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In its standard version, the PRO 12 allows for twin-track stereo, twin-track mono and dual-track mono on ¼ inch tape; an alternative version allows for quarter-track stereo or mono.

It also has separate heads and separate amplifiers for both recording and playback at either of its speeds, 3¾ or 7½ ips, and provides before and after tape (A-B) monitoring either visually or aurally.

A stroboscope for checking tape speeds is built in, and there are individual correction filters at both speeds plus microphone, diode and line inputs for each channel.

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Studio Sound

AND TAPE RECORDER

SEPTEMBER 1970 VOLUME 12 NUMBER 9

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COVER PICTURE

Mike Claydon at the
IBC Sound Recording Studios
mixing desk.

SUBSCRIPTION RATES

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

TALKING RECENTLY to a senior executive in a major British record company, we asked casually about progress on the 4-channel front. Yes, they had tried it in the studios and were producing some recordings for the American market, but he felt that it would probably make little headway. Anyway, 'most people who attended demonstrations remained unimpressed for one reason or another, didn't they?' This last remark reminded us of the quadraphonic dems put on by *Acoustic Research* in Paris and at the Sonex show, both of which produced mixed reactions—reactions very dependent, as it turned out, on listeners' positions in relation to the four loudspeakers.

However, having found some privileged editorial positions which could indeed transport one, aurally, right into the concert-hall, we were delighted recently to have some of the A-R equipment for extended trial under domestic conditions. Using a pair of Goodmans *Maxim* speakers mounted up at ceiling level back in the rear corners of the listening room, with carefully positioned platforms beneath them to contour the sound intensity in favour of more distant listeners (thus minimising unwanted Haas effect), we have found stereo seating to be remarkably *non*-critical.

With good 4-channel recordings, such a set-up can re-create a convincing concert-hall ambience over a wide listening area. But people won't believe this until they hear it, and they won't hear it unless those who wish to promote quadraphony for home use take rather more care with loudspeaker positioning at public demonstrations. We are sure that a large part of the secret here is to place the rear speakers well up, in addition to well back, thereby partly compensating for the missing vertical element *and* getting the sound sources farther from listeners' ears.

There is also the question, raised by Michael Gerzon in his current series of articles, of whether we really need four channels to re-create ambience—even though they may be demanded by pop artists or Leopold Stokowski for surrounding us with musicians. Three channels will probably suffice even for many of the latter effects, and before the whole record industry becomes too deeply committed to one system or another it would be worth taking a look at the remarkable and elegant proposals of David Hafler (*Hi-Fi News* August and *Audio* July), who offers a scheme for encoding the third signal in a conventional 2-channel stereo recording simply as out-of-phase information.

This works as follows. The 'forward' signal is compiled as usual, while a suitable reverberation signal is derived separately from extra microphones. This additional signal is phase-inverted, its normal and inverted versions then being added to the main left and right signals respectively.. The relative levels of the two signal pairs are adjusted to give an acceptable balance for normal 2-channel reproduction. On 3-channel replay, however, the added ambient information is regained by subtracting the L and R signals and feeding the resulting 'difference' to a rear speaker or speakers. This rear channel carries, unvoidably, some of the forward soundstage difference information in addition to the desired reverberation, but apart from some slight smudging and broadening of the main stereo image at its extremities (often a subjective advantage) there is apparently no snag.

The twofold beauty of this idea is that it could be adopted straight away by the industry, with only slight reservations, for use on disc, tape and radio, and it demands no more than the simplest gear in the home. No complex electronic decoder *à la* Scheiber system, no special pickup or 4-track tape player, in some cases nothing more than an extra loudspeaker connected between the left and right 'live' amplifier output terminals to reproduce the stereo difference signal. It even works to a degree on present day 2-channel recordings, some of the random out-of-phase components in recorded reverberation being pulled behind the listener. We commend Mr. Hafler's proposals to the recording industry for serious study, despite reports from the USA that it has been rather hastily discounted by the major American record companies.

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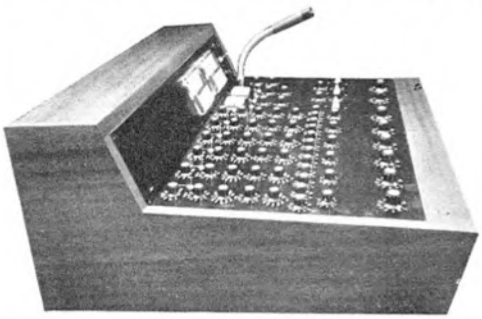

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studio diary

EMI IN CASSETTE MARKET

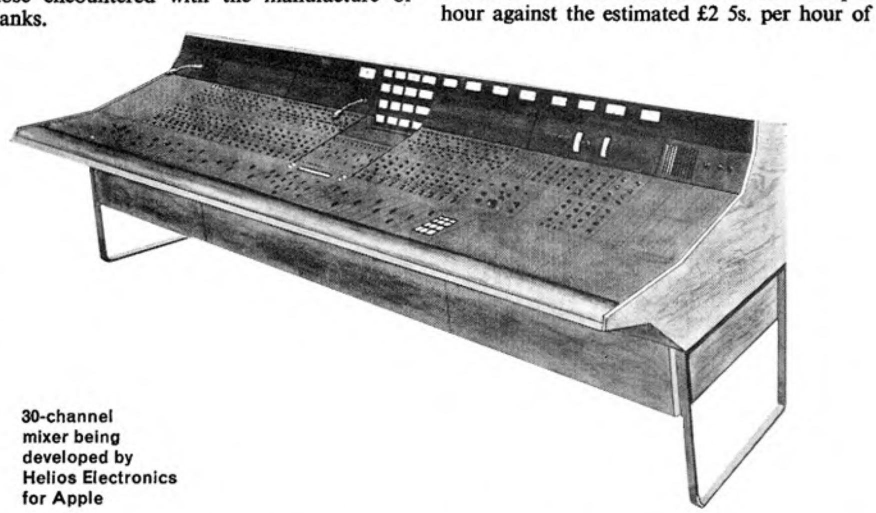
PIONEERS OF commercial tape records, EMI have recently opened an expanded tape duplication plant at Hayes to produce cassettes and 8-track cartridges. Aiming at some 500 titles by the end of the year, the company has invested over £100 000 in Gauss high speed duplicating and packaging equipment capable of handling both formats with a minimum of modification. Production is envisaged as 30 000 units weekly with an expansion potential considerably in excess of this, employing continuous shift and flowline techniques. EMI see tape sales booming in this country and envisage a 20% market share over the next few years. Though the cassette appears to be the most likely vehicle for this expansion, the Hayes plant is wholly compatible with the market demand.

Also to be continued are the 9.5 cm/s ¼-track open reel tapes which are produced in an adjacent plant on converted *BTR2*s. From the quality point of view, the Hayes engineers consider these generally as good as the disc equivalents, and the fairly careful copying procedure probably accounts for this. Master machines run at 38 cm/s and all four tracks are recorded in each six-minute run. Cassettes and cartridges fare less well, inevitably, suffering a 32-to-one reduction with the slave machines fed from continuous loop masters running at 304 or 608 cm/s. The bulk of the cartridge master tape is held in storage bins pneumatically fed through.

At present the plastic mouldings and the tape employed are predominantly of American manufacture but EMI are likely to employ their own materials in due course.

At present copying ratios, an LP disc, still the standard 'length', is duped in under a minute. Cutting and packing from the bulk reels is a more costly process. EMI splice the tape on to a cassette with leader already attached, the correct length being automatically run off by a timer. Despite pneumatic splicing blocks, the production line offers evidence of difficulty splicing thin base narrow tape.

Cost is a major factor in the production of blank cassettes as well, and various methods are being adopted by manufacturers in order to speed the process. A recent visit to BASF at Ludwigshafen, where cassettes are packed with tape produced by the company's Willstätt works, revealed a slightly different, albeit still experimental approach. The bulk material is supplied from Willstätt on large open spools with translucent leaders wound on and spliced in. Photoelectric cells detect the commencement of each transparent section and pneumatically-operated automatic splicers and reciprocating members cut, trim and attach the tape ends to the spools. The problems of packing pre-recorded cassettes—a market BASF may soon be attacking—are similar to those encountered with the manufacture of blanks.



30-channel mixer being developed by Helios Electronics for Apple

BUDGET FOUR-CHANNEL

FOUR-CHANNEL recording facilities are being offered at £4 per hour as an introduction to the services of SWM Studios, 32/34 Clerkenwell Road, London EC1 (253-6294). Vortexion and four-channel NAB Brenell equipment is being employed, in the hands of Steven Wadsey. Main mixing desk is a bank of four Vortexion *4/200* units feeding a secondary desk built by SWM with equalisation, plate and spring reverberation. Microphones are Neumann *U87*, AKG *D224e* and *D19c*, and Hammond capacitors. The studio holds up to 12 performers and large capacity is planned. Wadsey has four years experience in the recording industry and in song writing.

APAE 1971 EXHIBITION

FOR THE second year running, the Association of Public Address Engineers plans to hold its annual exhibition at the Camden Town Hall, Euston Road, N.W.1. *Sound 71* will open on Tuesday March 16, closing on Friday 19. Proposed admission times are 10 a.m. to 6 p.m. (5.30 p.m. Friday), though one late night opening is to be announced.

WALSALL TAKE OVER TRD

TAPE RECORDER Developments Ltd of Bushey Heath have been taken over by Walsall Timing Developments and their production facilities moved to Staffordshire. Peter Leversley becomes managing director, John Southard remaining with the company as sales manager.

MARQUEE INSTALL ALTEC SPEAKERS

ALTEC LANSING *9845A* loudspeakers have been installed at Marquee Studios, replacing existing monitors. Supplied by Carston Electronics, they incorporate a 380 mm bass unit and *806* HF driver operating through a *511* horn. Altec units have also been delivered to Tangerine.

VIDEO DISCS

THE RESULT of five years development by Telefunken, in conjunction with Decca, was demonstrated in Berlin on June 24. An intended rival to videotape, Selectavision and EVR, the Video Disc is potentially a low-price domestic television reproduction medium with a claimed material cost of little over £1 per hour against the estimated £2 5s. per hour of Selectavision and £12 per hour of magnetic tape. The medium is a flexible 100 μm plastic disc rotated at 25 revolutions per second (on 50 Hz mains) one cycle per picture frame. A diamond stylus shaped like the lower half of the letter D tracks the modulation at its trailing vertical edge. A piezo-electric transducer is employed, generating about 2 mV. The thin disc is cupped round the stylus by an air cushion above the playing desk, groove packing density being 120 to 140 per millimetre. Playing time of a 30 cm disc is 12 minutes for a 3 mHz bandwidth and 40 dB signal-to-noise ratio. Reproducing machinery is expected to cost £60 to £115 with marketing commencing before 1973.

TAPE RECORDER STATISTICS

MONTHLY TAPE recorder statistics are now being included in the Business Monitor Production series. Future issues of the *Tape Recorder Monitor* may be obtained on £1 annual subscription from HMSO.

NEXT MONTH

MICHAEL GERZON turns his attention to *'The Principles of Ultra-Directional Microphones'* in our October issue, Arthur Garratt field tests the 38 cm/s *Ferrograph Series 7*, and Stephen Court looks at the problems of *Going Mobile*. Bob Auger describes the production of *Spectrafonia*, an elaborate audio-visual exercise undertaken for the 1970 'Man and his World' Exhibition at Montreal.

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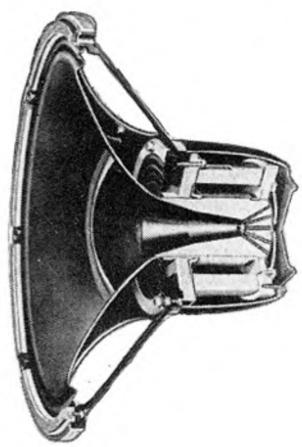

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A VARIABLE SPOOLING BRENELL

John Fisher describes a modification to the Brenell NAB deck

THIS article describes the modification of a standard Brenell NAB (27 cm spool) deck to provide variable spooling facilities. This gives smoother winding, easier searching when editing, and eliminates the risk of snapping tape, particularly the thinner tapes.

It has long been common practice among Brenell owners to flick the wind switch straight from fast forward to fast rewind, or vice-versa, to avoid the risk of tape snap, using the applied power on the trailing motor to bring the tape to a halt before the brakes are applied. The system to be described puts the power on smoothly with no risk of the brakes coming on through mishandling of the flicking process, as well as allowing controlled back-tension when winding forwards or backwards. Some Brenell machines have been equipped by the manufacturer with a mechanical brake operative on rewind only; the present system has been found greatly preferable.

The modification was carried out on the industrial version of the *Series 5 Mk. 3* NAB deck, which has external-rotor wind motors, but should be suitable for the other versions of the *Mk. 5* deck including those using internal-rotor motors. It is the author's impression that the newer motors have more torque, which makes the mod even more necessary. It will not be easy to accommodate the modification on one of Brenell's made-up machines; on the prototype it was undertaken to make the deck the basis of the transistorised semi-professional recorder.

Fig. 1 shows the deck circuit of the *Series 3* deck and **fig. 2** the modified circuit. Much of the colour-coded mains-bearing wiring can be left in place and utilised, provided this is done very carefully, and the only extra switch needed is the two-pole 11-way variable spooling control. An optional torque-reducing switch has been added, operative on wind and play for small spools. This is something of a luxury and can be omitted, certainly on the older decks. The circuit is then wired as if S2 were in the closed position, and the associated resistor and suppressor unit omitted. A certain amount of additional wiring must be added that cannot be accommodated in the existing plastic ducts, and the author found clear wine-maker's tubing particularly suitable for keeping wires bunched and giving additional protection to mains-bearing leads.

Brenell's existing terminal strip is retained for wiring up. An additional terminal board is necessary for the shunt resistors on the spooling control; on the prototype this was bolted to the underside of the rewind motor housing. The resistors are held in place by knurled nuts for easy replacement. The optional torque switch is a Rendar slide switch with gold plated contacts.

On the prototype, the spooling control was a ceramic ex-military switch with silvered contacts, originally in a sealed brass housing, part of which has been retained as a shield. A heavy duty 12-core shielded cable (G. W. Smith's of Edgware Road) carries power to and from the spooling control and shunt resistor terminal board.

The wind control is operative in either wind position, and off centrally. Winding direction is governed by the spooling control. With the spooling control central, the two motors are in series and unshunted. Moving the control in one direction or the other progressively shunts one motor so that the other motor increases its torque and the tape moves in that direction until full power is applied to the latter motor. The resistor values were chosen to give fairly smooth 'steps'.

As in the original circuit, a 1 K resistor is in series with the take-up motor on play and record. The small torque reducing resistor can also be brought into circuit during these functions, for small spools or 9.5 cm/s operation, but with this extra resistor spillage will occur when starting up at 38 cm/s, for which full torque is necessary.

Great care should be taken to check all connections before mains is applied for the first time—particularly switch connections and the motor capacitors. Colour coding is essential in the wiring, and a large number of colours will be needed—preferably those used in the multi-core cable. Good insulation is needed in this screened cable to prevent arcing between individual cores and between cores and screen, remembering that the load is reactive. The original suppressor units are retained for the deck switches. Suppressors should be fitted to the spooling control.

It would be possible to use a variable resistor system in place of the switched resistors, but the dissipation problems would be much greater. The switched resistors can conveniently be 20 W coated wire-wound types. The system has proved very satisfactory under the experimental conditions of its use, both with metal NAB and plastic cine spools.

FIG. 1

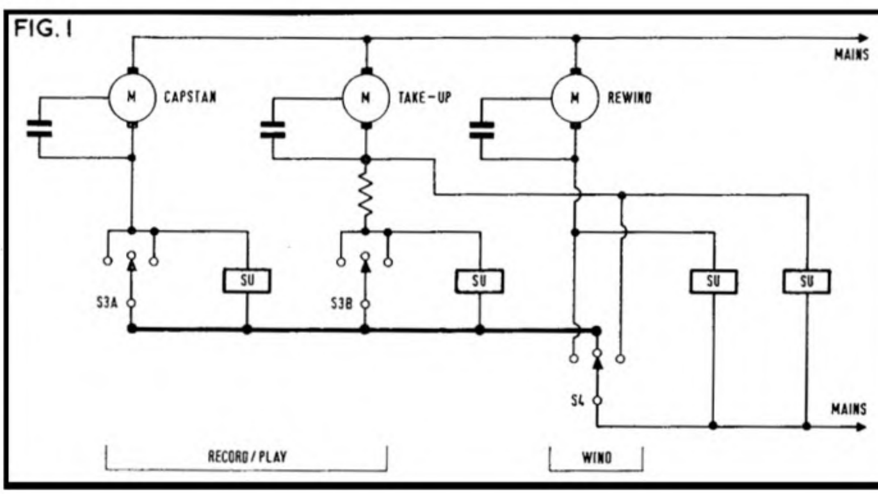
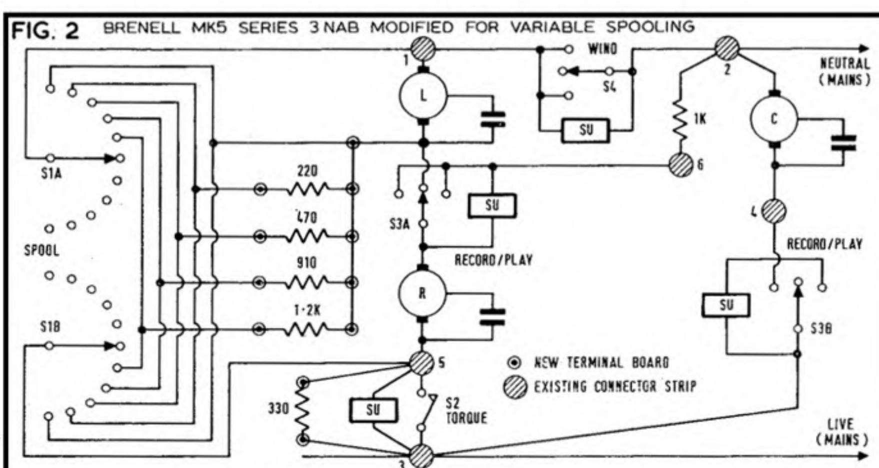


FIG. 2 BRENELL MK5 SERIES 3 NAB MODIFIED FOR VARIABLE SPOOLING



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The MM-1000 tape transport is designed to handle 1" and 2" tape. It's the same transport that's now in use on over 3000 Ampex video tape recorders. When you go from 1" and 2" tape, you just change the tape guides and the plug-in head assembly. Lets you quickly change from 1" for 8-channels to 2" for 16 or 24 channels,

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The MM-1000 offers more standard and optional features than any other master recorder. Tape Motion Sensing for instance. Allows you to change modes without going into stop and without stretching or breaking tape. Automatic Tape Lifters? Yes, and with manual override Ping Ponging? Sure, Sel-Sync? Naturally. Also remote Sel-Sync. How about Variable Speed Motor Drive Amplifier? Yes again, plus an Electronic Timer with up to 4 remote read-outs for pinpoint accuracy. Versatile? You bet!

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The wide range of applications for the MM-1000 mean its cost is amortized over a very short time. The MM-1000 may typically be used for Pop music recording, master Classic recordings, multi-language synchronised with videotape recordings, multi-channel sound source for film transcriptions. Or simply as a 'soul mate' in the search for innovation in music.

For further information on the Ampex MM-1000 recorder, send this coupon today.

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AMPEX

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A preview of the 1970 International Broadcasting Convention

IBC 70

LAST held in 1968, the International Broadcasting Convention is an ambitious combination of lectures and trade displays aimed equally at the television, film and audio markets. Opening on Monday September 7, the event runs through to mid-day Friday, admission times being 9 a.m. to 6 p.m. except Wednesday when the closing time is 10 p.m. Exhibition tickets are available to members of the communications industry and interested members of the public, from the Institute of Electrical Engineers, Savoy Place, London W.C.2. Of the companies exhibiting, the following have finalised their plans at the time we go to press:

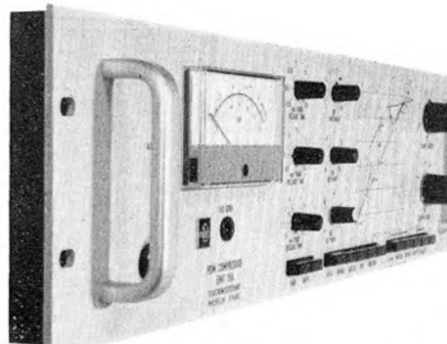
Albrecht will show the *Colour Spot*, a small battery-powered photometer with the characteristics of a colour camera and 1° measuring angle. The *CTM70* is a small colour temperature meter to suit colour film while the FAM Coder Decoder permits high quality colour recording on 25.4 mm and 12.7 mm video tape recorders. A colour bar generator, PAL colour corrector and TV light comparator complete their display.

Ampex are participating simultaneously in the IBC and a Broadcast Video Show at the US Trade Centre, St. James's Street. *VR-2000* VTRs, an *AVR-1* automated teleproduction recorder, *HS-100* disc recorder, *RA-4000* automatic programmer and *VS-600* will be demonstrated at the USTC in a live studio set-up handling musical entertainment and a fashion show. Tapes recorded through a broadcast camera will be played on Stand G6 at the IBC, via a *VR-7803* PAL VTR.

A *700* CCTV direct vision prompting system will be seen for the first time at the **Autocue** stand. The unit claims several advantages over competing designs, chiefly that scripts can be produced on standard typewriters. Immediate alterations and inserts can be made during rehearsal or transmission.

Two new units from EMT will be shown by **Bauch**, the *156* compressor-limiter (employing pulse width modulation) and the *160* polarity tester. The *156* is a stereo device giving up to 40 dB gain variation and accepting +4 dB to +15 dB balanced or floating, input impedance being 5 K. Compression attack time may be preset between 1 and 4 mS, gain being 0 to 18 dB. The *160* permits phase checking of microphones, loudspeakers or entire channels, polarity being indicated by a red or green light. A microphone is incorporated but direct connection can be made to a 10 K floating input, 200 mV sensitivity.

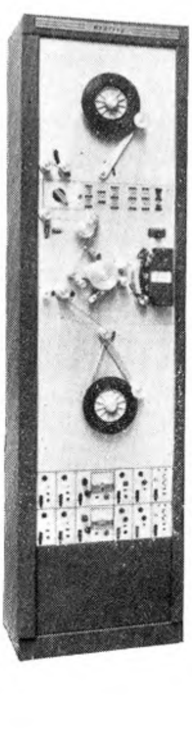
Cintron are displaying lighting equipment produced by **Ballancroft** and **Cremer**, plus a range of polyester-based filters. The Ballancroft *B10 Multibeam* incorporates adjustable focusing from spot to floor while the *Northlight* gives soft overall illumination.



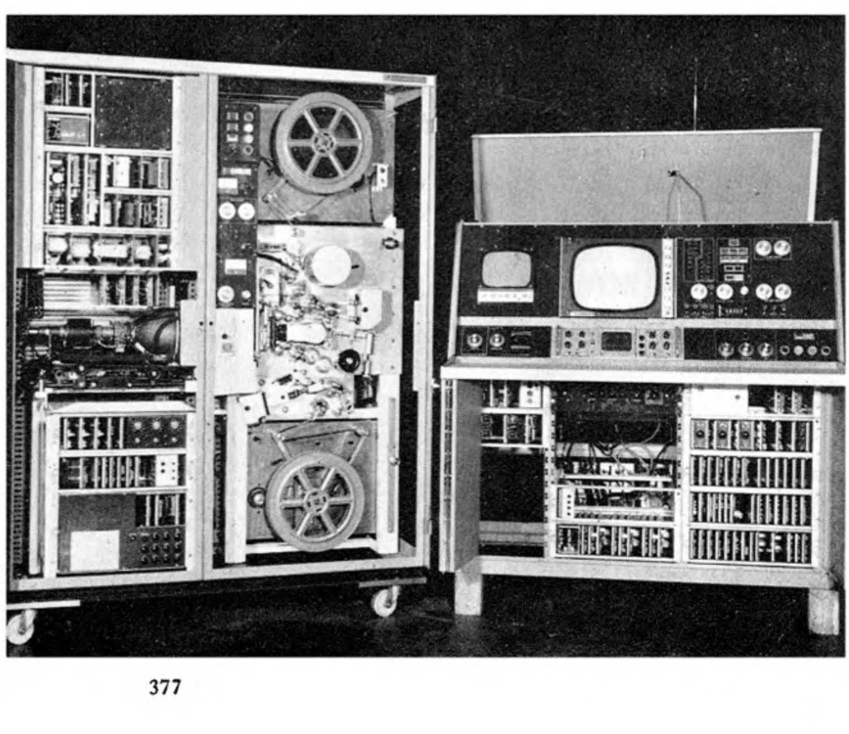
EMT 156 compressor-limiter.

