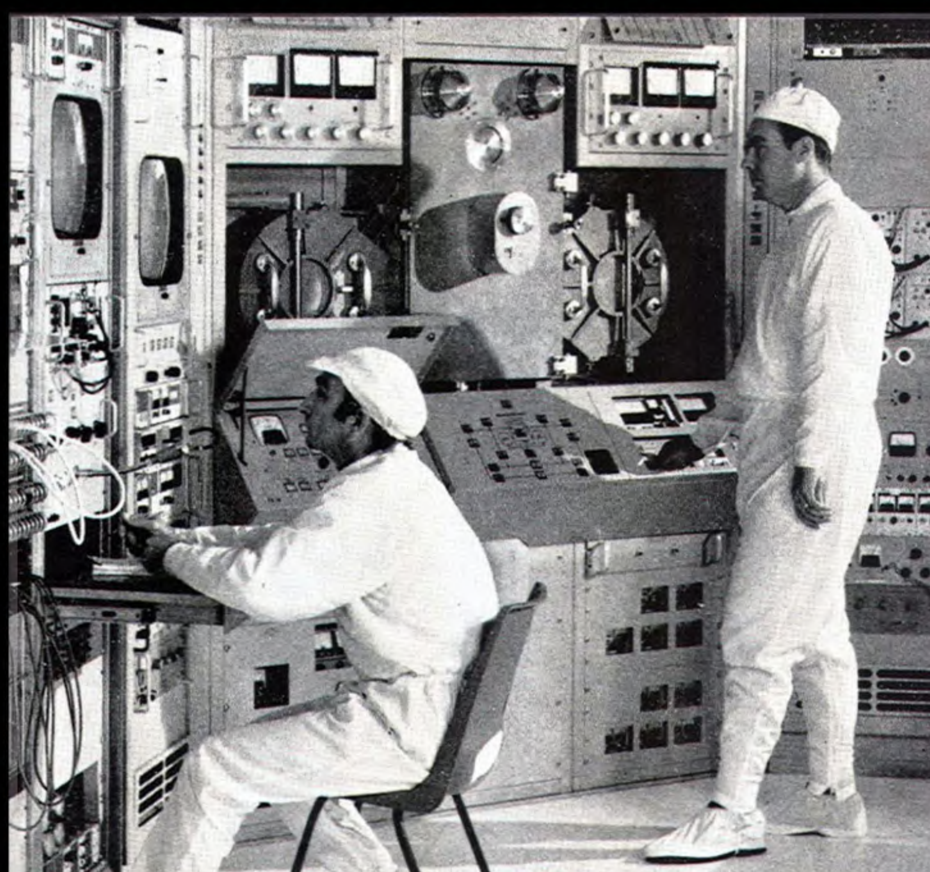
STUDIO SOUND

DECEMBER 1970 3s (15p)



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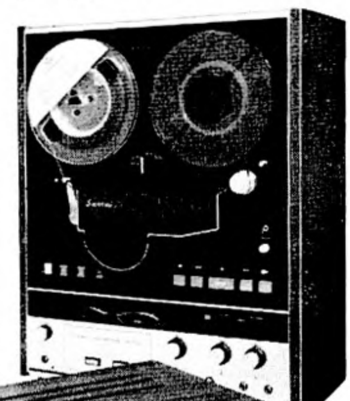

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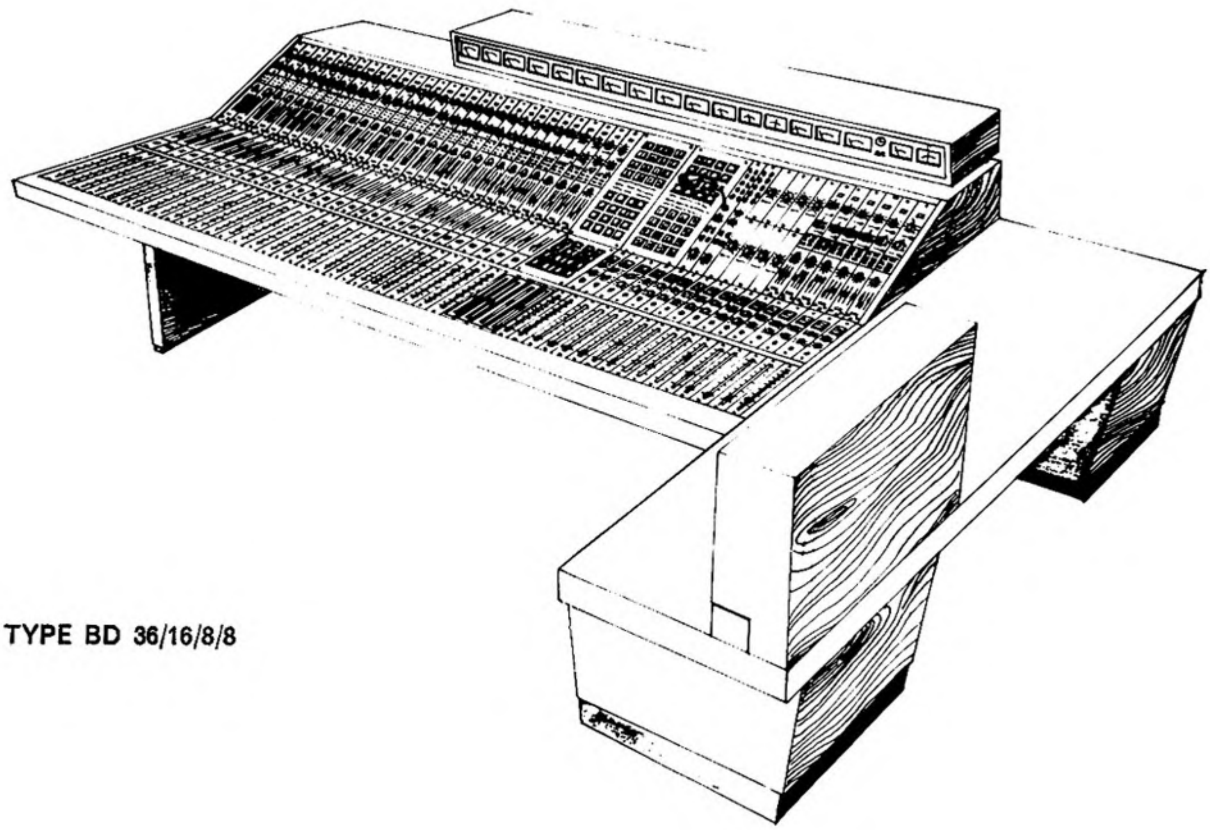

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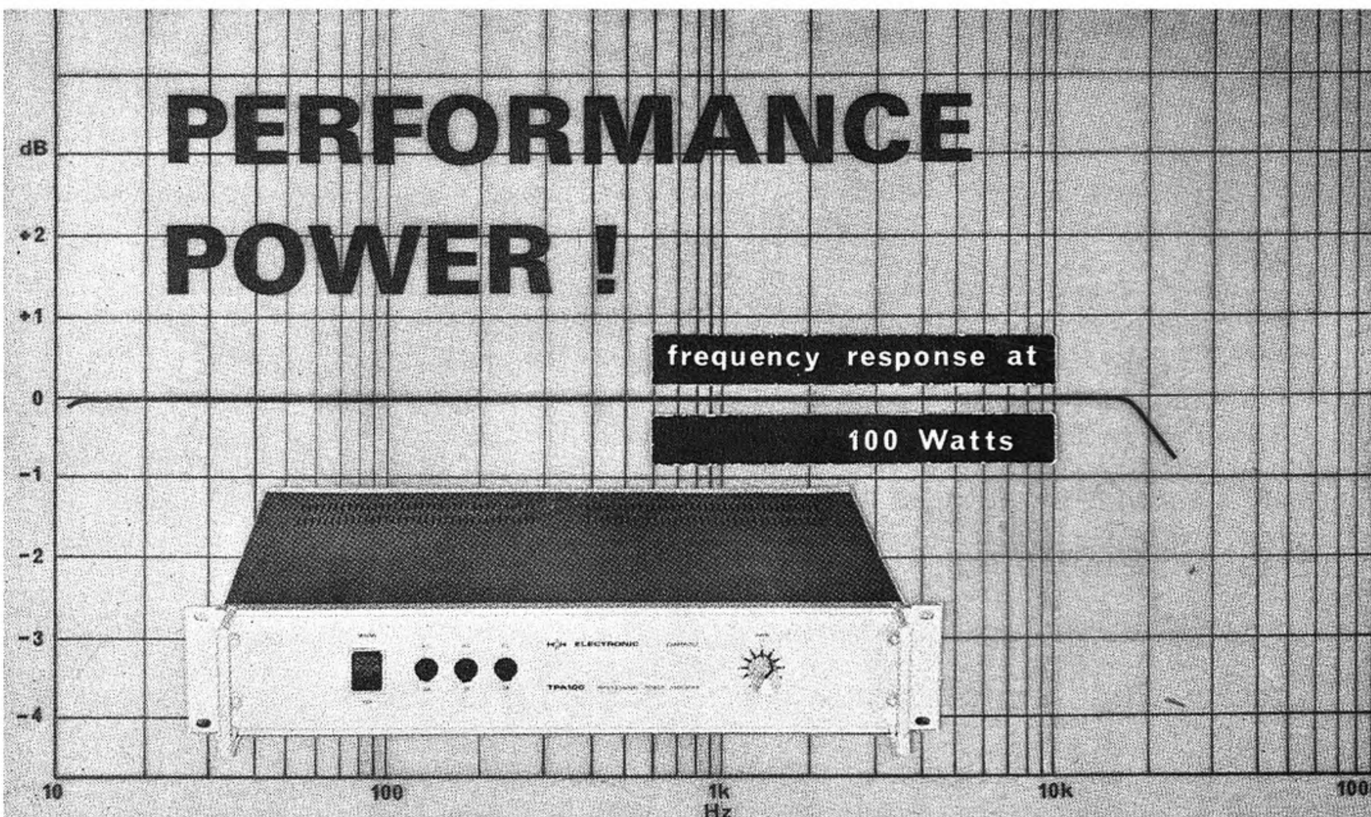

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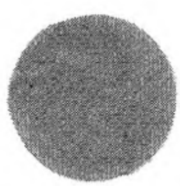

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Studio Sound

AND TAPE RECORDER

DECEMBER 1970 VOLUME 12 NUMBER 12

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COVER PICTURE

The heart of the EVR canned television system, the CBS electron beam recorder produces a 40 mm negative from videotape originals. This unit is situated at the EVR Partnership's Basildon plant, described on page 523.

SUBSCRIPTION RATES

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

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

DOMESTIC TELEVISION recording, the dream of the 1960s, will become reality in the early or mid 1970s. The outstanding question now is which of the many systems currently in development will win the hearts, mind and pockets of the general public? A major step forward has been achieved in videotape systems, entirely overlooked by the general press when Videocassettes were demonstrated recently. The first Sony helical VTR recorded 25 fields per second (skip-field) at 19 cm/s. Their second model (a version of which is tested on page 552) records all 50 fields at 29 cm/s. Both are monochrome. Compare these with the Videocassette's 50 field *colour* at just 10 cm/s and you realise the degree of improvement apparently offered by chrome dioxide tape.

