pW/mm given to me as a laboratory standard, and also several other test tapes. Neither the record equalisation nor the entire replay amplifier was touched during the measurement. The input gain to the tape recorder was carefully adjusted such that 0 dBm represented a replay level of 320 pW/mm replaying from the line out amplifier again at 0 dBm. The sensitivity at 1 kHz was measured with reference to *LR56* at a level of -20 dBm and the agreed sensitivity represented the amount of gain or loss of a particular tape when biased correctly. The treble sensitivity was measured at 10 kHz and this represents the amount by which the gain of the tape at 10 kHz exceeds 1 kHz with respect to *LR56*, i.e., the amount that the equaliser will have to be dropped or boosted at 10 kHz with respect to the latter tape.

The noise level of the tapes was measured by inserting a dBa weighting network in between the output of the tape recorder and and RMS millivolt meter, the loss of the weighting network being approximately 3.75 dB at 1 kHz, this loss not being compensated for in the figures. This weighted curve was

(continued on page 491)

Professional Recording Tapes Surveyed

ANGUS McKENZIE TESTS NINE CURRENT TAPES, COMPARING THESE WITH THE BEST OF 1948.

TAPE TYPE	AGFA FR4	AGFA 525	AGFA 555	AMPEX 434	BASF SP52	BASF LGR30	BASF LR56	EMI H57	EMI 815	SCOTCH 202	SCOTCH 206
SENSITIVITY, 1 kHz REF. LR56	—4.25	—1.25	—0.5	—2.25	—1.0	—0.5	0	(1948) —10.5	—0.5	—2.25	—1.75
SENSITIVITY, 10 kHz REF. 1 kHz EQUALISED FOR LR56	+0.5	+0.75	—1.75	+2.0	+0.75	+0.25	0	—6.0	+1.25	+1.0	+0.75
BIAS FOR 1 dB OVER DROP AT 1 kHz	4 cms	3.5 cms	4.3 cms	3.4 cms	3.4 cms	3.4 cms	3.7 cms	—	3.8 cms	3.6 cms	3.9 cms
DISTORTION (3rd HARMONIC) AT 1 kHz AT 32 mM/mm	0.9%	1%	0.5%	1.25%	1.1%	0.8%	0.55%	—	1%	1.25%	0.95%
INPUT dBs REF 32 mM/mm FOR 3% 3rd HARMONIC DISTORTION	+5.5	+5.75	+10.25	+5.0	+6.0	+6.75	+9.0	—6.0	+6.25	+4.5	+6.5
INPUT dBs AT 10 kHz FOR 1 dB SQUASH ON REPLAY (35 μS CURVE)	+3.5	+4.5	+3.5	+4.5	+4.5	+4.5	+3.75	—	+4.0	+4.0	+4.5
dBA WEIGHTED NOISE (RELATIVE) IN dBs	—74.5	—73	—72	—74.5	—72	—72	—71.75	—	—73.5	—74.5	—74.25
MODULATION NOISE	POOR	POOR	POOR	VERY GOOD	VERY GOOD	VERY GOOD	AVERAGE	POOR	VERY GOOD	VERY GOOD	AVERAGE
PRINT-THROUGH	AVERAGE	POOR	POOR	POOR	AVERAGE	GOOD	AVERAGE	POOR	GOOD	POOR	RATHER POOR
BACKING	MATT	MATT	MATT	SHINY	SHINY	MATT	MATT	SHINY	SHINY	SHINY	MATT
SPOOLING	GOOD	GOOD	VERY GOOD	FAIR	FAIR	VERY GOOD	VERY GOOD	FAIR	FAIR	GOOD	VERY GOOD
WEIGHTED NOISE/10 kHz SQUASH RATIO	77.5	77.0	76.5	78.5	76.5	76.25	75.0	—	77.5	78.5	78.5
WEIGHTED NOISE/PEAK NAB RECORD LEVEL RATIO	78.5	77.75	80	78.75	77.25	78.5	78.0	—	78.75	79.0	79.5
PRICE PER NAB SPOOL (APPROX. 2400ft) IN 1 DOZ. LOTS	OBSOLETE	52/-	58/-	55/6	47/6	57/6	62/6	—	48/-	48/-	PRICE NOT YET ESTABLISHED

Solid-state, 4-track, 3-speed stereo tape recorder

Model MR 939

"In summarising our conclusions we can say that the Sanyo MR-939 is the most complete and compact stereophonic record playback unit we have come across with a performance well within its manufacturer's specification"
Tape Recording Magazine July 1968

Solid state circuitry delivering 7-watts maximum music power per channel. 4-track stereo/monaural operation. 3 speeds selected by single lever. Recording levels controlled by 2 illuminated VU meters. Sound-on-sound, sound-with-sound facilities. Jacks for line out, speaker, stereo headphone outputs, microphone and auxiliary inputs, DIN (Record/Playback Connector). Automatic shut-off device. Vertical or horizontal operation.

SPECIFICATIONS

Recording system AC bias 4 track
Erasing system AC erase 4 track
Tape speeds
$7\frac{1}{2}$ ips (19cm/sec)
$3\frac{3}{4}$ ips (9.5 cm/sec)
$1\frac{7}{8}$ ips (4.8 cm/sec)
Wow & Flutter
$7\frac{1}{2}$ ips : 0.15% R.M.S.
$3\frac{3}{4}$ ips : 0.20% R.M.S.
$1\frac{7}{8}$ ips : 0.30% R.M.S.
Recording time
64 min at $7\frac{1}{2}$ ips (Stereo 1200 ft. tape)
128 min at $3\frac{3}{4}$ ips (Stereo 1200 ft. tape)
256 min at $1\frac{7}{8}$ ips (Stereo 1200 ft. tape)
Level indication VU meter x 2
Output power
Music power 7W x 2
Undistorted 4W x 2
Frequency response
$7\frac{1}{2}$ ips 20-20,000 c/s (30—15Kc $\pm$ 3db)
$3\frac{3}{4}$ ips 30-13,000 c/s
$1\frac{7}{8}$ ips 30- 8,000 c/s
Signal-to-noise ratio 45 db
Crosstalk
50 db (channel-channel)
65 db (track-track)
Output impedance
Line out : 2 Kohm
Speaker out : 8 ohm
Headphone : 10 Kohm
Input impedance
Microphone : 50 Kohm
Aux : 100 Kohm
Record/play DIN connector
Input : 10 Kohm
Output : 2 Kohm
Microphones
Two dynamic microphones
Speakers
Two 4" free edge permanent dynamic speakers
Voice coil impedance 8 ohm
Power source
AC 100V, 117V, 125V, 220V, 240V
50-60 c/s
Dimensions
Main unit: $18\frac{1}{2}$ x 6" x $13\frac{3}{4}$"
(470 x 150 x 350 mm)
Speaker boxes: 9" x 5" x $13\frac{3}{4}$"
(230 x 130 x 350 mm)
Weight 36.3 lbs (16.5 kg)

The MR-939 is available from the Sanyo dealer in your area, specially selected for first-class before-and-after-sales service. Or you can write for an illustrated leaflet to:

Sanyo Marubeni (U.K.) Ltd.,
Bushey Mill Lane, Watford, Herts.
Telephone: Watford 25355.

SANYO

People the world over agree there's something about a Sanyo found to correspond reasonably satisfactorily with the subjective effect of tape noise heard by the human ear. Although the difference between the worst and best tapes measured was approximately 3 dB, in fact the subjective difference unweighted did appear to be slightly more, and some engineers may prefer therefore to exaggerate these differences when considering the figures in the tables.

The distortion figures were measured with a wave analyser, only the 3rd harmonic distortion being noted. It was interesting that the even harmonic distortion was always exceptionally low, being only fractionally higher than the distortion of the oscillator used for these tests.

The 10 kHz squash point represents the point at which the non linearity of the tape produced a 1 dB reduction of output over input. It was found to vary considerably from batch to batch of any one kind of tape, and the setting of the bias was very critical for this measurement. Although distortion products of very high frequencies are outside the audible frequency spectrum, they nevertheless produce bad intermodulation products, both with other frequencies and with the bias itself, and it is not advisable therefore to use the high frequency squash property of tape as a limiter.

In assessing the quality of each particular tape apart from modulation noise, print-through and mechanical properties, two figures will be seen in the table. The first is the ratio between the weighted noise of the tape and the 10 kHz squash point. The second is the ratio of the weighted noise level and the arithmetical mean of the 10 kHz squash point and the 3% 3rd harmonic distortion point at 1 kHz, the latter figure being most useful when an NAB characteristic is used.

Modulation noise and print-through were measured subjectively and later confirmed from measurements taken electrically. The neatness of spooling was noted using a machine with a reasonably good tape transport, but nowhere near the best, rewinding fairly fast. It was noted without surprise that matt backed tapes spooled considerably better than shiny backed tapes, but in general it should be borne in mind that matt backed tapes will often wear heads faster. Also matt backed tapes usually were of the high output variety, and more suitable therefore for use with NAB equalisation at 38 cm/s. Tape recorders having a really good transport system spooled virtually all the tapes extremely well but many earlier recorders such as the EMI *BTR2* do not spool shiny tape so well. Many engineers using less expensive machines may well feel it advisable to use matt backed tapes because a poorly spooled tape can easily be damaged by a protruding edge being bent over, which will subsequently cause dropout.

Unfortunately a number of professional and semi-professional machines do not have recording amplifiers capable of fully driving some of the tapes listed, at least at the HF end, and therefore tapes having a greater sensitivity may well give a better performance on such machines. The highest output tapes are also very sensitive and therefore should not present a serious problem when a DIN characteristic is used, but may on the other hand cause some difficulty with an NAB curve if mid frequencies are driven very hard. It is also worth pointing out that on some machines replay amplifiers can overload when replaying high output tapes. It may well be that the recording amplifier is satisfactory whilst the replay amplifier needs to be modified. Examples of this are the EMI *BTR2* and early TRD models.

The effect of print-through can be virtually ignored if a noise reduction system is used, but can otherwise be extremely serious. Print-through is of course most noticeable on speech and I have heard many severe examples of this, which sometimes only appeared months or years after the original recording had been made. The effect of print-through can sometimes be reduced by spooling the offending tape through fairly slowly several times. If tapes are kept in a warm or hot atmosphere, they are more liable to print. Another way to reduce print-through is to pass the tapes over a record head through which an extremely small bias current is passed. Although it tends to reduce the higher frequencies slightly, this may be the lesser of two evils.

Without taking into account the type of material to be recorded, when a 35 μSec DIN characteristic is used it would appear that Ampex *434*, Scotch *202*, and the latest *206* tape not yet freely available, would give excellent results, apart from somewhat poorer than average print-through factors. EMI *815* would, however, seem to be a safer recommendation with all things considered, since not only has it a low print-through but is amongst the best tapes for low modulation noise. Attention should be drawn, however, to the fact that *815* does not spool particularly well, and I would recommend that EMI consider bringing out a matt backed version. Agfa *555* clearly rates the best, for use with recorders having NAB equalisation. It has the astonishing mid-frequency overload point of +10.25 dB. For the recording of sounds with a restricted HF content, and where a somewhat high modulation noise can be tolerated (i.e., for noise measurement purposes) Agfa *555* can also be strongly recommended because of its incredible dynamic range at mid and low frequencies. This tape, however, cannot be recommended for a number of applications because of its poor modulation noise.

Scotch types *202* and *206* and Ampex *434* can be recommended for their overall excellent performance except for the poorer print-through. For the same reason, therefore, perhaps EMI *815* will be chosen since the differences are in any case very marginal.

Some otherwise good tapes have their special weighted figures reduced because of a high hiss level, an unfortunate example being BASF *LR56* which would otherwise have been very highly recommended.

If a noise reduction system is used, tape noise and print-through cease to be important, and therefore distortion and lack of modulation noise are the most important factors. BASF *LR56*, *SP52* and *LGR30*, and EMI *815* would seem to give excellent performances consistent with a good overload level and low distortion, whilst also having very low modulation noise characteristics. Provided that Scotch *202* and *206* and Ampex *434* were not driven to a peak recording level exceeding approximately 510 pW/mm they are also considered extremely good, and considerations other than electrical performance may well count in their favour.

It must be emphasised that all the figures mentioned will stand only for the batch or batches measured by the writer and, for some makes, the variations in sample performance characteristics may well swing the figures by as much as 1 dB. The most variable feature was usually bias requirement, with sensitivity also slightly variable.

Susceptibility to dropout has been very closely watched but is considered to be so largely a tape transport problem rather than a tape problem that it has not been evaluated. No dropout was noticed on the Telefunken *M10*.

Measurements on two tapes no longer available have been included, *H57* because it is the earliest conventional tape made in Britain and the results should amuse the reader, and Agfa *FR4* because, although no longer available, it was used by many studios and regarded as a very good tape in its day, over a decade ago.

The cost of the tape per NAB spool may also be an extremely important factor and it would appear that, since EMI *815* and Scotch *202* both come out very well in the tests, in addition to having a low cost, this may well sway the engineer—or his accountant ! The reliability and speed of delivery is also of importance, in addition to the technical facilities of the manufacturer or his agent. I have found BASF and EMI the best in this respect as far as London is concerned, but would also like to emphasise that the 3M Company, marketing Scotch, have a most helpful attitude and a competent technical service. Since, however, they have their factory in South Wales, deliveries can sometimes be delayed, although the recent opening of a warehouse in West London should do much to improve the service, particularly in the London area. Many companies will consider lower prices than those quoted, provided the purchaser is prepared to take quite large quantities and come to an understanding to take an arranged minimum quantity per annum. It would not be fair to prejudice negotiations by asking manufacturers to disclose bulk prices since many factors come in to any contract agreement.

I would like to thank all the Companies whose tapes have been assessed for their co-operation, both technically and in the disclosure of prices that appear sensible compared with other manufacturers, for small but significant quantities.

A CARDIOID CAPACITOR MICROPHONE

A NUMBER of would-be constructors have been frustrated in their attempts to build the hypercardioid capacitor microphone, described in the January issue, by a sudden dearth of capsules. Further, false rumours have arisen in some quarters to the effect that those actually supplied were complete rejects of some kind.

To set the record straight, the simple facts are as follows. STC make the capsules in batches and, after an ageing period, test each unit, grading it into one of three groups. The first group contains those suitable in all respects for incorporation into *4136* microphones, while the second is made up of those which are just outside specification. The third group are, of course, the complete rejects. Those supplied to constructors have all come from the second group. The only significant difference between these and the best ones is that they show a slightly greater variation in sensitivity over the frequency range. STC state that this variation, which is quite smooth, averages about 6 dB over the whole band, compared with the maximum of 4 dB allowed in the *4136*, and a typical record, taken from a sample supplied to a reader, certainly seems to confirm this. Such a performance is very good by most standards, and especially so at the price asked.

At the time of publication of the original article, some 50 units were in stock and it was anticipated that these, plus a steady trickle from regular production, would meet the likely demand. In the event, 300 were ordered quite quickly, and still more might have been, had the word not gone around that STC had stopped taking orders after 140 had been promised, since they saw no possibility of supplying more on any practicable time-scale.