The *Statitrol P-557* will be demonstrated by **Alexander Cole.** Designed for use wherever static build-up creates inconvenience or damage, typically in transistor production or cartoon filming, the device generates a beam of ionized air. Manufactured in America by **Scientific Instruments,** it is complemented by the *M-1001* static detection meter. Existing customers include Ampex, IBM and Dupont. *Colclene TF,*

(*continued on page 379*)



Westrex *LRA 1551/1552* magnetic recorder.



Rank Cintel 16 mm film scanner and control console.

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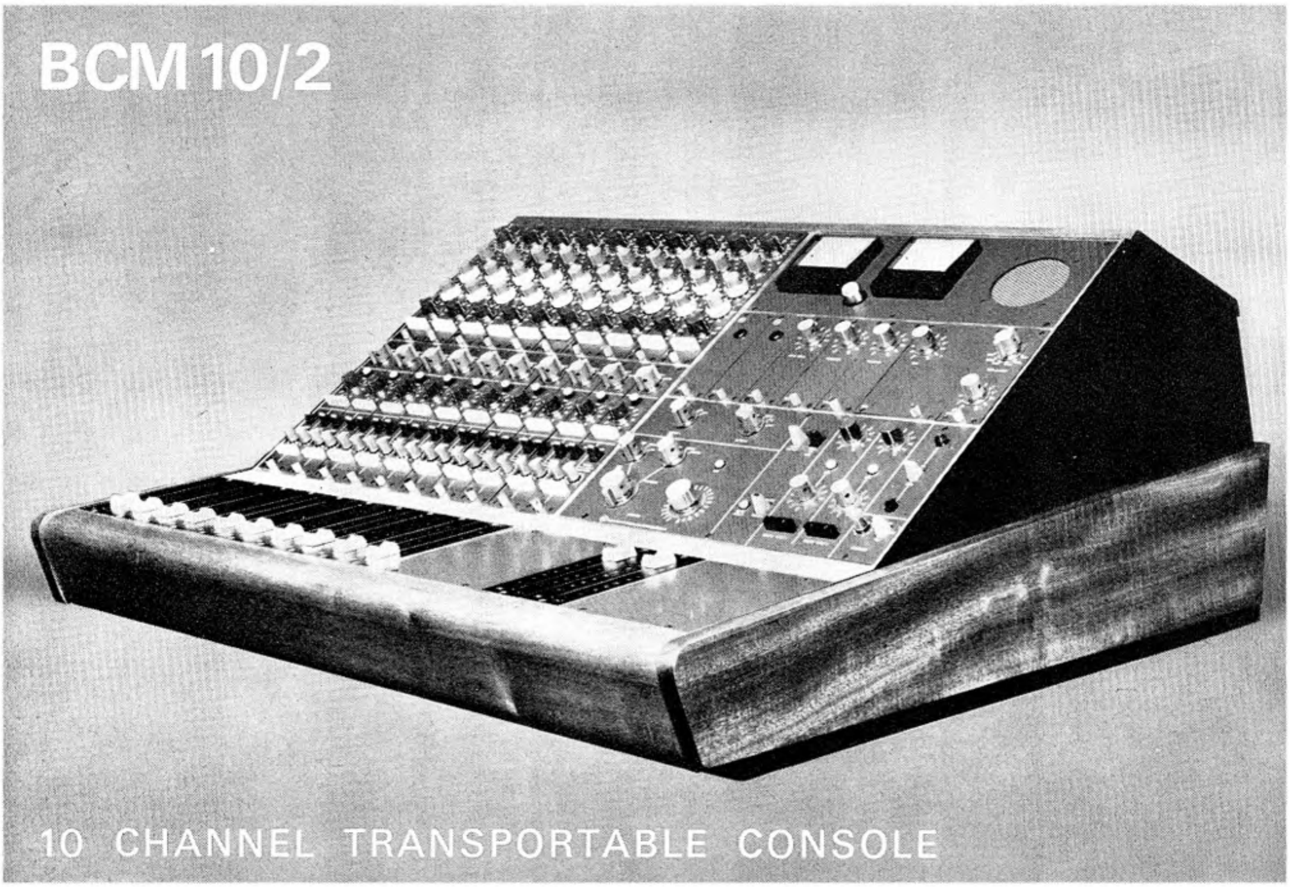
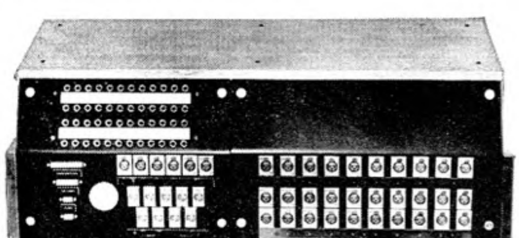
Neve

SOUND
CONTROL
EQUIPMENT



New compact versatile design by Neve styled to the needs of modern studios



The Neve BCM 10/2 marks a new departure into the field of sophisticated audio control. It embodies ten full mixing input channels and two output groups and is conveniently transportable.

Facilities are included for echo, studio foldback and talkback communication, stereo monitoring, cueing and D.J. "combo" working.

All signal inputs and outputs are on XLR connectors at the rear.

Thus the BCM 10/2 provides for every possible requirement within its class. It is competitively priced and available for quick delivery. Full specifications will be sent gladly on request.

Telephone 076 386 776 (Ten lines) Telex 81381

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

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English Electric Valve
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F & G (Carlswerk) Products
F.W.O. Bauch
Feldon Recording
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Hewlett-Packard
ITA
International Video Corporation
ITT Components Group Europe
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Marconi Company
Marconi Instruments
Matthey Printed Products
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Plessey
Prowest Electronics
Pye TVT
RCA Commercial Electronic Systems
Rank Audio Visual
Rank Precision Industries
Rocke International (UK)
Shure Electronics
Tektronix UK
Thorn Lighting
Unitrack Equipment
Vitronic
W. Vinten

widely used to clean tape equipment, will be shown along with *TE* solvent, capable of removing flux from printed circuit boards. Visitors are invited to bring sample boards and make their own tests of the latter material.

Michael Cox Electronics are showing their new three-level *Coxbox* colour synthesiser and its companion PAL coder on Stand B19.

Dolby are attending the IBC, displaying the established *A301* and recently introduced *360* series of noise reduction units. Further details in the APRS 70 report on page 401.

Electrocraft are exhibiting a range of television test equipment including the *Augmented Colour Pulse and Bar Generator* and a viewfinder CCTV vidicon camera. The TVT/6/EV camera is designed for industrial applications and employs an electostatic vidicon and FET/IC circuitry.

Evershed Power-Optics specialise in remote television camera control equipment and will demonstrate a system using digital circuit techniques. This governs pan, tilt, zoom, focus, iris, pedestal height, black level, RGB gain, chroma and so on (in conjunction with an EMI *2001* studio colour camera). Control data may be stored in a magnetic core until required. In addition to producing this equipment, Evershed are UK agents for **Perfectone** audio recorders and **Angenieux** TV lenses.

Leevers-Rich are concentrating their display on the 8-track *Series G* recorder, employing modular construction and operating at 38 and 19 cm/s with NAB or CCIR equalisation.

Matthey Printed Products have announced a new range of *Silver Star* video delay lines for 625, 525 and 405 TV broadcasting equipment. Three fixed modules, the largest measuring 76.2 x 57.15 x 11.4 mm, provide delays of 200 nS, 500 nS and 1μS at 750 ohms impedance. A fourth module provides delays in 5 nS steps from 5 to 155 nS which can be cascaded with other lines to increase delay.

Mellotronics are showing the Programme Effects Generator developed by the BBC and described in our April issue. Stand B7.

Mole-Richardson can now offer a 110 kW silent mobile generator for the film and television industry, replacing the earlier 50 kW unit. This is incorporated in a 10 ton Ford lorry and can power six-camera colour TV OB vehicles.

Camera tubes, UFH klystrons, travelling wave tubes, TV transposer components, and silicon planar power transistors for UHF and VHF transmitters—line-up for the Mullard display. A new range of ceramic tetrode transmitting valves, studio lighting semiconductors, and the new *19XQ* Plumbicon tube will be shown alongside a miniature Plumbicon for lightweight portable cameras.

Philips, represented by **Pye TVT**, are expected to show their *Pro 36* three-speed servo-capstan sound recorder. The transport employs an asynchronous motor driving a copper flywheel disc through a flat polyurethane belt. The disc rotates between magnetic poles creating a constant load in a manner designed to minimise motor speed fluctuations. Claimed 38 cm/s wow and flutter totals ±0.04% peak weighted. Full, twin and four-track models are being produced, the largest employing 12.7 mm tape.

Among items of Philips colour television equipment will be the *LDK13* Plumbicon portable camera, *LDK3* studio/OB camera, *LDK33* remote-controlled camera, *LDK63* 16 mm telecine system and *EL8560* 48 cm monitor.

In addition to a wide range of film production accessories, Rank are to show their 16 mm twin lens flying spot film scanner and 6-channel off-air TV receiver. A peak detector unit for the popular Rank-Kalee flutter meter will be on show. Rank also market Weircliffe bulk erasers.

IBC 70 is being held at Grosvenor House, Park Lane, London W.1.

SESSION TIMETABLE

Monday September 7

2.30 p.m.	Session One	—	Studio Design
4.30 p.m.	Session Two	—	Origination Equipment

Tuesday September 8

9.30 a.m.	Session Two	—	Origination Equipment (cont.)
2.30 p.m.	Session Three	—	Recording and Films
4.00 p.m.	Session Four	—	Digital Techniques

Wednesday September 9

9.30 a.m.	Session Five	—	Automation
2.30 p.m.	Session Six	—	Signal Distribution

Thursday September 10

9.30 a.m.	Session Seven	—	Receivers
11.00 a.m.	Session Eight	—	Transmitters and Transposers

Friday September 11

9.30 a.m.	Session Nine	—	Aerials
11.00 a.m.	Session Ten	—	Propagation, Service Planning and Satellites
2.30 p.m.	Session Eleven	—	Operational Experience

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THE PRINCIPLES OF QUADRAPHONIC RECORDING PART TWO

By Michael Gerzon

CURRENT quadraphonic systems are designed to reproduce sound from all horizontal directions around the listener, but still fail to reproduce height information. In Part One of this article, by means of considering the types of sound pick-up associated with the use of a coincident microphone technique, it was shown that only three channels were necessary for 'horizontal quadraphony'. In the following, these arguments will be extended to the reproduction of sound from all spatial directions about the listener, both horizontally and vertically. The author has christened reproduction techniques which reproduce all spatial directions 'periphonic' from the Greek prefix *peri-* meaning about, or around.

While Granville Cooper has recently described[3] a system of periphony called 'tetrahedral ambiophony', this is only one of many possible periphonic techniques. It is the purpose of this article to establish that four channels should usually be adequate to convey periphonic sound. It will further be shown that it is possible to convey a periphonic recording via four channels such that, when it is reproduced through four loudspeakers placed in a horizontal square around the listener (as in current American "horizontal quadraphony" proposals), a good conventional quadraphonic sound reproduction will be obtained. Thus the method of conveying periphony described in the following has the advantage of complete compatibility with conventional quadraphonic reproduction. A consequence of this is that the listener has a wide choice as to how complex his reproduction system is, and he may choose to reproduce the four channels over anything between three and eight speakers, according to his pocket and preferences.

First question

The first question to be resolved is why reproduce height information at all? The case against periphony has been wittily stated by Alec Nisbett, and it is worth quoting him:[4]

'I am not being totally facetious when I suggest that if God had meant us to take an interest in the vertical separation of sounds, we would have an ear on the top of our heads. Lacking such a rainwater collector, I don't see much need to feed directional information in this sense, even though it is present in the concert hall: the horizontal component is enough. Anyway, I am going to cut short this argument by saying that if you don't like the horizontal box format it's just too bad, because that's how it's going to be—there's no turning back, unless you want another big battle over standards, which would be exhausting, expensive and, I suspect, unwinnable. So everybody please agree with me.'

The fallacy with this argument is the assumption that human hearing is insensitive to height information. It is well known that it is possible to perceive the elevation of a sound quite accurately by means of small unconscious head movements.[5]

In the author's experience, height information can be of great musical importance. In orchestral and choral music, a strong impression of depth is often gained due to the fact that the orchestra frequently subtends a vertical angle of a few degrees at the listener's ears; this height information is then clearly audible with one's eyes shut. Of even greater musical importance is the existence of religious and secular music in which a large organ accompanies a choir or orchestra. In this case, composers have often (perhaps not consciously? used the fact that the organ will be placed high up above the other performers to obtain a remote, all pervading, or ethereal effect from the organ. This effect is totally destroyed by restricting the sound to the horizontal plane. It should also be mentioned that, even using the realistic coincident microphone technique, reverberation sounds curiously 'cramped' via horizontal quadraphony, due to the lack of the height dimension.

Alec Nisbett's other objection, that it is undesirable and impractical to introduce more than one system of quadraphony, ceases to hold if the periphonic recording is capable of being reproduced via a conventional quadraphonic set-up. This compatibility requirement can be completely fulfilled, as will be shown in the following.

Consider a conventional four-channel quadraphonic recording with signals A, B, C, and D corresponding to the four loudspeakers placed in a horizontal square about the listener, as in **fig. 1.** It was shown in Part One that a good quadraphonic sound could be obtained even if $\frac{1}{2}A - \frac{1}{2}B + \frac{1}{2}C - \frac{1}{2}D$ was equal to zero, and methods were described to convert arbitrary four-channel recordings into a form where this was true. Thus, in the rest of this article, we consider quadraphonic signals A, B, C, and D

FIG. I CONVENTIONAL FOUR-SPEAKER LAYOUT

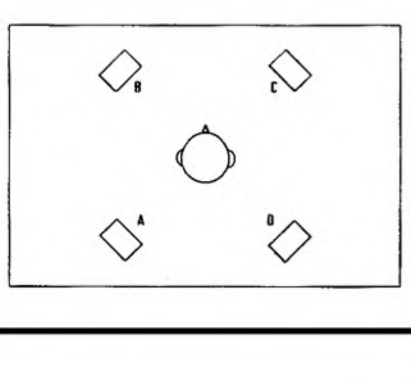
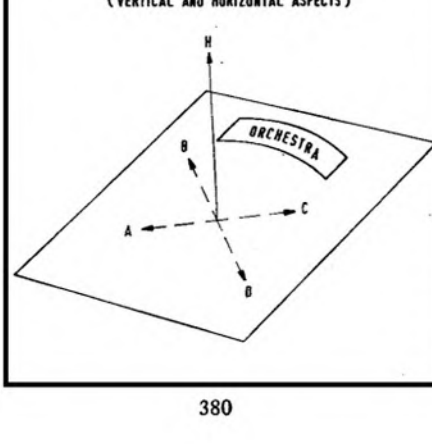


FIG. 2 PERIPHONIC COINCIDENT MICROPHONE DIRECTIONS (VERTICAL AND HORIZONTAL ASPECTS)



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THE PRINCIPLES OF QUADRAPHONIC RECORDING PART TWO

By Michael Gerzon

such that

$$\tfrac{1}{2}A - \tfrac{1}{2}B + \tfrac{1}{2}C - \tfrac{1}{2}D = 0 \qquad (1)$$

By imposing the condition (1) on our quadraphonic signals, we have produced signals that can be conveyed via only three channels, as explained in Part One.

Thus, if a four-channel recording medium is used, there is room to convey height information. Let H be a 'height' audio signal, whose precise nature will be considered later. Then one can make a four-channel recording conveying the four signals

$$A^{-} = A - \tfrac{1}{2}H, \quad B^{+} = B + \tfrac{1}{2}H,$$
$$C^{-} = C - \tfrac{1}{2}H, \quad D^{+} = D + \tfrac{1}{2}H. \qquad (2)$$

The four signals A^{-}, B^{+}, C^{-}, and D^{+} may be reproduced via the horizontal four-speaker set-up of **fig. 1** without any alteration of the directional effect that would have been reproduced if A, B, C, and D had been fed to the four speakers instead. The reason for this is that the 'focus' signal F' for the four signals A^{-}, B^{+}, C^{-}, and D^{+} is given by

$$F' = \tfrac{1}{2}A^{-} - \tfrac{1}{2}B^{+} + \tfrac{1}{2}C^{-} - \tfrac{1}{2}D^{+} = -H. \qquad (3)$$

As was shown in Part One, altering the focus signal in a four-channel quadraphonic recording does not alter the reproduced directional effect, but only affects the degree of crosstalk of a sound on to the other channels.

Thus, if we start off with a conventional quadraphonic recording whose signals A, B, C, D obey condition (1) and if we smuggle in a 'height' signal H as in formulae (2), then we have four signals which reproduce well via a conventional four-speaker set-up, but which contain height information as well as horizontal directional information.

Of course, this has not yet shown either how to record the height information, nor how to reproduce it. As in Part One, examining coincident microphone recording techniques is very revealing. Only microphones with horizontally-pointed axes were then considered but we must now consider coincident microphones with axes pointing in any direction. Standard mathematical theory reveals that there are only four linearly independent microphone directional characteristics. Put another way, given five coincident microphones, it is always possible to derive the audio output of at least one of the microphones by matrixing the outputs of the other four microphones together in suitable proportions.

This means that no matter how many loudspeakers are used to reproduce the sound, only four microphones are needed to pick up all the periphonic audio information that can be obtained from coincident microphones. (Of course, this no longer holds if the microphones are not precisely coincident. Neither will it hold if new types of microphone directional characteristics are developed.) The sound fed to each of the reproducing loudspeakers may be obtained by a suitable matrixing of the signals from these four microphones.

The nature of the four signals A^{-}, B^{+}, C^{-}, and D^{+} will now be investigated for coincident microphone periphonic recordings. This investigation yields useful information on how to reduce spaced microphone periphonic recordings down to four channels.

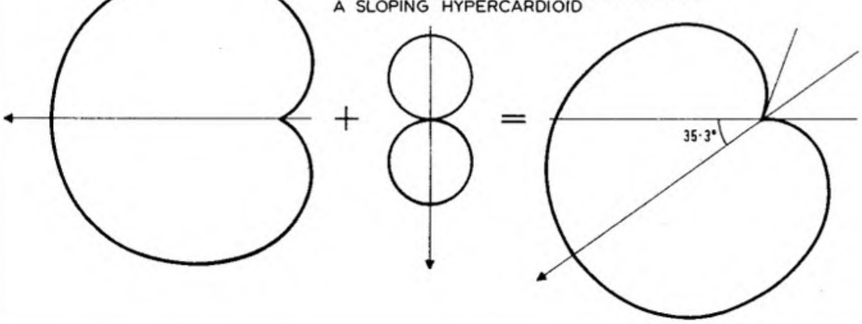
Clearly there are two ways of looking at the recording of the signals A^{-}, B^{+}, C^{-}, and D^{+} via coincident microphones. We can either consider the microphone directional characteristics required to pick up the signals A, B, C, D, and H, or we can consider the microphone directional characteristics required to pick up the signals A^{-}, B^{+}, C^{-}, and D^{+}. The first way of considering coincident microphone periphonic recording has the advantage that it lays special emphasis on the 'horizontal quadraphony' component A, B, C, D of the periphonic signal, while the second approach reveals the essentially three-dimensional geometric nature of periphonic recording.

As the signals A, B, C, and D correspond to horizontal quadraphonic sound they must be the signals obtained by four coincident identical cardioid or hypercardioid microphones whose axes point in a horizontal direction along four directions at right angles to each other as illustrated in **fig. 2.** Four such signals obey condition (1), as observed in Part One. Sounds originating from horizontal directions around the microphones clearly contain no height information, and so require that the signal H equals zero for such sounds. The only microphone directional characteristics which gives no output for sounds from all horizontal directions is a vertically oriented 'figure-of-eight' microphone. It is convenient to assume that the 'positive' lobe of the figure-of-eight points upwards, rather than downwards.

Thus, for coincident microphone recordings, the four signals conveying the periphonic sound are $A^{-} = A - \tfrac{1}{2}H$, $B^{+} = B + \tfrac{1}{2}H$, $C^{-} = C - \tfrac{1}{2}H$, and $D^{+} = D + \tfrac{1}{2}H$, where A,

(continued overleaf)

FIG. 3 COMBINING A HORIZONTAL CARDIOID WITH A VERTICAL FIGURE-OF-EIGHT TO OBTAIN A SLOPING HYPERCARDIOID



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B, C, and D are the conventional quadraphonic signals obtained by identical coincident horizontal cardioid or hypercardiod microphones, and where H is the output of an upward-pointing figure-of-eight microphone. However, this has not completely specified the nature of the periphonic signal A−, B+, C−, and D+ for coincident microphones, as we do not yet know the correct relative gains of the H signal and the A, B, C, and D signals. Put crudely, how loud should the height signal be compared to horizontal quadraphonic signal in formulae (2)?

To answer this, we look at the microphone directional characteristic required to pick up the signals A−, B+, C−, and D+. Each of these signals is obtained by adding the audio output of a horizontal cardioid or hypercardioid microphone to that of a vertical figure-of-eight microphone. Thus one may consider that the signals A−, B+, C−, and D+ are picked up by hypercardioid microphones pointing at an angle to the horizontal (see **fig. 3**). Thus the signals B+ and D+ are the signals that would be picked up by hypercardioid microphones pointing at an angle *above* the horizontal B and D directions, and the signals A− and C− are the signals that would be obtained by hypercardioid microphones pointing at an angle *below* the A and C directions, as illustrated in **fig. 4.**

It is desirable that the four directions in which the A−, B+, C− and D+ microphones point should be disposed as symmetrically as possible, and the most symmetrical arrangement possible is obtained if the four microphones point along the axes of a regular tetrahedron. (A tetrahedron is said to be *regular* if all its sides are equal.) This requirement is fulfilled if the axes of these four microphones are inclined at an angle of 35.3° to the horizontal. (This occurs if the sensitivity of the vertical figure-of-eight picking up H is $\sqrt{2}$ times the sensitivity of the figure-of-eight component of the horizontal directional characteristic used to pick up A, B, C, or D, ignoring the omnidirectional component.)

Thus the four periphonic signals A−, B+, C−, and D+ are required to be the signals picked up by four identical coincident hypercardioid microphones directed along tetrahedral axes pointing in a direction 35.3° above in the case of B+ and D+) or below (in the case of A− and C−) the horizontal directions A, B, C, and D illustrated in figs. 2 and 4. The requirements of simplicity and compatibility with conventional quadraphony have thus led to a periphonic recording system in which four identical hypercardioid microphones point along four tetrahedral axes.

This proposal for periphonic recording is very similar to Granville Cooper's,[3] except that in our case the axes of the tetrahedron point in different directions. The axes of the four microphones picking up A−, B+, C−, and D+ point along the lines connecting the centre of a cube to four of its eight corners, as illustrated in **fig. 5.**

The simplest method of reproducing the original directional effect of the periphonic signals A−, B+, C−, and D+ is to feed them to four loudspeakers placed at four corners of a cube, as illustrated in **fig. 5.** A− is fed to a floor-level rear left speaker, B+ is fed to a ceiling-level front left speaker, C− is fed to a floor-level front right speaker, and D+ is fed to a ceiling-level rear right speaker. For a given room height this tetrahedral speaker layout (and its mirror-image) encloses a larger volume than any other possible arrangement using four loudspeakers placed at the corners of a regular tetrahedron. For this reason, the listening area in which reasonable periphonic reproduction can be obtained is likely to be larger than with any other tetrahedral arrangement of loudspeakers, including that of Granville Cooper.[3] For a listener whose ears are half-way between the floor and ceiling, the portion of the room in which his head lies within the tetrahedron is indicated by the shaded area of **fig. 6.** Within this area, a reasonable periphonic effect should be obtained, although this has not been tried experimentally.