All the recorders mentioned above employ 12.5 mm tape. This width, and the Videocassette's tape speed, drum speed, track angle and electronic characteristics, conform to a recently finalised *Type 1* standard for domestic VTR systems. This has been laid down by the Engineering Industries Association, USA, and is being supported by Philips (with their own Videocassette) and Ampex/Toshiba (with Instavision).

The convenience and fairly low cost of *Type 1* recording casts doubt in our mind on the future prospects of EVR, Selectavision and Videodiscs, all of which were conceived solely as playback media. Gloom was cast over journalists visiting the EVR plant a few weeks ago when, during a question session, price structures were revealed. One thousand monochrome EVR copies of a customer's 60 minute film or videotape master come to around £4 each, which is fair enough. But the final market cost increases to between £20 and £40, they estimate, to cover performing rights, production, and so on. 'And so on' does not include 50% tax which can be expected on telerecordings offered for public sale.

Whatever the medium, the basic cost of a video recording is unlikely to fall much below £4 and even if it reached zero, would we still have to add a minimum of £16 to cover artists and middlemen? If so, the only possible future for such recordings is library rental. Programmes will have to be very much better than broadcast television to warrant their cost, which introduces the problem of competing with the BBC and ITV. The longer you consider the problem, the more you realise that domestic videotape can probably only survive its teething years as a method of preserving broadcast material. It is easy to criticise the generally low standard of broadcast programmes, but this makes the occasional gem all the more worth keeping.

The domestic applications of a home-bound television camera are miniscule. Ampex/Toshiba's concept of a fairly lightweight battery-portable system, supplied with a power unit for indoor operation, has a far greater appeal than 40 kg of chassis and mains cable.

Further details of Avco's Cartrivision system are now to hand. This involves a unique form of field skip, scanning every third field. 12.5 mm tape runs at 10 cm/s in a rectangular cartridge. Avco technical wizardry has resulted in a rental cartridge for one-time viewing, which can only be rewound by the dealer. Not the most appealing idea. Negotiations have been completed with motion picture producers for the release of recorded films on a hire or sale basis, though the only prices so far quoted relate to blank cartridges: $10 for 15 minutes to $25 for two hours.

Meanwhile, broadcast videotape systems grow increasingly versatile. An electronic editing control unit announced by Datatron, USA, provides digital indication of elapsed hours, minutes, seconds and individual frames. Suitable for quadruplex or helical VTRs, their Vidicue *5000* virtually allows the editor to dial the start and stop points of a video insert, controlling a recorder and two players simultaneously. The concept might eventually be applied to audio, provided a spare track is available to carry the time code.

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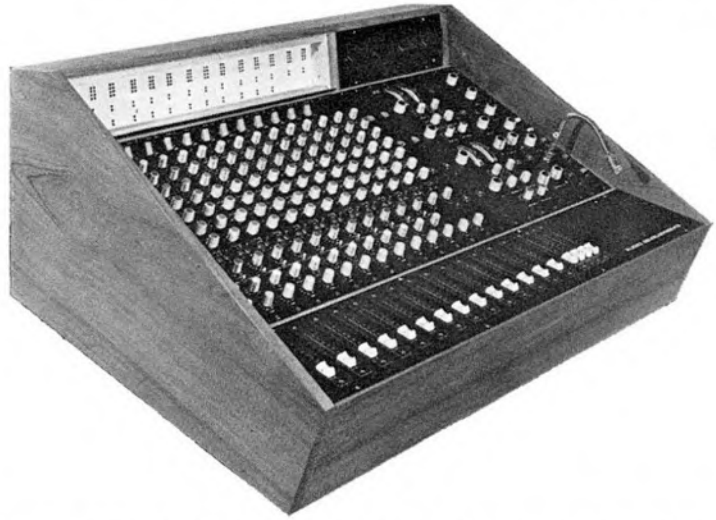

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studio diary

Studio Control Consoles were discussed by A. R. Neve and G. A. C. Watts (Rupert Neve & Co) on November 12, and will also be covered by R. W. Swettenham (Helios Electronics) on November 19. Other talks comprise *Microphones* (H. D. Harwood BBC Research, November 26), *Microphone Techniques* (R. S. C. Gundry, BBC, December 3), *Radio Microphones* (G. Blundell, Audio Ltd, December 10), *Studio Control Consoles* (P. Harris, Cine Tele Sound Studios, January 14), *Master Tape Recording Machines* (J. Robinson, Ampex GB Ltd, January 21), *Noise Reduction Techniques* (Dr R. Dolby, Dolby Labs, January 28), *Sound Effects* (H. D. Briscoe, BBC Radiophonic Workshop, February 4), *Monitor Loudspeakers* (R. E. Cooke, KEF Electronics, February 11), and *Signal Level Monitoring* (D. P. Robinson, Dolby Labs, February 18). A forum will be held by Ralph West on February 25.

LOW COST CASSETTE DUPLICATOR

B & A SYSTEMS, situated in Harrow, have developed a low-cost cassette duplicator operating at four times nominal speed. The system will copy up to four channels simultaneously on eight cassettes and is distributed by Audio Advertising, 21 Vaughan Road, Long Ditton, Surrey. AA themselves offer a cassette dubbing service.

UNITRACK FOLD

THE VOLUNTARY liquidation of Unitrack Equipment Ltd was announced in mid-October. Formed in May 1969, the company developed a range of studio recorders and recently delivered a 24-track to Morgan. A 16-track was supplied to Helios Electronics for installation in the Rolling Stones' mobile studio.

3M TAPE PRICES

SCOTCH DYNARANGE *202* 6.25 mm audio tape is now being marketed by 3M on a newly designed lightweight 27 cm NAB aluminium spool. Unit price is £2 13s in minimum quantities of 10 reels under catalogue number *202-½-2500 RO.* 3M wish to point out that the £2 8s price quoted for larger quantities in last month's Tape Survey was given to us in error, being actually £2.8 (£2 16s).

MODERN SOUND STUDIO TECHNIQUES

A COURSE OF lectures under the above heading is now running at the Northern Polytechnic, Holloway, London N.7. Organised by the Department of Electronic and Communications Engineering, the talks are being given on Thursday evenings from 6.30 to 8.30 pm.

CHROME TAPE IN SONY LOW-SPEED VIDEOCASSETTE

A COLOUR VIDEOCASSETTE recording system designed for the home was demonstrated in London on September 28. Developed by Sony, it employs 12.5 mm chrome dioxide running at 10 cm/s in a cassette package the size of a small book. This plays for up to an hour and may be extracted in mid-reel from the recorder without rewinding. A twin head helical drum records and reproduces the video signals, and two audio tracks permit either stereo sound, spoken cues or a bilingual commentary. Audio and video quality at the demonstration were very good by domestic colour standards. Sony expect to retail Videocassette players at about $400 in the USA, and 60 minute cassettes at $20. UK prices could prove subject to purchase tax, in which case the system may initially be restricted to education and industry.

Sony are gearing themselves to duplicate Videocassette records for eventual hire or outright sale. Initially they will dub on a 1:1 basis but work is progressing on a thermal-contact high-speed duplicator.

Videocassettes will be marketed by Sony from 1971, assuming that agreement is reached fairly soon between VTR manufacturers on a domestic recording standard.

AMPEX MINIATURE DOMESTIC VTR

A BATTERY PORTABLE video tape recorder has been developed for industrial closed circuit and home television markets. The *Instavision* tape unit, measuring 279 x 330 x 114 mm, is being manufactured in Tokyo by TOAMCO, a joint venture with Toshiba. It was designed by the Ampex Educational and Industrial Products Division, Elk Grove Village, Illinois. Recording medium is a 12.5 mm tape enclosed in a 117 mm x 18 mm circular cartridge lasting up to 60 minutes. This will conform to the EIA Type I standard, including stereo sound facilities. Automatic loading, extreme operational simplicity and relatively light weight are features of the system, which will be marketed in the USA and Europe towards the end of the year.

Price of a colour recorder/player is expected to be around $1 000, $900 for a colour player or monochrome recorder/player, and $800 for a monochrome player. Any model may be modified for colour or recording capability after purchase by adding plug-in modules. A companion monochrome camera will be offered at $400, including 'standard professional quality zoom lens' and CRT viewfinder. Ampex confirm that even these prices are likely to fall as increased demand permits higher volume production.

NEXT MONTH

AN INEXPENSIVE circuit converting VU meters to register peak modulation is described by Michael Naylor. John Fisher looks at tape as a tool for the musician and David Kirk visits Command Studios.

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at 3¾ and 7½ ips ensuring maximum speed constancy.

Fully comprehensive mixing facilities.

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

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

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

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

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

CONTACT: BRIAN ENGLISH

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Tel: 01-242 9944

INSIDE EVR

David Kirk visits the EVR partnership's processing plant at Basildon

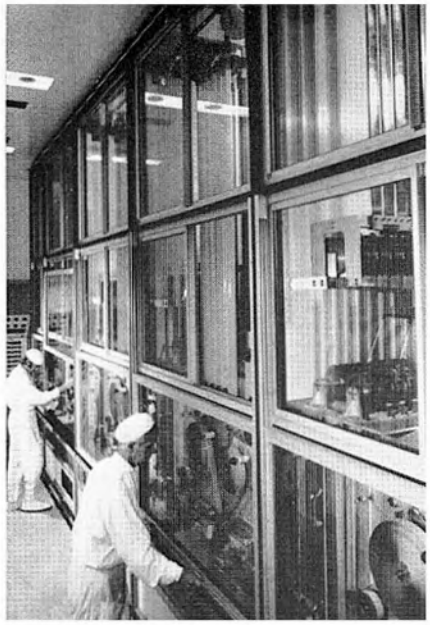
ELECTRONIC video recording was conceived in 1965 by Dr Peter Goldmark, President of CBS Laboratories Division, and has been developed into a practical system by CBS in conjunction with Ilford Films Ltd. EVR is essentially a low-cost telecine medium, using a specially developed fine-grain silver-halide film with two magnetic audio track coatings. Monochrome television recordings occupy half the film width and may be compared with $\frac{1}{2}$-track mono audio tape, except that both programmes run in the same direction. Colour programmes may be equated with $\frac{1}{2}$-track stereo since one frame track carries luminance and the adjacent track carries chrominance for each video field. The superfluous audio track in colour operation can be used to carry commentary in a second language, stereo or cue data (there are plans to introduce a Broadcast EVR system in due course).

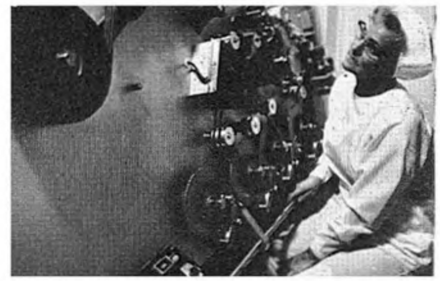
Sir Francis McLean, technical director of the EVR Partnership (and formerly Director of Engineering, BBC) compares the system with Peter Goldmark's earlier invention, the LP gramophone record. The latter gave an eight times improvement in audio packing density over the 78 rpm disc. EVR provides a 10 times reduction in storage area against 16 mm cine film and, as demonstrated to the technical press in September, superior picture quality. Film width is 8.75 mm and its length, in a standard 18 cm diameter cartridge, is 230 m. This plays for 30 minutes per track at a continuous linear speed of 12.7 cm/s. There are no sprocket holes though an equivalent 50 Hz sync pulse is printed between the frame tracks.