A search for a replacement soon brought home the fact that the number of firms making cardioid capacitor capsules is pretty limited—still more so once one has crossed off those who don't want to know about the DIY trade. The first ray of hope came from AKG, who quickly agreed to supply one from their range. Although an excellent performer, it was found difficult to adapt to this particular application, for several reasons. First, it is a complete 'front end', about 18 mm in diameter and 23 mm seated height, from which the actual capsule cannot (or at least *should* not) be removed. Attachment is by means of an extremely fine pitch thread, 95 tpi, and this would require a tapered adaptor with a corresponding internal thread at its outer end. The cutting of such a thread would probably be quite impossible for most constructors. Secondly, the microphone circuit would have to be modified, since the outside of the case is common to one side of the capsule, and the polarising voltage would also have to be changed. If any reader remains undeterred and wants to have a go, he can obtain the capsule through the author. The current price is £15 10s plus postage, and the method of ordering is the same as that for the recommended capsule, given at the end of the article. It is regretted that no tested information on adaptors or circuits is available, though some plausible suggestions will gladly be offered if required.

Most readers will obviously prefer an alternative involving the minimum of modification to the existing design, parts of which may have been constructed already. With this in mind, Calder Recordings have offered to modify capsules of the type used in their *600* series microphones to make them virtually direct replacements for the STC originals. The modification consists in fitting a perforated Perspex cover over the diaphragm, the cover having an internal brass ring to which a flying lead is connected. The cover retains the connection to the diaphragm and also removes the risk of a short-circuit between the microphone shield and the capsule (which is slightly larger than the STC one). This allows the capsule to be transported and handled, within reason, with no risk of damage to the diaphragm.

Fixing is by an 8 BA female thread in a small central boss in the back plate, and this is fitted on an 8 BA stud. The modifications required to the original microphone design are very simple and can be effected in different ways, depending on which of the original parts, if any, have been made already.

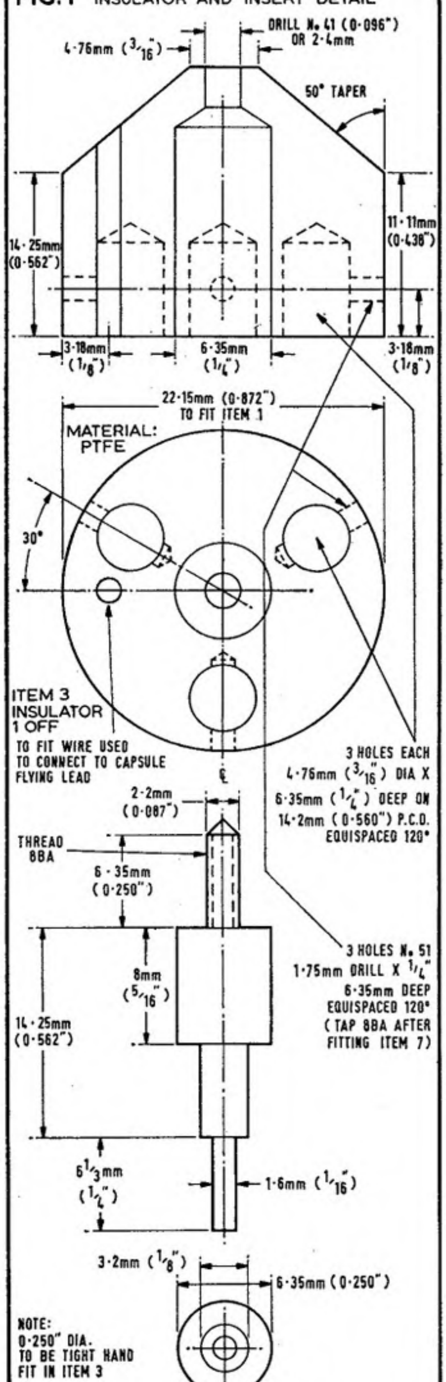
When starting from scratch, the conical insulator and its insert (items 3 and 4 of the original design) should be made to the drawings of **fig. 1**. It will be seen that the insulator is shortened slightly, with a steeper taper, and the diameter of its upper face is increased from 3.18 to 4.76 mm (⅛ to 3/16 inch). The side hole is omitted. Both drillings in item 4 are likewise omitted, the upper end being extended into an 8 BA stud to carry the capsule. Note that the insert must be a really tight push fit in the insulator since there is no longer a grub screw to provide location. On assembly, the capsule should be screwed on to the stud, which should then be locked with a spot of nail varnish. Care must be taken not to let this run into any hole in the back plate. The flying lead is then soldered to the wire which passes through the insulator (ensuring that vapour from the operation does not flow over the capsule) and the gauze shield fitted as before. There is no change in the other inserts (item 7), which are therefore not shown in this drawing.

If the formation of an 8 BA thread on the top of item 4 presents any difficulty, an alternative is to omit the threaded part altogether, and drill a hole (No. 50 drill, 1.8 mm) centrally in the top surface to a depth of 6.25 mm (¼-inch). This hole is tapped 8 BA and a piece of 8 BA studding 12.7 mm (½-inch) long is screwed in. Having first checked that the length protruding is satisfactory, the stud should also be locked into item 4 with varnish.

If items 3 and 4 have been made to the original pattern, proceed as follows. Make up the adapter pin, shown in **fig. 2**, by taking a short piece of 8 BA studding (or a long screw) and turning down the appropriate length to form the plain shank. When the threaded part is inserted into the capsule, no thread should be visible above the boss. If any is, this end should be shortened accordingly. Insert the plain portion into the assembled microphone, making sure that the capsule boss touches the top of the conical insulator, and lower the gauze shield until it touches the capsule cover. Note carefully the vertical distance by which the holes in the shield fail to line up with their counterparts in the body and machine off this length plus about 500 μm (0.02 inch) clearance from the top of the insulator, after removing it from the assembly. This will probably mean taking a little off the top of the insert (item 4) also, and this can be done, with care, with it in situ in the insulator. It should now be possible to assemble the microphone normally. Again, the stud should finally be locked in the capsule with a spot of varnish.

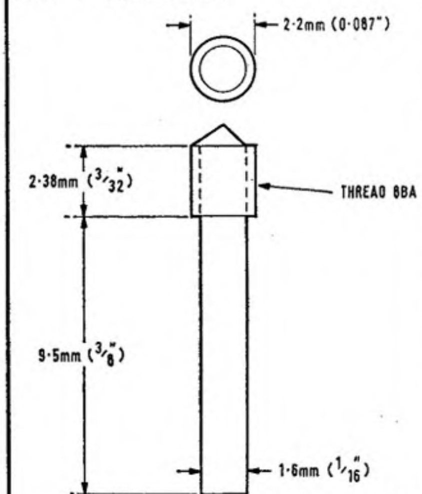
Trevor Attewell suggests alternative capsules for his January design

FIG. 1 INSULATOR AND INSERT DETAIL



ITEM 4 INSERT – 1 OFF MATERIAL: BRASS

FIG. 2 ADAPTOR PIN



1 OFF MATERIAL: BRASS

A still simpler method is available to anyone who happens to have made everything except the shield. In this case it is sufficient to deepen this by about 4.76 mm ($\frac{3}{16}$ inch) to give enough clearance around the capsule when it is fitted, on the original insulator, by means of the pin shown in **fig. 2.** The recommended method of shaping the gauze should allow enough margin for this. If it is thought worthwhile to modify the wooden jigs, the $1\frac{1}{16}$ inch dimension on die C (fig. 10 in the original article) can be increased to $1\frac{1}{4}$ inch, and the depth of the soldering jig (original fig. 12) can be increased from $\frac{15}{16}$ to $1\frac{1}{8}$ inch.

It is most important to note that the small screws which will be found inserted in the capsule back plate are *not* for fixing purposes, and *must on no account be disturbed.*

The Calrec capsule requires the same polarising voltage as the STC and no circuit change of any sort is needed.

Naturally, readers will want to know what results to expect from the new capsule, especially since it is more expensive—though it might be added that the cost of the complete microphone still shows a considerable saving over that of any commercial equivalent. Dealing first with objective results, measurements using one of the prototype microphones gave an output sensitivity of 2.5 mV/μB and an equivalent noise level of 18 phons, using the IEC curve A weighting. The amplifier overload point was better than 135 dB when measured with a short output cable. The frequency response was measured by Calder Recordings, and the measurement repeated by the author independently and in a different anechoic room. The results, shown by the full line in **fig. 3,** agreed excellently. The more cynical of our readers may question the smoothness of the curve; in fact the only irregularities which

FIG. 3 TYPICAL FREQUENCY RESPONSE

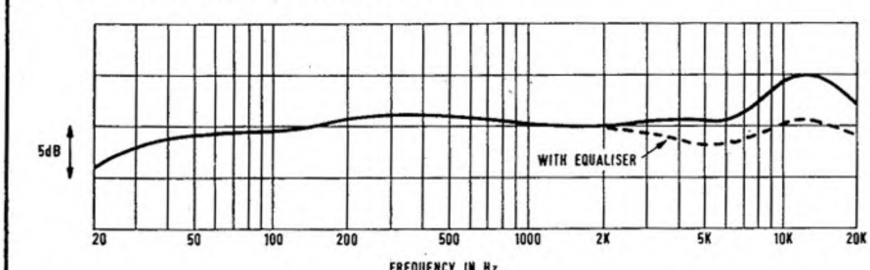
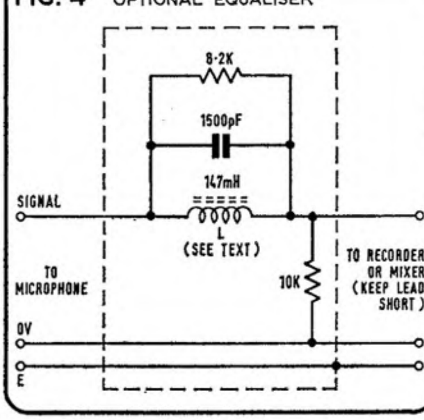


FIG. 4 OPTIONAL EQUALISER



(continued overleaf)

A CARDIOID CAPACITOR MICROPHONE CONTINUED

have been smoothed out are several which were found to be accurately repeatable, even with totally different makes of capsule, and are thus almost certainly attributable to the set-up used. In any case, they were within ± 2 dB of the curve shown.

The polar pattern is cardioid at low and middle frequencies, becoming slightly hyper-cardioid at high frequencies, the rear lobe being of the order of 10 dB at 10 kHz. The claimed front-to-back ratio is 15 dB, which would usually be adequate but this includes the effect of the rear lobe at high frequencies. The pattern nulls are certainly much lower than this modest claim suggests. The capsules on offer are similar to those used in the Calrec *652* microphone, which was reviewed very favourably by Angus McKenzie in the August issue, and the measurements quoted above agree completely with his findings.

There has not been time to carry out really exhaustive listening tests but results to date again confirm Angus's comments. The noise level is remarkably low, the general response is commendably smooth, and the bass performance satisfies even the author, who wages unceasing war on those response curves that stagger down to 50 Hz and then collapse on the floor.

The top is slightly crisp, and the reason for this will be plain on inspecting **fig. 3.** A small treble lift is often useful, and is actively preferred by some users, but anyone who objects can easily flatten it out by means of an equaliser, such as that of **fig. 4.** This circuit should be placed close to the mixer or recorder, to which it should be connected by reasonably short leads. It should be screened, and the input impedance of the following circuit should be not less than 100 K. The coil L is one specified by Mullard for use in their FM decoder, their tapping point being omitted or left unused. It should be available commercially, or can be home-made from 620 turns of 39 swg enamelled wire on a *Type LA 2534* ferrite pot-core. With the equaliser in circuit, the response of the sample capsule, shown dotted in **fig. 3**, was within about ± 2 dB from 25 Hz to 20 kHz.

One or two folk have got into difficulties through connecting the microphone directly into an amplifier having a transformer input. It must be noted that the microphone output line is at a positive potential of about 10.7 V and a blocking capacitor is needed between it and any DC path in following circuits. This capacitor is already built into most recorders and many mixers, and was therefore left out of the microphone to save space. The value of the blocking capacitor must be such that its reactance is negligible compared with the input impedance of the amplifier at the lowest frequency of interest.

Working into low impedance amplifiers will reduce the overload capacity of the microphone, and is not recommended. To work into 300 ohms, for example, would require a 100 μF blocking capacitor, and the overload point would occur at about 112 dB at all frequencies. This is not high enough for many applications, and will be reduced still further at high frequencies if a long cable is used.

Finally, readers are asked to note carefully the following ordering details. Calder Recordings cannot supply capsules to individuals and orders should therefore be sent to the author, c/o *Studio Sound*, marking the envelope ORDER. Other correspondence and technical queries must not be included, but sent under separate cover. The orders will be collected into small batches and passed on to the firm who will despatch the capsules directly to purchasers. To cut down paperwork, no acknowledgement of order will normally be sent, but may be had on request provided that a SAE is enclosed for the purpose. The price is £15 plus 5s packing and postage, and terms are strictly cash with order. Cheques, etc., should be made payable to the author, and *not* to this journal or its publishers. The delivery time will depend, to some extent, on the volume of orders, but the initial estimate is about four weeks. Calder Recordings say emphatically that, if the demand is higher than expected, they will take steps to meet it, so there should be no worries on that score.

There has been some interest in this project from readers in several Commonwealth countries, and there would seem to be no great difficulty in sending them capsules if required. With their order they should send a cheque, obtainable from their own bank, drawn in sterling on a London agent. They will have to comply with any exchange control regulations in force in their own country and it would be wise to enquire whether any additional charges will have to be paid before the incoming capsule can be rescued from their Customs officials! All overseas orders will be acknowledged.

tape recorder service

PHILIPS N4308

BY H. W. HELLYER

MY postbag yields a rich harvest of requests. Not all of them say 'Shut up' and only a few, in this enlightened age, ask for guidance among the pitfalls and ensnarements of The Law According to Ohm. Having answered to the best of a limited ability those questions on technical subjects, and passed to more erudite experts those upon which I am clueless, I am left with a hard core of letters which ask for no more than servicing information on the writers' own specific machines.

You may have noticed that *Studio Sound,* since its change of name, has become more professional in its approach. You did? Good. This may be taken to connote that the only machines we shall ever talk about are the Studers of this world. Further, that articles on servicing (you mean they ever *need* servicing?) will peter out with a sputter of head-cleaning goo and a feeble wave of a chinagraph. You could be wrong.

I shall let you into a little secret.

Among my activities is the membership of more than one illustrious professional society. Occasionally, members of these august bodies condescend to visit our shop. More often, seeking advice, they buttonhole we practising servicemen who hover, pariah-fashion, around the fringes while they talk incomprehensibilities. 'Look, old man,' they may say, 'I've got a *Humbox Special*, 1959 vintage. Just for knockabout purposes you know.' There is a pause, while the apologetic tone is allowed to infiltrate. It usually turns out that the ancient tape recorder requires service and its woeful owner has no access to spares, or even service information.

He may be accustomed to handling Ampex videogear worth thousands of dollars. He may be able to sign with a flourish some requisition on his stores that would keep an amateur recordist in tape till Kingdom Come. But as for the *Humbox Special*—he does not even know who made it. He appeals to the scavenging service engineer, always with the excuse that he retains the old HBS for sentimental reasons.

Naturally, we do our best to help. So it is with my postbag and this section of *SS*. Many readers have older tape recording equipment, or machines that do not cost a small fortune, and they lack information on them. 'When are you going to do a servicing article on the so-and-so range?' they plead.

Looking back through the list of servicing articles, marvelling that so much has been said on some and so little on others, I am hard put to know who to please. The greatest good to the greatest number, perhaps? My choice this month is dictated not by the actual machine, but by its being a general example. The Philips *N4308* has its direct equivalent in the Stella mark and a very near relation among the Pye 'Sound Camera' collection. More than this, its type of mechanism is very much typical. Reference to this model may help quite a bit with service information on others.