Reproduced sounds

Reproduced sounds will appear to come from a horizontal direction via the loudspeaker layout of **fig. 5** only if the signals A−, B+, C− and D+ contain no height information. This occurs when the focus signal $\frac{1}{2}A^- - \frac{1}{2}B^+ + \frac{1}{2}C^- - \frac{1}{2}D^+$ is equal to zero. Thus a coincident-microphone horizontal quadraphonic recording will reproduce well over the fig. 5 tetrahedral loudspeaker layout. However, conventional two-channel stereo or spaced-mike horizontal quadraphonic recordings will reproduce properly via this speaker layout only if their focus information is suppressed. As explained last month, several different matrixings are capable of suppressing the focus. Tables 8 and 9 give a typical matrixing that allows conventional stereo and horizontal quadraphony to be reproduced via tetrahedral loudspeakers. In the case of ordinary stereo, it will be seen that the tilt of the sound from the front speakers is compensated for by the opposing tilt of the rear speakers.

The identical cardioid or hypercardioid directional characteristics used to pick up the horizontal signals A, B, C, and D are not the same as the identical hypercardioid directional characteristics used to pick up the signals A−, B+, C−, and D+, due to the fact that the latter contain a proportion of the vertical figure-of-eight H signal. A hypercardioid directional characteristic may be specified either by its front-to-back ratio or by the angle from its axis at which its null response lies. Table 10 indicates the hypercardioid characteristic ('tetrahedral microphones') used to obtain A−, B+, C−, and D+ corresponding to each of a range of possible hypercardioid characteristics ('horizontal microphones') used to pick up the signals A, B, C, and D. It will be seen that the microphone characteristics used to pick up A−, B+, C−, and D+ are more hypercardioid, and less cardioid, than the corresponding microphone characteristics used to pick up A, B, C, and D.

Ideally, the microphone directional characteristics used to pick up A−, B+, C−, and D+ should have a good front-to-back ratio so as to prevent sounds being reproduced loudly from loudspeakers in the direction opposite to that from which the sound should appear to come. This requirement would imply that the microphone characteristics used to pick up the signals A−, B+, C−, and D+ should be cardioids, as in Granville Cooper's experimental recordings. However, it will be seen from Table 10 that the corresponding horizontal microphone pick-up is something between cardioid and omnidirectional, which means that horizontal sounds would be picked up with rather a lot of inter-speaker cross-talk. Also, for sounds originating on one of the tetrahedral axes, each of the three speakers corresponding to the other three axes in fig. 5 would reproduce such sounds only 9.54 dB more quietly than the

FIG. 4 PERIPHONIC COINCIDENT MICROPHONE DIRECTIONS FOR THE CHANNELS A−, B+, C− AND D+

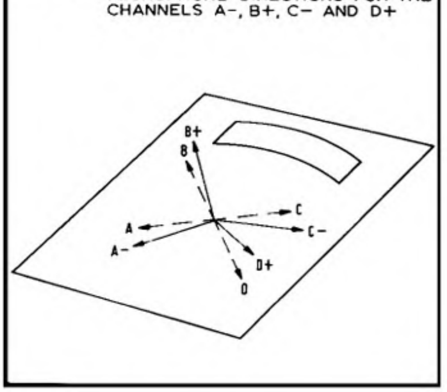

FIG. 5 TETRAHEDRAL LOUDSPEAKER ARRANGEMENT (SHOWING THE FOUR TETRAHEDRAL AXES)

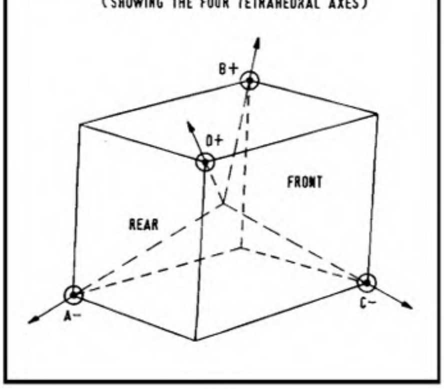

FIG. 6 AREA (SHADED) IN WHICH THE LISTENER IS WITHIN THE TETRAHEDRON FORMED BY THE FOUR LOUDSPEAKERS OF FIG. 6 (VIEW FROM ABOVE)

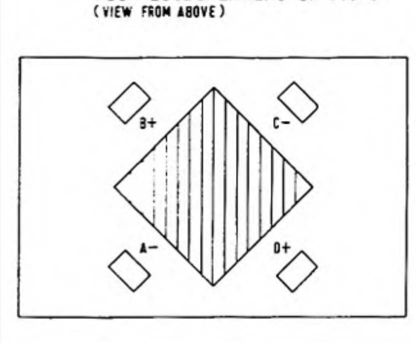

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TABLE 8 Playing a stereo signal L and R through the tetrahedral speaker layout of fig. 6

$$A^- = 0.354\,L - 0.146\,R$$
$$B^+ = 0.854\,L + 0.354\,R$$
$$C^- = 0.354\,L + 0.854\,R$$
$$D^+ = -0.146\,L + 0.354\,R$$

TABLE 9 Playing a horizontal quadraphonic signal A^1, B^1, C^1, and D^1 through the tetrahedral speaker layout of fig. 6.

$$A^- = 0.854\,A^1 + 0.354\,B^1 - 0.146\,C^1 + 0.354\,D^1$$
$$B^+ = 0.354\,A^1 + 0.854\,B^1 + 0.354\,C^1 - 0.146\,D^1$$
$$C^- = -0.146\,A^1 + 0.354\,B^1 + 0.854\,C^1 + 0.354\,D^1$$
$$D^+ = 0.354\,A^1 - 0.146\,B^1 + 0.354\,C^1 + 0.854\,D^1$$

main speaker, and a quarter of the total audio energy would be reproduced from directions on the opposite side of the listener to the desired direction.

To reduce these effects, some degree of compromise between inter-speaker cross-talk and good front-to-back ratio has to be adopted, and it may be that a 135°-null hypercardioid characteristic for the A^-, B^+, C^-, and D^+ microphones (or, equivalently, a 150°-null hypercardioid for the horizontal pick-up) will be a good compromise. In this case, the cross-talk of a sound appearing to come from one of the tetrahedral loudspeakers on to each of the other three loudspeakers is −13.19 dB. With 135°-null hypercardioids, only 0.026 of the energy of a sound being reproduced from a direction *opposite* to that of one of the tetrahedral axes will be reproduced from the speaker on that tetrahedral axis.

An alternative loudspeaker layout for periphonic reproduction might include eight loudspeakers arranged in a cube around the listener, as illustrated in **fig. 7**. When reproducing coincident microphone recordings, each of the eight speakers should be fed with the output that would be given by a hypercardioid microphone pointing in that speaker's direction. Labelling the speakers A^-, A^+, B^-, B^+, C^-, C^+, D^-, and D^+ in the obvious way, the signals fed to the eight speakers will be:

$$A^-, A^+ = \tfrac{1}{2}A^- + \tfrac{1}{2}B^+ - \tfrac{1}{2}C^- + \tfrac{1}{2}D^+$$
$$B^- = \tfrac{1}{2}A^- + \tfrac{1}{2}B^+ + \tfrac{1}{2}C^- - \tfrac{1}{2}D^+$$
$$B^+, C^-, C^+ = -\tfrac{1}{2}A^- + \tfrac{1}{2}B^+ + \tfrac{1}{2}C^- + \tfrac{1}{2}D^+$$
$$D^- = \tfrac{1}{2}A^- - \tfrac{1}{2}B^+ + \tfrac{1}{2}C^- + \tfrac{1}{2}D^+$$

and D^+ respectively. (This may be seen by using formulae (2) and (3) along with the obvious fact that

$$A^+ = A + \tfrac{1}{2}H$$
$$B^- = B - \tfrac{1}{2}H$$
$$C^+ = C + \tfrac{1}{2}H$$

and $D^- = D - \tfrac{1}{2}H$.)

One advantage of eight-speaker periphonic reproduction (apart from the profits for speaker and amplifier manufacturers!) is the fact that conventional horizontal quadraphony can be reproduced without loss. The four-speaker tetrahedral layout of fig. 5 can only reproduce horizontal quadraphony by suppressing its 'focus' information, as in the matrixing of Table 9. Another advantage of eight speakers is that the angle subtended between adjacent speakers at the listeners' ears is only 70.5°, as compared with 109.5° for the tetrahedral layout, and this should help to make stereo images more precise.

Clearly, much ingenuity could be expended devising various advantageous loudspeaker layouts using five, six or seven loudspeakers. For this reason, it is not proposed to investigate further loudspeaker layouts here.

The above has only discussed coincident microphone recordings, and if results are to be good with various different loudspeaker arrangements, the microphones have to be pretty coincident, with spacings of under 5 cm to avoid time-delay interference effects. The best results would thus probably be obtained by using four microphone capsules placed in close proximity, and a tetrahedral arrangement of four hypercardioid capsules placed back-to-back should prove satisfactory. In any case, separate bulky microphones would prevent the desired small spacing from being achieved. However, if only reproduction over the tetrahedral loudspeakers of fig. 5 is required, then the tetrahedral microphones need not be so precisely coincident.

It is possible to convey and reproduce spaced microphone periphonic recordings via the four channels A^-, B^+, C^-, and D^+ by pan-potting the outputs of the spaced microphones, so that these outputs appear to come from the desired directions. An audio signal X can be pan-potted to appear to come from any desired direction in space by feeding into each of the four channels the signal that would be picked up by four imaginary coincident tetrahedral hypercardioid microphones were one to imagine the sound of X to be reproduced from a loudspeaker in that direction. One can choose the imaginary tetrahedral microphones' directional characteristic to give the best results in any particular case.

It is particularly easy to pan-pot sounds which are required to appear to come from straight ahead, straight behind, straight above, straight below, or from the left or right side. For instance, a sound X can be made to appear to come from straight ahead by putting $A^- = D^+ = 0$ and $B^+ = C^- = 0.707$ X. (This particular pan-potting simulates the sound that would be picked up by tetrahedral coincident hypercardioids with 125.3° nulls if the sound source were straight ahead). Similarly, a sound X can be made to appear to come from above by putting $A^- = C^- = 0$ and $B^+ = D^+ = 0.707$ X. This simple pan-potting is particularly useful if the recording is made with six microphones at the vertices of an octahedron, pointing forward, backward, to each side, above and below. The sounds from the six microphones can then be pan-potted into position to give a four channel periphonic recording.

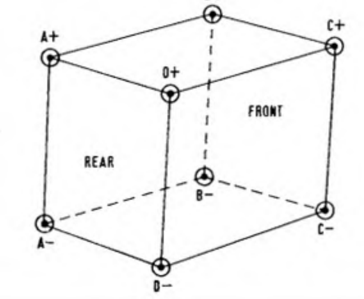
(continued overleaf)

TABLE 10 Corresponding horizontal and tetrahedral microphone directional pick-up characteristics (see text).

HORIZONTAL MICROPHONES		TETRAHEDRAL MICROPHONES	
angle of null off axis	front-to-back ratio	angle of null off axis	front-to-back ratio
not hypercardioid	19.91 dB	180° *	∞ dB *
180° *	∞ dB *	144.7°	19.91 dB
150°	22.88 dB	135°	15.31 dB
135°	15.31 dB	125.3°	11.44 dB

*N.B.—cardioid directional characteristic.

FIG. 7 REPRODUCTION OF PERIPHONY VIA 8 LOUDSPEAKERS



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It is less simple to pan-pot sounds to appear to come from other directions. If one wishes to make a sound X appear to come from some chosen horizontal direction, the four channels A^-, B^+, C^- and D^+ must be the four signals that would be picked up by four imaginary identical coincident cardioids or hypercardioids pointing along *horizontal* directions at 90° to one another, as in fig. 2, if the sound X were to be reproduced through a loudspeaker in the desired direction. Thus, for sounds to be pan-potted in the horizontal plane, one can ignore all three-dimensional considerations. As an example, a sound X may be made to appear to come from 45° to the left by putting $A^- = 0.408\ X$, $B^+ = 0.816\ X$, $C^- = 0.408\ X$, and $D^+ = 0$ (which simulates the sound pick-up of four coincident horizontal cardioid microphones). The tetrahedral symmetry of the channels may be used to derive similar pan-pottings for sounds in the vertical plane pointing forward and backward, or for sounds in the vertical plane pointing sideways. For example, a sound X will appear to come from 45° above straight behind if $A^- = 0.408\ X$, $B^+ = 0.408\ X$, $C^- = 0$, and $D^+ = 0.816\ X$.

It is not all that difficult to pan-pot sounds to come from slightly above or below horizontal. The procedure is first to pan-pot the sound X in the desired direction on the horizontal plane, obtaining four signals A, B, C, and D. One then derives the signals $A^- = A - kX$, $B^+ = B + kX$, $C^- = C - kX$, and $D^+ = D + kX$, where k is a small number which is chosen to be positive if the sound is to come from above horizontal, and negative if from below horizontal.

The pan-potting required for a sound to appear to come from the corners of the cube of figs. 5 and 7 may be illustrated by typical examples. A sound X may be made to seem to come from the corner B^+ by putting $B^+ = 0.935\ X$ and $A^- = C^- = D^+ = 0.205\ X$, which simulates the sound pick-up of 135°-null hypercardioids for a sound source along the B^+ axis. (The signals $B^+ = X$, $A^- = C^- = D^+ = 0$ are not really suitable, as they simulate the sound pick-up of 109.5°-null hypercardioids, and will not reproduce well over a cube of loudspeakers.) A sound X may be made to appear to come from the corner B^- of the cube of figs. 5 and 7 by putting $A^- = B^+ = C^- = 0.570\ X$ and $D^+ = -0.160\ X$, again simulating the pick-up of 135°-null hypercardioids.

By using means of pan-potting such as described above, the sounds from any number of spaced microphones may be fed into the four periphonic channels A^-, B^+, C^- and D^+.

Conclusions

In the two parts of this article, it has been shown that three channels are sufficient to convey horizontal quadraphonic sound, and four channels sufficient to convey periphonic sound in three dimensions. It has also been shown that it is possible to convey periphonic sound via channels A^-, B^+, C^-, and D^+ that can be reproduced via the horizontal quadraphonic 'box' speaker layout as in current American proposals, or via a tetrahedral loudspeaker layout giving three-dimensional sound reproduction over an exceptionally large listening area.

In the light of this, it would be wise for recording organisations to include height information on current quadraphonic mastertapes, to allow for the possibility that periphonic systems may become commercial. It would be feasible for companies to start issuing commercial ¼-track quadraphonic tapes conveying periphonic information almost immediately, due to the compatibility of the system described above. In order to ensure standardisation, it is recommended that the front left channel represents the output of an upward inclined microphone, rather than a downward inclined microphone.

It is further recommended that any three or four-channel system adopted for disc, radio or tape should not permit any ambiguity in the polarity of some of the channels with respect to the others, so that it will be possible to matrix signals for the various different loudspeaker layouts.

The author would like to emphasise that the above work is mainly the result of a theoretical analysis. Much remains to be done determining how well the various proposals work with different microphone techniques and different loudspeaker types.

References

3) Granville Cooper: Studio Sound, June 1970.
4) Alec Nisbett: Happy Birthday Ludwig! Studio Sound, March 1970.
5) N. V. Franssen: Stereophony, Philips Technical Library, 1964 (pages 25-27).

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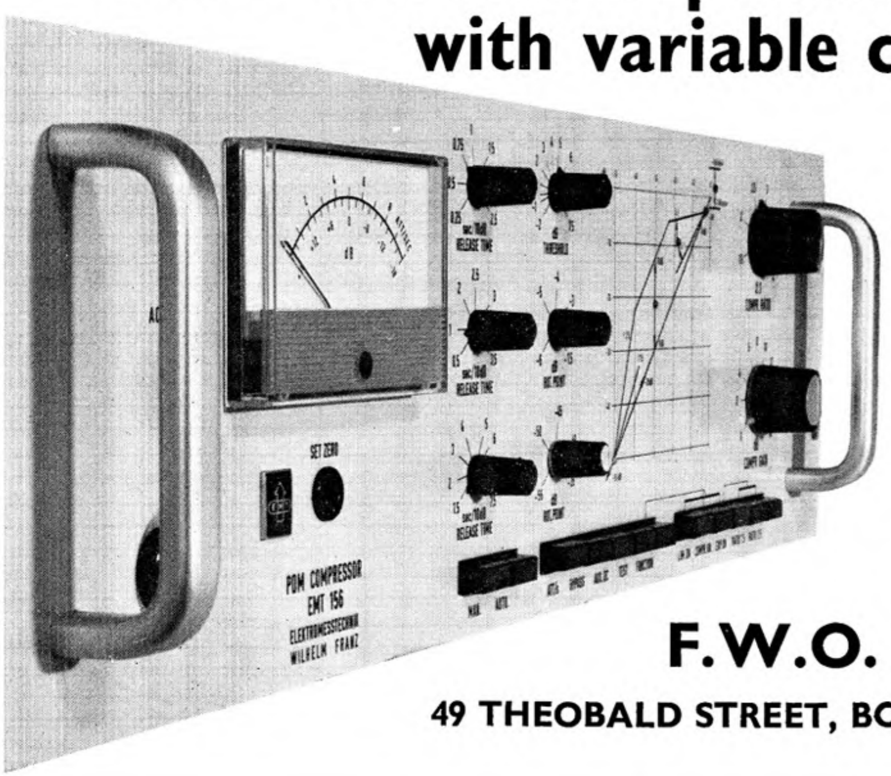

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PART NINE COPYING MAGNETIC TAPES

BY ANGUS McKENZIE (Roundabout Records)

IT may appear to many readers before seeing this that little need be said on the subject of tape copying, since one might just connect the replay socket of one machine to the record socket of another, start both machines and hey presto there is the copy. Alas, copying tapes is not often as simple as that, if the copy is to be fully satisfactory. The reasons may not be obvious unless the engineer is fully conversant with the setting up of the machines in use, the head configuration and the properties of the tape being used. I shall make two different recommendations of procedure depending on whether a Dolby *A301* system is in use or not, as the considerations are very different.

It is very difficult to make a fully satisfactory copy of a really good stereo master tape, not noticeably more distorted or hissy than the original and with a practically identical frequency balance. Almost all loud musical peaks are recorded to a peak distortion level of at least 2% and often as high as 3% or 4%. While distortion on the master may just about be tolerable because of its transient nature, if the tape is copied on a one-to-one level basis (i.e., the modulation level on the copy at any one point is identical to that on the master) it will be appreciated that distortion on the copy will be twice that of the original and can therefore reach what many would regard as intolerable limits. If on the other hand a copy is to have only slightly more distortion than the original, the tape hiss can become easily noticeable where hiss on the original was only just noticeable. Readers may imagine from the last statement that making a really excellent copy of a really good master tape is almost impossible, and this is true unless the engineer is prepared to take very considerable pains in the accurate setting up of his equipment. Much depends on the nature of the music or material to be copied. It may well be better to use a different type of tape for the copy than was used for the original. Many engineers allow a safety margin of 2 or 3 dB which may well occasionally be used up in the master programme. To obtain a clean copy it is probably better to record the extreme peaks at a level perhaps 2 dB lower than the extreme peaks on the original. This involves riding the gain in quiet passages and peaks, trying at the same time to preserve a wide dynamic range. It is therefore important to know the actual peak levels on the tape, rather than the average, so that as much level as possible can be put on the copy without distortion being heard. Once again I strongly recommend the use of PPMs. Some engineers use compressors or limiters for copying in an attempt to reduce the hiss level of material having a wide dynamic range. Unfortunately such use of limiting is not only obvious to a trained ear but almost intolerable, an example being a particular recording of Bruckner's *5th Symphony* made in America and subsequently issued in this country, which has severe limiting, particularly on the loud brass passages.

For the dubbing of stereo tapes, matters are made still more difficult because there are two main types of stereo record and playback heads employing different track widths. The difference between the two is basically in the percentage of unrecorded tape down the centre. In a professional stereo head, the centre guard band can be as little as 8% of the tape width, whereas a two-track head, usually possessing better crosstalk and therefore allowing half-track mono operation, can leave up to one-third the width of the tape. These differences are not widely appreciated but can cause alarming variations in level on copies from originals if the machines are set up for a one to one copying ratio with full-track test tapes. A stereo recording made on what is commonly termed a two-track recorder can be up to nearly 3 dB down in level when replayed on a stereo machine having a replay head scanning almost the entire tape width except for this small area down the centre. On the other hand, a tape made on the second machine will play perfectly satisfactorily on a machine having a wide centre guard band. If a master tape is recorded at such a level as to be, for instance, 3 dB inside a safety limit of 6 dB above 32 mM/mm, a common level in use with tapes such as BASF *LR 56*, then a copy made with as unfavourable head configuration can easily have a playback recording level barely more than 32 mM/mm, and this can sound very noisy indeed. Even more serious is the error produced in dubbing Dolbyed tapes, underlining Dolby's recommendation of putting a tone on the beginning of each tape at NAB level (4 dB below 32 mM/mm). If a tape has been made on a machine with a large unrecorded gap in the centre of the tape, the apparent loss of recording level on playback with a so-called stereo head can be instantly noticed by the engineer replaying the tape, who should then adjust the replay gains. I had trouble recently replaying a tape made on a TRD machine, excellent when replayed on that machine but 2.75 dB down in level when played on a Telefunken *M10A* having a very narrow guard band. When the replay gains were advanced on the *M10*, all the levels appeared to be correct.

Engineers sometimes play stereo master tapes on mono machines in order to make a mono copy. Once again, because of the lack of modulation between the two tracks, the total output from the full-track playback head can be considerably below the levels that would be given by a stereo replay head. To make this quite clear, I carried out a number of tests in which I recorded close tolerance 32 mM/mm on *LR56* with a TRD machine having a large guard band two-track head. Tracks were recorded individually and simultaneously. Identical recordings were made on the stereo headblock of the *M10A*. Having done this, the entire tape was played back on the Telefunken's full track headblock. Whereas each *M10* stereo track was about 6.5 dB down in level, the TRD recording was 8.75 dB down on the level that would have been obtained from a full track tape containing 32 mM/mm. With modulation on both tracks, the TRD was 3 dB down, whereas the *M10* recording was only 0.75 dB down. I quote these figures as they will not be immediately obvious to many engineers, although in fact they are predictable. Some studios and broadcasting organisations adopt a different standard again, this being to have a narrow guard track on record with a wide one on replay allowing the machine to replay half-

(*continued overleaf*)

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track mono recordings with virtually no cross-talk. It must be borne in mind however that, by using a replay head with a wide guard band, the signal-to-noise ratio will suffer by between 2 and 3 dB overall.

When it is required to copy Dolbyed tapes, the setting up is normally considerably easier. Most studios using Dolbys do not peak more than 2 dB above 32 mM/mm. Provided a NAB level tone has been put on the beginning of the master tape, the copy can be made on a strict one to one basis such that the tones on the master tape play back at exactly the same level on the copy. If, however, the original master has been accidentally recorded to a very high level, it may well be found necessary to de-Dolby, introduce some loss, and then Dolby back again. It is also possible, provided great care is taken, to brighten up or soften a Dolbyed recording by introducing equalisation controls before de-Dolbying, and introducing opposite boost or cut afterwards.

I have often heard of cases where outputs of a stereo tape recorder are paralleled in order to get a mono signal. On many machines, loading each channel with the tape output of the other will cause immediate and obvious distortion. In other cases the distortion may not be immediately obvious, though nevertheless marked. I would therefore recommend that series resistors of 600 ohms (for 600 ohm line feed machines) be provided in the outputs of the machine before paralleling. Most transistorised line output stages have very low source impedances, and it is this which primarily causes trouble when paralleling. Valve line output stages are not so troublesome in this respect but care should still be taken.