A factory producing EVR playback units has been established in the UK by Rank Bush Murphy Ltd. The players are expected to cost about £360 when marketing begins in January 1971. The heart of each unit is a small high resolution CRT, the flying spot scanner in fig. 2. This generates a plain raster which is focused on to the two frames by a double optical system. Light passing through the film is collected by a pair of photo cells and amplified into luminance and chrominance signals respectively. A major benefit is achieved from splitting colour signals in this way since even the chrominance data can then be recorded on relatively cheap monochrome film. A third photo cell picks up the sync signal and compares this with 50 Hz mains to maintain constant drive speed. Two raster forms are available in the EVR player, appropriate to motion picture or single-frame viewing. EVR differs in this respect from the theoretically simpler arrangement used in experimental thermoplastic video recording; there the recording head scans in only one plane, the opposite plane being supplied by the linear film motion.

Film, quadruplex or helical tape

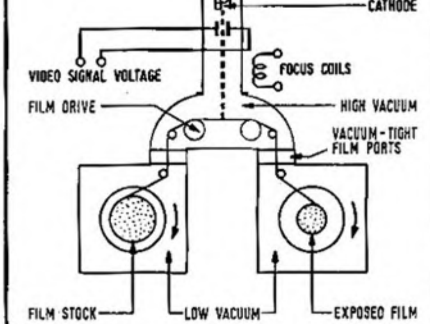
The EVR Partnership's Basildon plant is equipped to process film from quadruplex or 25 mm Ampex helical videotapes, 35 mm or 16 mm film. Customers are being quoted around £4 per 60 minute monochrome cartridge in runs of 1 000 units. In the Pre-Mastering Area, customer material is optimised and copied on to a 50 mm Ampex quadruplex VTR. This master tape is then fed to the Electron Beam Recording Area, a separate building operating under strict conditions of cleanliness. Film canisters are washed ultrasonically before entering this area, production staff and visitors are dressed in almost all-embracing overalls, and the air-conditioning system is complemented by isolated areas of extreme cleanliness enclosed in laminar-flow air curtains.





Above left: High-speed printers.
Above right: Master electron beam recorder.
Lower right: Slitter/reeler.

FIG. 1 BASIC COMPONENTS OF THE CBS ELECTRON BEAM RECORDER

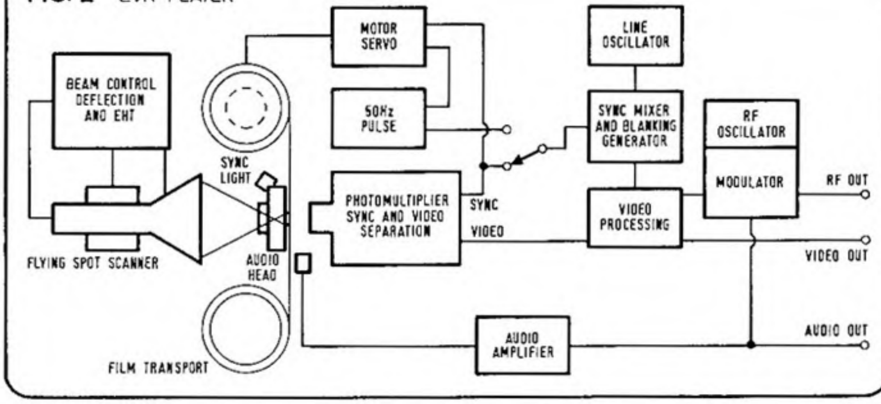


All EVR master films are produced on an electron beam recorder manufactured by CBS. A complete installation is now operational at Basildon and space has been left to accommodate a second system if demanded. The EBR operates in real time, inevitable since it is fed by a VTR, but produces a 40 mm master negative carrying eight EVR tracks suitable for eight monochrome or four colour programmes. Fig. 1 shows the basic components of the recorder, the EVR equivalent of a master disc cutting lathe. A high degree of vacuum is required during film exposure since the electron beam scans direct on to the photosensitive surface. This overcomes definition loss which would occur in a phosphor/glass screen face, permitting a 2.5×3.35 mm image size. Picture elements measure about 4 μm. The high energy content of the electron beam permits a much finer grain emulsion than would be possible for normal optical work. A film with high electrical conductivity proved essential to diffuse electrostatic charges created by the electron bombardment.

The master negative is developed and loaded as an endless loop into a high speed contact printer. Several hundred prints may be exposed in a typical run on an automated unit developed and produced by Ilford. Large reservoirs of film are held, to be partially drained while the operator loads fresh film supplies. The print stock is exposed by ultraviolet light and may safely be handled in daylight conditions. Sound is added to the print at this stage, supplied by a 12-track Sangamo

(continued overleaf)

FIG. 2 EVR PLAYER



tape player. Eight tracks are available for audio, the other four carrying cue data to synchronise with the video negative.

The printer runs at four times normal playing speed, exposing 32 frames at each traverse (four frames in each of the eight tracks). Film for a 60 minute cartridge is thus produced every 30 seconds.

Exposed prints are developed and transported to the Slitting/Reeling Area. It arrives in 35 mm widths (4 × 8.75 mm), the master negative being 40 mm wide to accommodate drive sprockets. Both the printers and slitter/reelers are being supplied by Ilford to the CBS/EVR plant at Rockleigh, USA. The films are chemically cleaned, then slit and wound on to plastic reels. A spring pulls the upper and ower spool flanges towards each other. They are held apart by a short leader made from stiff plastic rather wider than the film. If a reel is treated sensibly, virtually no dust can reach the film area. The EVR player neutralises the spring and laces the leader automatically beneath a plastic dust cover.

Why magnetic audio tracks rather than the more obvious optical system? Two reasons: firstly magnetic stripe offers superior quality, particularly important considering the low playing speed; secondly the buffer action of the edge coating prevents the film surfaces scratching against each other.

Compared with helical videotape and conventional cine film, EVR offers a stable, quiet and inexpensive format for educational, industrial and broadcast video programmes. It is not envisaged as a home entertainment system for the immediate future since programme rights and marketing profits will push the £4 unit copying charge for a telecartridge up to a selling price between £20 and £40. CIBA, ICI, The Carborundum Company, S.B. Modules, BBC TV Enterprises, Stockwell College, Harlech TV, Flying Spot Productions, EFVA, Gateway Educational Films, Granada and Grampian TV are among the organisations and companies already committed to EVR and whose programmes will be available for hire (at around 30s) or outright purchase by January 1971. The present state at Basildon is one of stockpiling films and encouraging potential customers. A clear indication of the market initially anticipated exists in the EVR catalogue of telecartridges, divided into sections for Schools, Further Education and Teacher Training, Medical and Management Training. For the home consumer, the cost appears daunting. Considerable saving in the price of a teleplayer can be achieved by incorporating the transport in a TV receiver and the prospect of an EVR library, with rental charges significantly less than 30s, might successfully tempt the public. As a medium for storing or purchasing the printed word, EVR film is very much cheaper than paper.

A HIGH QUALITY MIXER

David Robinson

PART SEVEN

VISUAL MONITORING CONTINUED

As is often the situation, the text for Part 6 was finished a few days before copy date and the last section had to be held over to this part. So, after promises for two months, the PPM circuit can now be described !

The meter drive amplifier (fig. 41 last month) is also used in the PPM circuit, but this time it feeds a transformer which in turn drives the non-linear network which produces the logarithmic scaling of the PPM (fig. 42 last month). It also provides rectification on both positive and negative peaks. Diode D3 compensates for the V_{be} drops of Tr1 and diodes 1 and 2. Thus, as soon as the audio signal is applied, a DC component is produced on C1 ; there are no forward biases to overcome before a meter reading can be registered.

Tr1 and 2 function as a volts-to-current converter ; Tr2 emitter current is directly proportional to the voltage on C1, which is proportional to the studio signal. This current flows initially entirely through the meter but, as the signal level rises, the current is diverted from the meter circuit by the non-linear network.

The specification is very tight on a broadcast PPM and care must be taken in setting the circuit up if this spec is to be met. The prototype met all the performance figures except at figs. 1 and 7, where the errors were 2 and 1 dB respectively, which is perfectly acceptable. Errors at the other points were typically 0.1 dB where the allowed tolerance is 0.3 dB. Setting up is simple provided there is a meter calibrated in dB available ; the accuracy of this will obviously determine the final PPM standard.

1) Initially turn all potentiometers to the lowest voltage setting on the sliders (clockwise on PCB).
2) Feed in 1 kHz to deflect to the 2 mark.
3) Increase by 8 dB and adjust RV1 for a reading of 4.
4) Repeat 2 and 3.
5) Increase by 4 dB, and adjust RV2 for a reading of 5.
6) Increase by 4 dB, and adjust RV3 for a reading of 6.
7) Repeat 5 and 6.
8) Check the reading of 7 is 4 ± 0.5 dB above 6 (R11 controls this, but has small effect on 6 as well).

If equipment is available, the decay time (from 7 to 1 takes 2.5 to 3.2 seconds) and attack time (a 5 mS burst of 5 kHz deflects to 5 ± 0.75 dB, relative to 6 for steady tone can be checked.

Fig. 44 shows a method of producing the necessary dB steps to the required accuracy. 1% resistors should be used except where marked otherwise but, if these are not available, 5% tolerances will give an acceptable result.

Working on the supposition that, once initial balancing is completed, incorrect modulation on either stereo channel will call for an equal level change in both channels to preserve that balance, a significant economy can be made on the PPM circuit described. A single meter can be used to register the greater peak of either left or right channel ; the balancing requirement is met by switching either left or right channel off, leaving only the other channel registering. **Fig. 45** shows the method used. The PPM circuit works on a rectified DC signal ; consider first the case of all the signal present in the L channel. Diodes D1 and D2 conduct and a corresponding DC voltage is set up on C1. A signal can then be introduced into the R channel, and its amplitude gradually increased. Initially diodes D8 and 9 are reverse biased and do not conduct. As soon as the amplitude is greater than that of the L channel, the diodes can conduct, charging C1 to a higher potential, and so a higher reading occurs. The L input can be removed at this time without affecting this new meter reading.

FIG. 43

Ernest Turner *642* VU

This technique saves money but is limited to stereo, or perhaps quadraphonic, recordings. Multichannel work still requires a meter for each channel.

Components D8, 9 and R14 are best mounted on tags. Another method is to use a printed circuit card similar to the PPM circuit card with most components omitted. This is expensive but may have advantages.

I have been asked to explain the difference between this new circuit and the 1964 design. This latter suffered from the great disadvantage that the characteristics were too dependent on meter resistance and diode characteristics, both of which vary considerably ; the result was very difficult setting up with the law controls being very interdependent. The new circuit uses higher value resistances and is therefore less dependent on these elements. The non-linear characteristic is determined by reference to a stabilised voltage (produced by the zener) which gives sharper and more calculable breakpoints in the transfer curve.