The circuitry, as can be seen from **fig. 1**, is not at all difficult. Based on conventional 'building bricks' formed from the circuits developed by the transistor makers, and thus employing easily obtainable semiconductors, it is economic and reasonably efficient. I hope Philips will not take exception to that word 'reasonably'. After all, the *4308* and its companions do not cost the earth, and they represent extremely good value for money if a mono machine at 9.5 cm/s will suffice for your requirements.

So what is this equipment, what does it do and how do we go about servicing it? The *N4308* is a ¼-track mono, two speed (9.5, 4.75 cm/s) recorder, feeding 4 W output to its 8 ohms 150 x 100 mm loudspeaker.

Its facilities include straight-through amplification (see later notes on this) and some degree of input mixing. With the aid of an external amplifier such as the Philips *EL3787A/00A*, stereo replay, multiplay and duoplay can be obtained. For those who wish to add to their equipment, or perhaps emulate Philips, the details of this amplifier and associated equipment can occupy a subsequent article: for now, let us continue to look at the basic machine.

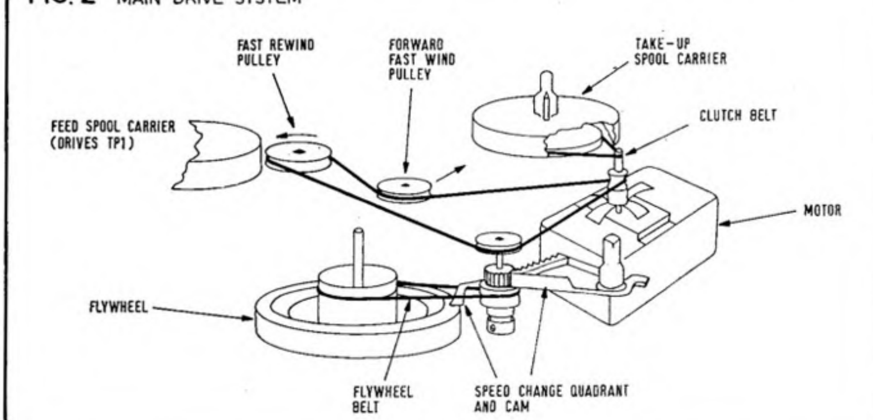
A VU meter circuit is employed and is sufficiently good for an indication, hardly for any measurement or accurate assessment of levels. Tape drive is by belt, but in a rather unusual and complicated method which I have attempted to point out in **fig. 2.** Operation is a little more noisy than many users would like, there being a tendency for rattles to develop, especially as bearing bushes of plastics wheels begin to wear. Wow and flutter are seldom much better than the quite modest 0.25% (at 9.5 cm/s) specification.

Information that may be of help, and which is always being requested, is the input and output sensitivity and impedance and, of equal importance, the pin connections relevant to these. I shall endeavour to give this information for every machine or group of machines I discuss, with a regular style of presentation. To conserve space and make for easy reference, I shall give impedance, then voltage, decibel figure if applicable, then the pin numbers or connection description.

Function	*Impedance*	*Sensitivity*	*Pins*	*Play, etc.*
Inputs				
Microphone	2K	0.2mV	1/4-2	Mic.
Radio	20K	2mV	1/4-2	Radio
Diode	1.5M	150mV	1/4-2	Radio via *EL3768/03* lead
Pick-up	1M	100mV	3/5-2	Radio
Outputs				
Line	20K	750mV	3, 5-2	Mic.
Headphones			4-1, 2	270° DIN
Ext. L/S	4 or 8	4W	1-2	J21 DIN

(In addition, an output to drive the *EL3787A/00* pre-amplifier is available from pins 1-2 of the Stereo socket. To this socket also is paralleled the Line output to pin 3 and a 9 V supply for the preamplifier to pin 5.)

FIG. 2 MAIN DRIVE SYSTEM



Separate preamplifiers for microphone and radio are used, their outputs being taken to individual recording level controls, thus affording a two-way mixing. To achieve the correct matching, a series resistor in the radio lead is Philips' usual answer, and in the *EL3768/03* we find a 1.5 M resistor. I think these are 125 mW, and have been trying to get some for a long while, but the usual suppliers of small quantity components do

(*continued on page 497*)

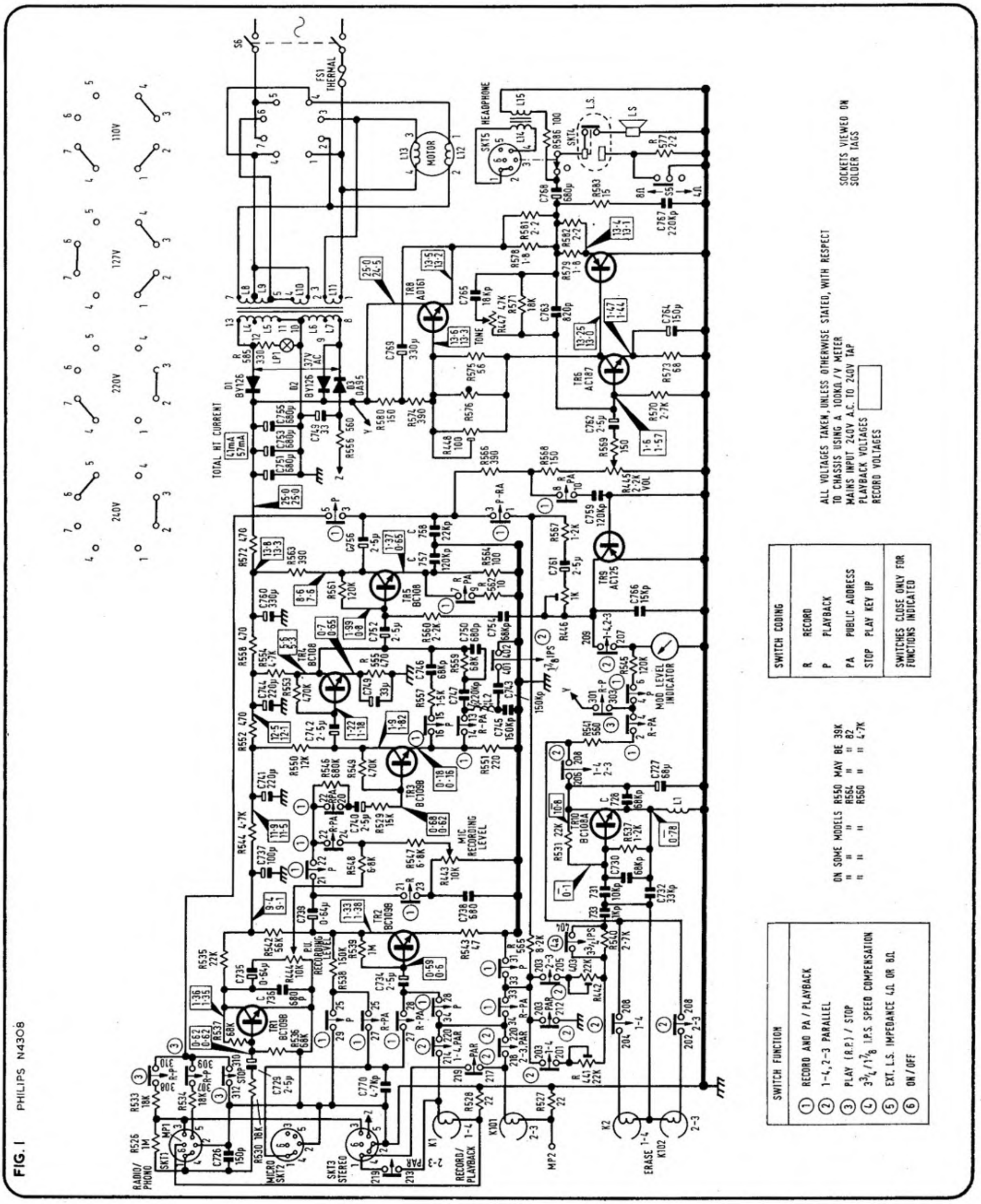


FIG. 1
PHILIPS N4308
SWITCH FUNCTION
1 RECORD AND PA / PLAYBACK
2 1-4, 2-3 PARALLEL
3 PLAY (R.P.) / STOP
4 3¾/1⅞ I.P.S. SPEED COMPENSATION
5 EXT. L.S. IMPEDANCE 4Ω OR 8Ω
6 ON/OFF
SWITCH CODING
R RECORD
P PLAYBACK
PA PUBLIC ADDRESS
STOP PLAY KEY UP
SWITCHES CLOSE ONLY FOR FUNCTIONS INDICATED
ON SOME MODELS R550 MAY BE 39K
" " " R564 " " 82
" " " R560 " " 4·7K
ALL VOLTAGES TAKEN, UNLESS OTHERWISE STATED, WITH RESPECT TO CHASSIS USING A 100KΩ/V METER
MAINS INPUT 240V A.C. TO 240V TAP
PLAYBACK VOLTAGES
RECORD VOLTAGES
SOCKETS VIEWED ON SOLDER TAGS
TOTAL HT CURRENT
MIC RECORDING LEVEL
MOD LEVEL INDICATOR
MOTOR
HEADPHONE
THERMAL
240V
220V
127V
110V

not list sub-miniature resistors of as high a value as this, and Philips themselves do not appear to have made them available in their spares catalogue. In the given lead, this resistor is in series with pin 1 (red connection), while the output connection, from pin 3 is direct (white end), and the screens are commoned to the black-ended lead.

Before we can make any electrical adjustments, it is, of course, necessary to dismantle the machine. This model—an improvement on earlier versions which came apart like a Chinese puzzle—can be operated with the case removed, and even the printed circuit panel can be swung clear to the extent of connecting leads adequately for access. But like all other simple operations, there are one or two hidden snags.

First step is to remove the knobs. The four control knobs and the speed change knob should pull off easily enough. Fair enough, on the Stella models and some later versions of Philips and Pye they will, but on the original *4308* some difficulty may be encountered by the smallness of the knob and its truncated conical shape. One's fingers slide off and levering the knob can lead to breakage. So we resort to the string method or the button stick.

Old soldiers will know what I mean by the latter. A piece of stiff card is slotted and slid under the flange of the knob, and leverage can then be applied to remove the knob without damage to the surrounding plate.

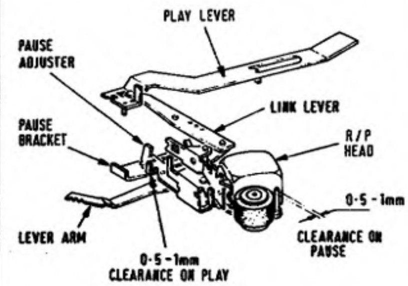
Now remove the four (sometimes five) obvious screws securing the top plate and lift it off. First snag—you can't. The stop bar prevents you, and on the *4308* it looks as if the keys will get in the way. The temptation is to undo the two small screws holding the plate around the keys—resist it. The plastics portion of the stop bar will pull off, after which it is only necessary to juggle a little with the top plate. When reassembling, the juggling is a bit more awkward by virtue of the meter, track selector, on/off button and digital indicator, which all have to come through apertures or fit recesses. The trick is to get the keys safely through first and fiddle the rest afterwards.

Taking the chassis out now requires only the unsoldering of loudspeaker leads and the chassis earthing wire. I note that some models use slide tags and applaud the change; but there appears to be no consistency and there is always the fellow who has been at it before you, who lost the broken tag and soldered the wires on safely.

Next step in dismantling, if you have deck troubles, is to separate the printed circuit, and here we run into difficulty. The track switch should be set to the PAR (parallel operation) position—remembering when you come to reassemble to put it back there again. Similarly, set the speed-change switch to the lowest speed. As the two switches engaged by the blades that this knob operates are very easily damaged, attempted reassembly in the wrong position can be serious.

There are four switch positions to consider and the location of tongues in slots provides the moving impetus. The other two switches

FIG. 3 PRESSURE ROLLER AND HEAD GATE ASSEMBLY



(selection of 4 or 8 ohms loudspeaker impedance and the mains on/off) are so straightforward as not to bother us here. The record/play switch is in two parts, the rearward longer section being the record/playback switch proper, actuated by the levers from the keys, and the shorter forward one being the play or stop switch, which is dependent on the record key. If you look at the switch numbering (S3) on the circuit diagram, you can see why. As well as this we have a similar switch block, nearer the centre of the board, which is just the track switch. Again, a look at the diagram reveals that the PAR position complicates matters.

One of the problems I have encountered on these models is the setting of the switches, or their replacement and repair when dirty or damaged. First operation must be to check the exact setting. This needs patient scrutiny. There are two crank arms, pivoted on a post at the bottom of the flywheel bracket. At the left side of the crank, and set higher, we have the tongues engaged by sliders from the keys and at the inner end the switch-blade tongues. These cause flat printed-circuit wafers to slide between contacts in an enclosed channel. They can be the very devil when offset, so don't touch this end of the switch mechanism unless you are absolutely certain the fault lies there. 'Suck-it-and-see' is decidedly not on.

The longer switch, record/play, should have 0.5 mm clearance between the first conductor 'blob' and the edge of the housing in the play position; the second blob should be nearly clear when the switch is in record.

The shorter switch at the left of the board should have a similar 0.5 mm of paxolin showing between the first blob and the housing when the machine is in stop, and a full 3 mm when in play. Any alteration to either of these should be done by careful bending of the actuating tongue.

The track switch needs a slightly different approach. When in the track 2-3 position, there should be almost half of the first 'square' of the conductor showing at the blade end. To adjust this again involves bending the actuating arm. Now we find a necked portion, where cutouts are opposite each other, and this gives us the necessary 'weak link' for bending.

Around the top of the motor pulley, the clutch belt is linked, and this always causes a reassembly problem. I have a selection of button-hooks (good old granny) which are invaluable for jobs like this, and for reassembling the turntables of belt-driven gramophone units. The secret is to loop the belt around its largest diameter, assemble the clutch parts, then hook the belt gently away until there is enough loop to allow it to seat over the smaller spindle.

Taking the clutch to bits can give trouble, too. Left and right assemblies are similar, except that the left lower drum has a spigot that goes through a hole in the deckplate, holding it still. This breaks, sometimes. But more often the problem is wear of the plastics disc that provides the friction engagement and clutch action. The powdering of plastics material around the spindle gives the game away. Replacement is the only true cure.

Beneath the disc we find four friction blocks that seat against raised flanges. By the time you have picked them out of the mechanism, you will have forgotten which way they go, and there is, of course, a choice. Remember that the 'flat' side of each block always wants to go the way the spool rotates when fast winding. Don't try and adjust vertical play at this point, but add washers at the circlip end. There is normally about 0.2 mm end play.

Brakes are adjusted by bending the little tongue that sits in the bracket at the upper side of the left brake. Correct setting is when there is between a half and one mm clearance between right brake and turntable as the *left* brake shoe is pushed toward its outer, i.e. engaged, position. Trouble starts when wear is uneven and this cannot be attained, when it is advisable to change both brakes. Look for excessive rubber stains on the turntable flanges.

Symptoms of wear can also beset the pressure roller assembly. Here, we find an adjustment in a not-so-obvious place, the clearance between the outer end of the pivoted arm on which the roller is mounted and a little upright tag should be 0.5 mm in the play position.