Masters recorded out of azimuth sound very poor when played back on a correctly azimuthed machine and the improvement gained by compensatory azimuthing can sometimes be quite astonishing. It is therefore a good idea to have at least one machine available with a replay head whose azimuth can easily be changed. I would like to remind readers of my article some months ago on the use of white noise azimuthing, as very precise settings can be achieved by the use of this method.

I have assumed all along that engineers make sure that the equalisation on both playback and record machines is set precisely with test tapes. I would now like to consider the differences between characteristics and their effect in copying.

Very different

The DIN standard for 38 cm/s is a replay curve with a bass boost having a time constant of 35 μS, the professional DIN characteristic for 19 cm/s being 70 μS. The NAB standard, however, is very different, having a general bass boost half way between these two characteristics, namely 50 μS for both 38 and 19 cm/s. In practice a NAB recorded tape at 38 cm/s will appear down in top when played back with a DIN characteristic, whereas a DIN recorded tape will appear to have excessive top when played back on a NAB machine. The opposite is the case for 19 cm/s. In addition to this, the NAB characteristic also has a bass roll-off applied to playback at very low frequencies, the roll-off being approximately 3 dB at 50 Hz. A quiet organ pedal note can go almost to inaudibility if a DIN tape is played back on a NAB machine and the recording has also been Dolbyed, accentuating the loss. I regard it as exceptionally important to mark any master tapes with the recording characteristic, allowing disc cutting engineers to carry out their job efficiently.

Incidentally, at the high frequency end, the effect of using the wrong characteristic will be a shelf of 3 dB boost or cut over the entire high frequency range of the recording. From considerations of recording characteristic it will be observed that up to 3 dB more peak level can be recorded at 38 cm/s on a NAB machine, whereas at 19 cm/s a lower peak recording level has frequently to be adopted. Signal-to-noise improvement will not necessarily be the full 3 dB since at 38 cm/s high frequencies are boosted more than with the DIN characteristic. It may be more correct to say that less bass is present rather than more top, the 3 dB point for the NAB curve being 3.2 kHz.

I trust that the foregoing will help some readers to understand why tape copying is a carefree procedure. It is fair to point out that there are no hard and fast rules, for it is frankly a matter of opinion. Each engineer should decide for himself whether he prefers distortion or hiss.

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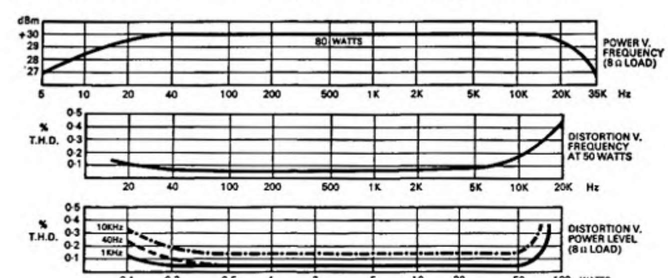

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UNITRACK Equipment Limited have been established for about a year, manufacturing professional recorders with the accent on multitrack equipment. The firm is based at 590 Wandsworth Road, South-West London, in premises formerly occupied by Dolby Laboratories. Part of a nearby building is also used for some of the work.

John Alcock, Unitrack's Sales Director, showed me around, and I first saw the workshop where parts for a deck were being turned and drilled (**figs. 1** and **2**). In another room wiring and assembly were carried out. **Figs. 3** and **4** show the wiring of amplifier modules and printed circuit boards, and the way the boards are inserted into the module chassis is illustrated in **fig. 5**.

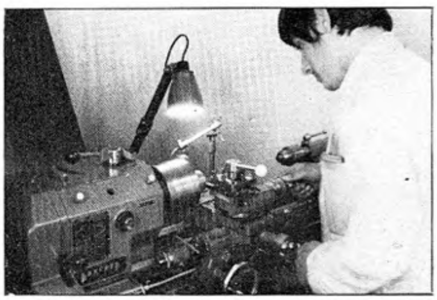

Fig. 1. Turning.

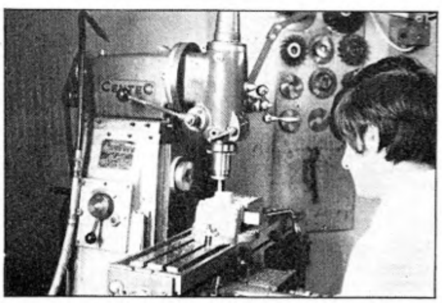

Fig. 2. Drilling.

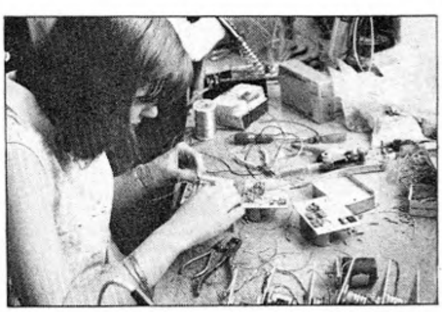

Fig. 3. Wiring amplifier modules.

I saw many recorders in various stages of completion, including the rather spectacular 24-track 50.8 mm (2 inch) machine ordered by Morgan Studios, and shown in July *Studio Sound*. This machine, which is Europe's first 24-track recorder, is shown in **fig. 6**. The 24 VU-meters must be enough to worry any engineer. I feel sure that a better visual monitoring system will soon make an appearance, as the fact no one can watch two meters at once (unless they have concentric pointers) makes 24 meters rather a waste of money. I should have thought that on the recorder, one meter and a 24 way switch would suffice for line-up purposes, while the meters on the studio control desk could be used for continuous monitoring of levels. However, it appears that customers expect 24 meters on a 24-track machine, so that is what they get. Below each meter are three buttons for selection of SAFE, SYNC and RECORD. Tracks selected to RECORD go into this mode on pressing the master record button situated below the deck.

The transport system uses two capstans, one each side of the headblock, the right hand drive being very slightly faster than the left. The resultant tape tension across the heads is kept constant by allowing a small amount of slip to take place at the left-hand pinch wheel. Unitrack use this transport on all their machines except the 6.25 mm (0.25 inch) models where they consider the conventional single capstan drive to be sufficient.

Feed and take up tensions are kept constant by two sensing arms. Associated with each arm are a lamp and phototransistor. The amount of light falling on the phototransistor, and therefore the current through it, is determined by the position of the arm. Variations in tension thus cause corresponding variations in the current which are amplified and used to control the spool motor torque in such a way as to keep the tape tension virtually constant. The assembly of the tape tension servos is shown in **fig. 7**.

The heads for the 24-track machine were made by Gresham. A headblock with 16-track

(*continued on page 389*)

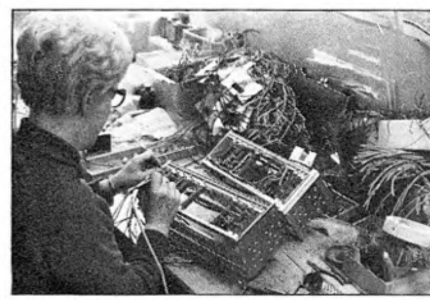

Fig. 4. Wiring circuit boards.

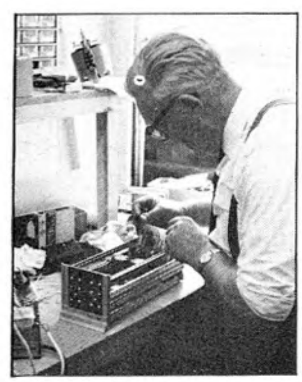

Fig. 5. Module assembly.

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Fig. 6. Europe's first 24-track recorder.

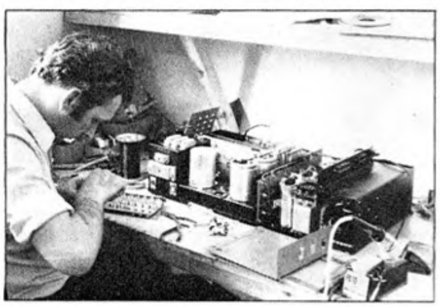

Fig. 7. Assembly of tape tension servos.

50.8 mm Gresham heads is shown in **fig. 8**, the interesting thing being that there is no provision for azimuth adjustment. While variable azimuth is standard on their 6.25, 12.5 and 25.4 mm machines, Unitrack do not approve of this facility for 50.8 mm tape. They found it about impossible to obtain a screw with sufficiently fine thread to give a reasonable adjustment, so although they *can* supply this facility, they are not happy about doing so. It seems that not all of their customers agree with this policy, and one has recently specified the facility on seven 50.8 mm machines. Where fixed heads are used Unitrack achieve accurate positioning by grinding and lapping the baseplate of the headblock and bolting it to 3 bushes in the deckplate. These bushes are about 9 mm in diameter and are inserted into the deck so that they protrude. The tops are then machined flat but they are still just clear of the deck, so determining the positioning of the headblock.

The accuracy obtained by this method is shown by the specification which quotes phaseshift between adjacent tracks at 10 kHz, 38 cm/s, as 5° (presumably the maximum figure). Phaseshift between outside tracks at the same frequency and speed is quoted as 40°, which might seem rather poor until you work out the azimuth error angle that this implies. According to my calculations, the maximum off-azimuth angle will be approximately $\tan^{-1}$ 0.000085 which is about $\frac{1}{3}$ of a minute of a degree, and it is this error angle which will determine the maximum treble loss when a tape is transferred from one machine to another. The fact that the phase of an HF signal on Track One could be considerably shifted with respect to a signal on Track 16 will not matter in normal use because the ear is not capable of detecting such differences.

The width of each track on these heads is 0.07 inch. Track spacing is 0.057 inch and there is a guard strip of 0.0125 inch along each edge of the tape. Record and replay heads are identical having an inductance of 8 mH and a gap of 0.0002 inch. This means that both normal replay and sync quality are identical and does away with the need for separate sync replay equalisation which was necessary in earlier models employing different record and playback heads.

The relatively narrow gap record heads require a high bias frequency and 180 kHz is used. Unfortunately, the erase heads cannot be fed from the same supply because of overheating problems. A low erase frequency gives little trouble but, as the frequency is increased, efficiency decreases because of hysteresis losses (proportional to frequency) and eddy current losses (proportional to frequency squared). Thus, as frequency is increased, the proportion of applied power wasted in heat rises sharply. For this reason, Unitrack use a 60 kHz master oscillator which supplies the erase heads direct, while the 180 kHz bias supply is obtained via a frequency tripler. All stages of this circuitry are balanced to ensure a symmetrical bias waveform, which in turn ensures low bias noise. A waveform with positive and negative peaks of different amplitudes may be regarded as a symmetrical wave plus an additional DC component, the latter giving rise to hiss. Unitrack quote a biased tape noise of 2 dB above the noise level of bulk erased tape, which I take to mean virgin tape as supplied by the makers rather than the stuff we all know with the once-per-rev buzz. Erase efficiency is quoted as 60 dB below 32 mM/mm at 1 kHz.

For the complete machine (the *Uni-16*), crosstalk between adjacent tracks is specified as 60 dB at 1 kHz, and only 2 dB worse at 10 kHz. Signal-to-noise ratio at 38 cm/s is 58 dB below 32 mM/mm at 1 kHz, and 2 dB worse at 19 cm/s. These are the standard speeds for the *Uni-16*, although 76 and 38 cm/s can be supplied to order. In addition, variable speed facilities are available. The recorder accepts an input level from −20 to +18 dBm, with 2% distortion at the upper limit. Frequency response is within 2 dB from 40 Hz to 20 kHz at 76 cm/s, 30 Hz to 18 kHz at 38 cm/s.

Wow and flutter as measured on an EMI *420A* is given as ±0.1% (peak unweighted) at both speeds.

A feature of this machine is the electronic counter with digital readout. Its accuracy is said to be ±0.1% (4 seconds in 1 hour), with a repeat accuracy of ±0.3%.

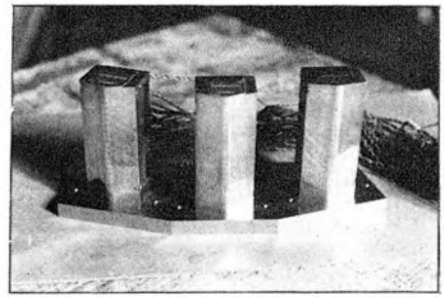

Fig. 8. 16-track 50.8 mm Gresham heads

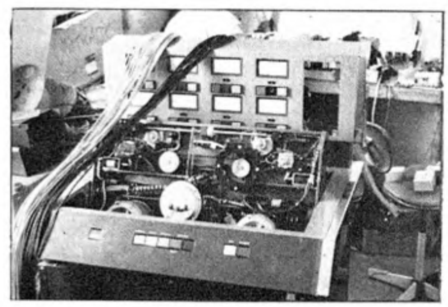

Fig. 9. 8-track 25.4 mm recorder partially assembled.

Other recorders I saw at Unitrack included an 8-track for Sutton Sound (**fig. 9**) and a 16-track for the Rolling Stones' mobile unit. John Alcock has much faith in the use of mobile recording equipment allowing musicians to record in their own homes rather than in studios. Any loss in technical quality is (in theory at least) more than offset by the better musical performance obtained under these conditions. Studio time, once booked, has to be used, or a cancellation fee is incurred, so the situation often arises where a group are not in the right mood for recording, but for financial reasons are obliged to do it. With mobile equipment, this problem is avoided and the saving in studio fees tends to offset the cost of the equipment.

Unitrack have plans to market an 8-track machine with a control desk made by Cadac. This equipment will cost 'certainly under £9 000' I was told, and it will be interesting to see how many groups take the plunge and go mobile. The cost would obviously be too much for many artists, but well within the scope of the more popular groups who normally spend a great deal of money in studios.

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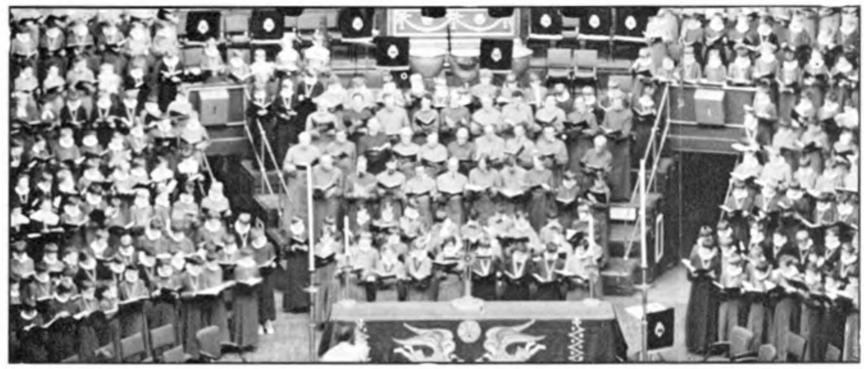
FORTY-FIVE HUNDRED VOICES



Angus McKenzie describes the difficulties, and the way they were overcome, recording 4 500 voices with brass, percussion and organ at the Royal Albert

ALTHOUGH in general the acoustics of the Royal Albert Hall do not present any great difficulties to balancers of orchestral sessions, very considerable problems arise when a large choir is used, and even more when the organ plays a large part in the performance. Several times over the last few decades the Royal School of Church Music have taken over the Royal Albert Hall for a day to prepare the hall for the rehearsal and performance of a choir comprising up to 850 performers, and on previous occasions with just an organ accompaniment. For the evening ceremony, the audience amounts usually to between 2 500 and 4 000 people. The choir consists of church choir representatives from all over central and southern England. The most glorious church music is sung, and during the hymns the choir is joined by the immense congregation, the total sound of which must amount to some of the loudest peaks ever to have been received by mikes in the hall.

This year on June 25 the task was even more difficult because the performers also included a military band of trumpets, trombones and percussion. Since the Queen was to be present all the performers were even more keyed up than usual. As far as the recording was concerned, I felt it necessary to have all the equipment duplicated as of course the performance could not be repeated. The recording will shortly be issued on two LPs by the Royal School of Church Music.

As on previous occasions, the recording team completely monopolised the famous artists' Green Room situated behind the left hand side of the stage, at the end of the passage nicknamed by many the 'bull run', up which so many famous soloists and conductors have passed. Three tape recorders were used so that at least two machines were running at one time. The main machine was a Telefunken *M10A* 6.25 mm, which is under review at the time of writing. A TRD machine and a Telefunken *M28* were also running most of the time, all the recordings being at 38 cm/s on BASF *LGR 30* tape, for which all the machines were very carefully set up. The output of the mixer employed fed a Dolby *A301* system (the output of this feeding all three machines). The output of the *M10* was used for monitoring and playback purposes. Since all the equipment had to be transported in an estate car and a saloon it was not possible, although I would have preferred it, to take my Tannoy 15 inch *Monitor Golds* in large BBC type enclosures. Leak *Sandwich* speakers were used, driven by a Leak *Stereo 30+* amplifier. Although the speakers might have been considered modest, the sound produced by them was very reasonable, particularly at the bass end where the organ produced considerable power. The mixer was relatively simple, which is important when doing mobile recordings of classical music where setting up time in the control room is limited, since most of this time was employed in extremely careful setting up of the mikes. The mixer is basically three stereo channels, one of which includes pan pots which can place the sound of one stereo channel anywhere from dead centre to full stereo width or any combination of this. Each channel has treble and bass controls on the back of the mixer which also includes a line up oscillator having four switchable frequencies at 40 Hz, 1, 10 and 15 kHz, switchable to left, right or both channels. The mixer includes transistorised PPMs of a similar type to those used by the BBC and many studios, the movements made by Turner Instruments. Two of the stereo inputs were at microphone level, balanced, whereas the third input was line level. A separate stereo transistor microphone amplifier box was therefore used to drive this channel with preset gains. This separate microphone amplifier box was preceded by a balanced passive mixer capable of mixing two stereo inputs to one stereo output, using balanced stud faders. In an emergency all the tape recorder channels could have been driven directly from the output of the microphone amplifier box, had the mixer broken down, and although of course this is not likely to happen I feel that engineers should cover this eventuality when recording important public events. It is interesting to note that, despite the preset gain inside the mixer being reduced so that a maximum gain in the mixer of only 58 dB was possible, it was still found necessary to pad one of the *C24* mikes by 12 dB to avoid overloading. This meant in fact that the microphone was actually giving an output as high as -20 dBm during periods of the performance, and this represented one of the highest levels that I have experienced from one of these microphones when not working in close mike conditions. The mixer incidentally was built to my specification by Richardson Electronics and performed extremely well.

Two stereo AKG *C24* capacitor mikes were used, suspended on thick cords from the end of the gallery rails. Two AKG *C451E* FET capacitors were used on floor stands to pick up lessons read by the Lord Bishop of Ely and the Precentor of Coventry. Towards the end of the service it was necessary to move one of the *C451E* mikes to a different position on the rostrum to pick up the Archbishop of Canterbury who gave the blessing.

The main difficulty was to pick up the organ satisfactorily as well as the presence of the huge choir, without loss of clarity on either, and for this reason one *C24* used mainly for the choir and part of the congregation was suspended to a height of approximately 6 m above the arena floor and about 2 m back from the conductor. The canopy above the rostrum normally used to improve the dispersion of orchestral sound almost completely blocks off any direct sound from the organ to the members of the audience seated in the arena and round the sides of the hall. On the other hand, the organ is considerably louder to those in the gallery, who can see the pipes quite easily. It is virtually impossible to suspend mikes from the dome to pick up the organ direct, and therefore the second *C24*

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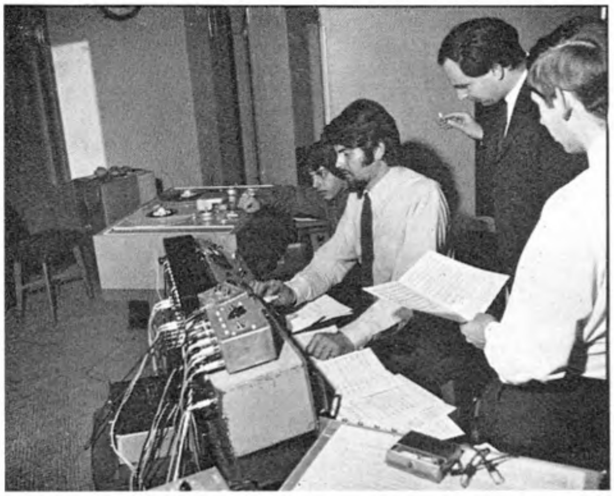
FORTY-FIVE HUNDRED VOICES



Above (left to right): Peter Self, Tony Askew Angus McKenzie and Kenneth Gundry.

was suspended as high as possible with the suspension ropes very tight. I was told that the mikes were considerably higher than has ever been used by the BBC for the transmission of concerts from the hall, and this same mike also picked up members of the congregation in the balcony and boxes. The Kneller Hall musicians from the Royal Military School of Music were placed immediately underneath the front of the organ whilst the choirs extended from the highest choir stalls down to the rostrum itself. In front of the brass and percussion was the processional choir of 50 which had entered from the West Door immediately before the ceremony, with the Archbishop of Canterbury and church dignitaries. Although parts of the performance had been rehearsed during the afternoon, no precise idea of levels could be gained because of the absence of the participating congregation.

The service began with a fanfare taken just on the lower *C24* which, after considerable experiment during the afternoon, had a crossed bi-directional characteristic. This was immediately followed by a sensational performance of the National Anthem in which the upper *C24* was used also. Very great care was taken to ensure that the directions of the two capsules were identical and that all the mikes were in phase. Since the higher *C24* was much farther away from the choir and also much closer to a large number of the congregation, the mixture of the two mikes did not appear to present any problems, although in the afternoon continual spits on one of the channels of the upper mike were audible and could not be removed. This in fact was produced by very heavy lighting being switched on and off, but we were assured that it would not happen during the performance. It was a mystery why one mike picked it up when the others did not, since all the cables were identically balanced, and it is assumed that the earthing arrangement in this borrowed and earlier *C24* may have been different to my own. This particular effect is incidentally well known to the BBC who in past years have often had the trouble about which I have previously written. Psalm 121 which followed the Anthem presented a magnificent contrast between the small processional choir and the massed choir of 800, and the dynamic contrast between the two was fully preserved in the balance.

It was most interesting to notice the exceptionally low distortion level from the tape on playback, together with the almost inaudible hiss level—very slight mike noise and certainly not the tape itself because of the use of the Dolby system. No distortion of any kind was noticed on the tape, despite the incredibly complicated waveform, which proved the excellence of the *A301* system. The actual measured distortion of the equipment from the mike input socket to the monitor output sockets of the mixer had been measured prior to the recording session and was found to be only 0.5% at 1 kHz for a peak recording level of 32 mM/mm, which level was only exceeded slightly on two occasions although very close peaks were fairly frequent. I found it interesting to compare the sound of this latest event with the two previous occasions in 1958 and 1965. In 1958 I used only two Neumann *U47* mikes in cardioid 4 m behind the conductor and only 5 m up, recording on Agfa *FR4* tape with a very early EMI *TR90* machine, whilst in 1965 I used a *C24* approximately 8 m up and nearly 3 m back, recording on two modified 38 cm/s Revoxes with BASF *LR56* tape. To achieve the dynamic range it was necessary to peak nearly 8 dB above 32 mM/mm to avoid very noticeable tape hiss, and unfortunately was occasionally just evident on very wide range equipment. The distortion level of the tapes in both 1958 and 1965 would have been approximately 3% harmonic and, had I recorded at any lower level, there would have definitely been serious hiss problems in 1965. I therefore regard a noise reduction system as essential for this type of work. Compared with the two previous ceremonies, the presence of the so-called flying saucers certainly improved the acoustics in all respects except the sound from the organ which previously had reverberation from the dome down to the arena. I feel strongly that the Royal Albert Hall authorities should seriously consider an easily movable canopy, as one was not required on this occasion.