A useful circuit incorporated in the prototype and retained in this version is an indicator to give a visual warning of an unusual situation in the mixer, which could cause a recording to be unsatisfactory.

Fig 46 shows the flashing circuit which drives a red panel light on the mixer to indicate some sort of a fault condition. For example, if a recording is started when the tape-to-studio is pressed, a sound picked up by the microphones will be played back to the

(continued on page 527)

SPENDOR AUDIO SYSTEMS

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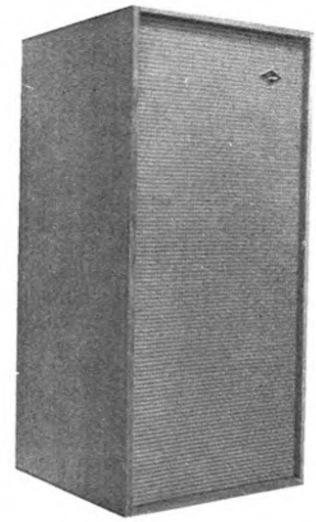
THE BCI
A top quality medium sized, professional monitoring loudspeaker system. The BCI has a more accurate reproduction quality than almost any other, irrespective of size.



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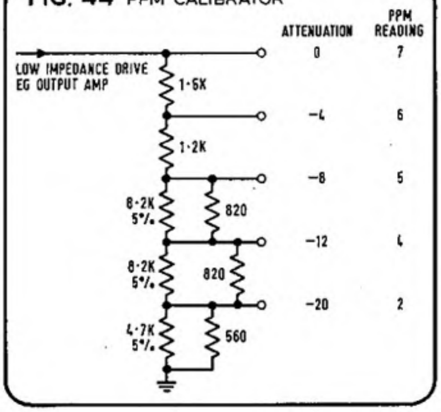
22 STATION ROAD, REDHILL, SURREY. **Tel: Redhill 64772**

performers a fraction of a second later when the tape passes the playback head. This in its turn will be picked up and echo is recorded on the tape. The loop gain is greater than unity, the echo will build up until it overloads the tape. The lamp is linked to the tape key so that a clear visual indication is provided to lessen the likelihood of this happening. On the prototype this facility was used for the oscillator, tape-to-studio, and talkback circuits, although it can be used for any other circuit if necessary, provided a separate switch is available for each function. Some of the lever switches had no spare ways left after the signal switching was done, so a small microswitch was ranged under the operating bar of the lever.

The circuit used for the flasher is a multivibrator type, also known as the Eccles-Jordan circuit after the designers who built the valve original. Square-waves are produced at the collectors of the transistors and, since a square-wave is very rich in harmonics, this circuit is used in electronic organs ; filtering and recombining will produce the tone colours characteristic of such instruments. The operation of the circuit can be described, simply as follows, assuming for the moment that Tr2 and 3 are taken as a single transistor.

Take the moment immediately after Tr1 has switched off and Tr2/3 have just switched on. The collector of Tr2 and 3 has just moved from the supply voltage, + 6 V (corresponding to no current in the lamp) to almost zero volts (full current through the bulb). This swing in voltage was passed directly through C2 on to the base of Tr1 which is thus cut off. C2 then attempts to charge up to +6 V, through R2,

FIG. 44 PPM CALIBRATOR



other. C1 then charges up slowly towards the supply voltage via R3 and the process is repeated. The cutout is a square wave and the two time-constants, C1/R3 and C2/R2, are chosen to give a rapid flash from the bulb, which is a 6 V 40 mA Post Office type.

Two transistors are used in the compound arrangement to produce, in effect, one with a very high current-gain so that the bulb can be driven to the maximum brightness without unduly loading the circuit. The average current taken by the circuit is 23 mA. If only two transistors were used in this configuration, instead of the three, the current demanded would be 40 mA. The resistor R5 is used together with the zener diode ZD1 to produce a relatively stable supply of 6 V from the main +24 V rail and the other resistor R4 is added across the bulb.

FIG. 45 SINGLE METER FOR STEREO USE

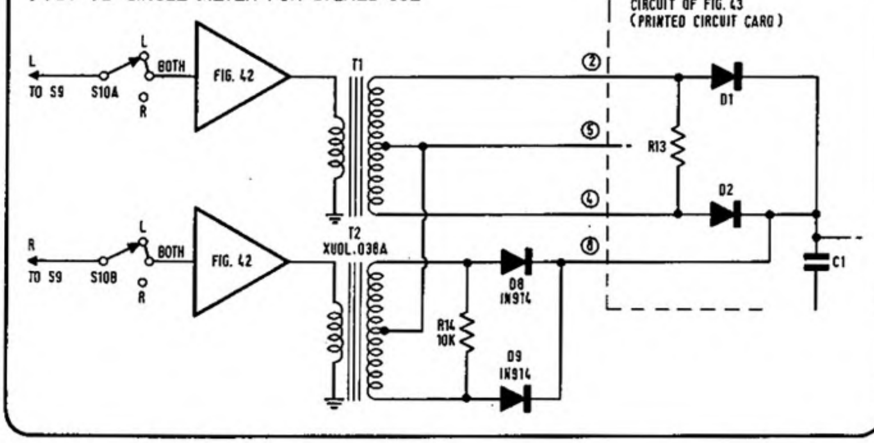
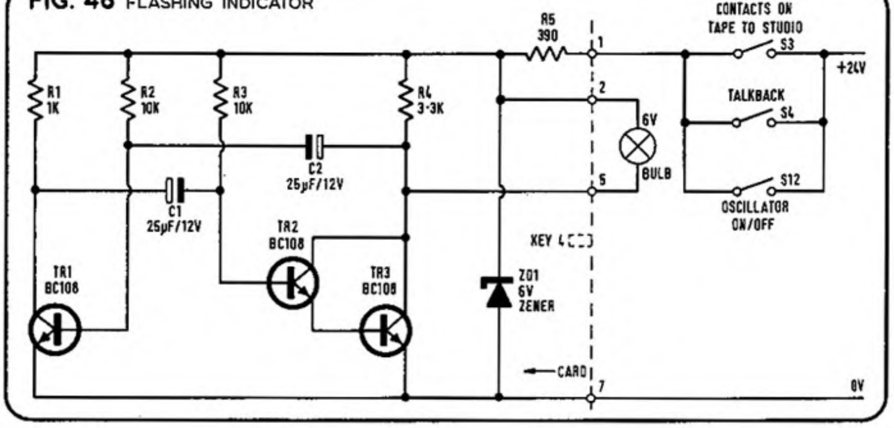
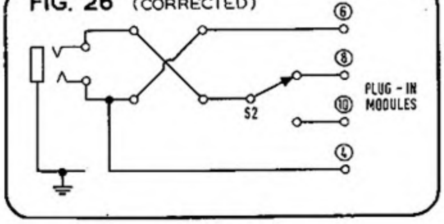


FIG. 46 FLASHING INDICATOR



and after a while passed through zero volts on its way. At this point Tr1 starts to conduct and the voltage at the collector drops from +6 V towards earth. This drop is passed instantaneously through C1, since it is an AC wave form, to the base of Tr2/3, tending to turn this pair off. The voltage at these collectors will rise and this rise is passed through C2 to Tr1 and so turns this transistor on farther. Positive feedback snaps the circuit from one state to the

FIG. 26 (CORRECTED)



If the bulb fails, the flashing circuit will still operate and there is no possibility of any damage occurring from back-biasing the transistors. This is a very simple circuit to build and can be adapted for many other uses. It was added to a very early mixer of somewhat similar type mainly as a gimmick but very soon proved its worth in the field and became very useful. It is only too easy to forget the recorder is still switched to the studio when the next take is attempted.

To close, three further corrections should be made. Fig. 26 (August) has the wires to the input jack socket incorrectly shown, and the corrected version is reprinted here.

C4, in fig. 24 is incorrectly biased, the positive side should go to Tr2 collector.

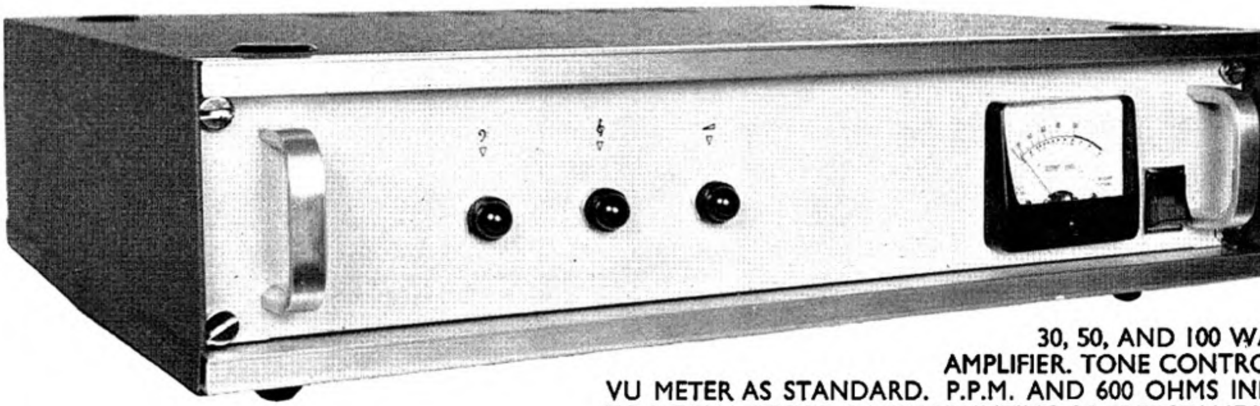
C4, in fig. 27 should be 1500 pf, not 1500µf, which would give no output at all, as some readers have been quick to point out.

I hope to finish this series with descriptions and photographs of readers' versions of the Mark I mixer (and the Mark II if anyone is that far advanced). I would, therefore, be most grateful to receive photographs and brief details as soon as possible.

Component Suppliers

Printed circuit board, flashing indicator circuit. Ref. 109, 6s, from the author, c/o Link House.

Components from Home Radio Components Ltd, 234 London Road, Mitcham, Surrey (Tel. 01-648-8422)



book reviews

MINIFLUX MONOGRAPH (Vol. 1). 130 pages with line illustrations. Price 31s. Published by Miniflux Electronics Ltd, 8 Hale Lane, London N.W.7

SOME while ago I received a circular suggesting that I might like to purchase a copy of the new Miniflux Monograph on transistorised tape replay amplifiers. Bearing in mind that at least one Miniflux circuit had already appeared in *Tape Recorder* and that a number of good transistor designs have appeared elswhere in the technical press, I didn't really feel that I wanted to pay this amount for even the best circuit in the monograph. Also, I had just finished building a pair of FET replay preamps of my own design and did not want to be convinced that I could have done better! However, I was delighted subsequently to receive the Monograph for review.

In its 130 pages, the Monograph contains a very full treatment of equalisation standards, transistor input stages, high frequency loss correction, head magnetisation by leakage currents and switching surges, the *MEG-1* germanium preamp, frequency response measurements, the *MEG-2* and *MEG-3* silicon preamps, integrated circuits and the *MEG-4* and *MEG-5* preamps, replay head design and data, and a mathematical appendix to the *MEG-1* design (you have to be dedicated to read through *that*!).