All this, and we have said little about electrical adjustments. They are few. Mainly, we are concerned with bias current and modulation level. There are a couple of handy test points. The centre tag of the radio socket is a tapping to the upper track, and a small terminal (looks more like a rivet) beside the socket, is the connection to the upper track. Measure between 10 and 20 mV at this point for either track and you are not far out. Optimum value is 18 mV for the tape supplied with the machine. A preset 22 K resistor is provided for each track, and these are situated right in the middle of the circuit board, between microphone and volume controls.

To check sensitivity, measure at these same points, expecting to get between 3 and 3.5 mV at 1 kHz when 5 mV is fed in to the phono input. If you are using plugs and do not want false readings, apply the signal to Pin 3/2 of the stereo socket. Turn radio level control to maximum and volume to minimum. When there is a 3 mV reading at these head connection tags, the meter should indicate 0 dB—the red/black division. Adjust the potentiometer at the front left of board to get this.

The only other adjustment is for quiescent current of the output pair, which should be 5 to 7 mA (6 mV across R581 or R582), set by R448 with no signal input and minimum volume control setting.

the gentle art of Busking

By BOB AUGER

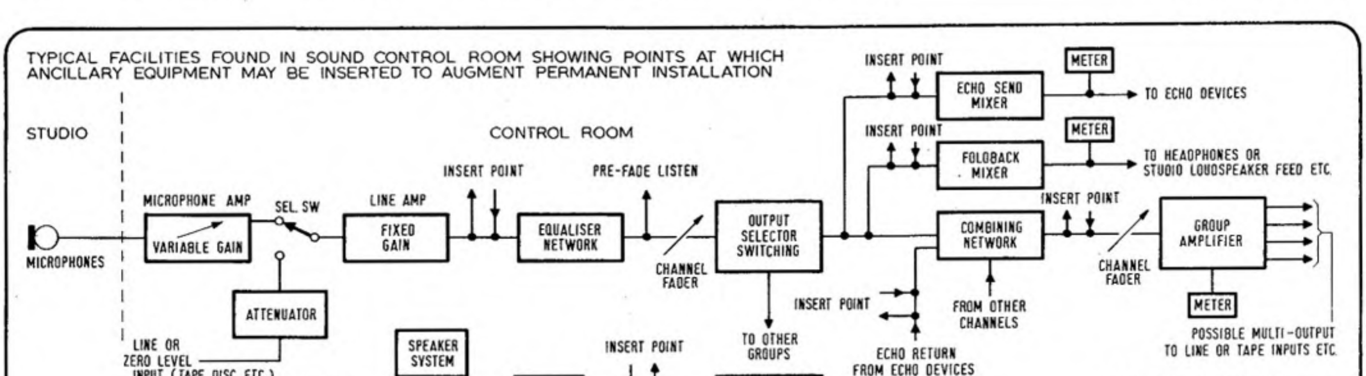
ONE aspect of the recording engineer's work which is seldom discussed is his ability to improvise with the equipment under his control and one can usually assess the amount of experience which a particular engineer has in this kind of work by his aptitude in tracing a faulty piece of apparatus during a recording session, replacing it either physically (with modular equipment) or by 'plugging round' in the case of older valve equipment. Other occasions when such aptitude is necessary occur when the record producer asks the engineer to 'try to do something different' with maybe the guitar or piano sound. Many a time I have searched a mixing desk in vain for the DIFFERENCE knob, hoping that one could be found or that I might discover some kind of converter which could be used to decode the visual diagrams in the air which the producer is drawing with his hands to describe the shape of the sound he wants !

On these occasions one usually has to resort to the use of ancillary equipment, probably in the form of additional equalisation facilities or some kind of artificial compression of the dynamic range of the music. Whether the requirement of the moment is for the addition of extra equipment or the replacement of something faulty, the engineer cannot hope to overcome the problem unless he is carrying a clear metal block diagram of the whole of the equipment he is using at that time. Many studios do in fact have a complete block diagram of the control room equipment readily to hand, but this should only have to be resorted to in extreme cases, when, for instance, the engineer may be working in a studio which is new to him. A typical diagram is shown here, together with the relative signal levels at the various stages.

It should be borne in mind that the echo-send and foldback lines can always be used as additional outputs from the mixing desk since nowadays most mixers utilise the same line amplifiers for these facilities as are used in the main group outputs. Similarly the echo return inputs can always be used as additional high-level feeds to the desk, thereby allowing, for instance, all the channels on the desk to be used for microphones, the echo return lines being used to augment the main channels, perhaps adding three or four more channels to the desk. If the problem is one of shortage of microphone channels then why not use the recording amplifiers of a spare tape machine as microphone amplifiers, the record level controls being used as pre-set gain controls for the amplifiers? Once this kind of ingenuity is achieved the balance engineer is really at home with his equipment and can use it virtually as a set of building bricks.

The recent development of eight- and 16-track (even 24), recording has introduced an additional piece of apparatus to be controlled by the engineer, namely the monitor mixer. In many studios, the panel used for the basically simple requirement of mixing down the 8 or 16 tracks so that they can be monitored on two loudspeakers is now becoming almost as fearsome as the microphone mixer itself. On several occasions recently, when working with my own equipment, it has been decided to install a second complete mixing desk for the sole purpose of providing comprehensive monitor facilities. A typical instance of this was during the recent recording of the Verdi *Requiem* at the Albert Hall, when one desk was installed so that we could achieve any kind of balance the artists wished to hear during tape playback. When the conductor was in the room we were able to hold the soloists and chorus down so that the orchestra detail could be checked. Conversely, whenever the conductor left the room we were able to pull the soloists well forward so that we could assess the vocal performance. I think it was the general tinkering about with the playback balance which has led many visiting writers to make curious assessments of the sound balance which they heard at the sessions. It has to be appreciated that with modern multi-track recording techniques one should not taste the pudding before it is cooked, since the engineer's function at the session

(continued overleaf)



today is primarily to collect information on tape as quickly and as cleanly as possible, the artistic nuances being attended to in the dubbing room later.

One should not be afraid to take calculated risks with recording equipment, either, and in this connection only experience can help ; one can only hope that the producer has enough confidence in the engineer to allow him to make the necessary judgement. An instance of the use of non-professional equipment being used as a calculated risk also arose during the Verdi sessions mentioned above, namely the provision of small domestic loudspeakers placed at the rear of the control room for the monitoring of the ambience tracks. Here it should be appreciated that ideally a square-ish control room is necessary for quadraphonic monitoring, but those familiar with the Albert Hall will, I'm sure, realise after a moment's reflection that there isn't a 90° angle in the whole hall : all rooms, both above and below ground level being wedge-shaped ! This meant that space was at a premium, and the installation of four large monitor speakers completely impossible. At the beginning of the sessions the producer and myself carefully checked the level and quality of the ambience tracks, thereafter monitoring on small talkback speakers.

Perhaps the best training ground for a would-be balance engineer is with a mobile recording unit since each recording involves virtually the construction of a complete recording studio and control room. The tendency nowadays is to make no technical concession whatever to the fact that the recording is being made on location and producers expect to find the same facilities available in some obscure provincial hall as they would find in the most elaborate London studio. This often leads to the hurried improvisation of echo chambers, and usually it comprises the installation of a large loudspeaker and microphone in an adjacent toilet. Experience has taught me that it is better to use a Gents than a Ladies, since there tends to be more porcelain around and fewer dividing walls, and that one must remember to turn off the plumbing before leaving the room ; also to put large 'Out of Order' notices on the door. You won't find any of these warnings in any handbook of sound recording that I know of, but they are the kind of points which can save a great deal of money on recording sessions, where the artists' costs can be as high as £1 000 per hour.

A point which often arises in conversation between engineers and producers is the vexed question of finding suitable acoustics in the temporary control room on a mobile recording location. Certainly it can be very disturbing when attempting to set up the initial balance if one is suddenly aware that everything seems to sound bright and steely, for instance, but I have found over the years that after 30 minutes or so concentrated listening in any environment the ear quickly adjusts to the problem and one is still able to assess the correct quality of the sound which is being monitored. I've always found it very hard to understand so-called professionals who maintain that they can only produce proper work in one environment. However, there is a system of assessing the acoustic of the temporary control room which is new to the engineer or producer. This consists of playing a specially prepared 'wobble tape' prior to the sessions, the tape having a series of tones made up of a basic frequency, say 1 kHz, interspersed with bursts of other frequencies of say from 10 kHz to 50 Hz. This constant alternating of the tones will soon show up any major peaks or deficiencies in the control room acoustics and once the engineer has mentally noted these irregularities he can keep the problem in mind while balancing the music subsequently.

Perhaps the main point which comes to mind when reviewing the whole practice of improvisation by the balance engineer is that the main ability the balance engineer brings to the sessions is his talent for subjective judgement. One should not forget, especially in the case of classical music, that when the lowest distortion figures, widest and flattest frequency response and best signal-to-noise ratio have been achieved, the end product will be reviewed by a critic on his own equipment, applying his own subjective judgement and reflecting opinions which are entirely his own. One can only hope to achieve a small majority of good reviews of any particular recording's technical quality which leaves the engineer in a similar position to any politician elected by the democratic process. When one considers how sudden the end was for our last prime minister, one shudders !

Applications of Blumlein difference technique

ultra-directional microphones

Part Two

by Michael Gerzon

IN the first part of this article, it was explained how the 'Blumlein difference technique' enables one to obtain new microphone directional characteristics from a pair of identical closely spaced microphones. The Blumlein difference technique allows one to obtain such new directional characteristics as the clover-leaf and the unilobe. **Fig. 13** shows the polar response of these microphone characteristics in the horizontal plane.

Unlike the figure-of-eight or the cardioid, the clover-leaf and the unilobe have a polar response whose shape in the vertical plane through their axis is different from the polar response in the horizontal plane. The vertical polar characteristics of the clover-leaf and the unilobe are plotted in **fig. 14**. It will be noted that, while a unilobe is not so directional in the vertical plane as in the horizontal plane, it is still more directional than a cardioid.

As explained last month, the Blumlein difference technique no longer works perfectly when the sound has a frequency high enough to make its wavelength comparable with the distance between the two identical microphones. As a rough guide, it was suggested that the highest frequency at which the technique works 'reasonably well' is $\frac{1}{2}$(c/d), where c is the speed of sound in air (340 m/s), and d is the distance between the two microphones. However, what one might consider a 'reasonably well' behaved signal for some purposes might not be considered so reasonable for others. It is thus advisable to see in more detail how the Blumlein difference technique departs from its ideal behaviour at high frequencies.

Two things go wrong when the wavelength of the sound becomes comparable with the microphone separation. First, the polar response of the 'Blumlein output' (i.e. the integrated difference of the two mike outputs) departs from its theoretical low frequency shape. However, this effect only alters the Blumlein output by at most 1 dB at a frequency of $\frac{1}{4}$(c/d), and by at most 4 dB at a frequency of $\frac{1}{2}$(c/d). Furthermore, even at a frequency of $\frac{1}{2}$(c/d), the polar response is never in error by more than 2 dB for sounds originating from a direction within 45° of front or back. Thus the alteration in the polar response of the Blumlein output, while significant, should not alter the stereo effect obtained by the Blumlein difference technique too much for frequencies up to $\frac{1}{2}$(c/d).

The second thing that goes wrong at high frequencies is more serious. This is the effect of phase shifts in the sound. The Blumlein output acts as if it originates from an imaginary microphone placed exactly half-way between the two identical microphones used to derive it. To obtain a stereo signal, the Blumlein output S is added to and subtracted from the original output M of one of the two microphones. This means that the 'sum' M of the stereo signal is picked up by a microphone placed a distance $\frac{1}{2}$(d) to one side of the imagined mic. picking up the 'difference' S of the stereo. For sounds arriving from the sides, this means that there is a phase shift between the M and S signals that increases with frequency. At a frequency of $\frac{1}{2}$(c/d), this phase shift is 90° and has a severe effect on the microphone characteristic obtained by adding and subtracting S to M.

This phase shift cannot be corrected electrically, as it varies according to the direction of the original sound. One could get rid of the phase shift by using the average of the two microphone outputs as the sum signal M. However, at frequencies comparable with $\frac{1}{2}$(c/d), taking such an average itself causes gross irregularities in the polar response of the M signal, and it is almost certainly better to use the output of only one microphone as the

(continued overleaf)

FIG. 13 HORIZONTAL POLAR RESPONSE OF UNILOBE (FULL LINE) AND CLOVER-LEAF (BROKEN LINE) MICROPHONES

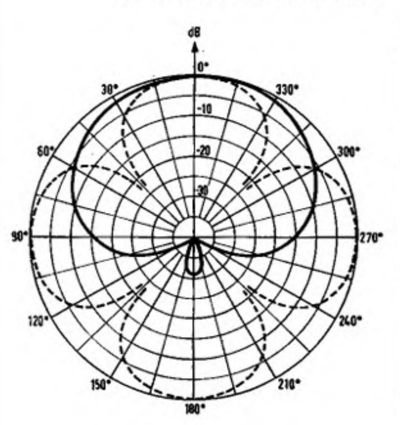
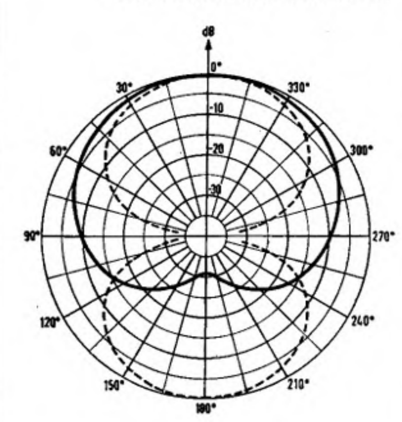


FIG. 14 VERTICAL POLAR RESPONSE OF UNILOBE (FULL LINE) AND CLOVER-LEAF (BROKEN LINE) MICROPHONES



M signal. (However, this does not exclude the possibility of using, say, the output of the left microphone as M for left channel signal and the output of the right microphone as M for the right channel signal.)

It is possible to calculate theoretically the actual polar diagrams obtained by the Blumlein difference technique at different frequencies. In **figs. 15** to **19** we illustrate the polar response obtained by applying the Blumlein difference technique to a pair of forward pointing cardioids. In order to compute these figures, it was assumed that both microphones are perfect and identical forward pointing cardioids at all frequencies, that the sound reaching each microphone is not appreciably affected by the proximity of the other mike, and that the effect of any low frequency roll-off in the Blumlein output is negligible for the frequencies illustrated. Only the left-channel output is illustrated, the right-channel output being identical except for it pointing to the right instead of the left. The shapes of these polar diagrams are the same whether the sum signal M is the output of the left microphone or the output of the right microphone.