Readers may wonder why I used *LGR30* rather than *LR56*. With the noise reduction system I was far more interested in low distortion and it was not felt necessary to record at higher than 32 mM/mm, allowing a safety margin of 4 dB. As *LGR30* has a more acceptable tape background, and print-through characteristics are better at this level, there was in any case no reason to use the more expensive *LR56* tape. To achieve a playing time of 44 minutes, platters of 1 km were used on the Telefunken *M10*. These are of course already in stock at BASF but only available with difficulty from British tape suppliers. When using platters, it is also very important to use tape with excellent spooling since, having no upper protective ridge to prevent tape spilling, a spooling accident would be extremely serious. In my experience, *LGR30* and *LR56* spool exceptionally well because of the matt backing and the slight increase in low frequency tape noise produced by this backing is in any case virtually eliminated by the use of noise reduction. I shall be pleased to demonstrate parts of the recording to any professional classical recording engineers who may wish to contact me.

I would like to thank the Royal School of Church Music for asking me to record their historic events, Mr. Brian English of AEG Ltd. for the use of two of their machines, Livingston Studios for the loan of one of their *C24* microphones, and Anthony Askew, Kenneth Gundry and Peter Self who spent the entire day helping me install the equipment and recording the event.

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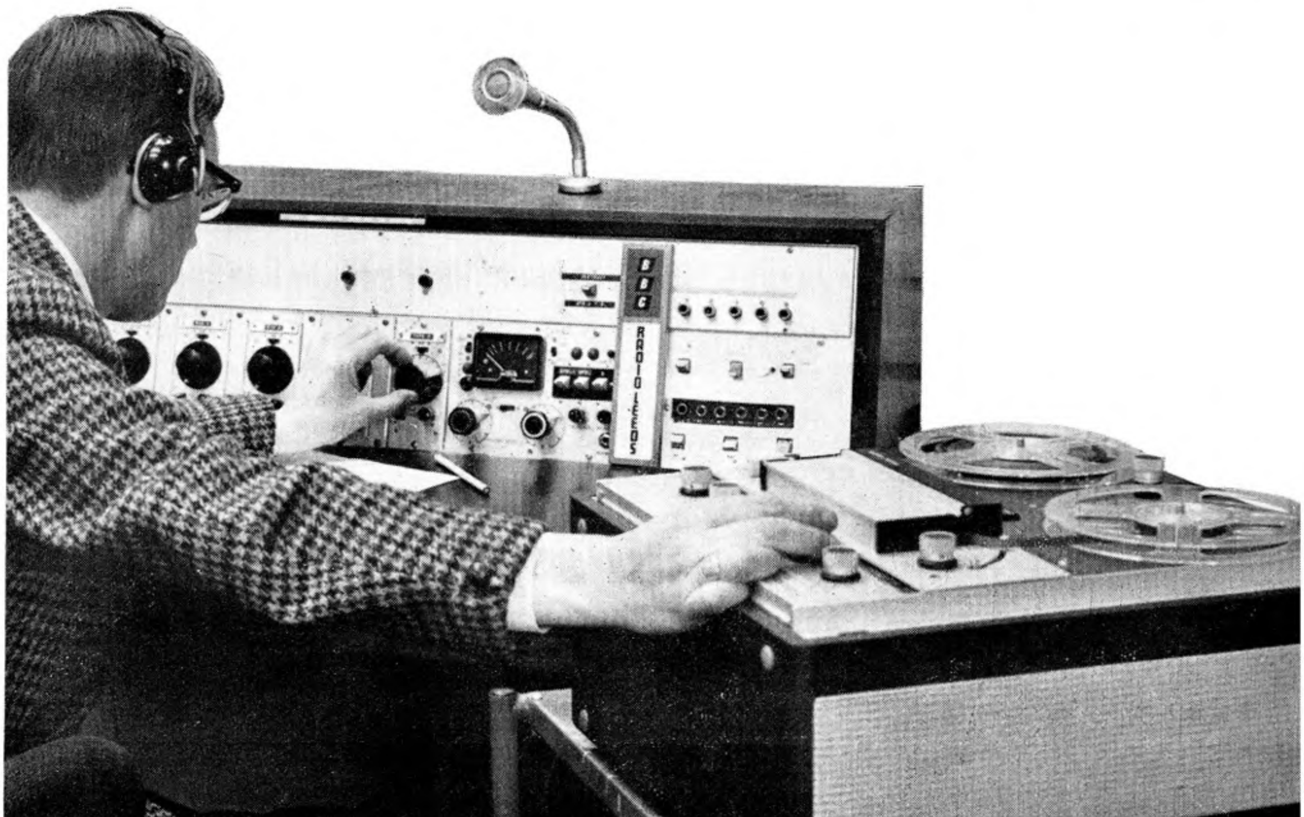

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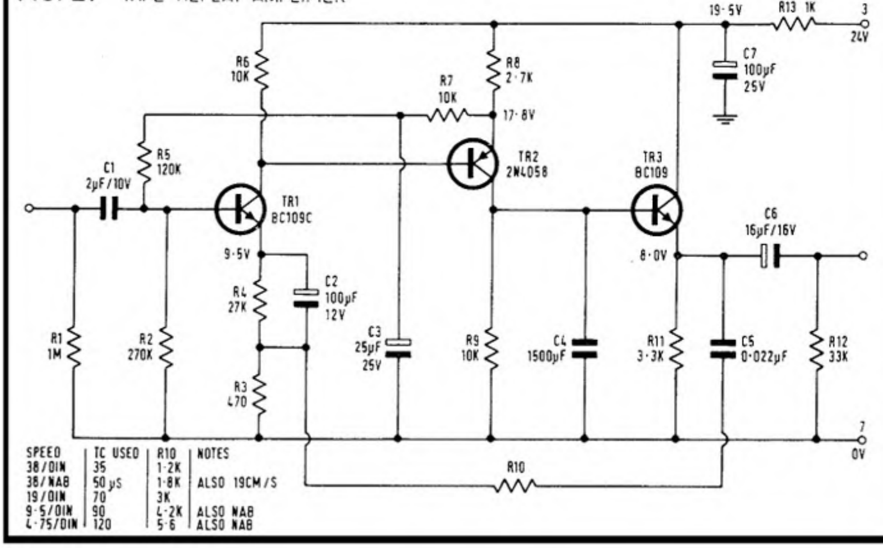
PART FOUR

MIXING AMPLIFIERS

FIG. 27 TAPE REPLAY AMPLIFIER



SPEED	TC USED	R10	NOTES
38/DIN	35	1·2K	
38/NAB	50 µS	1·8K	ALSO 19CM/S
19/DIN	70	3K	
9·5/DIN	90	4·2K	ALSO NAB
4·75/DIN	120	5·6	ALSO NAB

FIG. 28 STEREO COMBINER CIRCUIT

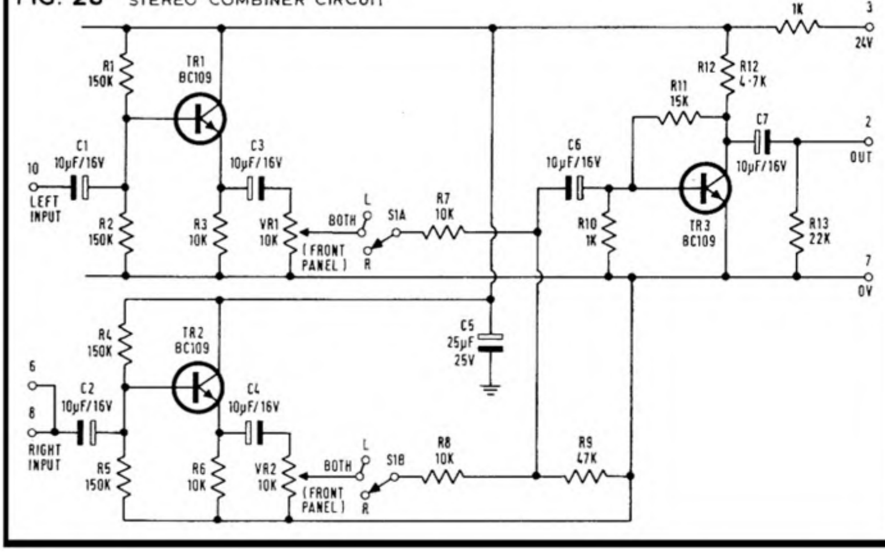
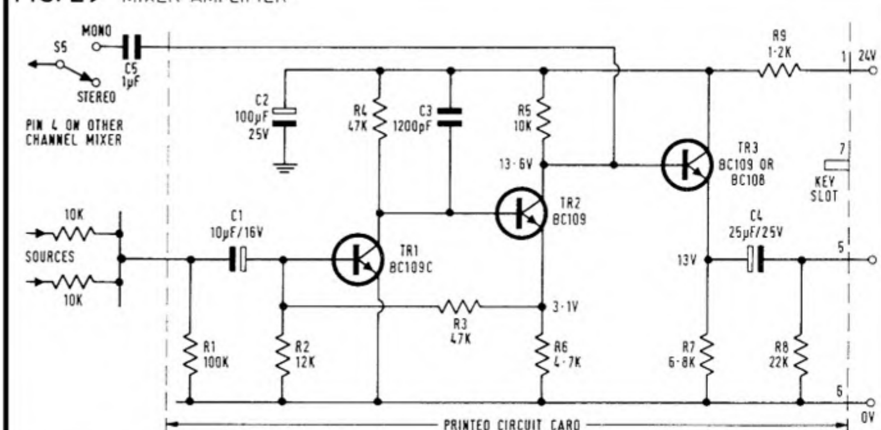


FIG. 29 MIXER AMPLIFIER



Two further circuits complete the front panel plug-in units; although I am sure that there will be many more special versions made to suit constructors' particular requirements. Firstly there is an equalised preamplifier for tape head replay. Most tape recorders will of course have preamplifiers already built in, and so this module is usually unnecessary for the mixer. However, often an old tape deck can be pressed into service to act as a playback-only machine for dubbing purposes, and the module was designed for this application. It will suit tape heads from 200 mH to 1 H inductance. **Fig. 27** shows the circuit. It is similar to previously described circuits, using a DC pair with heavy feedback. Tr3 is an emitter-follower to provide the low output impedance necessary to drive the feedback path. The high frequency turn-over points are provided by C5 and R10, and the table lists values for the commonly used tape speeds. Low frequency equalisation is a compromise between the NAB and the DIN standards. If the module is to suit more than one standard the varying components can be mounted on miniature switches on the front panel.

The other front panel module is very specialised, and is included only for completeness. The need arose to produce a series of monophonic tapes from stereo masters, and the stereo combiner module was the result. I use unbalanced lines between mixer and recorder, since the distances involved are small, and my signal convention is to use twin screened wire and three-pole jacks with tip as left channel, ring as right channel, and sleeve for common. The input jacks are also three-pole and, by using the circuit of **fig. 29**, the two channels can be picked up from these inputs and paired individually through a simple emitter follower and front panel gain control. S1 selects the

(*continued on page 395*)

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3"	150'	2/-	5/9	3"	220'	2/6	7/-	3"	400'	4/6	13/-	3"	7d.
4"	300'	4/-	10/-	4"	450'	5/-	14/-	4"	600'	6/9	19/6	4"	1/8
5"	600'	6/-	17/6	5"	900'	8/-	23/6	5"	1200'	12/6	37/-	5"	1/9
5¾"	900'	7/-	20/6	5¾"	1200'	10/6	30/6	5¾"	1800'	17/-	50/-	5¾"	1/9
7"	1200'	9/-	25/6	7"	1800'	13/-	38/6	7"	2400'	21/-	61/-	7"	2/-

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STARMAN TAPES, 421 Staines Road, Bedfont, Middlesex

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input to the mixer stage Tr3 to be either only left, only right or both; this is used for setting up the gains. If a stereo or two track tape of tone (at say 32 mM/mm or PPM 6) is played back, setting the gain controls for each channel separately to give 3 dB less (i.e. about PPM 5) will give the correct output when mixing the semi-correlated stereo programme.

The next circuits to consider are the internal amplifiers, contained in the body of the mixer. The first of these is the mixing amplifier; by the time an input signal has reached these it has passed through one of the plug-in amplifiers and so is of about the same amplitude as any other input signal; also, should it be necessary, it is frequency corrected—as for example from a magnetic or crystal pickup. **Fig. 29** shows the circuit of the mixing amplifier, of which two will be needed for complete stereo operation. The input impedance at the base of Tr1 is low, so that each input is isolated from the others by the series mixing resistors. Each mixer will accept up to 20 inputs; these are the programme feeds and the oscillator feed, the latter being connected to both channels. For stereo, the two mixers are paralleled with C5 which commons the two signals but retains separate main gain controls for both channels which can be a useful feature.

The first two transistors in the circuit are connected in a similar manner to those in the amplifiers already described, with both AC and DC feedback; Tr3 is an isolated stage before the main gain control. From this control the signal passes two ways, the first to a buffer amplifier (see original block diagram) which eventually feeds the monitor amplifier. This is to ensure that any switch clicks which might be made in changing the monitor switching from input to output will not appear on the output signal which is recorded; this path will be described in more detail next month. The second path is to the front panel preset control which is used to balance the channels for stereo use and to adjust the level out to suit the recorder in use. The signal level at this point is still low, and a further stage of gain is required.

There are often occasions when it is required to feed more than one recorder. To prevent accidents on location it is always better that the various outlets should be isolated; nothing is more annoying than to ruin an important recording because one of the ancillary pieces of equipment has a faulty plug which has shorted the whole signal. The output stage **fig. 30** provides a maximum gain of about 10 times at a very low output impedance from the emitter of the second transistor. Three outputs are shown, each with a series resistor which essentially sets the output impedance. The mixer can, therefore, be connected to other equipment which may have a 600 ohm input. If one of these outputs is accidentally shorted, the level at either of the others changes by about 1 dB only, which would not be noticed in practice with speech or music.

The circuitry is very similar to that used in the preceding amplifiers, and so will not be described in detail. To obtain the maximum output, which can be RMS if required, it is important to have the DC conditions accurately set up. For this the emitter of Tr2 should be at about 8V, and R3 can be adjusted if necessary. Increasing R3 will reduce the DC at the output, and vice-versa. With normal tolerances on components, the voltage will be between 7V and 9V.

The buffer amplifier is again straightforward, and has been described already for use in the plug-in front panel modules; for completeness the circuit is shown again in **fig. 31**, which also shows that one small internal card will accommodate two such buffers, quite independently.

All the circuits are on printed circuit cards (**fig. 32**), which plug into 9-way edge connectors. **Fig. 33** shows the internal construction of the first prototype. Each socket contains a movable plastic plug which is moved to correspond with a slot cut in the circuit card so that only the current board can be plugged into the appropriate socket. The plugs are mounted on 1 inch centres and aluminium angle, which is then fastened inside the mixer making a very easily serviced arrangement. A similar construction is used for the cards in the fader rack.

Most professional studios use balanced lines to ensure that, no matter what the earthing conditions are, no hum loops can appear as equipment is plugged in and out of the circuit. While not essential in closely controlled situations, the flexibility and sureness of everything working together on balanced lines makes them well worthwhile in a studio. For sending signals down long lines (GPO circuits, or from room to room) they are essential, and for this application the circuit of **fig. 34** was developed to replace that of **fig. 30.** Two stages of amplification are used to feed a compound emitter follower and the transformer; a maximum of +20 dB into 600 ohms can be achieved. The normal output level is +8 dBm for a tape flux 32 mM/mm, the most commonly used international standard. The output impedance is low, about 80 ohms, and is almost entirely due to the winding resistance and reactances of the transformer. To use a true 600 ohm source is not necessary, and in fact wastes 6 dB of signal when terminated. Modern practice is to use a low output impedance which therefore provides a signal level essentially independent of load applied, and the old problem of double terminations (or no terminations) can be forgotten.

At this stage it is convenient to discuss the testing of the circuits. It is probably easier for the constructor if each unit is tested as it is made, using batteries or the power supply shown in Part Two to give the 24 V needed. In this way any mistakes in the wiring are quickly found, which is better than being faced with a rather complicated piece of electronic detection work at the end of the completed construction.

There are two points to watch, the first is the base of the first transistor in the high level or buffer amplifiers, and the other is the base of the measuring transistor in the PPM circuit, which will be discussed later. The voltages at these points should only be measured with a valve-voltmeter or similar device with an input impedance of at least 5 M. If other instruments are used, the shunt effect will lead to incorrect and misleading results. The voltages read at

(*continued on page 397*)

FIG. 30 OUTPUT AMPLIFIER

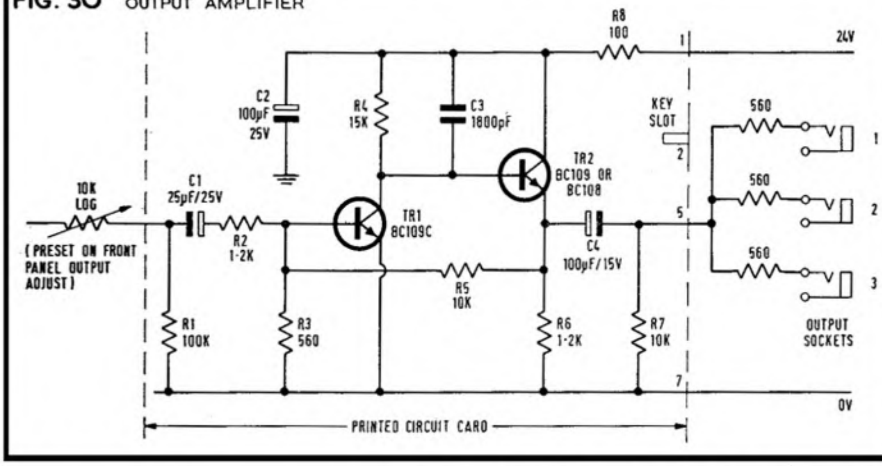
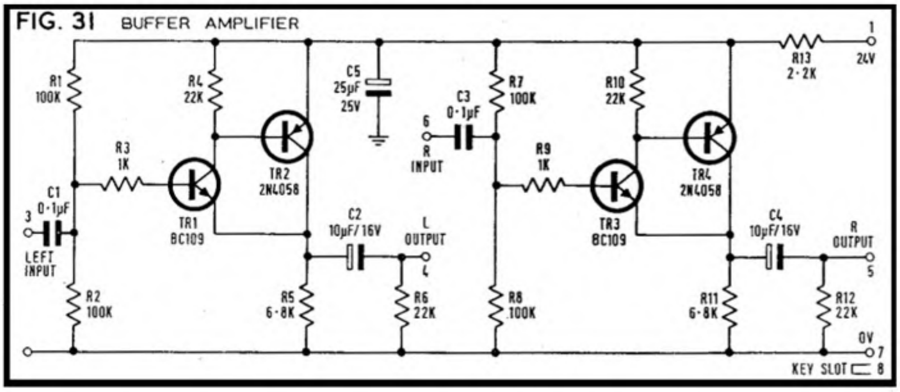


FIG. 31 BUFFER AMPLIFIER



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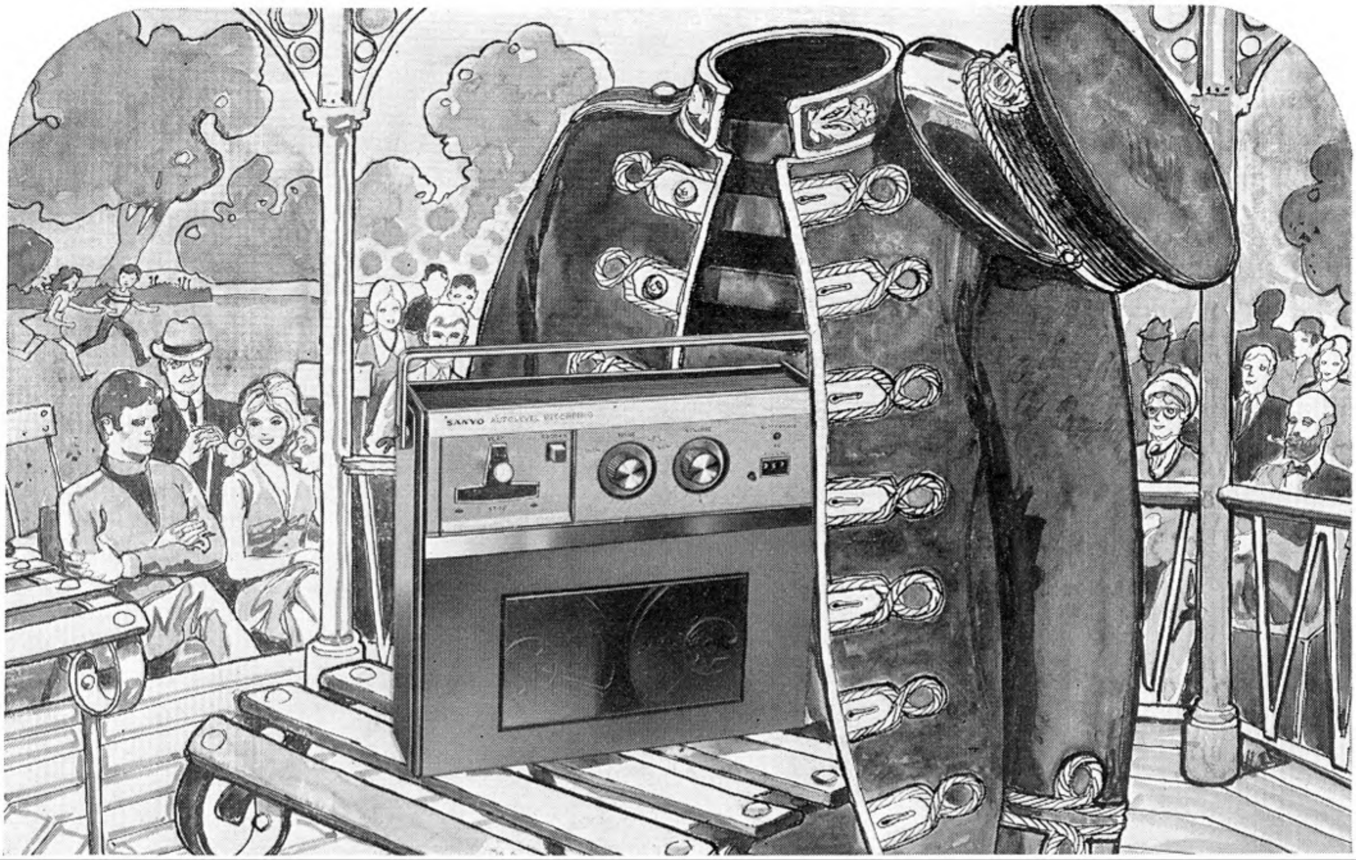

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Choose the programme and Sanyo will play it.

You can make your own musical arrangements. This amazing £39–15–0 portable will take two signal sources simultaneously. And you have all the freedom of a two speed, two track tape.

During performance really big sounds can be achieved through the tremendous 1,200 mW output power. Whilst a continuous tone control will keep the pitch perfect. Here is the complete score.

Transistors	7	Speaker	$6\frac{1}{4}$"x $3\frac{1}{8}$"
Reel Size	5"	Connections	Mic
Tape Speed (IPS)	$3\frac{3}{4}$		Remote
	$1\frac{7}{8}$		Earphone
Recording Time (mins)	64 @ $3\frac{3}{4}$		Radio
	128 @ $1\frac{7}{8}$	Power Source	DC 9V (6xHP2)
Wow and Flutter	0.30% RMS		AC 220/240V
	0.40% RMS	Dimensions	$11\frac{5}{8}$" x 10" x $3\frac{7}{8}$"
Frequency Response		Weight	9.4 lbs
(Hz)	150–6000 @ $3\frac{3}{4}$	Accessories	
	150–4000 @ $1\frac{7}{8}$	(Supplied)	Mic
Output Power (max)	1.2W		Tape and Spool
			Splicing Tape

the Sanyo MR–115 Portable Tape Recorder

Sanyo tape recorders have achieved a world wide reputation.
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other points in any of the circuits should agree with the values given to within 15% at the outside, and will probably be much nearer since the actual transistor parameters are not significant in establishing the operating conditions. This is mainly achieved by the feedback resistors. A quick check can be made around each transistor to ensure it is operating correctly. Starting from the emitter, in the case of a non-silicon transistor the base should be about 0.6 V more positive and the collector at least 1 V more positive.