The *MEG-1* design is now of little practical interest, except in a negative sort of way; the *MEG-2* is an exercise in 'siliconising' a germanium circuit; the *MEG-3* is the preferred design, giving the best signal-to-noise ratio and output, being able to feed a 600 ohm load at up to 3 V RMS with 66 dB signal-to-noise ratio (80 dB weighted). The optimum transistors are given for both positive and negative supplies. The *MEG-4* is a basic design using a Motorola integrated circuit amplifier, and the *MEG-5*, derived from it, uses an additional IC for gain and buffering. The design is interesting, and no doubt indicates the shape of things to come but the present performance does not approach that of the discrete transistor *MEG-3* circuit. As a matter of interest, a friend of mine has for some while been using the same Motorola IC in a disc replay preamp, fed from a Decca *ffss* pickup, with very satisfactory results.

Particular attention is given to the noise generated in input stages, and to the design of stages that in no way degrade the inherent signal-to-noise ratio of the recorded tape. This section also deals with head noise and the influence of head resistance on the signal-to-noise ratio; the noise generated in a transistor and optimum source resistance; the noise spectrum of a transistor preamp and its relation to transistor collector current; a comparison of the performance of germanium and silicon transistors (in which a clear case for using the silicon ones is made); the short-term ageing of transistors and the effect on flicker noise; and the determination of optimum head inductance.

A further section deals with the correction of high frequency losses in metal replay heads and also illustrates the superior HF efficiency and high Q of tuned ferrite heads, which nevertheless may pose some problems when it comes to bias rejection; I felt that perhaps ferrite heads could have been given fuller treatment, and the effect of loading a sharply tuned ferrite head considered. Practical details of tuning heads to compensate for HF losses in metal heads are given.

The choice of input coupling capacitor, something often dealt with scantily, is given thorough treatment here, both in terms of ensuring that it does not degrade the LF signal-to-noise ratio and that the head is not polarised by leakage currents or by surges as the supply is switched on or off. This, I think, is the only detailed consideration of the problem of replay head magnetisation that I have seen, and the Monograph is worthwhile on this score alone. The effect of a rear gap is also considered.

A further section deals with three methods of determining the overall frequency response of the amplifiers, using test tapes and test equipment; perhaps more interesting, careful consideration is given to accurate determination of a replay machine's response at low frequencies, pointing out certain traps in making measurements where the recorded track is wider than the replay head—particularly in the case of a ¼-track head scanning a full track test tape; the more frequently noted phenomenon of 'pole tip resonance' or LF fluctuations because of finite pole length, variations in tape wrap, the effect of head shields, etc, are also considered, together with possible remedies available in the design of the head—or in one's choice of head, if purchasing.

The *MEG-3* silicon transistor preamp emerges clearly as the one constructors would wish to build, but the design of the two IC preamps is of considerable interest, and with better ICs becoming available it might be possible to improve on their performance to a point where they compete with the discrete transistor amplifier. IC noise problems are also dealt with briefly.

The section on replay heads deals with the requirements of replay heads and ways of maintaining tape contact with them, and the physical construction and electrical performance of a selection of Miniflux and other heads is compared briefly.

For anyone seriously interested in tape amplifier design, this book makes good and helpful reading. For the home constructor, who really requires simply the chapters on the *MEG-3*, head tuning and equalisation, and perhaps response measurement, I hope Miniflux will see fit to produce a constructors' manual in potted form, or make this information available to constructors through the technical press. I found the section on input coupling and leakage currents particularly interesting, as it was this problem that directed me to FETs. Having seen the subject dealt with carefully for the first time, I am a little more willing to consider abandoning my FET preamps, at least when the present heads wear out!

The spartan plastic spiral/slotted page binding and soft cardboard covers have something of the air of a document produced for internal company distribution or very limited circulation. They look wrong on an expensive publication but have the great virtue of allowing the book to fold out flat, or inside out, so that the circuits can be easily used and worked from. The type is clear, well spaced and easy to read, each section being well laid out and indexed. The text is illustrated with circuits, line drawings, graphs and photographs. The monograph concludes with the mathematical appendix which, understandably, is reproduced from a handwritten text. The standard of production is on the whole good. One or two slips, including equations, have crept through the proof-reading but are unlikely to throw anyone reading seriously as they are fairly obvious and the sense of the rest indicates what they should have been.

To sum up, a very worthwhile publication, probably not for the majority of home constructors in its present form. **J.H.F.**

INTEGRATED CIRCUITS (Short form planar device selector and full characteristic data for all SGS Integrated Circuit devices announced before August 1969). 324 pages with line illustrations. Price 21s. Published by SGS (United Kingdom) Ltd, Planar House, Walton Street, Aylesbury, Bucks.

THIS large and well-produced soft-back publication indicates in short form the categories into which SGS integrated circuits are divided. Farther on, the book gives in greater detail the characteristics of the various devices together with package outlines and connection diagrams. Inevitably most of the devices are diode-transistor logic, transistor-transistor logic and low-power diode-transistor logic, with associated devices, of concern mainly to non-audio applications. However, there is a substantial section dealing with Linear Integrated Circuits, including the popular μ*709* manufactured by SGS, and RF-IF amplifiers, precision voltage regulators and temperature-dependent differential preamps, all of which have possible application within the audio field.

The short form data section gives ratings, performance and tolerances in brief, and the later sections repeat this data with other ratings, curves, circuit configurations, stabilising components and protection arrangements, trimming controls, etc.

Despite the redundant information (in audio terms), the manual is a convenient collection of the available SGS integrated circuit devices, and may in general be found useful for data on the μ series of ICs. At the price, its appeal will be mainly to the professional user. **J.H.F.**

JOHN WRIGHT, JOHN AND GWEN CRABBE, TALK TO JERRY BRUCK (POST HORN RECORDINGS)

INTERVIEW

BETWEEN July 22 and 29 at the Fairfield Concert Hall in Croydon, Bob Auger and his Granada team recorded Mahler's *Third Symphony* for Unicorn Records, played by the London Symphony Orchestra under Jascha Horenstein with Harold Lawrence producing. An eight-track 25 mm master was taped on Scully equipment with one Neve desk for channel balancing and another for monitoring. Four Tannoy/Lockwood loudspeakers were positioned in the control room corners, the rear units relaying sound from microphones positioned to capture hall ambience.

Horenstein's performance, recorded with eminent Mahlerian Deryke Cooke at hand to advise on points of interpretation, is likely to be regarded as of great importance. It will be issued eventually in quadraphonic form—and was demonstrated thus at a special public playback in the Commonwealth Institute theatre in September—but has been released this month as a conventional stereo disc set, to be reviewed in the December issue of *Hi-Fi News & Record Review*.

By arrangement with John Goldsmith, general manager of Unicorn, American engineer Jerry Bruck also recorded the performance, using a 12.5 mm four-track Scully in a separate control room, as a practical test of tetrahedral ambiophony. Bruck was interviewed after the session by John Crabbe, his wife Gwen, and John Wright.

G.C. Did you come over from the States just for this recording session?

J.B. That's right. I'm a freelance engineer in New York so I can set my own schedules for my own itinerary. I've been a great fan of Gustav Mahler for some years now and I feel that the man best suited to conduct his music is Jascha Horenstein. I contacted Goldsmith of Unicorn about the recordings he was doing with Horenstein—principally Mahler, of course—and he invited me to come over. I wrote back saying that I would not only like to come, I would like to bring my equipment.

G.C. What did you bring?

J.B. Everything except a tape recorder. Converting my Ampex to 50 Hz mains and then shipping it over would be terribly costly so I asked Bob Auger if he'd be kind enough to rent me a recorder. He found me a four-channel Scully.

G.C. And what else did you use?

J.B. John Goldsmith lent me a Dolby so I brought over another Dolby, more than a dozen microphones, all my microphone cables, and so on. Before I got on the plane, I realized it would have cost less simply to name it all 'Sam'. It was paying as much to come over as I was. Because of my liking for Mahler, I've extended a standing offer to anyone within a reasonable distance of New York City who wants to perform a major work that I will tape it for nothing, and I've been taken up on this offer (which has pleased me no end) by half a dozen people.

G.C. Do you find any outstanding frustrations when recording with no say in the position of the orchestra and microphones?

J.B. Yes. My recording technique requires that the orchestra be placed exactly as it would be in concert. I believe the orchestral recording engineer is there to preserve an occasion, not to create one. I want to hear the sound as much as possible the way I hear it in a live concert. The only change Bob Auger made was to pull the harps out in front of the orchestra and to put the percussion on one side in the front, so what I have is a reasonable representation of an orchestral sound.

G.C. Have you ever had the opportunity of recording a live concert?

J.B. Many times. I like the spontaneity of the performance. I loathe what usually goes on at a recording session where the conductor or soloists are often forced to play five or ten bars at a time, the whole thing being put together later. When I conduct a recording session in the U.S. I usually tell the musicians at the beginning that they can do the piece any way they choose but that, in the course of the session, they must play it straight through, just for me. Of course they moan

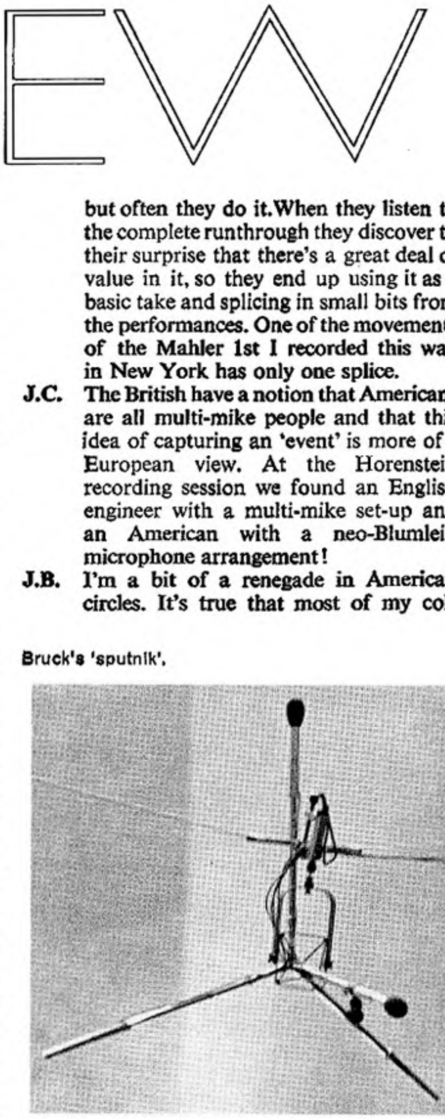
Jerry Bruck (ight) talks to John Wright at the Fairfield Hall.

but often they do it. When they listen to the complete runthrough they discover to their surprise that there's a great deal of value in it, so they end up using it as a basic take and splicing in small bits from the performances. **One of the movements of the Mahler 1st I recorded this way in New York has only one splice.**

J.C. The British have a notion that Americans are all multi-mike people and that this idea of capturing an 'event' is more of a European view. At the Horenstein recording session we found an English engineer with a multi-mike set-up and an American with a neo-Blumlein microphone arrangement!