Fig. 15 illustrates the theoretical polar diagram at low frequencies, and is a unilobe pointing 45° to the left. (In practice, at *very* low frequencies, the incorporation of a bass-cut in the Blumlein output would cause the polar diagram to become a forward-pointing cardioid (**fig. 12**)). As the frequency increases to $\frac{1}{8}$(c/d), e.g. to 1.7 kHz for a microphone separation of 2.5 cm, then the polar diagram becomes as in **fig. 16.** The main alteration to the unilobe response at this frequency is a bulge, about 15 to 20 dB down, in the response to sounds from the right, which swamps the tiny rear lobe of the unilobe. As the frequency increases to $\frac{1}{4}$(c/d) (e.g. 3.4 kHz when d = 2.5 cm), then this bulge on the right swells out further, as illustrated in **fig. 17,** and begins to affect stereo separation seriously. Simultaneously, the response at the left begins to diminish slightly, and the direction of maximum sensitivity is now a little less than 45°. At a frequency of $\frac{1}{2}$(c/d), nominally the highest frequency at which the Blumlein difference technique works 'reasonably well', **fig. 18** shows that the bulge on the right of the polar response is only a few decibels down, and practically all stereo separation is lost. Moreover, the maximum sensitivity has dropped by about 1.2 dB and points in a direction nearer 25° than 45°. By the time the frequency has been raised to (c/d), all resemblance of the polar diagram to a unilobe pointing 45° to the left has been lost, and **fig. 19** shows that the output of the Blumlein difference technique looks like a cardoid drawn by a drunken draughtsman. Because of the 6 dB/octave treble cut used to derive the Blumlein output S, the polar response approaches the forward-pointing cardioid shape of the 'sum' output M as the frequency increases further.

Despite the fact that the stereo image obtained with the Blumlein difference technique degrades rapidly as the frequency approaches $\frac{1}{2}$(c/d), the overall frequency response of the stereo sound picked up is reasonably flat for sounds coming from all directions, as most of the reproduced energy is due to the flat 'sum' signal M. However, the response will be flattest for sounds arriving from the front, and most bumpy for sounds arriving from the side.

The Blumlein difference technique used with a microphone separation of 2.5 cm is thus seen to give rather poor stereo at 3.4 kHz, and practically no stereo separation at 6.8 kHz. These results are really not good enough for high quality stereo, and so it is important to find ways of making the Blumlein difference technique work well at higher frequencies. The simplest way is to reduce the microphone separation, but unfortunately this would require the use of very small microphones if significant improvements were to be obtained. With a spacing of 1.5 cm, about the smallest practical with conventional high quality microphones, the stereo would still only be reasonable up to $\frac{1}{4}$(c/d) = 5.7 kHz, and would practically disappear above 10 kHz. Another disadvantage of using a small microphone separation is that slight differences in the sensitivity would necessitate a higher bass roll-off frequency in the Blumlein output (as described last month), thereby reducing further the stereo separation in the bass.

For high quality work we can rule out such artifices as the use of a baffle between the microphones to increase their HF directivity, although Blumlein's British patent 394 325 described such a method in detail. Thus the only really feasible way of improving the high frequency stereo performance is to use yet more microphones.

Phase shift effect

It will be recalled that the most important cause of the poor high frequency polar response is the phase shift resulting from the spatial separation between the effective point at which the Blumlein output S is picked up, and the point at which M is picked up. It thus seems reasonable to pick up the 'sum' signal M with a third microphone placed half-way between the Blumlein difference technique pair. In order to ensure good HF stereo separation, the pair of microphones picking up the Blumlein output must be close together, so the third 'sum' microphone will have to be placed just above (or just below) half-way between them, as pictured in **fig. 20.** By using the bottom pair of microphones to derive the Blumlein output S, and the third, upper, microphone to provide the sum signal M, one can derive stereo signals, as illustrated in **fig. 21,** which do not suffer from the frequency-dependent phase shift effects of the two-microphone arrangement, at least for sounds arriving from horizontal directions.

The improvement in the polar response given by the three-microphone arrangement of **fig. 20** is very marked. Very approximately, the polar response at a frequency f given by the three-microphone arrangement is similar to the polar response an octave higher, at a frequency 2f, obtained when the two-microphone arrangement is used. The use of the three-microphone arrangement extends the stereo separation over an octave higher for a given distance d between the Blumlein-output microphones. For example, when the

FIG. 15 LOW FREQUENCIES

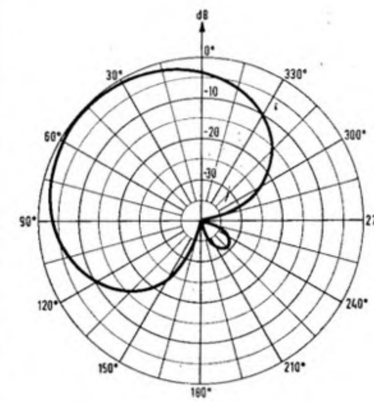


FIG. 16 FREQUENCY = $\frac{1}{8}$ (c/d)

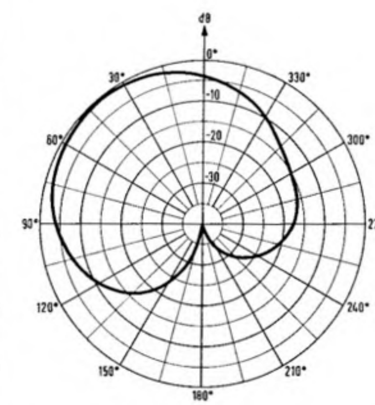


FIG. 17 FREQUENCY = $\frac{1}{4}$ (c/d)

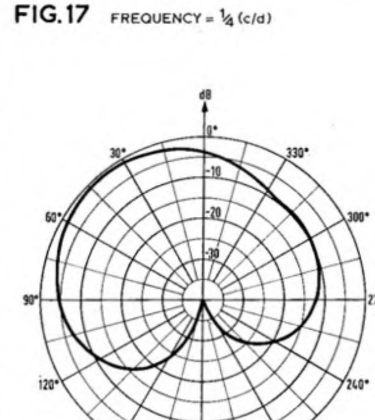


FIG. 18 FREQUENCY = ½(c/d)

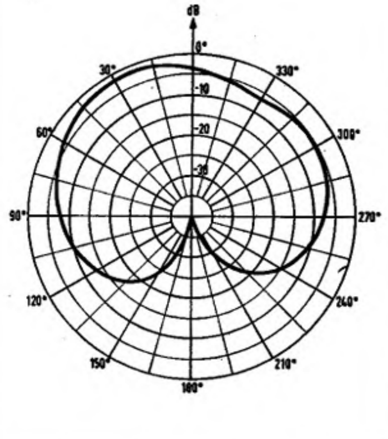


FIG. 19 FREQUENCY = (c/d)

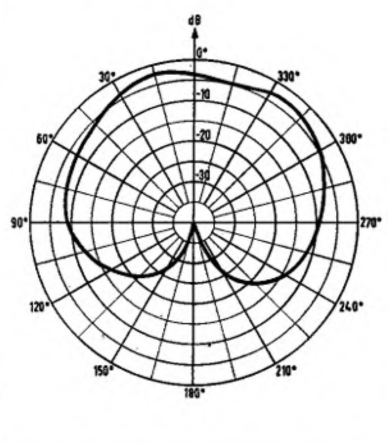
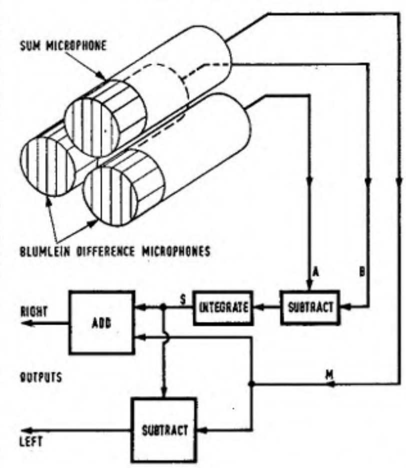


FIG. 20 USE OF THREE MICROPHONES TO DERIVE A STEREO SIGNAL



distance d is 2.5 cm, the three-microphone arrangement gives a reasonable unilobe characteristic and excellent stereo separation up to a frequency of ½(c/d) = 6.8 kHz, and the stereo separation virtually disappears at a frequency of about (c/d) = 13.6 kHz. Thus good stereo can be obtained by using the Blumlein difference technique with three microphones, even with a microphone separation of 2.5 cm. The results with smaller microphone separations will be even better.

Appendix A

Here we derive the formulae which enabled **figs. 16** to **20** to be computed. Only the bare bones are given, but the mathematically inclined reader should be able to fill in the missing gaps for himself.

Let the two microphones A and B be a distance d apart, let O be the point half-way between them, and consider a sound of frequency f arriving from a direction making an angle θ with the forward direction (see **fig. 21**). Suppose that the sound pressure at point O and time t is $\sin 2\pi ft$. Looking at **fig. 21**, the sound at point B has travelled a distance $CB = \frac{1}{2}d \sin\theta$ further from its source than the sound at point O, so set out at a time $\frac{1}{2}(d/c)\sin\theta$ earlier, where c is the speed of sound. Thus the sound pressure at point B is $\sin(2\pi f[t - \frac{1}{2}(d/c)\sin\theta])$. Similarly, the sound pressure at microphone A is $\sin(2\pi f[t = \frac{1}{2}(d/c)\sin\theta])$. If the microphones at A and B are forward-pointing cardioids, then their polar response has the formula $(1 + \cos\theta)$, and the electrical output of the two microphones is :

$A = (1 + \cos\theta)\sin(2\pi f[t + \frac{1}{2}(d/c)\sin\theta])$ and
$B = (1 + \cos\theta) = \sin(2\pi f[t - \frac{1}{2}(d/c)\sin\theta])$.

We may compute the Blumlein output to be :

$$S = (c/d) \int (A\text{-}B)dt$$

$$= (1 + \cos\theta)\frac{\sin[\pi f(d/c)\sin\theta]}{\pi f(d/c)} \sin 2\pi ft$$

where we have multiplied the integral by (c/d) to make S of a suitable size.

By taking M to be equal to either A or B, the left and right stereo outputs obtained by the Blumlein difference technique are given by $L = M + S$ and $R = M - S$. It may then be shown by algebraic and trigonometric manipulation that the amplitude of the left hand output L is :

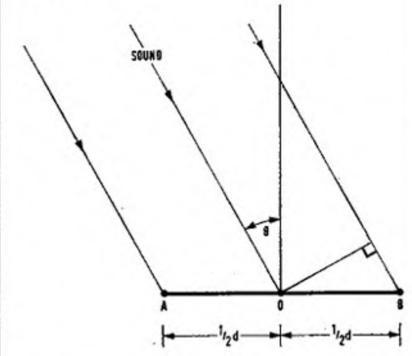
$$(1 + \cos\theta)\sqrt{\left\{1 + \frac{\sin[2\pi f(d/c)\sin\theta]}{\pi f(d/c)} + \left[\frac{\sin[\pi f(d/c)\sin\theta]}{\pi f(d/c)}\right]^2\right\}}$$

This is the polar response of the left channel output derived from a pair of forward-pointing cardioids at a frequency f. **Figs. 16** to **20** represent the result of computing this formula in decibels for different values of f ; I would like to thank Dr Roger Mallion for carrying out these computations for me.

Appendix B Spherical harmonics

Spherical harmonics are a useful means of describing the new types of microphones obtained using the Blumlein difference technique, and form a convenient mathematical aid to designers and engineers. Unfortunately, conventional text-book approaches do them

FIG. 21



either in terms of the solutions of Laplace's equation, or in terms of advanced operator theory. For this reason, the following gives a description using only straightforward integration theory, as well as describing their application to microphone design.

Any direction around a point may be described by means of its *direction cosines* (x,y,z), which are the three coordinates of a point placed a unit distance from the origin along that direction. It is convenient to think of the z-axis as pointing upwards, the x-axis as pointing to the left, and the y-axis as pointing forward. The point (x,y,z) describing a direction lies on the surface of the unit sphere $x^2 + y^2 + z^2 = 1$, and so one may regard the directions around a point as being points on the surface of this sphere. The directional characteristic of a microphone may then be regarded as a function f(x,y,z) on the surface of the unit sphere, which assigns to each point (x,y,z) the number equal to the amplitude sensitivity of the microphone in that direction. For example, the polar diagram of a forward-pointing cardioid is described by the function $f(x,y,z) = 1 + y$ on the unit sphere, and an upward-pointing figure-of-eight has the formula $f(x,y,z) = z$.

Any function f(x,y,z) on the unit sphere has an 'energy' defined by $\int_S [f(x,y,z)]^2 \, dS$,

where the integral is taken over the surface S of the unit sphere. Two functions f(x,y,z) and g(x,y,z) are said to be *orthogonal* if

$$\int_S f(x,y,z) \; g(x,y,z) \; dS = O.$$

Orthogonality ensures that the two functions are independent, in the sense that the energy of their sum equals the sum of their energies. This property is one that, in another audio context, is true for two audio signals that lie in non-over lapping frequency ranges. Thus the different harmonics of an audio waveform are orthogonal to one another, and it is by analogy with this that one talks about 'spherical harmonics'.

A function f(x,y,z) on the unit sphere is said to be a *zero order spherical harmonic* if it is constant. Omnidirectional microphones have a polar diagram that is a zero order spherical harmonic. f(x,y,z,) on the unit sphere is said to be a *first order spherical*

(*continued overleaf*)

harmonic if it is linear and is orthogonal to all zero order spherical harmonics; 1st order harmonics are functions of the form ax + by + cz, and correspond to figure-of-eight microphones. In general, a function f(x,y,z) is said to be an *n'th order spherical harmonic* if it is a polynomial of degree n in x, y and z and is orthogonal to all lower order (i.e. zero, first, . . ., (n-1)'th) spherical harmonics. Thus second order spherical harmonics are functions f(x,y,z) on the unit sphere such as xy, yz, zx, $x^2 - y^2$, or $\frac{1}{3} - z^2$. The first four of these characteristics are clover-leafs, and the fifth is a second order harmonic that happens to have a different shape. All second order spherical harmonics can be obtained by adding these five together in various proportions. Spherical harmonics are useful because, as with conventional harmonics, all sensible functions f(x,y,z) on the sphere may be expressed as the sum of a zero, a first, a second, and higher order spherical harmonics.

Conventional microphone characteristics are made up from zero and first order spherical harmonics, and characteristics obtained by the Blumlein difference technique consist of zero, first and second order harmonics.

The first use of spherical harmonics is in investigating the bass-boost produced on sounds close to the microphone. It can be shown mathematically that each order of spherical harmonic produces its own distinctive type of bass-boost for close sounds, and this simplifies the problem of determining the amount of bass-boost occurring. See the next part of this article.

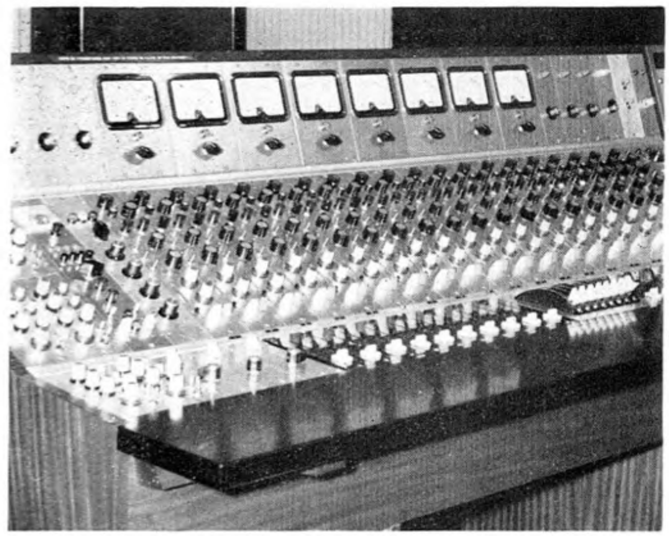
The 'energy' of a directional characteristic f(x, y, z) determines the amount of background noise or reverberation pick-up of a microphone. To minimise the low and high frequency deficiencies caused by the Blumlein difference technique, one should use conventional microphones to pick up the zero and first order terms of a directional characteristic, and the Blumlein difference technique only for the second order spherical harmonic. One thereby minimises the energy picked up by the deficient Blumlein difference technique.