If possible, the AC performance of the stages should then be checked, using a signal generator as the source. The response should be flat, defined here as +0 dB to −1 dB from 20 Hz to 20 kHz for all units, with the exception of the line amplifier which, at full gain, is −3 dB at 50 kHz. With the preset control turned down by 6 dB this unit also is flat to the above limits. This is a fairly tight specification to meet, but is not too difficult using the types of transistors quoted in the text—in fact the high frequency response extends well above 20 kHz. The following figures should be obtained for the complete system, with the gain controls all set at maximum, and −0.775V, at the output terminals using the simple output amplifier.

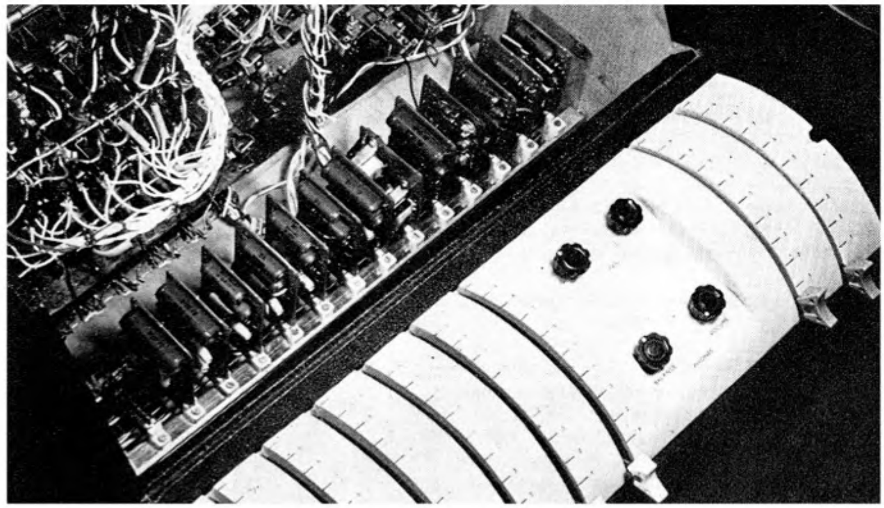


FIG. 32

High level, input for full output = 20 dB; max input level = +6 dB

Line Amp, input for full output = −62 dB; max level = +2 dB or −42 DB in −20 position; max +22 dB

Mike Amp, input for full output = −90 dB in 600 ohm; max = −25 dB or −103 dB in 30 ohm; max = − 38 dB

Required input for 60 dB signal-to-noise: *Mike*, 30 ohm = −78 dB 600 ohm = −65 dB; *Line*, 30 ohm = −48 dB, 600 ohm = −35 dB

The overall noise factor can be derived from these figures; with a gain of 67 dB on the microphone input, from a 600 ohm source, the Johnson noise at the output will be −127 +67, or −60 dB. The required input of −65 dB will be amplified to +2, and since this gives 60 dB signal-to-noise ratio, the noise must be −58 dB or 2 dB worse than the theoretical limit. The noise figure is thus 2 dB and so compares extremely favourably with anything on the market at the present time. **Fig. 35** shows the signal flow through the mixer, together with the noise levels and overload points. A figure of 60 dB for the signal-to-noise ratio was chosen here; in practice the microphone signal is much higher than −67 so that the signal-to-noise will be increased. Notice how the limiting amplifier from the noise aspect is the first stage, which is as it should be; the noise contribution of following stages is insignificant. This chart also gives the correct operating levels inside the mixer, and should be followed in the setting-up procedure.

As well as the main chain, a subsidiary path provides full monitoring facilities. In both listening and metering the monitoring amplifier

(continued overleaf)

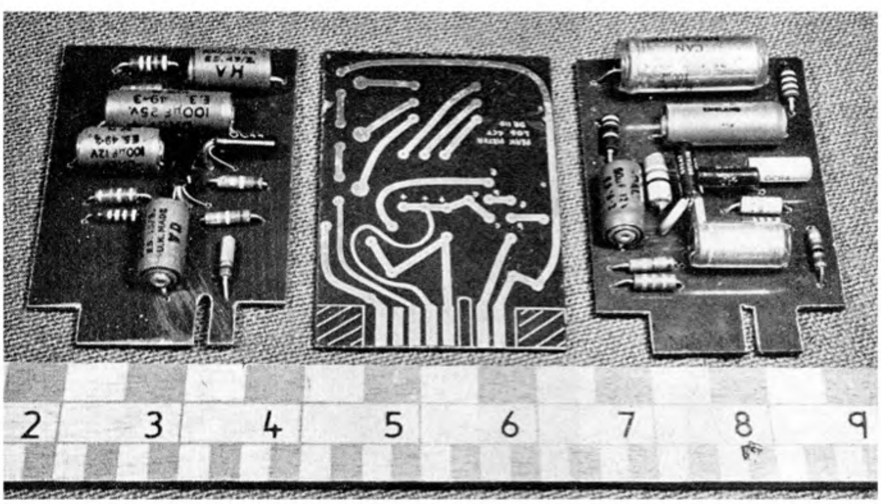


FIG. 33

Component Suppliers:

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

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

Ref. *177-2*	Tape Head Amplifier	7s.
130-2	Stereo Combiner	6s.
105-2	Mixer Amplifier	6s.
106-2	Output Amplifier	6s.
215	Buffer Amplifier	6s.
216	Balanced Output Amplifier	6s.

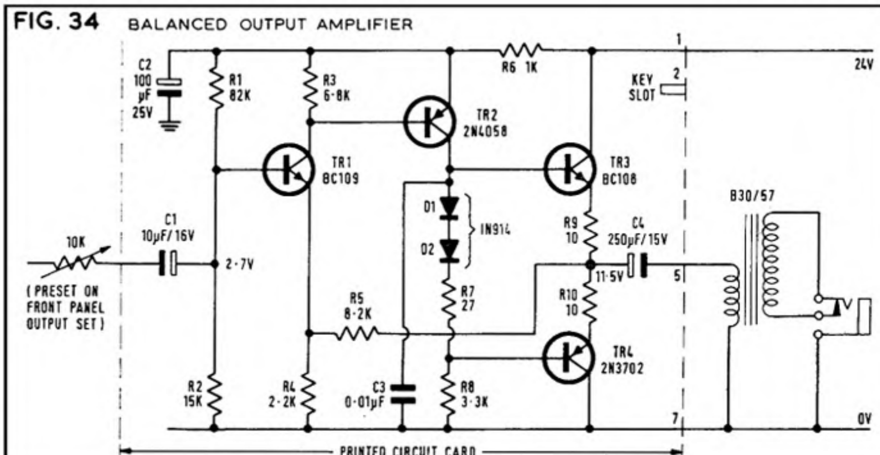
Transformer: Sowter *B30/57* **£3 8s.**
7 Dedham Place, Fore Street, Ipswich, Suffolk

Edge connectors for cards inside mixer framework:

a) **Radiospares (from local shops)**
General purpose type, 8-way **7s 2d.**
Professional grade, 8-way **8s 6d.**

b) **Ether type *KBS/8/S/03/01*. Supplied by Intel Connectors Ltd, Vereker House, 1-6 Gresse Street, London W.1.**

FIG. 34 BALANCED OUTPUT AMPLIFIER



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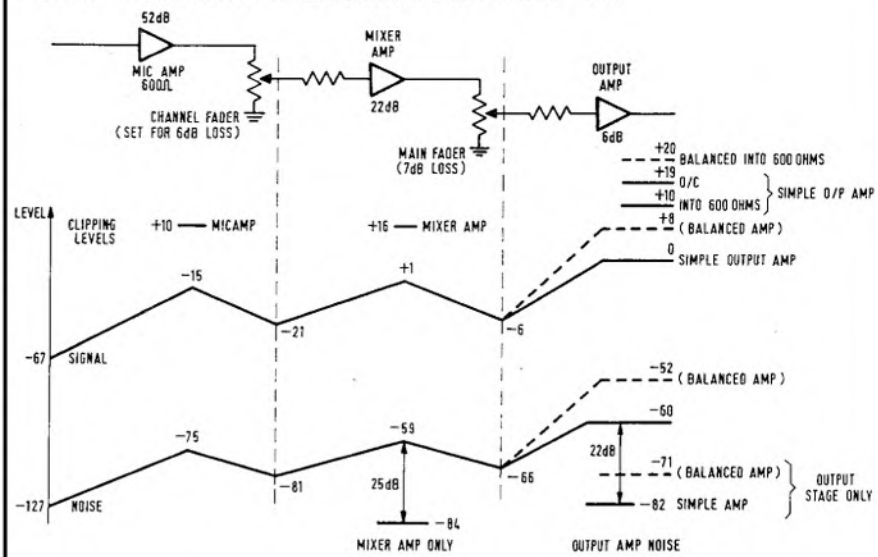
can be switched to either the signal to be recorded, or alternatively the playback signal; in most professional recorders there is usually an extra head connected permanently to a playback amplifier, thus by switching between the output of this and the incoming signal, it is possible to make a direct comparison so that the quality of the tape can be assessed as it is made rather than waiting to the end and rewinding.

Provision is made in the mixer to accept the playback signal so that the comparison switch can be mounted on the front panel, where it is labelled INPUT-PLAYBACK. There is also a volume control so that the two signals can be adjusted to be of exactly the same amplitude, since it is extremely difficult to judge small differences between two signals if they are not the same level. In this way, using the two control keys, the recorder may be situated in a remote position and forgotten during a recording and more time spent on important work such as balancing and timing cues. More on this aspect of monitoring next month.

FIG. 35 SIGNAL LEVELS IN MIXER, SHOWN FOR A S/N OF 60dB



For driving the monitor loudspeakers, external amplifiers are used, and these can be either valve or transistor-driven as wished. There are many designs for both types on the market, and the actual type chosen will depend on the exact use envisaged. It should be remembered that for use in a permanent installation this same amplifier drives the studio loudspeakers, when it may be that a large room is used which will need considerably more power than a small recording studio. The input sensitivity of these amplifiers, for full output, may vary from volts to millivolts, so it was thought necessary to include an amplifier stage which is used—in addition—to amplify the signal from the tape recorder playback. The same unit as the recording output stage (**fig. 2**) is used, with the exception that the 10K variable potentiometer in series with the input is omitted and the input passes in from the slider of a potentiometer on the front panel, marked MONITOR. Also, the 560 ohm resistors at the output are omitted, since there is only one output for each channel.

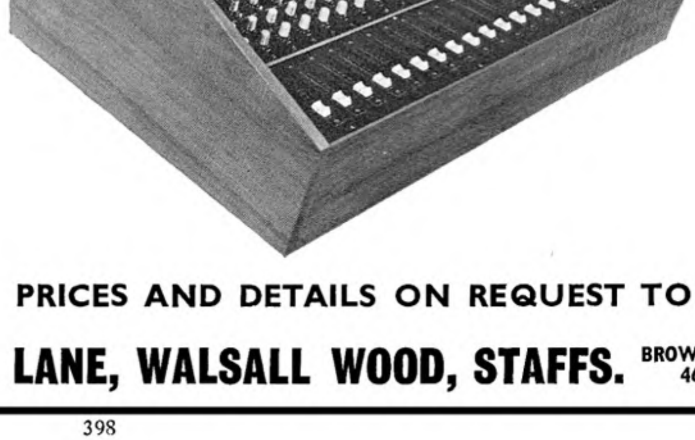
Next month concludes the discussion of the monitoring facilities, and gives details of a peak programme meter.

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.



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APRS 70

REPORT ON THE 1970 ASSOCIATION OF PROFESSIONAL RECORDING STUDIOS EXHIBITION

EXHIBITION reports are perhaps best subtitled 'Things We Missed In The Preview', or more accurately 'Things The PR Man Wasn't Told'. There were quite a number at APRS 70, the single-channel Dolby, the Moog, the *ABR* Ampex, the 8-track Studer, the 24-track Unitrack, and so on. Taking matters alphabetically . . .

AEG's two-speed *M28* was shown together with a Telefunken studio monitor loudspeaker (to be reviewed next month). Basic price of the recorder is £575, facilities including full solenoid control through illuminating push buttons, optional mixing and meter circuitry, interchangeable head assembly and a three-motor transport with tension servos. Interested readers are reminded of the *M28C* review in our March issue.

AKG centred their microphone display on the *C451* FET capacitor microphone and its supporting accessories.

At the **Ampex** stand we enquired whether anyone has yet ordered a 24-track *MM-1000*. Apparently not; both in the UK and USA, we were told, 16-track has been found ample for all forms of music recording, A 16-track *1000* is expected for review this autumn. The new *ABR* was displayed, a two-speed recorder handling 6.25 mm tape on spools of 27 (Model *ABR10*) to 38 cm (*ABR15*) maximum diameter. The larger model measures 630 mm high x 480 mm wide and weighs 23 kg. Full, half or quarter track heads can be incorporated, with automatic drive reversal if desired. An oscillator-controlled capstan contributes to a specified 0.1% wow and flutter at 38 cm/s. Versions operating down to 2.375 cm/s are available. Bias frequency is 100 kHz, with a 4 dB reserve bias above normal record level.

Mike Beville represented **Audio Design (Recording)** with a display of stereo and voice-over compressors. These were demonstrated through equipment on the neighbouring **Helios** stand.

The pin-board matrix employed in **Audio Developments** mixers provides an unusually clear method of route selection which is now being used by Hollick & Taylor studios in Birmingham. A 12-channel portable mixer was shown, based on *M70* modules, with Penny & Giles *1800* faders and a separate power unit to reduce hum. Rumours that the company might take over another exhibitor, **Tape Recorder Developments,** have since been confirmed.

A four-speed stereo battery portable with 27 cm spool capacity (using extension arms): the Stellavox *SP7* imported by **Audio Engineering.** This operates at 9.5, 19 and 38 cm/s on batteries and, when connected to mains, will record at 72 cm/s. Electronics are resin-encapsulated in metal-screened plug-in modules. Items in the Sennheiser range of capacitor microphones were shown, and the *HD414* stereo headphones and Audio Engineering PPMs demonstrated.

Tony Newman *(Studio Sound)*, on left, talks to Ian Marshall of Carston Electronics.

Stellavox battery portable with 27 cm spool extenders.

Eight-track Studer *A80*.

Audix concentrated on their *Studio 80* power amplifier, delivering 80 W RMS into an 8 ohm load from 5 Hz to 35 kHz with 0.05% distortion at 1 kHz. Noise is 95 dB below maximum output. The amplifier incorporates 11 silicon transistors and seven diodes, signal inputs and outputs being through Cannon connectors. It is supplied housed in the stove enamel metal cabinet illustrated.

Details of *Bias Test Tape 38* were supplied by **BASF.** The tape suits record head gaps of 5 to 20 μm and comprises alternating 60 cm lengths of two tapes with differing magnetic characteristics. If the bias is too high, the lighter tape will provide a smaller replay level than the dark. Too low a bias level reverses this situation. Tapes displayed included *LR65* High Output, *LGS52*, *LGR30* and *PES40*. Two double-coated tapes for Moebius loop cartridges: *PES35D* and *45D*.

Our August cover showed the Studer *A80* (with John **Bauch,** not Michael as stated). By virtue of its price, this was one of the most interesting recorders at the exhibition. Assembled round a swivelling die-cast metal frame, the *A80* is available in one, two, four, eight or 16-track form. Twin-guide tape tension control potentiometers are mounted each side of the head block. The tape time counter is located between the capstan and right-hand sensor. Capstan speed control is by a tachometric engraving on the flywheel. Unweighted peak wow and flutter is 0.08% at 38 cm/s, overall frequency response being 30 Hz to 18 kHz +1 −2 dB, 60 Hz to 12 kHz ±0.75 dB. Overall 1 kHz distortion is less than 2% at 51.4 mM/mm tape flux for 62 dB signal-to-noise ratio (Agfa *PER 525*). Erase frequency is 80 kHz with 240 kHz bias. Intriguing to note that 77 transistors, 73 diodes and 25 ICs are among the components of the tape transport circuit alone. Full remote control, including a remote five-digit tape time counter.

Cadac have introduced the *Studio Monitor* loudspeaker based on an Altec *604E* dual 380 mM/mm 55 mm unit and 100 mm units. Individual frequency response tailoring to suit control room conditions results in a claimed 20 Hz to 20 kHz ±1 dB, adjustment being undertaken by Cadac during installation. Power handling is 40 W continuous RSM (120 W

(continued on page 401)

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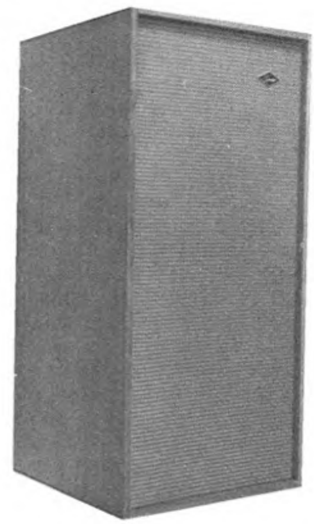
SPENDOR AUDIO SYSTEMS

ANNOUNCE THREE NEW HIGH QUALITY PRODUCTS

THE BC1
A top quality medium sized, professional monitoring loudspeaker system. The BC1 has a more accurate reproduction quality than almost any other, irrespective of size.

THE BC1A
Fitted with the SPENDOR 20 WATT POWER AMPLIFIER M20/9, this combination provides a portable powered loudspeaker which is the finest of its type at present available.



TYPE BC1. Size: 25" x $11\frac{3}{4}$" x $11\frac{3}{4}$". L.F. Unit: 8" Plastic Cone. H.F. Unit: Celestion H.F. 1300. Nominal Impedance: 9 ohms. Frequency Response: $\pm$ 3 dB 60 Hz to 14000 Hz. Power Rating: 8 watts RMS continuous 20 watts programme.
PRICE: £52. 10s. 0d.

TYPE BC1A. Specification as above. SPENDOR POWER AMPLIFIER TYPE M20/9, with gain control, fitted into back panel. Signal Input: Balanced or Unbalanced. Mains Input: Bulgin 3 Pin.
PRICE: Balanced: £65. 10s. 0d.
Unbalanced: £62. 10s. 0d.

THE SPENDOR POWER AMPLIFIER TYPE S20/9

Has been designed as a drive amplifier for high quality speaker systems. It is a stereo amplifier of fixed gain and is compatible with most makes of pre-amplifiers and studio equipment.

Input Impedance: A.C. 47k in parallel with 10pF. Load Resistance for Maximum Output: Between 8 and 9 ohms inclusive. Power Output for 9 ohms Load: 20 watts. Input, Maximum Power: 0.5V RMS. Rating: Continuous. Frequency Response: –1 dB at 20 Hz and 50 kHz. Channel Separation: 66 dB 20 Hz and 20 kHz. Noise and Hum: –98 dB W.R.T. Maximum Out. Distortion: 0.03% at any level up to full power.

PRICE: £32. 10s. 0d.

SPENDOR AUDIO SYSTEMS

22 STATION ROAD, REDHILL, SURREY. **Tel: Redhill 64772**

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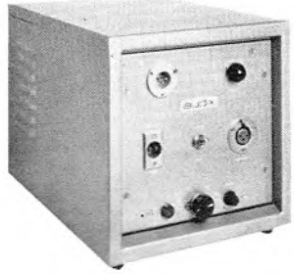

Audix *Studio 80* amplifier.

Richardson semi-modular mixer.

Dag Felner (Feldon Recording) and eight-track Scully.

H/H Electronic *TPA-25* amplifier

transient), 35 W giving 106 dB SPL at 2.5 m. Crossovers operate at 1.5 kHz and 6 kHz, nominal impedance being 8 ohms.

The company is equipped to produce custom-designed mixers based on the *M210* system input amplifier, *M220* line amplifier, *M230* pan switch with two-output amplifiers, and *M240* programme equaliser. All are designed for ISEP frame systems.

A four-track in-line 6.25 mm recorder, the Crown *CX844*, was displayed by **Carston Electronics.** The Crown *IMA* intermodulation distortion analyser was also shown, indicating quantities down to 0.005% on internal oscillators. Crown claimed their *DC300* to be 'the most perfect (?) amplifier available today'. Power bandwidth is DC to 20 kHz ± 1 dB (150 W RMS into 8 ohms), IM distortion at this level being 0.1%, with -100 dB hum and noise. The products of another American manufacturer were shown: *HA10 Mk 2* and *HA660 Pro* headphones by Sharpe. Liquid-filled ear cushions contribute to particularly effective ambient noise attenuation in both models.

Carston are now importing the Altec *9845A* monitor speaker system, handling 50 W continuous power and producing 114 dB SPL at 1.3 m (600 Hz to 2.5 kHz warble).

Compact single-channel versions of the four-band *A301* noise reduction system proved a surprise exhibit on the **Dolby** stand. Suitable for mounting direct into control consoles or tape recorders, the *360* costs £240. This compares with £560 for the two-channel *301*. Scully are now producing recorders with built-in Dolby units. A prototype Dolby *B* unit was also seen, anticipated price being around £100.

Having lately acquired the UK agency for R. A. Moog & Co., **Feldon Recording** displayed a Moog electronic music synthesiser lent by Mike Vickers (ex Manfred Mann), also playing music produced on the instrument by its owner. The synthesiser was unattended during one part of the exhibition and had been reduced to a repeating sqrrrk squawk by a succession of visiting knob twiddlers. By the time we'd finished, it wouldn't even do that. An eight track Scully represented Feldon's staple interest, exhibited with a range of test equipment and the *Complimiter* compressor limiter.

Compact duplicating equipment for cassettes and reel-to-reel tapes were demonstrated by **Fraser-Peacock,** agents for the American Infonics company. The basic cassette duplicator copies up to four tracks of four *C60* cassettes in one four-minute pass at eight times normal speed (38 cm/s for 4.75 cm/s replay). A Teac tape transport is employed.

Visitors to the **Grampian** stand saw the *RA/7* disc cutterhead and amplifiers, *636* spring reverberation unit, *666 Ambiophonic* unit and a selection of microphones. The *PB6/4* mike embodies a preamplifier permitting connection to post office lines.

Stephan Kudelski demonstrated the new miniature Nagra *SN*, a 145 x 102 x 26 mm battery portable operating at 9.5 and 4.75 cm/s (not 19 cm/s as originally stated by the manufacturer). Performance on 3 mm tape at 9.5 cm/s is 60 Hz to 10 kHz ± 2 dB frequency response, 60 dB ASA weighted signal-to-noise ratio (ref. 2% third harmonic distortion). Wow and flutter total ± 0.1% (DIN weighted), with ± 0.5% average speed stability. A 48 x 18 x 10 mm capacitor microphone can be supplied, feeding the 600 μV to 20 mV 200 ohm input. High level input is 560 mV at 10 K. Features include ALC, with meter indication of compression and battery voltage. Crystal speed control, pilot film sync and a capacitor microphone with internal gain control and meter available to order. Remote control facilities are also available.

Sharing the **Haydon Laboratories** stand with Kudelski were the Appel *316* endless cartridge recorder and Sondor sprocketed film sound system.

H/H Electronic displayed their *TPA* series of transistor power amplifiers, prices of which are £75 (*TPA100*), £49 (*TPA50*), and £32 (*TPA25*). The *100* supplies 100 W continuous RMS into 15 ohms at less than 0.2% distortion; power frequency response is 20 Hz to 20 kHz ± 0.5 dB.

As well as producing loudspeakers, **KEF** import Electro-Voice microphones to suit a variety of applications, including the 2.2 m long *643* ultra-directional unit designed for long-distance outdoor sound pick-up.

An eight track **Leevers-Rich** was displayed beside the recently improved two-track *Series E* and *A501* graphic equaliser. The latter unit will be reviewed shortly.

Samples of the new **Miniflux** range of multi-track tape heads were seen on the Lennard Developments stand, including an 8-track *3M-368X*.

Our July issue carried a photo of the Lockwood *LEI/S* monitor loudspeaker but failed to convey its mammoth size. Plans for a demonstration by **Lockwood** were cancelled after difficulties with the Waldorf Hotel staff.

No news was available from **3M** of their *206* tape, an improved brand of *Dynarange*, though a sample has been forwarded for test. A multi-track Mincom was displayed.

Centrepiece of the **Neve** stand was the *BCM 11/2*, a portable system typical of the mixing desks Neve can produce for location recording.