J.B. I'm a bit of a renegade in American circles. It's true that most of my col-

Bruck's 'sputnik'.



leagues are committed to multi-miking.

J.C. Do you feel that to some extent the popularity of multi-miking might be due to the fact that two-channel stereo doesn't capture genuine multi-directional ambience? Now we've got the possibility of multi-directional ambience, we may see a trend back to fewer mikes.

J.B. I wish I could think that, but I don't. Multi-mike technique is not so much an **improvement in sound. It is far more an improvement in the engineer's condition and his ability to control the environment in which he works. He can play God behind that control panel but it has** nothing to do with reality. What most engineers want to do is turn music into a **'new experience'. They say 'We'll give you Beethoven a different way this evening'. Frankly, I have no interest in**

INTERVIEW

hearing Beethoven turned inside-out; I like him the way he is.

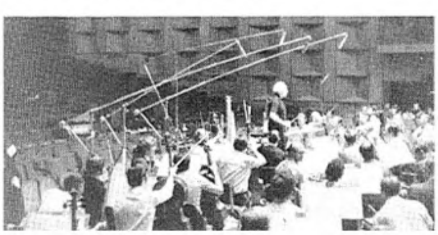
J.C. **Not only engineers have said this. Stokowski has advocated four channels or more for home reproduction, not just to capture the concert-hall ambience but to recreate music in all directions. Have you any comment on that?**

J.B. If you fancy the conductor's position on the podium, then his is a valid approach. But I prefer a more conventional listening position and I came to London to record the Mahler 3rd completely on my own hook because I believe that this performance under the direction of Jascha Horenstein is going to be something that will, in years to come, represent a high point of interpretation and performance. My intention was to do the finest possible job within my own abilities, both in terms of an engineer and of the equipment I was able to accumulate. What I'm doing requires an unusual arrangement of speakers in the playback situation, but one which is not totally unreasonable and may, in the next two or three years, become even more reasonable than it appears to be today.

J.W. **Could you describe, in simple terms, the four-channel rig you used for the Horenstein recording, and could you suggest a speaker set-up to get optimum results from it?**

J.B. What I attempted to do was to create a spherical environment. Following this in the geometrical sense you have a microphone arranged at each apex of a

Horenstein conducting the LSO.



regular tetrahedron, each microphone being highly directional. The success of this rig depends to a large extent on the selection of the mikes. I used hypercardioid Schoeps with cancellation at about 150° off axis. The null of each microphone, then, is at the maximum point of sensitivity of all the other microphones. The mikes are placed a metre apart and angled at 110°, which approximates the points of a tetrahedron. Along each side, then, you have a stereo image. As I've placed the mikes for this session, those sides are respectively one edge across the orchestra (which is the conventional two channel stereo pick-up); two of the remaining edges are horizontal in reference to the floor of the hall, going toward the rear. So you have a triangle lying flat, parallel to the floor, one side of the triangle facing the orchestra, the other two facing the sides and rear of the hall. You then have, built upon this, other triangles to form a pyramid, so that you have three additional stereo images appearing vertically so as to pick up the sides and ceiling of the hall.

J.W. **And the playback?**

J.B. It should, it seems to me, be played back

Bob Auger (right foreground) at the Granada desk with Harold Lawrence.

with the speakers occupying roughly the same positions as the microphones, although obviously spaced farther apart because we are now interposing a listener or listeners inside that tetrahedron. We require two speakers placed conventionally in the front of the room, one on either side, one speaker placed at the centre of the rear wall, and one speaker placed on the front wall, centrally, but at the ceiling, so that if you faced the speakers, you would see a triangle on your front wall.

J.W. **Any particular directional pattern for the speakers?**

J.B. I wouldn't think so. I think with this particular rig-up you would rely far less on the directional characteristics of a speaker than you would in most other rigs where you rely on the way the sound is spread about the room to get an effect. Here the effect is self-contained and the point is to eliminate, as far as possible, the room.

J.W. **We've now played back part of your Mahler tape, using a horizontal four-channel system, a speaker in each corner. Are you reasonably happy with what you've heard?**

J.B. It doesn't sound as it did live. It was impressive, but I think it'll be more so played back correctly.

J.C. **I think it sounds magnificent. Bearing in mind your success, without rehearsal in a concert hall used as a temporary studio, what if a major recording company uses a particular hall or studio time and time again, and gets to know it inside-out. Could they not keep to an optimum microphone position and balance for each type of music they've recorded there, and stick to it forever afterwards?**

J.B. I think they could, but what's right for one engineer or producer is not right for another; people are forever experimenting and trying to do something different. Incidentally, there was a lot of extraneous noise in the hall today. Little of this should be apparent in the commercial recording made with many close mikes, whereas a lot of it is audible in my recording.

J.C. **Well, that is a minor point that could be overcome in many locations. Returning to your basic philosophy, will there be any need in future to create a fresh aesthetic when the original sound, properly reproduced, is so convincing?**

J.B. I heartily wish that your view was, in fact, the case. But I know for instance that one recording company in New York has seized the opportunity of four-channel sound to place a string quartet so that each player comes out of a different corner of the room. A lot of this is due to the current panic over selling classical records. Sales of classical music records in the States have now sunk to an all-time low of $1\frac{1}{2}\%$ of the market. Companies are going out of business, or cutting down or closing their classical sections. One producer told me he was hoping that four-channel sound would cause a resurrection of interest in classical music.

Jerry Bruck's hired (from Granada) Scully four-track.

J.C. **Fortunately the situation is healthier in Europe, as you know. These very sessions we have been attending were organised by a minor company employing one of the world's greatest orchestras and possibly the greatest living Mahler conductor. We all found Horenstein's interpretation very gripping and I for one look forward to this important Unicorn release.**

J.B. So do I, especially as I have a permanent record of what it actually sounded like in the Fairfield Hall.

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FET building bricks

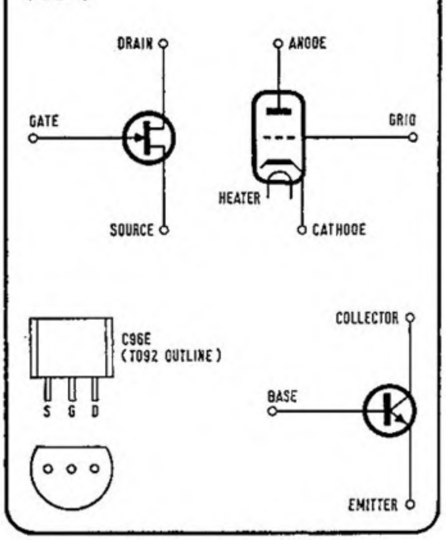
by
John Fisher

ONLY a couple of years ago, field effect transistors (FETs) were rather exotic and highly expensive devices as far as most people building their own audio equipment were concerned. They were easily damaged by stray static charges or leakage voltages from a poorly earthed soldering iron, and at £1 upwards losses were expensive. Now, FETs are available from about 5s upwards, spreads are becoming narrower, noise performance is often much better than with the early types, gains are often higher—in fact they have become an attractive proposition for the input stages of audio amplifiers where a very high input impedance is required. For although the voltage amplification from a FET is small by comparison with a conventional bipolar transistor, it has an inherently high input impedance —several hundred megohms or more—which can be put to good advantage in producing simple high-impedance input stages.

All the circuits to be described are based on the Semitron *C96E*, available at about 8s each in small quantities at the time of writing from Semitron Ltd, Cricklade, Wiltshire. With suitable adjustment of components to provide the required biasing, other FETs may be substituted, and suitable alternatives are indicated. Similarly, other silicon bipolar transistors may be used in place of the ones indicated, and by and large they should not significantly affect the circuits' performance provided they are similar types. The *C96E* FETs are suggested because the author has found them to be consistently good as regards noise and gain spreads. They are junction N-channel FETs, and within their ratings seem to be robust and easy to handle. It is advisable, however, to keep the leads shorted together until all components in the circuit have been wired in, using a heat shunt when soldering the FET, and preferably unplugging the soldering iron as well while soldering joints until there is a resistive path between gate and source.

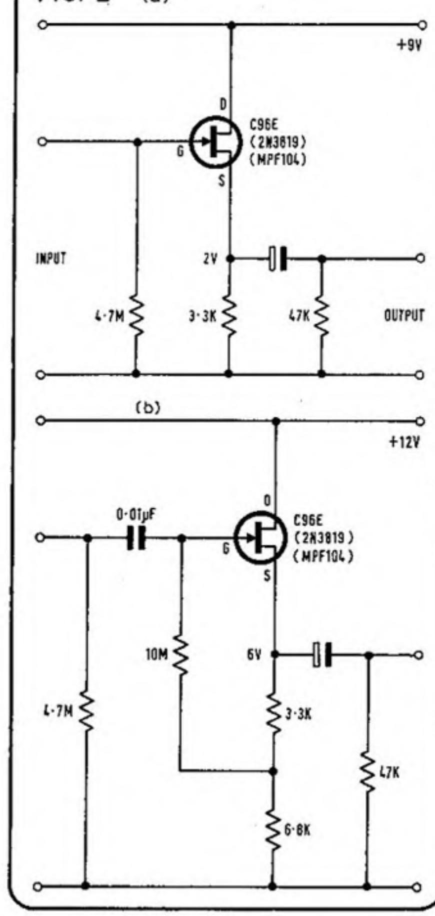
It is not the purpose of this article to examine the theory of FETs but rather to offer some sample circuits which may form useful building bricks for constructors. For our purposes, FETs may be considered as behaving rather like valves, with comparable input impedance, and with the small size and low voltage operation of transistors. They offer particular advantages in RF work, but at AF their most useful properties are their very high input impedance and the fact that, like a valve, it is simple to arrange that the control element—the gate— is at earth potential (with depletion mode FETs, the ones to be considered here; enhancement mode FETs required to be biased 'on' like a bipolar transistor, and will not be considered; most of the types commonly used for domestic purposes are depletion types). The FETs illustrated are *n*-channel types, corresponding in polarity to valves and *n-p-n* transistors; *p*-channel types also exist, corresponding in polarity to *p-n-p* transistors, and the polarity of the circuits should be reversed throughout to use these. Roughly speaking, the FET *source* corresponds to valve *cathode* or transistor *emitter* ; the *gate* to valve *grid* or transistor *base;* and the *drain* to valve *anode* or transistor *collector* (**fig. 1**). Like valves, FETs may have more than one control electrode, but these will not be considered here.

FIG. I



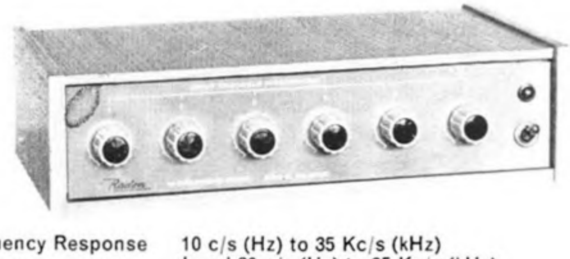
The simplest circuit is the source-follower (**fig. 2**) which with the minimum of components acts as an impedance converter. The input impedance is determined largely by the gate-leak resistor at audio frequencies, and the output impedance is of the general order of 1 K, depending on the individual transistor's characteristics. Due to the complete voltage feedback, the circuit is virtually unaffected by the transistor's particular characteristics, as regards operating satisfactorily without adjusting DC conditions. With a typical *C96E*, an output of a couple of hundred millivolts is possible without serious distortion. Because of the generally good noise performance of this transistor, it is also suitable for low level inputs.