For example, a unilobe pointing 45° to the left has a directional characteristic f(x, y, z) = (1+x)(1+y) whose second harmonic term is xy and whose zero and first harmonic terms are 1+x+y. The latter terms describe a hypercardioid microphone with 15.31 dB front-to-back ratio pointing 45° to the left, while the second harmonic term describes a clover-leaf. Thus one can obtain an accurate unilobe over the widest possible frequency range by placing the above-described hypercardioid immediately above the centre of a pair of forward pointing figure-of-eights whose clover-leaf Blumlein output can be added to that of the hypercardioid to give a unilobe microphone. In practice this technique involves a number of difficulties due to the large size of suitable available microphones, but with small microphones would give a good unilobe about an octave lower in the bass and an octave higher in the treble than the three-cardioid technique. It is to be hoped that suitable small microphones are made available by manufacturers for this sort of application.

around the studios
TRIDENT

By Keith Wicks

Top left: Alan Townsend and Howie Casey.
Bottom left: Malcombe Toft (left) and Richard Kerr at the main mixer.
Top right: Neumann disc cutter.
Bottom right: Desk in reduction room.



TRIDENT Studios in St Anne's Court, Soho, were designed by Sandy Brown, and are among the most modern and well-equipped studios I have visited. The main control desk was built by Sound Techniques to Trident's specifications and has 20 input channels and 16 outputs. In addition, there are four auxiliary outputs to which sources can be selected and echo effects added. These four outputs are normally used only for monitoring purposes.

The desk is conventional in that it provides all the usual facilities. Layout is very neat, everything being within easy reach of the engineer. The levels of the 16 main outputs are checked by VU meters and aural monitoring is provided by three J. B. Lansing speakers fed by 100 W H. H. Electronics transistor amplifiers. Malcombe Toft, Trident's studio manager, was enthusiastic about the speakers because they are so consistent when switching from one speaker to another. On the subject of power amplifiers, Malcombe admitted that he had been rather biased towards valves and it was some time before he found a transistor design able to handle high power with negligible distortion. However, he is very satisfied with the system they now have, and mentioned that, unlike some manufacturers, H. H. Electronics quote distortion levels at full output and in practice keep within their specifications.

The most noticeable thing about the control room is the absence of tape machines. These are kept in a separate room linked with the control room by two-way CCTV. This has the advantage that customers don't find themselves confronted by a tape operator involved in clearing up from the previous session. Once loaded the machines are operated remotely from the studio, and the system works well. Also remote from the control room are the echo plates and Dolby *A301* noise reduction units. In the basement there are four EMT stereo plates with the usual remote control facilities allowing reverberation time to be adjusted from the studio. The Dolby *A301* units have a room to themselves and are 'normalled' through to various recorders, although any unit can be over plugged if required. Dolbys are used on almost all 8 and 16 track recordings.

From the control room, the mixing engineer can look down into the studio which measures about 6 x 15 m. Adjoining the studio, and directly below the control room is a cubicle measuring 3 x 4 m, used for separating drums, etc., from other instruments.

Trident have a reduction room which is better than some companies' main studios. The desk, again by Sound Techniques, has 20 inputs and 8 outputs. It feeds an 8 track Ampex recorder situated alongside mono and stereo Studer machines. For monitoring, H. H. Electronics' amplifiers feed Lockwood speakers. Next door is what is modestly called a 'small voice-over booth' with six microphone lines, and room for a small rhythm group. Finally, there is a room equipped with the latest Neumann stereo disc cutting lathe, and a Studer tape machine with a pre-read head assembly for use with the lathe's variable groove-spacing mechanism.

On the evening of my visit to Trident, Richard Kerr was producing a session with the Roy Young Band. Roy Young has been in the music business for many years and used

(continued overleaf)

to play in Adam Faith's group. More recently, he was with Cliff Bennett and the Rebel Rousers. He has now formed his own group for which he writes the material and provides the vocal and piano. With him were Howie Casey (tenor sax), Alan Townsend (trumpet), Cliff Davis (drums), Dave Wendells (lead guitar), and Paul Harris (bass guitar). The band, which has been together for nine months, plays mostly in the rock-jazz style currently popular. The number I heard being recorded was entitled *Revolution* and it made a pleasant change to see six musicians playing in the studio at the same time. (Most often, I have to make do with seeing just one musician adding an instrument to a multitrack recording.)

Some time was spent sticking dusters on to drumskins to reduce the ringing that becomes noticeable with close microphones. For the lead guitar, a microphone in front of the guitar amplifier was used, whilst for the bass guitar a direct feed was obtained from the pickup via a transformer. Malcombe explained that the quality direct from a lead guitar is usually too 'thin', so the amplified sound is normally used. For the bass guitar, a combination of direct and amplified sound is sometimes used to change the sound quality, though not in this case. Limiters are not used during the session except on some vocals where it is difficult for the singer to maintain a constant output. In general it is better to play safe and try the effects of limiting during reduction to stereo or mono. Two BBC designed *4038* ribbon microphones were used for trumpet and tenor sax, the players being shielded from the rest of the studio by acoustic screens with perspex viewing panels.

Eventually, vocal will be added to this number, which is a track of their first LP. due to be released by RCA around the time this *Studio Sound* is published. What I heard, I enjoyed, and I wish the Roy Young Band every success.

Finally, my thanks to Trident Studios for an enjoyable visit to a first class organisation.

" *When I say andante non troppo e con molto espressione, I bloody well mean it.*"

equipment reviews

DOLBY B SINGLE-BAND NOISE REDUCTION SYSTEM

LICENSER'S SPECIFICATION. Noise reduction characteristic: 3 dB at 600 Hz, 6 dB at 1.2 kHz, 10 dB at 5 kHz, dBa weighted. **Signal-to-noise ratio:** better than 70 dB. **Frequency response:** 20 Hz to 20 kHz ±1 dB. **Licenser:** Dolby Laboratories, 346 Clapham Road, London S.W.9.

Black box units are currently being manufactured by the **Advent Corporation, 377 Putnam Avenue, Cambridge, Massachusetts, 02139, USA.** Model *100* (four processors, two record and two play): $250. Model *101* (two processors switchable between record and play): $125.

THERE have been countless attempts by different companies over the years to market stereo prerecorded tapes, cassettes and cartridges, in an effort to transfer the allegiance of the public from disc to tape. It is unfortunate that neither the HF response nor the noise levels have ever been really satisfactory, although almost everyone who had heard really good duplicated tapes has agreed that they have a smoothness and clarity that is missing from gramophone records. The cost, too, has always been high, for instance in 1957 a 40 minute stereo tape cost 63s (no tax) whereas the equivalent disc was just under £2. Today's prerecorded cassettes cost 47s 6d or a little over, which is not so very much more than an LP. Although they are more convenient to handle than a disc, they still fall far short of a desirable standard since the frequency response certainly does not extend to the 15 kHz of a good disc. Even more serious than this is the intolerable background noise on even the best high speed duplicated cassettes. The large amount of volume compression needed to combat this would make them entirely unsuitable for classical music.

After having had many requests to design a noise reduction system suitable for the domestic market, Ray Dolby developed his *B* system, working on the same principle as his *A* system, reviewed by me some months ago. Several subtle changes allow it to be greatly simplified while still giving a very useful hiss reduction of up to 10 dB. It proved possible for manufacturers to mass produce it at an astonishingly low cost which makes it easily economic to include in domestic and semi-professional recording equipment, and also into simple playback cassette machines, increasing the cost of the equipment by only £10 to £30, depending upon whether the unit is playback only, switchable for record and playback, or having independent record and playback processors allowing correct monitoring of tapes recorded to the B system whilst they are being made. The effect of 10 dB noise reduction is basically equivalent to comparing a 4.75 cm/s cassette with the noise of 19 cm/s ½-track equivalent recording.

With the use of one micron record/replay gaps it becomes easily possible to extend the replay response of a cassette to 15 kHz, as will be seen later, which gives an intolerable noise level without noise reduction but an acceptable one with noise reduction. Before assessing any further the performance of the system, a description of the basic essentials of the circuit will be given to explain fully what in fact happens in the processing.

As with the A system, the B system splits the audio after the record volume control into two separate paths, the first path being absolutely linear in response and gain. The second path is compressed, then added back to the first path and applied to the record head driver amplifier. The audio in the compression path first passes through a relatively low value series capacitor to the drain of an FET and also to a linear amplifier whose output feeds both a rectifier chain with special characteristics and a mixer which adds the output of the side chain back to the direct linear audio chain. The second side chain referred to as the rectifier chain boosts higher frequencies by a predetermined preset amount with a normal 6 dB per octave curve, then its output is rectified. This rectified output is connected to the gate of the FET previously referred to, at the front end of the main side chain, and effectively alters the dynamic resistance of the FET connected across the input of the side chain amplifier in such a way as to reduce resistance when the instantaneous dynamic level is high and to increase resistance to a maximum when the input dynamic level is low. The general effect of this will be seen to give a boost of audio level from the side chain at low dynamic levels, and virtually no boost of level at high levels from the side chain by cutting off the additional audio mixing in with the main chain from the side chain. A single-band system working over the entire audio range would be obviously audible in operation. Ray Dolby found that, by restricting the noise reduction to frequencies above 1 kHz (the full noise reduction not coming in until approximately 2 kHz), the effect of the noise reduction became almost unnoticeable in operation, whilst giving a remarkable improvement in hiss levels on magnetic recording systems. This frequency-conscious operational turnover is achieved simply by the FET being driven by the small input coupling capacitor which effectively not only drops the general gain of the side chain as the dynamic level is increased but also alters the turnover frequency of the side chain as the level is increased. At low levels, the value of capacitor is chosen such that the side chain achieves a 10 dB boost to the main chain at frequencies of 2 kHz and above. As the level is increased, the frequency above which the full boost applies progressively increases. At still higher levels, the treble boost in the rectifier chain stops too much extra HF being boosted, and thus over-saturating the tape. The effect of the somewhat complicated dynamic process characteristics is therefore to drive the tape no harder at high dynamic levels than a conventional machine would, but to allow up to 10 dB of gain in HF at low dynamic levels.

In the replay mode, the process is exactly reciprocal to the recording mode in that the reduction of gain at low dynamic levels is achieved by inserting the entire side chain in a feedback loop around the main chain such that the circuit subtracts levels rather than adds them, thus giving at its output the original audio signal as applied to the recording processor, provided of course that the tape medium itself has a linear recording characteristic.

Since the basic noise reduction circuit is identical for record and replay processing, the same printed circuit board may be used for both modes of operation provided that all the necessary switching is incorporated, thus greatly simplifying the electronics and reducing the cost when built into a tape recorder having a single record/replay head.

For some time I have been evaluating a special unit known as the Dolby *A505* which includes two record processors, two replay processors, overall A B switch, calibration oscillator, and input/output potentiometers allowing the evaluation unit to be used with any normal level. A meter is incorporated, switchable to the output of the record or replay processor for setting up purposes, and preset controls are provided for adjusting the levels to and from the tape recorder. To evaluate the system with cassettes, I was provided with a conventional Wollensak stereo cassette recorder which had only one modification consisting of an extension of the replay amplifier response to above 15 kHz rather than the normal limited response. The Wollensak itself, after modification, has the amazing response of ±1 dB from 35 Hz to 15 kHz on BASF *C90* cassettes for which the machine was carefully biased, and also the extraordinarily low (for a cassette!) wow and flutter figure of 0.12%. The overall signal-to-noise ratio was measured as 50 dB below 30 mM/mm which was in itself an exceptionally good figure, the noise mainly being due to hum as measured, but audibly almost entirely hiss. With the *B* system switched in on replay, the unweighted noise figure improved by just under 2 dB, but the dBa weighted figure improved by 8 dB. It was then decided to eliminate the treble cut component in the dBa weighted network and again measure the difference which then became 9.25 dB. Since the dBa curve arrows, a significant output below the frequency at which the full noise reduction is achieved, the true 10 dB improvement above 2 kHz was not measured, this only being measurable when octave filters are employed. The frequency response throughout the entire chain of Dolby *B* system and cassette machine still remained within a close tolerance of ±1.5d B from 35 Hz to 15 kHz, and the resultant sound from cassettes completely transformed them from the 'lo-fi' category to one which I personally regard as hi-fi, while of course not being up to master tape quality. I have made several com-

(continued overleaf)

parisons of cassette tape recordings using this system with conventional tape recordings made on high quality equipment at various speeds, and certainly was very hard put to tell the difference between a cassette of a stereo broadcast and a 19 cm/s copy on low noise tape of the same broadcast, both recorded direct from the tuner. When listening very carefully to cassette playback I sometimes noticed a slight haziness of clarity in positioning of instruments and on some cassettes noticed a tendency for slight azimuth wavering which was usually caused by the cassette not being seated quite correctly. I am also a little worried that one micron gap heads appear to wear rather faster than one might expect. On the other hand, the sound of Dolbyed cassettes can be so good that it poses quite serious problems in the design of cassette hardware, since past cassette recorders had relatively poor wow and flutter figures, and frequently very poor hum levels in the case of mains-operated units. Serious faults in cassette tape transport mechanisms will obviously stand out more noticeably with the great reduction in hiss gained from the Dolby *B* system and it is therefore important for manufacturers incorporating this system to improve the general standard of the machine. When Philips first designed the cassette, the capstan hole was of small diameter thus necessitating a very thin capstan. Several manufacturers have pointed out that it would be easier to achieve lower flutter figures with a larger capstan but it is now too late to change. Nakamachi in Japan have produced some comparatively good cassette units using the Dolby *B* circuits which several British manufacturers are incorporating into complete machines, including both Kellar and Decca.

Dolby has now produced a professional version of the *B* system known as the *A320*, selling at just under £400 and allowing manufacturers of prerecorded cassettes and tapes to duplicate these such that they can be replayed on a machine having a Dolby *B* playback processor included. It will very shortly be possible to purchase Dolbyed cassettes of a quality never before considered possible, made from Dolbyed master tapes, although I am still waiting to see what commercial prerecorded Dolbyed cassettes sound like having only heard an experimental one made in the States, which unfortunately had rather poor crosstalk between the recordings on the two tracks. The best results can only be achieved if good cassette tape is used (I find that *C90* is better than *C60* or *C120*), with the machine biased correctly. Only very rarely have I heard a dropout on the Wollensak, although alas dropouts have been very noticeable on some European makes of cassette recorder.

The same system was also tried with a $\frac{1}{4}$-track Revox *A77* recorder. At 9.5 cm/s, the Dolby gave a noise performance very similar to that of a 38 cm/s $\frac{1}{2}$-track recording, made with the same tape under the same no-Dolby conditions. Such a comparison does not hold with professional standard play tape since the latter is not satisfactory for use at the slower speed of 9.5 cm/s because of the nature of the oxide coating. High frequency signal-to-noise ratios of some 65 dB can be easily achieved at 9.5 cm/s. These are so good that the hiss level from such recordings will usually be found considerably lower than the hiss level on the incoming programme being recorded in the home, for instance from a ribbon mike source, or stereo radio tuner. I was delighted to hear, just before writing this article, that Studer have just agreed to incorporate the Dolby *B* system into their Revox tape recorders in the spring of next year. No doubt many other tape recorder manufacturers will be doing likewise, before long.