The one request from **Philips** was that we refrain from mentioning the *Pro 36* until the International Broadcasting Convention preview. Details, therefore, on page 379.

Richardson took the opportunity of distributing tape recorder design questionnaires at the exhibition to determine the facilities required by potential customers, and the prices they would like to pay. The company is now producing a range of tape amplifier modules, the *SA170/2* 30 W RMS stereo power amplifier (valve) and its *MA135/2* mono equivalent. A semi-modular mixing system is also being marketed.

Scopetronics displayed a range of tape heads, the *1150* transport and *1151* transistor recorder.

Unexpected exhibit on the **Unitrack** stand was a 24-track console, largest of a series of machines now offered by the company. Facilities include continuously variable speed, dual capstan drive and an electronic tape timer with a claimed accuracy of four seconds in an hour.

A very successful and well-organised exhibition. Most exhibitors wishing to demonstrate their equipment did so without disturbing the neighbours by using headphones and if any complaint is due it is of the Waldorf Hotel air conditioning system—they didn't have one, and the mid-June heat became unpleasant during the two afternoons.

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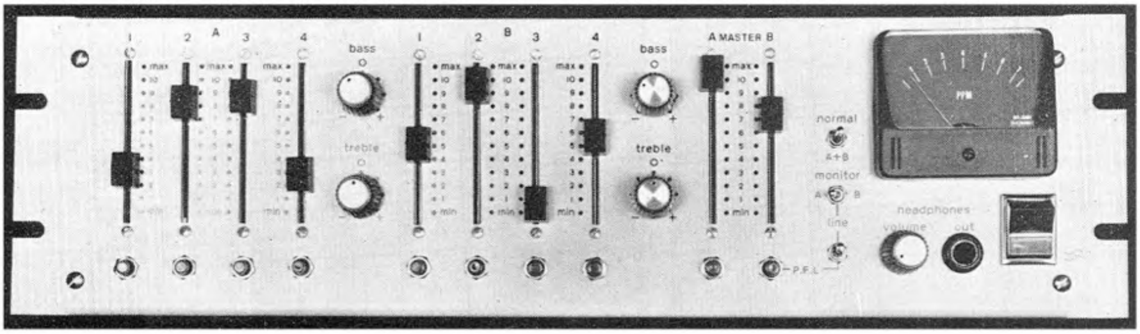

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Ferguson 3232	33 5 0	5 1 10	93 5 0
Sanyo MR929	33 4 9	5 6 10	97 4 9
Sony TC252	33 5 0	5 10 10	99 15 0
Philips N4407	35 0 0	6 13 4	105 0 0
Akai 1710L	36 6 8	6 1 2	109 0 0
Sanyo MR939	38 13 6	6 2 3	112 0 2
Grundig TK247	37 10 0	6 5 0	112 10 0
Sony TC630	66 15 0	11 18 0	199 15 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 TC 130 cassette ...	38 10 0	6 3 4	112 10 0
Ferrograph 722/4 ...	68 16 9	11 6 8	204 16 9
Philips Pro 12	83 10 0	13 16 8	249 10 0
Revox 1122/24	78 15 0	13 2 6	236 5 0

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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

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Telefunken 302TS ...	22 15 0	3 15 10	68 5 0
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FERROGRAPH SEVEN STEREO

By H. W. Hellyer

BEFORE we can find a fault, we must find our way around the equipment. Ferrograph are kind enough to issue what is about the best user's manual on the market; one with each machine. But human nature being what it is, by the time this article is ferreted from the bottom of a dusty pile to check one or two possibly relevant details, the book issued by the makers, despite its hard covers and tough pages, will have been used as a doorstop or a source of paper aeroplanes for the nipper.

One or two drawings might have saved a few words here, but we could easily fill the entire magazine with layout diagrams, so let's imagine first that the *Series Seven* is removed from its cabinet and is standing upright with its rear toward us so that we can see the printed circuit panels.

The layout differs in the mono and stereo machines—and, obviously, in the deck and full models. Last month we showed the circuit of the mono version, the *713*, and this month we should be able to fill in the gaps with a diagram of the *724* stereo model, complete with power amplifiers. (The deck only version is the *702/704*.) On these drawings you will note that the individual sections of the circuitry are dotted in. These sections are each contained on an individual printed circuit board, wired to studs along the edge from a common harness. Perhaps the biggest job of the lot is tracing out wiring with a system like this, and any owner with nothing but the operator's handbook for reference may find life a little difficult when he comes to delve into the circuitry. So I propose to dispense with a circuit diagram next month and publish instead the layout and pin connections of the principal boards, with colour coding of the wires, and their destination where such information may be helpful.

The electronics

Looking at the rear of the uncased mono machine, we have all the electronics at the bottom. Three boards lie horizontally. These are, left to right, the replay, pre-emphasis, and meter and tone control boards. The oscillator board stands vertically facing us and the record board is also vertical, but at the right-hand side. Power unit parts are on the vertical struts, large black heat sinks with the output board spaced off from them, that face us above the main amplifier.

The stereo versions have a slightly changed layout and are not merely mono construction with the second channel added. Instead, we now find the meter board and the replay board of each channel in a neat sandwich on one side. Again looking at the uncased machine with its rear facing us, the boards for the upper track are all at the right side, and the relevant parts of the common boards are also oriented to the same side. So the pre-emphasis board, with twice as many components this time, is again at the bottom centre, the oscillator board again standing vertically with its print side facing us. Of the two sandwiches, the upper layer is in each case the meter board and the replay board fetches up on the bottom.

It is possible to remove the complete amplifier section, to separate it from the mechanism and its power section, but before doing so beware! Although plug and socket connections make life easy, you will find that the usual Ferrograph scrupulousness has made life for the service man a bit more difficult: the head connections, with their screening, are soldered to the record and replay boards directly. This is, of course, to beat the bogey of hum loops. To identify these connections (which will be given in detail next month), remember that the red sleeved cables, as used in the mono machines are 'equivalent mono', i.e., upper channel, in the stereo models. The lower replay connection of the stereo version is white sleeved and the connection to the stereo record lower channel has a black sleeve. After disconnecting these, it is only necessary to unplug the phono connections from the oscillator located along the top of each section, and the nine and fourteen pin plugs from the sockets at top left of the amplifier back. Then the removal of three screws at each side completes the separation.

The power unit section can be completely removed also, and in this case we have only plugs and sockets to contend with: the 14-pin one and the rectangular one at the top of the chassis. But it is a fiddling business, needs great care if the switch by the speed control is to be safeguarded, and requires also that the line sockets be removed. It is easier to slack off the securing nuts and let the sockets dangle than to try to unsolder and resolder in this location, but take care to retain and replace the spacer washers.

Funny thing about these jack sockets. I have many times cussed the necessity to hold panel, washers, barrel and nut in position when replacing jacks in difficult positions, yet retain my loyalty to the old GPO jack. I deplore the remark at the end of a review of the *Series Seven* in the American magazine *Audio* (June 1970) that their only objection to the machine was the use of jacks. For my part, I dislike the phono plug and socket, having seen so many melted inners and rusted outers when machines came in for service. But then, I admit to my prejudice, just as David Kirk must when he slates the versatile DIN plug.

And now, before I stick my neck out any farther, let us take a brief look at the circuit. From the playback head the signal is taken to the base of a low-noise *n-p-n* transistor, *BC154*. The capacitor across the base-emitter circuit and the series 100 ohm resistor are for RF suppression. Readers who suffer from TV broadcast pickup in the replay mode, especially noticeable on some cheaper models, might care to experiment along these lines, remembering that positioning is important. The components must be mounted as near the transistor as possible and must have no stray leads floating around. Even a spare centimetre or so of clumsy wiring here can spoil the suppression.

The signal is coupled capacitively to the second *BC154* and feedback from the collector of this second transistor to the emitter of the first provides the required correction. In our diagram, the speed selection is indicated, and with reference to this, we need only describe one network. Taking the lower leg, which is the highest speed, and supposing that this is the 19 cm/s machine, we find the treble response

(continued overleaf)

TABLE 1

SPEED	TIME CONSTANT	FREQUENCY RESPONSE	19 cm/s MODELS		EARLY 19 cm/s AND ALL H MODELS	
			HF	LF	HF	LF
38 cm/s	35 µS	30 Hz to 20 kHz ±2 dB	—	—	C313	R317
19 cm/s	50/3180 µS	30 Hz to 17 kHz ±2 dB	C316	R315	C315	R317
9.5 cm/s	90/3180 µS	40 Hz to 14 kHz ±3 dB	C315	R317	C316	R315
4.75 cm/s	120/1590 µS	60 Hz to 7 kHz ±3 dB	C313	R317	—	—

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determined by *C316*. This capacitor is 1.5 kpF on earlier models, 2 kpF later and 4 kpF on *H* versions. The extreme bass is affected by the value of *R317*, which is 120 K on the earlier models and also on the high-speed version, while later models of the *M* series had a 150 K in this position.

The phase-shift network across the output of the second stage, (C305 corresponding to our high-speed switching) gives a small treble lift and then a fairly sharp cut-off slightly beyond the required response. This is designed to give protection against RF bias breakthrough and also to reduce the hiss. This component is 0.022 μF in the *M* versions, 0.015 μF in the *H* versions.

We have deliberately left the equalisation network components unqualified in last month's drawing and again here, because the differences between versions and between earlier and later models were nearly all centred around this part of the circuit. Including all the alternative component values would have cluttered the drawing up hopelessly.

Filter network

A couple more components need explaining before we tackle the adjustment of the replay circuits. These are the filter network, R313, C312, across the output of the third stage, at the point where the signal is taken to the replay level control (this is one of the presets under the hinged flap). The end remote from the amplifier appears to go nowhere—or at least to end at pin five of the nine-pin socket. Looking up and to the left we can see the associated plug and note that the connection from pin five goes through the fast wind position of the selector switch to pin two of the rectangular plug, which then goes (eyes right this time) via the corresponding socket to the earth line of the power supply. In other words, this network shunts the higher frequencies from the output when we are fast winding, leaving enough sound for intelligence, but cutting out the screech.

Adjusting and checking the replay channel requires the use of the correct test tapes. It is presumed that head alignment has been done at this stage. Not much purpose carrying out electrical checks until the scene is properly set, the machine running truly, the heads adjusted, the instruments coupled . . . Test tapes suitable for the Ferrograph should be recorded to 32 mM/mm at 38 and 19 cm/s.

I have always found the *Series Seven* to be better than its specification anyway. **Table 1** gives details of the response figures, with the relevant time constants and also the components which affect the high and low frequencies. Now the catch is that these are not adjustable components. They are factory chosen: in the parts lists they are described as 'average value'. If you want to make changes, you have to solder new components across the tags of the replay board. The components are easily identified, being the only ones affixed to stand-off tags. If you are going to insist on that lowest speed, then the component that needs special attention is C313.

A warning is given by Ferrograph about misinterpretation of results on ¼-track machines when replaying a full-track test tape. Fringing flux from the part of the tape between the tracks will cause a bass rise. At 40 Hz this can be +2 dB on the upper track and +3 dB on the lower track. Compensating for this will of course lead to low frequency loss when the machine is once again used in the correct track mode.

The response checks lead us on to the output level tests, and again we have some special precautions. Testing at the highest speed and with the millivolt meter across the 600 ohms output, using the 32 mM/mm tape at reference frequency of 1 kHz, we should get a reading of 2 V, and can adjust by the 'A' preset under the hinged flap.

But—**this is when using a European test tape. There are some other folks across the seas, I am told, who have slightly different standards. Using an American test tape, we must first find the part of the tape that contains the recorded level 4 dB to 6 dB below peak. So, as this corresponds to 0 VU, we now run this section of tape through and correct with 'A' to get, not +4 VU, (i.e. 2 V at the 600 ohms output) but 0 VU as indicated on the Ferrograph meter.**

The obvious snag there is, of course, that we have to rely on the correct setting of the meter, and this is one of the things we shall be concerned with next month, along with bias adjustments, overall response checks (and the recording channel is very important in these models), noise and distortion measurements.

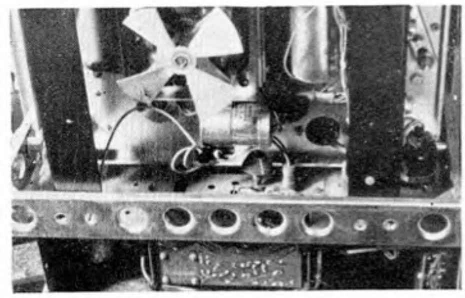

FIG. 2. Rear view of uncased mono Series Seven. Note oscillator board and adjustment knob (something Ferrograph had not thought of!), also phono plugs and multiplugs positions.

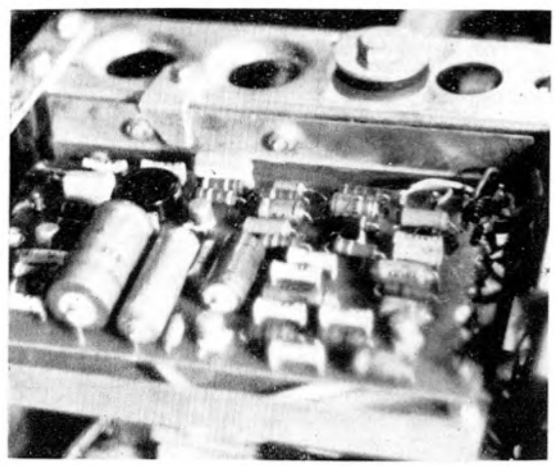

FIG. 3. Close-up of the record amplifier board at the chassis side.

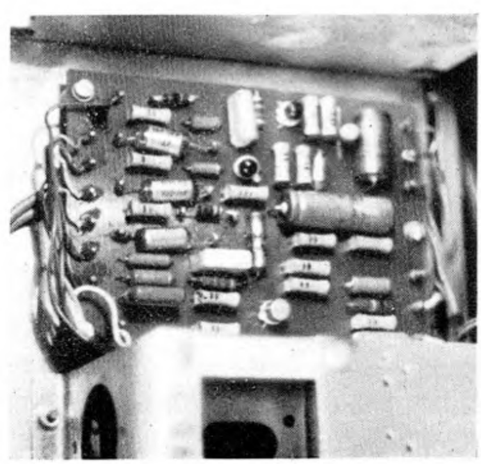

FIG. 4. Replay amplifier board. Note tag fixing of feedback network components.

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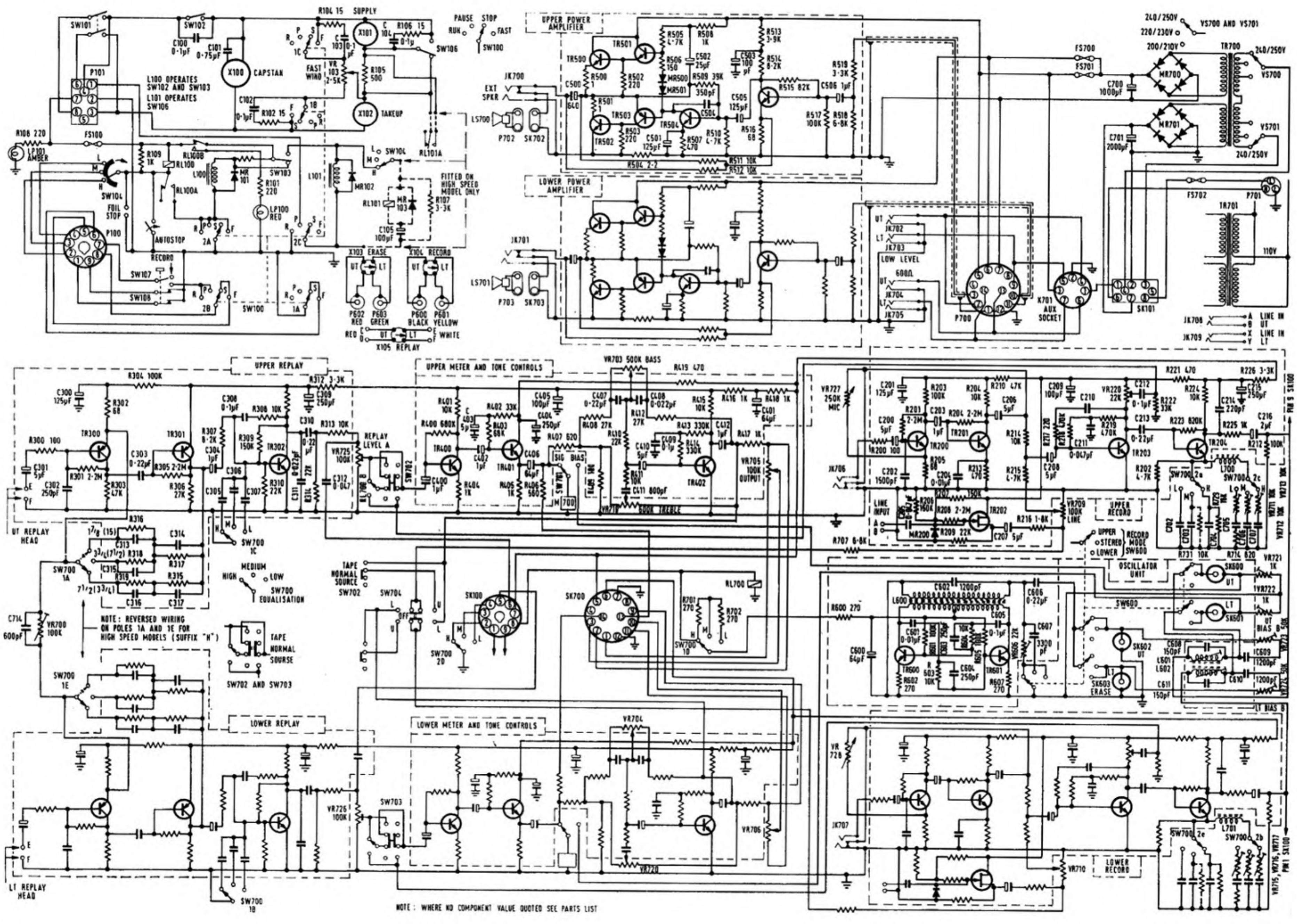
FIG. 1 CIRCUIT DIAGRAM OF FERROGRAPH MODELS 722 AND 724 STEREO (SERIAL No. 70500 ONWARDS)



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equipment reviews

TELEFUNKEN M10

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THE Telefunken M10 was supplied in console form with the tape deck removable for transportation, and in this form it has been taken to mobile recording locations both at the Queen Elizabeth Hall and the Royal Albert Hall (see page 390). It runs at 38 and 19 cm/s and will accept cine and professional NAB spools, and also platters containing 1 km of standard play tape. Two head blocks were provided with the machine, the first mono full-track and the second stereo with a full-track erase head. The electronics for the two head blocks are completely different, permitting separate tape amplifier and oscillator setting up for each block. The mono amplifiers are mounted immediately below the deck with the stereo amplifiers below them, and below this again are the Cannon *XLR* sockets to both the stereo and mono inputs and outputs.

All the amplifiers are on quickly replaceable printed circuit boards. The presets can be reached easily while the machine is running, with the exception of the 80 kHz bias traps on the oscillator board. Although found precisely set, the traps are difficult to get at. Once set, however, they should not need adjustment. The recording amplifier includes level controls for each speed and independent equalisers for adjusting the mid HF lift and extreme top peaking. Whilst the machine was under review, the opportunity was taken to measure accurately the performance of many standard play professional tapes. A wave analyser was connected across the recording amplifier output transformer secondary and I was most impressed by the exceptionally low distortion at recording levels far above any that would ever be used in reality. The tapes tested included some very insensitive old brands in addition to more recent ones on which it is possible to record nearly 10 dB above 32 mM/mm at 3% third harmonic distortion caused by the tape itself. The distortion of the recording amplifier under these conditions was never more than 0.2% total. Distortion of 5 kHz at an exceptionally high recording level was also measured for both second and third harmonics and was again very low. In addition to the level control and two equalisers previously described for the record amplifiers, the replay amps have an LF control with which it is possible to set the playback frequency response to the incredible accuracy of ± 0.3 dB using DIN 38 and 19 cm/s test tapes. The hyperbolic heads provided almost eliminated bass woodles.

The record replay frequency response at 38 cm/s, measured on B & K equipment, was within ± 0.5 dB from 31.5 Hz to 18 kHz. This in itself is astonishing and by far the finest response I have ever measured at this speed. Strangely the 19 cm/s response was even better, never varying by more than ± ¼ dB after carefully setting all the playback equalisers. It must be stressed that the extraordinarily good replay curve is actually better than the claimed accuracy of the test tape, but I am quite confident that, with the flexibility of the playback equalisers, they would reach an equivalent response on other test tapes. This was actually tried at 38 cm/s since my own test tape was some years old. The tapes coincided very closely, with the exception of the 18 kHz band which had approximately 1 dB more output at this frequency than my own, the other test tape being very new. This was easily compensated for with the extreme HF presets and again an almost perfect response was obtained. The playback noise figures were very good—not quite the best that I have ever measured but, since tape noise considerably exceeded playback noise, this is of little consequence. The figures are quoted in the accompanying table for both mono and stereo head blocks. The uniformity of outputs from the test tapes was also extraordinarily good, this being due to the excellent tape tension device on the deck, together with the anti-scrape flutter roller in between the record and replay heads.

SIGNAL-TO-NOISE (dB ref 32 mM/mm) 38 cm/s

	Replay amp	Motors running	Overall (3M 202)
Mono full	70	62.5*	62*
Stereo left	69	66.5	63
Stereo right	63	63	59.5

*Mainly due to hum induced into mono headblock on replay.

Although in Germany the machine is normally used to give a peak output level of −6 dBm, the playback amplifier did not overload until a level of just above +16 dBm was reached. The distortion of the replay amplifier itself was measured with a wave analyser by feeding the output from an oscillator padded down to give an exceptionally low source impedance in parallel with the replay head. The distortion was considerably below 0.1% at any harmonic of 1 kHz when the oscillator was adjusted to give a replay amplifier output of up to +16 dBm. At normal levels the distortion measured was to all intents and purposes purely that of the oscillator.

It must never be assumed that a playback amplifier will not overload as I have in the past experienced several professional machines with replay amplifiers which distort when playing tapes of a very high level, unless the machines are modified. The *M10* can be safely used at +8 dBm for 32 mM/mm and allows the recording engineer to peak some 8 dB above this level with only tape distortion to consider. Most users would of course set the output level considerably below this unless they are using a Dolby system. The push pull bias and erase circuits provide an exceptionally clean waveform and no magging-up noises or even tape bubbling were noticed, despite the machine being continually stopped and started in all modes. It was never found necessary to degauss the headblocks since no improvement resulted when this was in fact carried out.

The range of the bias control was more than ample to cover any tape known by me. On the other hand the 19 cm/s mid-HF record equalliser, even when turned completely off, did not drop the HF response sufficiently for several long play tapes having a particularly good HF response, an example being BASF *LP35 LH*. Although the machine was never designed to be used with such tapes, I contacted AEG in Germany and they agreed to look into the problem. With these exceptions, all types of tape I have tested and used in the last 15 years could have their response brought up to the remarkable overall performance of ± 0.75 dB from 20 Hz to 18 kHz, and several tapes could be equalised to considerably closer limits, BASF *LR56* for instance having a response of ± 0.5 dB between these limits with reference to 1 kHz.

Possibly no greater compliment could be paid to a machine than the recommendation that it can be used for making accurate test tapes and a number of experiments were carried out to determine this. After both the mono and stereo record and replay equalisers had been carefully set up for BASF *LGR30* tape, a full-track recording was made at both 1 kHz and 10 kHz such that the outputs coincided to within 0.25 dB of the outputs of these frequencies from a 38 cm/s mono test tape. I then played the recording on the stereo head block and found that the outputs from the two-channels coincided to within 0.25 dB, thus proving that the full-track record head and stereo replay head gaps were near perfect. The BASF stereo test tape was then played on the full-track head block and the outputs

(*continued on page 409*)

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from both left and right were once again within 0.24 dB. Similarly the stereo record head was checked with the same results. The guard band recording of 1 kHz on the centre of the stereo test tape gave an equally low output when replayed with the stereo head block.