FIG. 2 (a)



Voltage gain is rather less than unity. Applications would include that of buffer between a low-output ceramic pickup cartridge and a tape recorder or amplifier, via long leads or where the input impedance of the recorder or amplifier is less than several megohms. The circuit could also be used with a crystal microphone, and would be particularly suitable, for instance, for building into the case of a reasonable crystal such as the Acos *Mic 39* to allow the lead to be extended without noise pickup. In this case it would probably be easiest to use screened twin cable, using the extra core to carry the supply voltage from an external battery. As shown, the circuit has an input impedance of 4.7 M shunted by a few pF and is suitable for the applications mentioned.

(*continued on page 535*)



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FET building bricks

Fig 2b takes the gate leak resistor to a tapping on the source load resistance, allowing higher signal levels to be handled. To maintain at least 6 V across the FET, a higher supply voltage is used, in this case 12 V. The gate is now at a DC potential above earth and must be isolated by a small input coupling capacitor. The 10 M gate resistor is bootstrapped to some extent by the source load and will only slightly shunt the 4.7 M input leak resistor.

FIG. 3

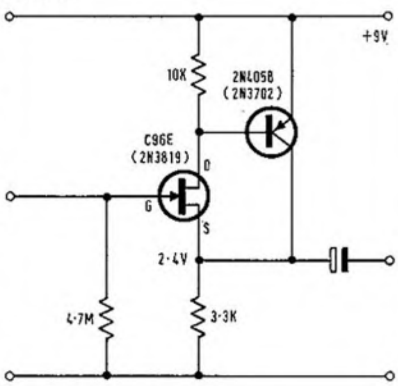
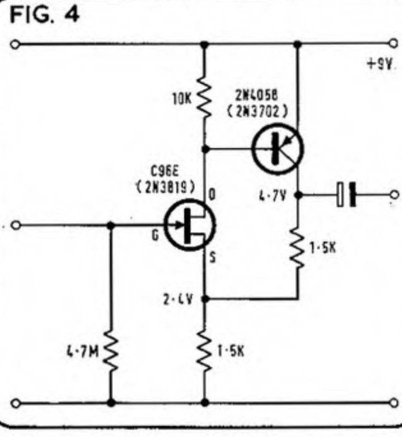


Fig. 3 adds a *p-n-p* bipolar transistor and resistor to **fig. 2a** to improve its linearity and give a lower output impedance of several tens of ohms. As before, the voltage gain is less than unity and the input impedance is determined mainly by the gate leak resistor, shunted by a few pF of reflected capacitance. The high degree of feedback contributes to good linearity at higher levels, and an output of 500 mV RMS or more should be obtainable without distortion, at an output impedance typically under 100 ohms.

FIG. 4



Adding another resistor, as in **fig. 4**, permits a small amount of voltage gain, approximately 6 dB as drawn. The gain may be increased at the expense of output handling capacity. The output impedance will increase with decreasing feedback but will still be low, allowing the use of long leads. **Fig. 4** would have some advantage in use as a mike preamp as previously described, in that the signal level in the cable would be higher and the chance of noise pickup being obtrusive correspondingly lower.

The foregoing circuits must not be significantly loaded if maximum undistorted output is to be obtained. An emitter-follower buffer can be added to **fig. 4** to give **fig. 5a** or **5b**; the latter may need particular care with supply decoupling to avoid low frequency instability which sometimes occurs. The circuit provides high input impedance, voltage gain and good linearity.

More gain can be obtained from the circuit of **fig. 4** by shunting part of the source load (**fig. 6**), the voltage gain approximating to

$$\frac{R1 + R2}{R2} \text{ at AF.}$$

So far all the circuits considered have been ones in which audio signals are concerned, and where noise, frequency response and distortion are of prime concern. FETs may also be used in DC amplifiers. **Fig. 7** shows a simple meter circuit, where noise in the FET should be unimportant, enabling one of the cheaper FETs such as the 2*N*5163 to be used. These may or may not be noisy but certainly there is no need in a circuit such as this to pay for a low noise type as a general purpose and cheaper type will do. As drawn, the circuit is intended for a 1 mA meter but could easily be adapted for more sensitive meters. The application could be a simple record level meter—not as satisfactory as a proper PPM circuit with log amplifier and specially scaled movement. But if a meter movement with a fast rise to full scale and negligible overshoot (about 5% or so, preferably less) is used, and the meter calibrated in dB to give a scale similar to that of a VU, it could prove a useful supplement to a magic-eye or to one of the mini meters fitted to battery portables. It will at least read peaks on half the cycle and, assuming a low impedance drive amplifier is used, the charge time constant is short enough and the decay time constant long enough to give useful results. The circuit obviously lends itself to battery operation in a small portable unit, particularly if a 100 μA or 200 μA unit is used to keep down the standing current on no-signal. A right-hand zero movement must be used; if this is not available, simply use a normal movement upside down and rescale to suit. The standing current in the FET is adjusted with VR1 to give the required current for full deflection to scale zero. The current is then reduced on peaks by charging the capacitor on the gate negative with respect to earth. The charge decays slowly through the gate leak resistor to give a decay time constant of about 1.5 seconds. About 2 to 2.5 V peak DC is required to cut off the meter current.

FIG. 5 (a)

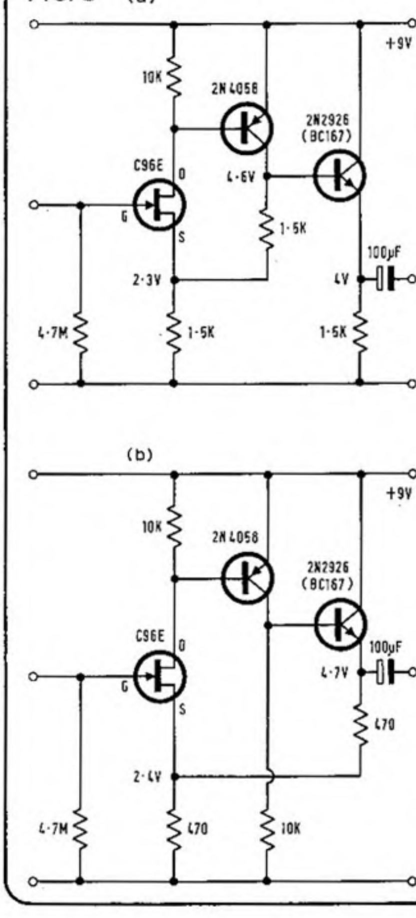


FIG. 6

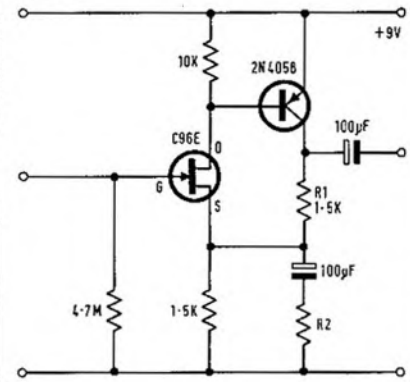
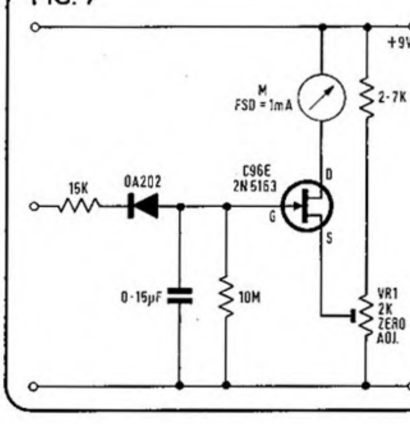


FIG. 7



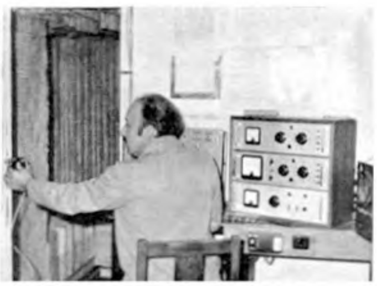
INSIDE CALREC

Trevor Attewell visits Calder Recordings Ltd.

Top left: Howard Smith assembling power units.

Top right: Alan Beaumont checks a completed microphone. The door of the anechoic room, together with the mike mounting, slides in and out by remote control.

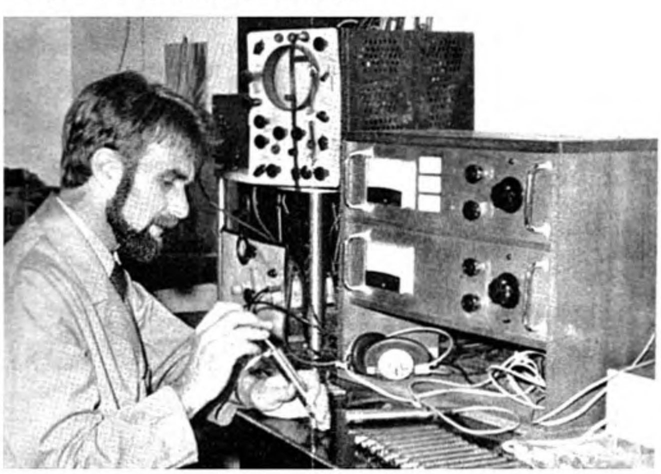
Middle left: Jigs used to fit capsule diaphragms.



Centre: Machining capsule.

Middle right: Drilling holes in capsule backplates.

Bottom: Final assembly of microphones.



VISITORS to Calder Recordings can hardly fail to notice that this is a lively company, run by a group of enthusiasts. These impressions are confirmed on hearing the firm's background.

The story begins in 1957, when five audio addicts (in the nicest sense of the word!) formed a recording team. Their ambition, to acquire some first-class equipment and to use it to turn out tapes of professional standard, was incompatible with the depth of their pockets—a situation with which many of us are all too familiar. The major headaches were recorders and microphones, especially the latter: capacitor microphones were almost essential for much of the work, and these tended to be expensive.

Nothing daunted, Clem Beaumont, Ken Ellis, Ken Farrar, Percy Hopwood and Howard Smith set out to make microphones, recorders, mixers—the lot—from scratch.

Before long, they had completed a 38 and 19 cm/s recorder, two or three capacitor mikes and a (just) transportable mixer. A second recorder soon followed. The whole of the tape transport mechanism was hand-made except for motors, three Papst units being employed. Valves throughout, of course, and the standards to which it was built can best be judged from the simple fact that much of it is still in use, and giving first-class results. There have been additions and improvements, of course, including ferrite heads.

Their early recordings were almost all made on location. The Calder Valley Sound Recording Group, as they were then known, made tapes for the Halifax Orchestral Society and numerous other orchestral and choral associations. They also hired the local Little Theatre from time to time, recording pop groups there as well as concerts. All the time they were improving their microphones, using test facilities, when they could be borrowed, and a good deal of subjective judgement—their own and other people's.