I have made some very careful measurements of the instantaneous peak recording levels that I found it possible to obtain when using the *B* system on cassettes. For this purpose I have speeded up the attack time of my PPMs to respond to transients as short as 1 mS. On most material it has been possible to record to a level of 2 dB above 32 mM/mm which is at least 2 dB above the level that sounded best when not using the system, thus giving an effective 2 dB increase in signal-to-noise ratio in addition to 10 dB of noise reduction. I found, when using a VU meter to judge recording levels with cassettes, that a safety margin of at least 3 dB had to be given to allow different types of music to be recorded without distortion. The average cassette is often under-recorded by as much as 5 dB below the level that could be recorded with the *B* system in use. I must therefore recommend the use of PPMs or oscilloscopes in the making of cassette duplication masters so that gains can be set up at the factory by tone at the beginning of each tape and then the music dubbed with the operator knowing that the cassettes will have a very high but relatively undistorted signal on them. I have recently heard that Ampex have just installed PPMs in their mass duplicating set up and I am greatly looking forward to hearing some of their duplicated material.

I find it difficult to prophesy exactly how far reaching the use of the domestic system will be but can see that it would be extremely useful for optical film recording and magnetic stripe recording for home projectors. I can also see a possibility for its eventual use in stereo broadcasting and I see no reason why it should not be used in the recording of the sound channel of domestic video tape recorders, and even for the video disc.

I have checked a considerable amount of Dolby *B* material without using the playback processor on replay and have found that more or less acceptable results can be obtained by applying a considerable treble roll-off from 1 kHz on my Quad *33* preamp. Although cassettes lacked punch in climaxes, there was a definite improvement in hiss level by greatly reducing the treble response of the preamp, and I have found that the general sound quality produced was not subjectively inferior to a normal cassette with its high hiss level and reduced dynamic range. Cassette machines not having a treble control, however, would give a toppy sound from Dolbyed cassettes. Now that I have used the Dolby *B* system with a cassette recorder I would advise anyone against purchasing a stereo cassette installation not having a Dolby playback processor included, even if this means waiting two or three months.

Should any professional engineer wish to be convinced of the validity and performance of the system, I should be pleased to demonstrate it to him. Please phone 01-203 3060 for details.

Angus McKenzie

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 9d. per word; minimum 12s., Box Nos. 2s. extra. Copy and remittance for advertisements in **DECEMBER 1970** issue must reach these offices by **17th OCTOBER 1970** addressed to: The Advertisement Manager, **Studio Sound,** Link House, Dingwall Avenue, Croydon CR9 2TA.
NOTE: Advertisement copy must be clearly printed in block capitals or typewritten.
Replies to Box Nos. should be addressed to the Advertisement Manager, Studio Sound, 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.

SITUATIONS VACANT

Student requires partner with equipment to assist in Sound Recording assignments. Box No. 590 (London).

FOR SALE—PRIVATE

Heathkit Distortion Meter, made and modified by Terence Long. £50. Box No. 589 (London).

Gaumont Kalee wow and flutter meter, very good condition, £125. Level transistor voltmeter, £30. Mixer components, PPMs, circuit modules, etc. All at half cost price, new and unused in original packing. Details on request. Neumann and AKG microphone stands, both as new with boom arms. £10 each. Box No. 588 (London).

AKG C24 stereo capacitor microphone outstanding sample, with extension leads, etc., three spare valves, in case £300. Neumann KM56 capacitor microphone with Nickel Cadmium charger, as new, £80. Beyer M160 double cardioid, new, £30. Beyer M119 and STC stick microphones, £10 the pair. Box No. 587 (London).

Beat the Tax man—your chance to buy Akai M8 semi-professional tape recorder at realistic price. Recorder has only had six hours use from new and cost over £130. Offers to 47, Ramshead Hill, Leeds 14.

Brenell Mark 5 Recording Amplifier Meter Power Pack, as new, £10 or offer. 22 North Grove, London, N5 47L.

FC 650 Condenser mics with power supplies (mains), as new, 3 only, £27 10s. each. Hayling Island 4152 (business hours only).

Tandberg 6000X Tape Recorder. 4-track. Rosewood case. New and completely unused. £160. N. K. Anderson (phone 01-788-1640).

FOR SALE—TRADE

UNIMIXER 4S

Mixing unit for professionals in studio and on location. (1 stereo pair and 2 pan controlled mics.) Any input imp. 25-600 ohms. S/n ratio greater than 55 dB with an input signal of 180 µV at 200 ohms or 70 µV at 30 ohms. Individual test certificate. Price **£45.** Further details:

SOUNDEX LTD.

18 Blenheim Road, London, W.4. *Tel.* 01-995 1661

Copyright Free Sound Effects Discs. 7" E.P's and 12" L.P's. Catalogue from Rapid Recording Services, 21 Bishops Close, London, E.17.

Lancashire. Tandberg, Ferrograph Tape Recorders, etc. Plus over 10,000 high fidelity systems. After-sales service. Holdings Photo-Audio Centre, 39-41 Mincing Lane, Blackburn BBA 2AF. Tel. 59595/6.

If quality matters consult first our 75-page illustrated Hi-fi catalogue with technical specifications (6/6). Members enjoy unbiased advisory service, preferential terms. Membership 7/6. Our associates also manufacture records from your own tapes, or record the Master at our studios (Steinway Grand). Bulk terms for choirs, fund-raising. Please specify requirements. Audio Supply Association, 18 Blenheim Road, London W.4.

P.P.M. Displays built from our Logarithmic driver Amplifiers from £17 10s. S.A.E. R. Daniel, 4 Latham Road, Twickenham, Middx.

Bulk Erasers. Will erase up to 8¼in. tapes including cassettes, 42/6 each, postage 2/6. Clement Wain Ltd., Newcastle, Staffordshire.

RAC Plug-in Audio Modules. For professional and amateur users. Prices from 35s. Range includes microphone and line amplifiers, disc and tape equalisers buffer amplifiers and 24V power pack. Mixers built to your requirements mono and stereo. Write for details to Rugby Automation Consultants, 220 Alwyn Road, Rugby.

REVOX A77 OWNERS

An illuminated push-button remote control unit (fully engraved) in a beautifully styled case can be yours for only 15 gns. plus 5/- p.p. All remote facilities at your fingertips. Trade enquiries welcomed.

PROGRESSIVE SOUND STUDIOS
593 HIGH ROAD, LEYTON, LONDON, E.10.

MISCELLANEOUS

Repairs. Our modern service department, equipped with the latest test equipment including a wow and flutter meter and multiplex stereo signal generator, is able to repair Hi-Fi and Tape Recording equipment to manufacturers' standards. Telesonic Ltd., 92 Tottenham Court Road, London, W.1. Tel. 01-387-7467.

Tape housing cabinets made to your specification by the makers of the famous NEW CLASSIC perfectly sprung anti-warp record storage. 12 Rosoman Street, London, E.C.1. 01-837-5920.

Dictating and Audio Service Ltd., 5 Coptic Street, London, W.C.1 (near the British Museum). Telephone 636-6314/5. Authorised Service Agents. Grundig, Philips and other leading makes of Tape Recording equipment repaired to Manufacturers' standards by skilled staff using modern test equipment — audio generators, oscilloscopes, audio volt-meters, etc.

Tape Recorder Repairs by Specialists. The Tape Recorder Centre, 82 High Holborn, London, W.C.1.

STUDIO FACILITIES

County Recording Service. Send your tape for transfer to disc to the people who care about quality. Full time disc recording engineers, using modern cutting techniques. Telephone Bracknell 4935. London Road, Binfield, Bracknell, Berkshire.

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.

Pressing Specialists, stereo or mono discs manufactured from your own tapes. Mobile recording service. North Surrey Recording Co., 59 Hillfield Avenue, Morden, Surrey.

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.

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

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

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

Fanfare Records. Tape-disc pressings, demo's, masters, any quantity. Studio/mobile. Neumann disc cutter. S.A.E. brochure. 1 Broomfield Close, Rydes Hill, Guildford. Telephone 0483-61684.

mjb **recording and transcription service**

Vinyl pressings and acetate demodiscs. Limiting, compression and equalisation facilities; high undistorted cutting levels with feedback cutter heads. Booklet available.

10 LOWER ROAD, COOKHAM RISE, MAIDENHEAD, BERKS.
Tel. Bourne End 22231 Member A.P.R.S.

V.C.S. 3 SYNTHESIZER WITH KEYBOARD FOR HIRE

£8 per session or **£15** per day
Free delivery and collection within the London area.
Tel: 042 874 3320

STUDIO FACILITIES (cont.)

EDEN STUDIOS LTD.

Word's getting around that the Studio that's having great success with its own recorded productions, also has a particularly fine pressing and disc cutting service. Please write or phone for leaflet.

11 EDEN ST., KINGSTON, SURREY
01-546-5577

A FANTASTIC OPPORTUNITY

A ten-channel stereo mixing console with plug-in printed circuit cards and additional space for extra channels. Each channel consists of foldback mic. app gain, treble, bass, echo send, pan-pot, channel mute and 20 db Pads, slider fader.
Twin main gains echo return, echo return pan-pot, built-in F.E.T. compressor; built-in P.P.M's four frequency oscillator, four individual patch bays, illuminated mode selection, illuminated Revox remote control unit, comprehensive monitor selection, talk-back cue-lamps, facilities, external power supply. All housed in a beautiful cabinet with detachable legs.
For further details please contact Gerald Chevin,
PROGRESSIVE SOUND STUDIOS
95 Ardwell Avenue, Barkingside, Essex
or ring 01-539-5263 or 554-7267

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.

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

Wanted: Ampex 351 Electronics Unit—condition unimportant. Tel. 01-857-1652.

Wanted. Two STC Capsules 6SR—DP00-742633 as required for capacitor mike detailed in 'Tape Recorder' January '70. Matheson, 13 Ailsa Drive, Glasgow, S.2.

TAPE EXCHANGES

Join in today's most fascinating hobby and really begin to use your recorder! Particulars: **Worldwide Tapetalk,** 35 The Gardens, Harrow.

KEEP IN TOUCH

WITH

STUDIO SOUND EVERY MONTH

3/-

Place a regular order with your Newsagent or take advantage of a ***POST FREE*** Annual Subscription—see order form on page 506 this issue.

INDEX TO ADVERTISERS

HERTS HI-FI

166 ST. ALBANS ROAD, WATFORD.
Telephone: WATFORD 34644

	LIST PRICE	OUR PRICE
● 8 TRACK CARTRIDGE STEREO (PP £2 0 0)		
Teleton STP800	£52 5 0	£45 0 0
Metrosound SS30	£85 1 2	£72 0 0
Akai CR80D (recorder)	£95 0 5	£82 0 0
● TAPE RECORDERS (PP £2 0 0)		
Revox 1102/4...	£204 15 0	£179 0 0
Revox 1122/4...	£236 5 0	£203 0 0
Revox 1222/4...	£246 15 0	£215 0 0
Revox 1102 HS	£255 3 0	£222 0 0
Revox 1122 HS	£286 13 0	£253 0 0
Revox 1222 HS	£297 3 0	£255 0 0
Ferrograph 722H	£251 6 8	£220 0 0
Akai XV	£187 10 9	£160 0 0
Akai 1800SD ...	£199 18 4	£166 0 0
Akai X360	£380 1 6	£320 0 0
Akai 4000D	£89 19 1	£68 0 0
Akai 4000	£124 18 0	£94 0 0
Akai X330	£342 11 4	£280 0 0
Akai X330D ...	£312 11 3	£250 0 0
Akai 1710L	£109 0 0	£84 0 0
Akai X-5000 L & W...	£177 19 6	£135 0 0
Akai M 10L	£245 1 0	£198 0 0
Akai X-360DS	£318 16 4	£243 0 0
Akai 2000SD ...	£300 0 0	£255 0 0
Ferguson-Marconi		
3245/4245	£37 1 0	£33 0 0
3246/4246	£43 0 0	£36 10 0
3247/4247	£48 9 0	£39 15 0
3248/4248	£54 6 0	£45 10 0
3244	£97 18 0	£75 0 0
3249	£64 6 0	£49 0 0
Teleton FXB 510D	£62 10 0	£53 10 0
Teleton 999	£97 10 0	£77 0 0
Teleton T710...	£34 15 0	£28 10 0
Pye 9106	£37 13 1	£29 19 0
Pye 9123	£60 0 10	£49 10 0
Pye 9137	£103 15 4	£83 0 0
Philips 4302	£39 0 0	£30 10 0
Philips 4307	£49 10 0	£39 19 0
Philips 4308	£60 10 0	£49 19 0
Philips 4404	£87 0 0	£69 5 0
Philips 4407	£105 0 0	£87 0 0
Philips 4408	£139 0 0	£111 0 0
Philips 4500	£126 0 0	£104 0 0
Philips PRO 12	£249 10 0	£219 0 0
Uher 714	£55 10 0	£47 10 0
Uher 2325	£120 6 0	£99 10 0
Uher 2345	£128 10 0	£107 0 0
Uher 2527	£132 12 0	£110 0 0
Uher 2547	£140 15 0	£118 0 0
Uher 2825	£167 8 0	£138 0 0
Uher 2845	£167 8 0	£138 0 0
Uher Royal 2...	£287 0 0	£229 0 0
Uher Royal 4...	£287 0 0	£229 0 0
Uher Royal C2	£254 5 0	£208 0 0
Uher Royal C4	£254 5 0	£208 0 0
Uher 4000L	£145 10 0	£120 0 0
Uher 4200	£187 5 0	£149 0 0
Uher 4400	£187 5 0	£149 0 0
● CASSETTE RECORDERS (PP 10/-)		
Aiwa 736E	£29 8 0	£21 0 0
Bush TP60	£29 8 0	£23 10 0
Bush TP70	£29 18 0	£24 0 0
Ferguson 3240	£26 10 0	£22 0 0
Philips EL 3302A	£28 7 0	£22 0 0
Philips N2205	£43 3 0	£35 10 0
Philips N2401+spkrs	£99 0 0	£83 10 0
Philips N2400+spkrs	£86 0 0	£74 0 0
Pye 9109	£28 7 0	£22 1 0
Pye 9115	£43 3 0	£35 10 0
Sencor 5001	£22 1 0	£15 18 0
● CASSETTE RECORDERS WITH RADIO		
Philips RR290	£31 10 0	£23 0 0
Pye 9000	£44 0 0	£36 10 0
Teleton TRC 130	£39 10 0	£33 0 0

STANDARD PLAY				
Reel	4"	5"	5¾"	7"
ft.	300	600	900	1200
BASF	—	20/-	26/-	31/-
BASF round pack	8/9	15/3	20/3	23/6
EMI	9/6	18/-	24/6	30/-
PHILIPS	—	18/6	24/6	28/-
SCOTCH	—	16/-	21/-	26/6
SCOTCH Dynarange	—	19/6	26/-	33/-

LONG PLAY					
Reel	3"	4"	5"	5¾"	7"
ft.	210	450	900	1200	1800
BASF	8/9	17/6	25/-	28/6	41/-
BASF round pack	6/9	13/6	20/3	23/6	34/9
EMI	8/6	12/6	24/6	30/6	42/-
PHILIPS	8/-	13/6	20/6	26/-	36/6
SCOTCH	7/-	11/-	21/-	26/6	38/-
SCOTCH Dynarange	—	—	25/6	32/3	45/3