The overall consistency and uniformity of response at high frequencies was particularly noticeable and several very old tapes were bulk wiped and reused on the stereo head block to see if tapes in poor condition weaved over the heads giving an inconsistent HF response. Not only was no weaving of high frequencies noticed but the freedom from dropout was also remarkable. The spooling was excellent even with tapes which spool badly on most other machines, many tapes having the appearance after spooling of being new.

A very slight beat note was audible when recording frequencies in the region of 20 kHz at a speed of 19 cm/s. This was presumably due to a very small percentage of harmonic distortion beating with the bias frequency. This was only noticeable at levels just above the normal levels of frequency bands on test tapes, and was definitely due to the recording amplifier, not the tape. A very minor fault, however, as it never showed up in the recording of music.

The deck itself is very heavy and solid. The manufacturers have obviously considered ergonomics in that the deck is easy to operate from a standing position without any strain on the user's back, even after long periods. It is also pleasant to look at, a surprisingly important factor when one is editing during an entire working day. At the front on the extreme right is an editing block assembly which includes both a tape cutter and an editing groove, although this latter was considered by some operators to be not quite the right shape. At the left front are the transport controls, operating on push buttons controlling solenoids. In between the playback and record controls is the spooling speed control lever, working over an angle of approximately 75° and having three speeds in each direction. The centre position gives a small and equal torque to the tape in each direction. A complete change of direction from fast forward to fast reverse can be obtained in about six seconds without any tape stretch, the tape halting and reversing after about approximately two seconds. The tape position indicator is in the form of a minutes and seconds clock calibrated for 38 cm/s up to 30 minutes after which it goes round again, allowing an accurate timing of long tapes. The clock was set to zero at the beginning of an NAB reel and, after spooling at full speed to both ends, the clock had returned to exactly its original setting, within a fraction of a second. During an entire day's editing, the positions of the clock were frequently noted, and the precise beginning of a piece of music could be found to within an accuracy of one second without the tape output being monitored during spooling—considerably impressing the client whose tape was being edited!

Two tape tension positions are available for both small and large spools. The switch for this, however, together with the deck on/off switch, is located underneath the deck and is accessible only by lifting the entire surround of the deck. These were checked on tension gauges and found to be within the limits specified in the instructions. The hubs on which the spools are placed take small screw-in cine adaptors which screw in to two holes under the deck when not in use, When other than cine spools are in use, a European hub adaptor can be screwed on and a 30 cm platter placed on each hub, locking into place. European hubs can then be used over this, or NAB spools with their adaptors. One slight snag was found with these hubs, this being the occasional catching of the rim of an uneven plastic 27 cm cine spool on the end stop pin of a lever containing guides over which the tape passes after leaving the spools.

Before the tape enters the head path assembly it passes round a stroboscope, through a capstan assembly, over the head block, then over the main capstan, from which it runs round the tape position indicator and on to the right hand spool, tension levers being present just before the tape goes on to either spool.

The tape reaches nominal speed in 200 mS and specified wow and flutter within one second. Fast start is accomplished by means of a second capstan to the left of the head block. At the moment of starting, this is driven by the main capstan. Immediately after starting it is then partly declutched and pulled by the tape itself,

Wow and flutter were checked at several positions along a 27 cm NAB reel. The 38 cm/s figure varied from .02% to .025% peak, weighted to DIN specification. At 19 cm/s the corresponding figure was 0.035% to 0.04%, this being regarded as excellent. A test tape containing a tone of a known frequency showed the speeds of the machine to be accurate within 0.2% and probably better than 0.1%. The ratio of the two speeds was 2:1 to an accuracy of .05%. A further test was carried out by recording 1 kHz set accurately with a frequency counter on the first 30 m of an NAB reel. The tape was then transferred to the opposite hub and played backwards, the frequency being the same to better than 0.1% accuracy. The two extreme differences of tape diameter on the spools therefore caused hardly any variation on the speed of the machine.

The machining of all parts of the deck is obviously accurate and I understand that the capstans are turned using diamond grinding techniques. The tape was very easy to thread over the various guides and the deck pleasant to handle. It was found necessary to set very carefully the position of the left hand pinch wheel to obtain the best results from the two head blocks. Once this was done, either head block could be used at will without any further setting up being necessary. The tape path is very smooth indeed and no marking on the tape was noticed after use.

The speed and equalisation buttons are at the back of the deck, the appropriate button lighting up when depressed as soon as the amplifiers have switched over.

The capstan motor starts running as soon as the left tape tension lever is pulled in when beginning to thread the tape. The lever will remain in whatever position it is pulled to until the start or wind button is depressed. Should the tape break at any time this lever returns to its off position and causes the machine to stop in under two seconds.

One or two small criticisms should be made from an operational point of view. It is possible for pencils or razor blades to fall into the machine through the gap between the deck and the hinged surround, although no damage results. The stroboscope did not appear to be completely air tight and, after a month of use, traces of oxide were present under the glass. It was only rarely found necessary to clean the heads, although this is simple to do, the greatest care must obviously be taken. Some users may well find it inconvenient to have all the input and output sockets on the front, but I understand that they can be placed at the rear to special order. During editing sessions it was found a little tiresome to have to raise the hinged surround in order to change tension when different spool types were in use. I would also have preferred the main on/off switch to have been more accessible. A small meter would have been useful in the amplifier compartment to read erase and bias current, though in normal operation these adjustments would be made by noting the effect on the performance of the tape in use. The machine is large (see spec). Where control room space is cramped, a remote control facility is available to duplicate all the normal functions of the machine. A cue lever is provided though I should point out that the heads are Alfenol, not ferrite, and repeated cueing may reduce head life. (The heads are guaranteed 10 000 hours.)

In general use, the machine gives a recorded quality considerably cleaner than any other machine I have used in the past, and I particularly noted the freedom from distortion on a piano recording I made of Tamas Vasary playing Beethoven's *Hammerklavier* in the Queen Elizabeth Hall at the end of June, with the Dolby *A301* and an AKG *C24* stereo microphone. The quality of the reproduced piano was superb with no audible distortion or wow and only extremely faint hiss in the quietest of passages, almost certainly from the microphone capsule rather than the tape recorder The machine on its own had an exceptionally low recorded hiss level, one particular brand of tape having a replay hiss level 73 dB down from the 32 mM/mm reference level, this figure being weighted to the normal dBa curve. An elapsed time clock is also provided giving the total number of hours that the capstan motor has run. A tool kit and an edit marker are available at extra cost. The 6.25 mm machine can also be provided with a pilot tone head block or a two-channel head block—narrower tracks than the stereo one. A socket on the front is provided for use with pilot tone accessories. The 12.5 mm version is also available fitted with either three or four-track head blocks and the 25.4 mm version with four, six or eight track blocks. A few of these machines are already in use in the UK and I would expect such a machine to do well in the obvious recording boom that is to come with the expansion of local broadcasting.

The manufacturers have offered to loan me the *M10* for a few weeks and I am so enthusiastic about it as to be prepared to show it to any professional recording engineer interested in seeing an outstanding instrument. In the meantime I shall take the opportunity of making myself several test tapes which I can use to judge other machines not quite in the same class.

Angus McKenzie

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'PROFESSIONAL quality at a non-professional price.' This was the stated aim of the Spendor Sound System and I was therefore interested to test a pair of their small monitor loudspeakers with this in mind.

There are difficulties in reviewing a speaker system, as at present it is difficult to measure all the parameters; those we can measure need a lot of elaborate equipment. We know that if a speaker's frequency response curve is really bad, then the speaker will sound coloured, but the converse does not apply: a speaker with a flat response can sound dreadful and some of them do. The impedance curve is important in so far as some amplifiers are fussy about their loading, though except in extreme cases this tells us little about the sound we are likely to get. Distortion curves can also be taken.

These measurements are useful at the design stage as, if a speaker does not sound right, they may indicate the reason. By the time the model is in production, however, what we really need to know is how well it does its job. Here there is no substitute for listening tests. These tests present problems as well, if one is to be fair and accurate. It would obviously be wrong to test in domestic surroundings using domestic equipment a speaker designed for professional use.

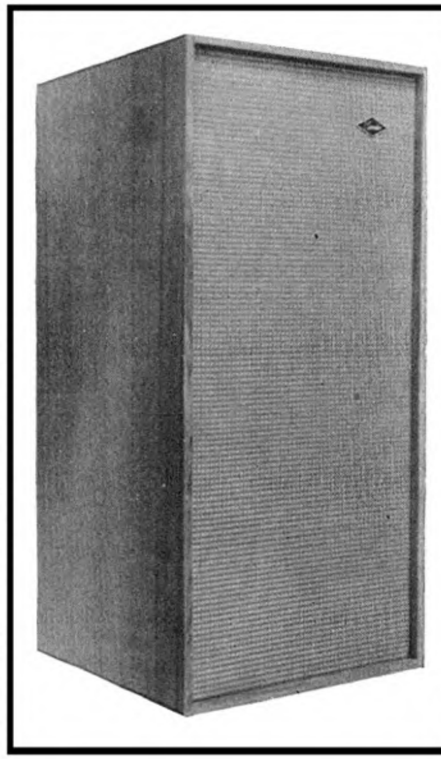
In addition to obtaining the frequency response and impedance curves mentioned above, I used the following equipment to try and make a meaningful assessment of a speaker's performance. Philips *Pro 20* recorder and 38 cm/s stereo master tapes, Quad *303*, AKG *C24*, recording studio with musicians prepared to assist, and a listening room near enough for the original sound to be compared quickly with the sound reproduced from the speakers.

I used the tapes as it is seldom possible to arrange a direct comparison between reproduced and live sound on a wide enough variety of music. Also, if any of the tapes have known imperfections, it is useful to hear if the speakers pick them up.

It is obviously important for monitoring that a speaker should reproduce the signal fed into it. While speakers that mask tape hiss and disc surface noise might be pleasant in the home, they would not be adequate in the studio.

I also fed signals from disc (Decca/Garrard *301*) and from a Quad stereo tuner, so that I could hear the speaker on as wide a range of programmes as possible.

I like to make a comparison with other high



quality monitor speakers, as this can tell a little about the relative qualities of the systems, though this is no substitute for comparison with the real thing. It is easy to fall into the trap of thinking that the speaker system one likes and uses most is the ideal by which all others should be judged—the results of a recent *Which?* report on 'hi-fi' show the dangers of this approach.

Finally I like to invite friends with keen hearing to listen with me and make their comments. It is surprising how often others hear something one has missed.

The Spendor speakers are small by monitor standards having a volume of only 56 litres (two cubic feet) in a 300 x 300 x 600 mm cabinet. The drivers are a specially designed 200 mm unit with a plastic cone and surround, and a Celestion *HF 1300* tweeter. The system has an elaborate crossover and frequency correction network. The speakers can be obtained with their own 20 W amplifiers

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mounted in the cabinet, or without. I understand that no attempt has been made to match amplifier and speaker, the manufacturers claiming that this is not necessary. The cabinets are made of 9 mm veneered plywood, with a small vent.

This design gets away from the thick heavy wood construction in favour of a lighter panel, well damped, to avoid post-transient ringing. The manufacturers claim that a plastic cone has enabled them to overcome several faults inherent in paper construction.

My first impression of the speakers, listening to a tape I keep for the purpose, was of a clear clean sound, particularly in the treble. There was very much more bass than I would expect from a speaker of this size with no sign of 'muddiness'. The test tape contains a variety of items and these are listed together with my comments on the speakers' performance.

Organ. This is a new instrument with a very bright tone and plenty of bass, except that it has no 32 foot stop. Reproduced faithfully with pleasing clarity and just the right 'edge' on the brighter stops.

Folk singer with guitar. No signs of distortion, obviously the transient response is good, though the voice sounded less 'mellow' than I remembered it.

Dance orchestra. The right sort of bite to the brass.

Unaccompanied choral singing. Very clean with no trace of colouration. This is a section where many speakers fall down by giving a 'nasal' quality to the sound which is not true to life. The Spendor speakers were the best I have heard on this section.

Speech. Another testing section. Very natural speech reproduction with no chestiness on male speech.

Piano. Beautifully clear and clean, particularly in the upper registers but slightly lacking in 'warmth'.

Wind Band. Clean and clear as on the other tracks; the reproduced piccolo was the nearest I have heard to the real thing.

String Orchestra. Slightly lacking in 'warmth' for my taste.

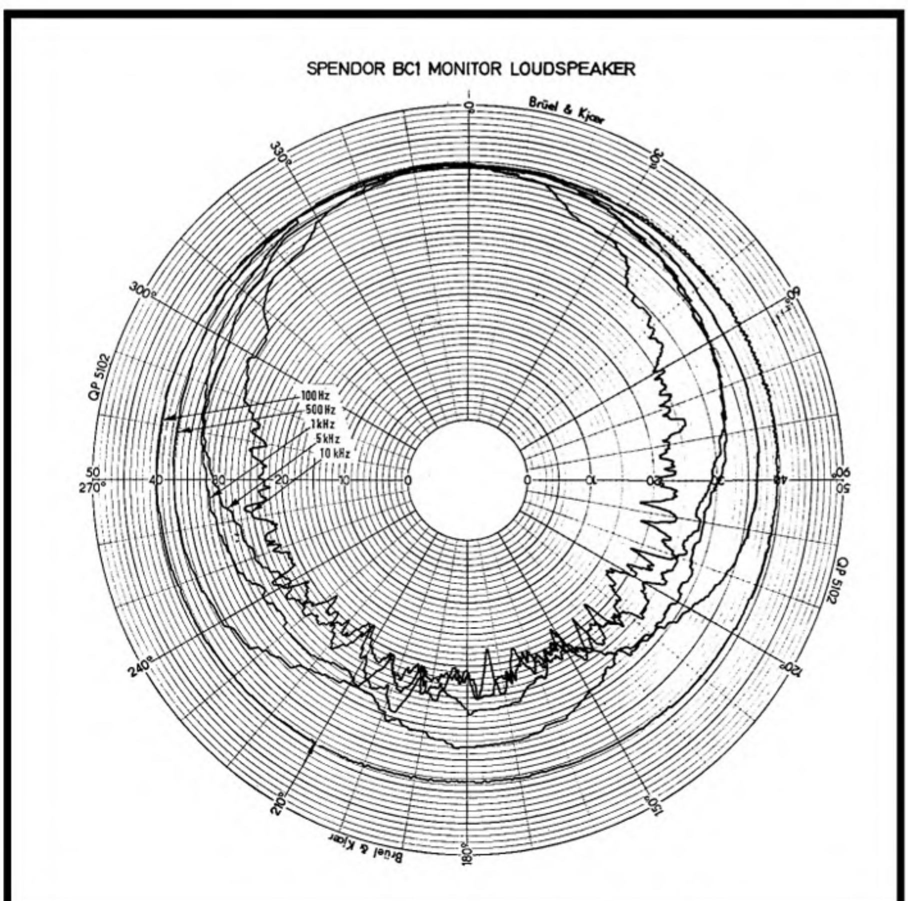
Full orchestra. This is not a very testing section as most speakers cope with it. While these speakers handled the climaxes well, they would not handle enough power for monitoring in a large studio. They would, however, be satisfactory in a small control room or average size living room.

Bells and percussion. Excellent transient response. Extended listening tests using disc and radio inputs as well as tape confirmed my first favourable impressions. If there seemed to be faults in reproduction, they could always be traced to the original source and not the speaker.

I found the Spendors very critical of programme faults though they are not very efficient transducers. The gain setting on the Quad control unit had to be much higher than with other speaker systems I have used.

My comparisons with other high quality

(continued overleaf)



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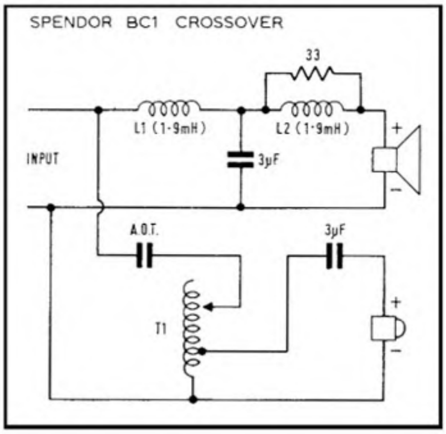

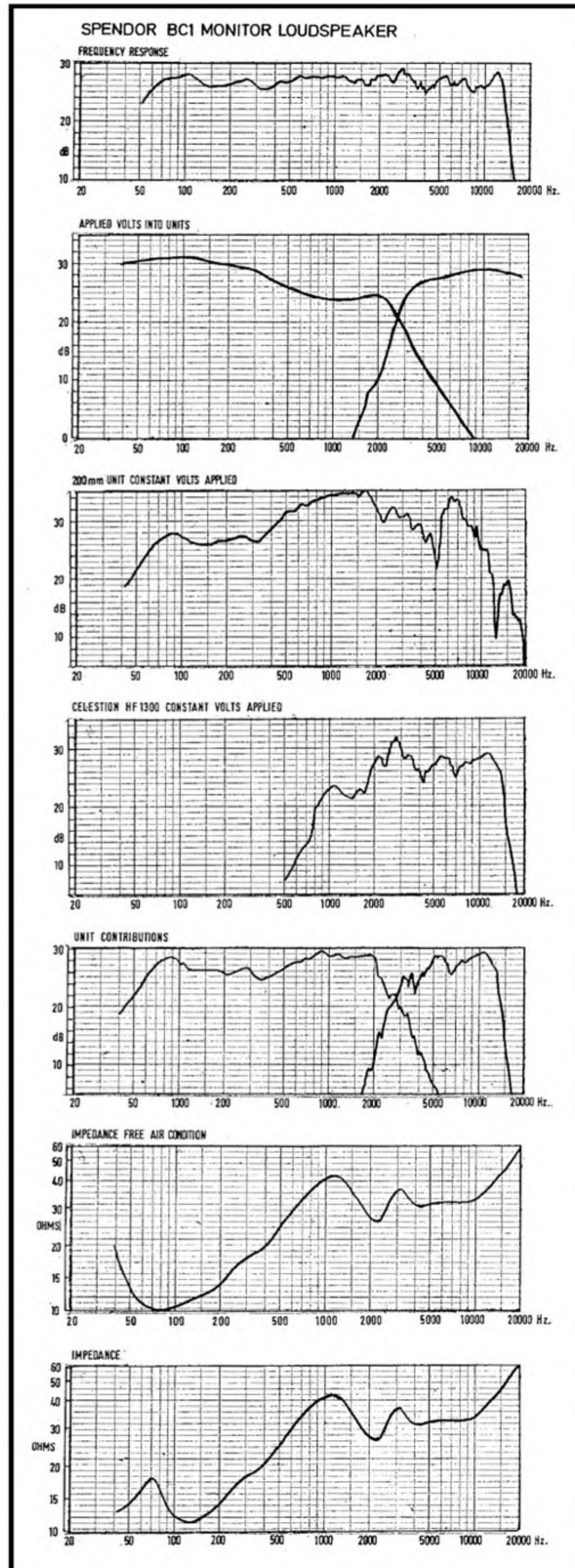

monitor systems, some of them custom built regardless of expense, showed the Spendors to be in the very top class, and in most cases they showed up faults in the other systems.

The frequency response and impedance curves show that this speaker should not have any vices. It is particularly smooth in the middle and upper registers, with a firm bass down to about 40 Hz. It lacks the extreme bass of some larger monitors though this would only be noticeable on rare occasions.

I have used a pair of Spendors for monitoring during recording sessions and find their small size an advantage for location work since they fit easily on the back seat of a car.

Comparison with live sound was the most convincing I have heard. The effect on piano music particularly interested me as I had felt that the 38 cm/s tapes were lacking in warmth, as already mentioned. When I stood close to the *C24* in the studio, I realised that the speakers were in fact reproducing what the microphone was hearing. A little more care in mike placement and switching from cardioid to cottage loaf made all the difference. I have now replaced the piano recording on the speaker test tape with one made in the improved position.

Direct comparison with live speech and other types of music was equally satisfactory and the speakers again showed themselves more true to life than any others I have heard.

The 200 mm units have plates in front with a slit of optimum width to give a better polar response without affecting frequency response. The polar diagram shows how well this has been achieved.

All listening tests were conducted with speakers clear of the walls and away from room corners to avoid as much as possible the coloration that would otherwise have occurred. The Spendors are designed to stand on small tables about 15 cm above the floor. Used in this way the Spendors set a new standard in small-speaker sound reproduction and give better results than many much larger and more expensive speakers. I can thoroughly recommend them to anyone who does not want to listen at painfully high levels.

John Shuttleworth

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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 **OCTOBER 1970** issue must reach these offices by **17th AUGUST 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

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ITN has a vacancy for an ENGINEER GRADE D for the maintenance of a wide variety of sound equipment including mixing consoles, magnetic film and tape recorders, and sound equipment allied to projectors, cameras and editing machines. Applicants should have a good theoretical and practical knowledge of audio equipment and be fully conversant with modern transistor circuitry.

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TECHNICIAN

Applications are invited for a post of technician to assist with an inter-disciplinary Music/Physics project. The technician will be based in the Physics Department and most of his time will be spent in building and maintaining an electronic music studio. A basic practical knowledge of electronics is required and an interest in one or more of the following would be an advantage: contemporary music, computer sound synthesis and control, sound recording and reproduction. Salary will be within the scale £905-£1273 and the starting point will depend on qualifications, experience and age and additional allowances are payable for approved qualifications. Applicants who should be over 21 should write to the Registrar, University College, P.O. Box 78, Cardiff, not later than the 31st August, and quoting reference No. REG8251 giving (1) age (2) full details of any qualifications (3) full details of previous experience (4) the names and addresses of two persons (one of whom should have first-hand knowledge of work or training) to whom reference may be made.

Tape recorder enthusiast required as Retail Dept. Manager. Must be familiar with current trade trends and have some servicing or sales knowledge. Good remuneration. B'ham Tape Recorder Centre, Hurst Street, Birmingham 5. 021-622-2324.

Tape Recorder Engineer required, experienced most makes. Telesonic, 92 Tottenham Court Road, London, W.1. 01-387-7467.

Wanted. Young man to join a team working on audio sound mixing equipment. For further details, salary, conditions, etc., contact Mr. R. Cleverley, Audio Developments, Hall Lane, Walsall Wood, Staffs.

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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.

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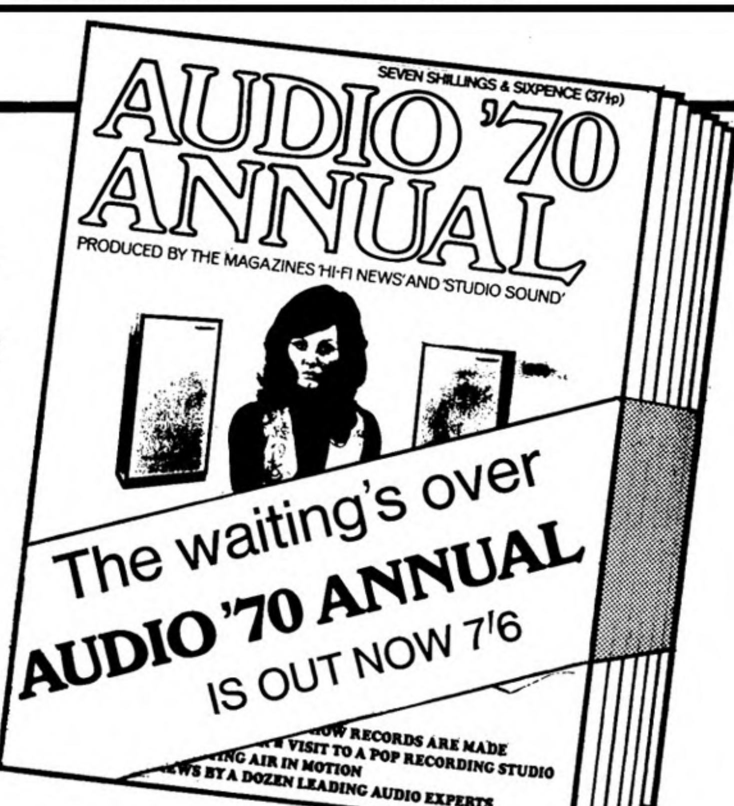

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