DOUBLE PLAY					
Reel	3"	4"	5"	5¾"	7"
ft.	300	600	1200	1800	2400
BASF	10/9	20/-	28/-	40/6	49/-
BASF round pack	8/6	15/3	23/6	34/9	43/6
EMI	12/6	21/6	36/-	48/-	66/-
PHILIPS	10/6	19/-	29/6	42/6	59/6
SCOTCH	12/9	19/-	31/8	42/-	58/6
SCOTCH Dynarange	14/-	22/6	36/-	47/3	66/10

TRIPLE PLAY					
Reel	3"	4"	5"	5¾"	7"
ft.	450	900	1800	2400	3600
BASF	17/-	24/-	40/-	49/-	61/-
BASF round pack	13/6	20/3	34/9	43/6	55/9
EMI	19/6	32/6	56/-	—	—
PHILIPS	17/-	30/6	50/-	—	—
SCOTCH	18/6	30/-	—	—	—
SCOTCH Dynarange	—	—	—	—	—

F CAVE

5 BRIDGE STREET RICHMOND SURREY

TOP DISCOUNTS Tel. 01-948 1441 up to 8pm

RECORD DEPARTMENT
CREDIT TERMS
DEMONSTRATIONS
REPAIR FACILITIES

TAPE RECORDERS	List Price	Cash Price
Revox 1122/1124	£236 5 0	£208 10 0
Revox 1302/1304	£204 15 0	£180 10 0
Revox 1322/1324	£236 5 0	£208 0 0
Revox 1222/1224	£246 15 0	£217 10 0
Ferrograph 713	£188 10 0	£166 0 0
Ferro. 702/704...	£207 7 0	£180 10 0
Ferro. 722/724...	£242 10 9	£202 19 0
Akai 4000D ...	£89 19 1	£71 19 0
Akai 1710L ...	£89 0 0	£77 12 0
Akai 4000 ...	£124 18 0	£103 19 0
Akai X5000L ...	£177 19 6	£156 13 0
Akai X5000W ...	£177 19 6	£156 13 0
Akai M10L ...	£245 1 0	£215 13 0
Tandberg 64X ...	£147 13 0	£121 4 0
Tand. 1221/1224	£154 0 0	£135 10 0
Philips 4302 Auto	£35 17 6	£30 16 0
Philips 4307 ...	£49 10 0	£42 10 0
Philips 4404 ...	£83 0 0	£71 5 0
Philips 2401 ...	£81 0 0	£71 5 0
Philips 2502 Auto Changer Cassette	£49 10 0	£42 11 0
Philips 2401 Including Speakers	£99 0 0	£87 0 0
Philips EL3302	£28 7 0	£21 10 0
Sanyo Cassette		£20 19 6
Telefunken M501	£43 11 6	£38 8 0
Telef'n M204TS	£124 19 0	£109 18 0
Grundig TK120	£39 5 0	£28 18 0
Grundig TK124	£44 18 0	£35 7 0
Grundig TK144	£49 19 0	£42 5 0
Grundig TK149	£57 12 8	£46 19 0
Grundig TK121	£54 15 7	£45 19 0
Grundig TK141	£59 4 8	£49 14 0
Grundig TK146	£68 2 10	£57 3 0
Truvox R44 ...		£45 10 0
Teleton T710 ...	£34 15 0	£30 10 0
Teleton 5L40 ...	£37 10 0	£32 19 0
Teleton FXB 510D	£62 0 0	£52 15 0
Crown CTR8750	£32 11 0	£24 19 0
Marconiph. 4218	£89 11 0	£80 10 0
Marconiph. 4248	£52 14 0	£47 7 0

	List Price	Cash Price
Standard Cassette		£15 15 0

TANDBERG, UHER, VORTEXION, AIWA, SANSUI, PIONEER.
Send for lists of special discount prices.

HEADSETS	List Price	Cash Price
Akai ASE 9 ...	£6 10 0	£5 14 0
Akai ASE 20 ...	£9 0 0	£7 18 0
Akai AEH 10 ...	£20 0 0	£17 0 0
Beyer DT 48 ...	£33 18 0	£27 19 0
Beyer DT 48S ...	£33 14 0	£28 13 0
Beyer DT 100 ...	£13 18 6	£11 17 0
Beyer DT 109 ...	£23 18 6	£20 7 0
Beyer DT 480 ...	£29 5 0	£24 17 0
Eagle SE 1 ...	£4 19 9	£4 7 0
Pioneer SE 50 ...	£19 3 8	£16 6 0
Pioneer SE 30 ...	£12 12 0	£10 14 0
Pioneer SE 20 ...	£7 2 11	£6 2 0
Pioneer SE 2P ...	£6 15 5	£5 15 0
Rotel RH 600 ...	£5 10 0	£4 14 0
Rotel RH 711 ...	£9 0 0	£7 13 0
Sansui SS 2 ...	£7 14 6	£6 12 0
Sansui SS 20 ...	£17 10 0	£14 0 0
Secom 650 ...		£3 12 0
Teleton SH 301P	£4 0 0	£3 10 0
MICROPHONES		
Beyer S'star X1N	£19 18 0	£16 18 0
Beyer ,, X1HLM	£23 1 6	£19 12 0
Beyer M64 ...	£10 7 0	£8 16 0
Beyer M64 SH ...	£14 7 0	£12 4 0
Beyer M67 ...	£29 6 0	£24 18 0
Beyer M260 ...	£25 0 0	£21 5 0
Beyer M81 HL...	£11 5 0	£9 11 0
Beyer M818 HL	£22 18 6	£19 10 0
Beyer M55 HL...	£8 18 0	£7 11 0
Eagle DM16 HL	£6 12 4	£5 15 0
Eagle DM58 ...	£11 0 6	£9 13 0
A.K.G. D9D HL	£7 0 0	£6 3 0
A.K.G. D109 ...	£12 0 0	£10 10 0
A.K.G. D119 ES	£27 0 0	£23 12 0
A.K.G. D202 ES	£32 0 0	£28 0 0
Akai DM13 ...	£7 10 0	£6 11 0
Akai ADM5 ...	£4 15 0	£4 3 0
Akai ADM10 ...	£5 10 0	£4 16 0
Akai AFM4 ...	£3 17 6	£3 8 0
Tand. TM3 for 6X	£7 10 0	£6 11 0
Tandberg TM4	£12 10 0	£10 19 0
Tandberg TM4 Hand Microphone	£7 10 0	£6 11 0
AMPLIFIERS		
Armstrong 521	£56 0 0	£48 10 0
Ferrograph F307 Stereo Amplifier	£59 0 0	£49 0 0
Leak 30 Stereo Amplifier (Chassis)	£53 0 0	£41 19 0
Leak 70 Stereo Amplifier (Chassis)	£63 0 0	£52 0 0
Lux SQ1220 Stereo Amplifier	£124 10 0	£95 0 0
Lux SQ77T Stereo Amplifier	£67 7 6	£48 19 0
Lux SQ505 Stereo Amplifier	£97 10 0	£65 19 0
Rotel 100 Stereo Amplifier	£45 10 0	£37 10 0
Quad 303 and 33 Stereo Amplifier	£98 0 0	£87 19 0
Revox A50 Amp	£106 1 0	£92 19 0
Teleton SAQ 203E Stereo Amplifier	£27 15 0	£21 15 0
Tele. SAQ 150E	£26 5 0	£22 5 0
Teleton SAQ 150E 12 Watt Stereo Amp.	£26 5 0	£22 5 0
Teleton GA101 Stereo Amplifier	£37 10 0	£31 0 0

We stock a very wide range of loudspeakers, including BOWERS & WILKINS, GOODMANS, LEAK, QUAD, ROGERS, LOWTHER, SANSUI, AR, TANDBERG, CELESTION, KEF, WHARFEDALE, RADON, TANNOY, PIONEER, JORDAN-WATTS, SONAB, PHILIPS

YOU CAN BUY BETTER AT CAVES

BASF LOW NOISE HIGH OUTPUT TAPE	List	Cash Singles	Cash 6 or more
5" 900'	37/9	27/5	25/-
7" 1800'	62/1	45/5	41/-
5¾" 1800'	61/11	45/6	40/9
7" 2400'	76/7	56/3	50/4
5" 1800'	61/9	45/4	40/7
5¾" 2400'	76/5	56/3	50/2
7" 3600'	95/1	70/1	62/4

EMI LOW NOISE ROUND PACK TAPE AT SPECIAL DISCOUNT PRICES
7" 1200' **21/-** 5¾" 1200' **22/9** 7" 1800' **29/9**

BASF MAGNETIC TAPE			
7" 1200'	39/7	28/6	26/4
5" 900'	34/3	24/9	22/9
5¾" 1200'	39/5	28/6	26/2
7" 1800'	56/7	41/3	37/4
5¾" 1800'	56/5	41/3	37/5
7" 2400'	69/7	51/-	45/9
5" 1800'	56/3	41/3	37/-
5¾" 2400'	69/5	51/-	45/7
7" 3600'	86/7	63/9	56/10
BASF CASSETTES			
C60	17/7	11/-	9/9
C90	25/1	16/3	14/9
C120	33/7	21/6	19/6
PHILIPS CASSETTES			
C30	10/7	8/6	7/6
C60	17/7	13/6	12/6
C90	25/-	19/6	17/6
C120	33/7	26/-	23/-

Musicassettes and all brands of 8 track stereo cassettes at 15% discount.
ALL TAPE AND CASSETTE ORDERS 3/6 POSTAGE AND PACKING
PACKING AND CARRIAGE AND INSURANCE EXTRA. SEND STAMPS FOR LISTS OF SPECIAL DISCOUNT PRICES.

GUARANTEED QUALITY & SATISFACTION

4 TRACK STEREO/MONO

	Deposit	12 monthly Instalments	Cash Price
Philips 3312	23 4 1	3 14 5	67 17 1
Philips N4404	28 0 0	4 11 8	83 0 0
Ferguson 3232	33 5 0	5 1 10	93 5 0
Sanyo MR929	33 4 9	5 6 10	97 4 9
Sony TC252	33 5 0	5 10 10	99 15 0
Philips N4407	35 0 0	6 13 4	105 0 0
Akai 1710L	36 6 8	6 1 2	109 0 0
Sanyo MR939	38 13 6	6 2 3	112 0 2
Grundig TK247	37 10 0	6 5 0	112 10 0
Sony TC130 cassette ...	38 10 0	6 3 4	112 10 0
Sony TC230	40 11 9	6 15 0	121 11 9
Telefunken 204TS ...	41 19 0	6 13 4	124 19 0
Philips N4408	47 0 0	7 13 4	139 0 0
Tandberg 1241X ...	49 0 0	8 6 8	149 0 0
Sony TC540	50 15 0	8 5 0	149 15 0
Akai 1800...	53 0 0	8 13 0	158 0 0
Akai 1800SD	66 6 8	11 1 2	199 0 0
Akai M9	65 0 0	10 16 8	195 0 0
Sony TC630	66 15 0	11 18 0	199 15 0
Ferrograph 722/4 ...	68 16 9	11 6 8	204 16 9
Revox 1122/24	78 15 0	13 2 6	236 5 0
Philips Pro 12	83 10 0	13 16 8	249 10 0

4 TRACK MONAURAL

	Deposit	12 monthly Instalments	Cash Price
Fidelity Braemar ...	11 12 8	1 17 4	34 4 8
Fidelity Studio	15 17 10	2 10 2	46 0 10
Philips 4307	16 15 3	2 13 1	48 11 11
Telefunken 201	17 3 0	2 17 2	51 9 0
Grundig TK149	18 18 10	3 1 8	55 18 10
Ferguson 3238	20 12 0	3 5 0	59 12 0
Philips 4308	20 14 2	3 5 7	60 0 10
Ferguson 3249	22 9 0	3 3 8	62 9 0
Ferguson 3216	22 16 0	3 12 2	66 2 0
Tandberg 1541	28 0 0	4 10 0	82 0 0

STEREO TAPE UNITS

	Deposit	12 monthly Instalments	Cash Price
Sanyo MR801	24 3 0	4 0 6	72 9 0
Sony TC252D	24 9 0	4 0 6	72 15 0
Tandberg 1641-X ...	30 0 0	4 19 2	89 10 0
Akai 4000D	30 18 8	4 18 4	89 18 8
Sony TC355	34 2 6	5 10 0	100 2 6
Tandberg 62/64-X ...	52 6 8	8 14 6	157 0 0
Ferrograph 702/4 ...	64 15 8	10 16 8	194 15 8

CASSETTES

	Deposit	12 monthly Instalments	Cash Price
Sanyo M48M	7 5 0	1 3 4	21 5 0
Sanyo M410G Mns/Bat.	11 5 0	1 17 6	33 15 0
Philips RR290 + Radio ...	11 10 0	1 17 6	34 0 0
Sony TC100A Mns/Bat.	14 9 3	2 6 8	42 9 6
Sanyo MR411 Mns/Bat. + FM/AM	16 15 0	2 15 0	49 15 0
Philips 2400 Stereo ...	22 14 0	3 15 6	68 0 0
Philips 2400 incl. L. Spkrs.	28 14 0	4 15 6	86 0 0
Sony TC 130 Stereo ...	37 10 0	6 5 0	112 10 0

BATTERY OPERATED

	Deposit	12 monthly Instalments	Cash Price
Philips RR290	11 10 0	1 17 6	34 0 0
Grundig C200	12 7 6	2 0 10	37 17 6
Philips RR482	18 4 0	3 0 8	54 12 0
Telefunken 300TS ...	19 5 0	3 4 2	57 15 0
Telefunken 302TS ...	22 15 0	3 15 10	68 5 0
Uher 4000L	48 10 0	8 1 8	145 10 0
Uher 4200/4400	62 10 0	10 7 11	187 5 0

INTEREST FREE H.P. TERMS

(EXCEPT SPECIAL OFFERS)
OPEN SATURDAY 6 p.m. FRIDAY 6.30 p.m. THURSDAY 1 p.m. IF UNABLE TO CALL, WRITE FOR BROCHURES, PART EXCHANGES, 18 and 24 MONTHLY TERMS

SPECIAL OFFER

SANYO MR 990 STEREO
(illustrated)

* 4-Track * 3 speeds * Sound-on-Sound * Sound-with-Sound * 2 Detachable Speaker Boxes * Output 2 x 10 watts Music Power * Natural Wood Cabinet * Supplied complete with 2 Dynamic Microphones; 7" Demonstration Tape, Leads, etc., Makers 12 months guarantee and instructions * Automatic Shut-Off.

List Price £132.5.0.

OUR PRICE 95 gns.

Deposit £33.15.0. 12 Payments of £5.18.3. Total HP Price £104.14.0.

THE RECORDER CO.

(DEPT. R) 186-188 WEST END LANE · WEST HAMPSTEAD · LONDON · NW6 . Telephone: 01-794 4977

Neve SOUND CONTROL EQUIPMENT

26 channel sound control console

One of the recent examples of Neve craftsmanship designed and built to the requirements of Cine Tele Studios Ltd., London.

This console incorporates 26 full mixing equalized input channels each with microphone and line inputs. There are eight output tracks with three mixed down groups for stereo and mono mastering, six echo groups, studio foldback, and an impressive list of built-in equalizers, compressors and other signal processing devices. A comprehensive communications system links the Studio floor, balance engineer, projection room and the producer.

The Neve organisation specialises in the design and installation of complex professional control consoles and systems for clients throughout the world.

Telephone 076 386 776 (Ten lines) Telex 81381

Rupert Neve & Co. Ltd. Cambridge House, Melbourn, Royston, Herts, England.