The next move was to acquire a studio and set about making a reasonable commercial proposition of recording. In 1960 the first floor of their present building became vacant and the group moved in. The floor provided a good-sized studio plus a control room. Sound treatment was carried out, and all the usual facilities installed, including a 16-channel mixer and Tannoy dual-concentric monitors. Everything was hand-built but the results were nothing if not professional. They built a full-sized echo plate, though not, they hastened to add, quite to EMT standards. Later, demo discs were provided for by the installation of a modified MSS cutter with a Grampian feedback head, to BBC design, with a 200 W amplifier.

INSIDE CALREC

The studio proved to be a very healthy concern, and was a constant stimulus to the making of more still better microphones. These were now reaching high standards of performance and were beginning to be thought of as saleable items in their own right. Certain dealers in the area became interested, and samples were supplied to them in order to test customer reaction. This proved favourable, but slow, and the real breakthrough came in mid-1965, when a Fi-Cord representative spotted one in a Halifax shop. His firm were so impressed by tests carried out on this sample that they invited the Calder group to produce capacitor microphones for them. At just this time, the ground floor of their building became vacant, and Percy's full-time job folded up. Such portents from the gods could hardly be ignored—both the space and the Fi-Cord offer were promptly taken!

The earliest microphones made under this arrangement were the *FC 1200*, using a nuvistor with an encapsulated amplifier and balanced transformer output, and the cheaper *FC 1200A*. Not long afterwards, transistors were introduced into capacitor microphones generally. 'The early FET's were pretty grim by to-day's standards,' Clem recalled. 'Many of them were noisier than valves, and their tolerances were hopelessly wide.' Percy added, wryly, that 'they cost £4 10s each'.

'We learned a lot from Fi-Cord on the production side,' Clem said, 'especially about standards of finish. Plating is still a major headache, and we've seriously considered installing plant to do it ourselves.'

Fi-Cord also passed their service work on Beyer dynamic microphones to Calder, and this became a Ken Ellis speciality. At first the mikes were collected and returned through Fi-Cord's East Grinstead address, but this soon proved too clumsy. By 1969, Calder were handling this work directly, their many customers including the BBC. The company's name had also been found a bit unwieldy. A slight change in status (and the usual dialogue with the Registrar) produced the present title: Calder Recordings Limited, and their registered trademark *Calrec*.

Later in 1969 the Fi-Cord company in England was liquidated. Calder Recordings carried on with the Beyer contract and commenced marketing microphones under their own name. Production was rationalised into three series, again with omni-directional and cardioid versions in each. These are the *CM 600* series (unbalanced output), the *CM800* balanced output and phantomed power supply and the *CM1000* series, with a fully professional specification; the cardioid version (CM 1050) providing the appropriate extreme bass roll-off (about 6 dB/octave below 50 Hz).

They also make specials, including a particularly robust model with built-in windshield which has found favour among pop groups. An invitation to crush the gauze of one of these, resplendent in its gold plating, found me unable even to deflect it slightly, short of belting it with a hammer. 'But people do manage to bend them.' Howard told me. 'One was run over by a lorry, which flattened the gauze on to the capsule, and another was dropped from a moving van on to a concrete road. When they picked it up, the business end was at a 30° angle to the body. They both worked quite normally when we examined them—in fact, one was demonstrated, for fun, at the APRS Exhibition!'

Calrec have now acquired all three floors in their building. The ground floor is used for machining and general manufacture, while the top floor is devoted to microphone and power supply assembly and test. An anechoic room has been built—just visible in one of the photographs—and, despite its small size, is adequate down to 200 Hz. There is also a plane-wave duct, usable from 20 to 800 Hz, and measurements in the room and in the duct, in the frequency overlap region, agree within 1 dB. Their test equipment includes a most effective polar-diagram display. For this purpose, the microphone must be rotatable. It is mechanically decoupled from the driving motor at all audio frequencies, and connections are made via slip-rings. The lack of noise generation is its own tribute to the care in design and manufacture of this set-up. All sensitivity measurements are, naturally, standardised against a B & K control microphone.

The exact manufacturing and setting-up procedures for the capsules were not revealed. 'It's easy to knock up a capsule that'll act as some sort of microphone,' they pointed out, 'but discovering how to make a really good one to a particular spec on a production basis is quite another story. Know-how is vital, and we aren't overanxious to give that away.' The accompanying photographs do, however, show one or two basic operations, including the mounting of the diaphragms.

With mechanical dimensions measured in hundredths of a millimetre, there must be occasional rejects. If a capsule cannot be brought up to specification, re-working may sometimes be possible, within certain restrictions. Should this fail, the capsule must be scrapped. The good ones—and they claim a high yield—are graded for use in the appropriate microphone series. 'Even with a good yield, the capsule accounts for a high proportion of the cost of the complete job,' Ken Farrar pointed out. 'We had to explain this to one of your readers who rang us complaining that the capsules we are offering through you are far too expensive!'

The studio on the first floor still sees a good deal of use for recording and this, they will tell you, is a good antidote for the ivory-tower attitude that can all too easily creep in when a manufacturer doesn't use his products in the field. Their master tapes include a surprising amount of strict-tempo dance music, issued by a Yorkshire man for instruction and practice purposes. 'We foldback a metronome to the players on cans,' says Howard, who doubles as recording engineer and sales manager, 'and it's got to be *exactly* right. We sometimes have sessions going on for a week at a time.' Any tricky jobs? Howard indicated an LP sleeve bearing the simple legend *Relaxation*. 'That one was a bit unusual, just a woman talking. It's intended to relieve tension, help people to sleep, and so on. But she couldn't manage the completely neutral tone that she wanted if anyone else was present—even in the control room—so we had to set everything up and then clear out for half an hour. Editing was the worst part. I could only do it in short sessions, because the stuff was so effective that 20 minutes of it had me nodding over the faders.'

Apart from microphones, Calder Recordings Limited make some custom-built sound equipment, such as the mixing facilities recently installed in a hospital as part of a local broadcast scheme, and the mixing desk which, together with a number of their microphones, was ordered for the Lyons Concert Hall in the University of York. They also make their own microphone stands. With microphones sales climbing steadily, and some good ideas in the pipeline, the company seems likely to gain an increasing share of this specialised, but very competitive, market.

Ferrograph in Polaris

The dependability of the Ferrograph Series 7 tape recorder is relied upon by the Royal Navy. The photograph shows Ferrograph recorders at work in the Sonar Room aboard the Hunter Killer nuclear-powered Submarine H.M.S. 'Churchill'. The unique specification of Series 7 recorders also makes them the ideal choice for home or professional recording, where their versatility as well as their reliability give rein to imaginative applications.

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Applications of Blumlein difference technique

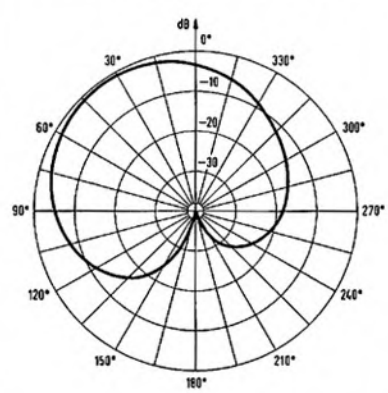
ultra-directional microphones

Part Three

by Michael Gerzon

AS explained in Part One, there is no theoretical reason why Blumlein difference technique should not work right down to the lowest audio frequencies—only a practical one! Deriving the Blumlein output involves a 6 dB/octave bass boost of the difference in the outputs of two nominally identical microphones placed side-by-side. Thus if the two nominally identical microphones in fact have slightly different sensitivities, then this difference in sensitivity will also be bass boosted, and will swamp the wanted output as the frequency gets lower. Thus, because of slight differences in microphone sensitivity, the Blumlein output will become unusable below a certain frequency. For this reason, it is necessary to roll off the bass of the Blumlein output below the lowest usable frequency. Another reason for rolling off the bass is that microphone noise in the Blumlein output will also be boosted by 6 dB/octave in the bass, and this could be especially objectionable if the low frequency noise is already of the bass-heavy '1/f noise' type, as in many capacitor microphones.

FIG. 22 UNILOBE DERIVED FROM THREE CARDIOIDS (FREQUENCY = $\frac{1}{2}$ (c/d))



The precise frequency at which the bass roll-off starts clearly depends on how much spurious bassy signal is tolerated by the user in the Blumlein output. If the microphone spacing is a distance d, and the speed of sound is c (=340 m/s), then the Blumlein output has the same gain as the difference of the two mike outputs at a frequency of $c/(2\pi d)$. Thus if one microphone has an output amplitude $(1 + \varepsilon)$ times that of the other, then the spurious component of the Blumlein output at a frequency f is $(\varepsilon c)/(2\pi df)$ times the level of the sum signal M. Thus the frequency at which the spurious component is 10 dB below (i.e. 0.32 times the amplitude of) the sum signal is given by $(\varepsilon c)/(2\pi df) = 0.32$, i.e. $f = (\varepsilon c)/(2d)$. For example, if the sensitivities differ by 1 dB, then $\varepsilon = 0.12$, and the spurious component of the Blumlein output is 10 dB below the level of the sum signal at a frequency $f = 0.06c/d$, which is about 800 Hz for a microphone separation of 2.5 cm. As many would consider a level of -10 dB to be the highest tolerable for the spurious signal, the frequency at which that level is attained determines the lowest usable frequency.

FIG. 23 UNILOBE DERIVED FROM TWO FIGURE-OF-EIGHTS AND A HYPER-CARDIOID (FREQUENCY = $\frac{1}{2}$ (c/d))

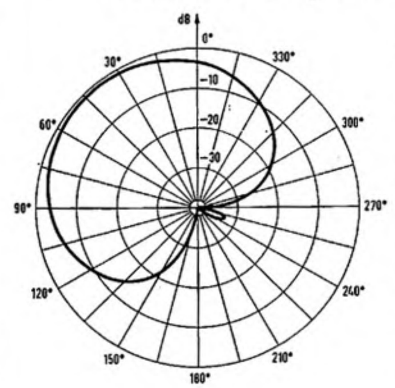
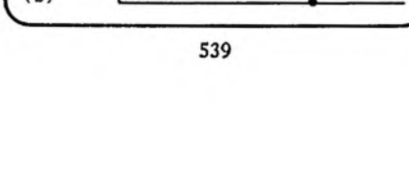


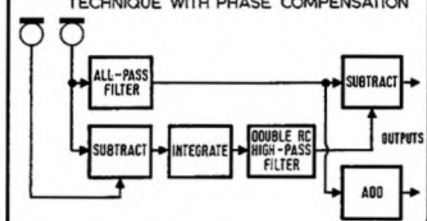
FIG. 24 ALL-PASS FILTER

FIG. 25 ALL-PASS FILTER



The actual bass roll-off frequency used also depends somewhat on the type of high-pass filter employed. A roll-off rate of only 6 dB/octave will cause the level of the spurious component of the Blumlein output to be of constant amplitude below the roll-off frequency. It would thus be better to use a faster roll-off (say 12 dB/octave), thereby supressing any very low frequency spurious outputs. This would ensure that the microphones need be accurately matched only near the roll-off frequency. In order to think in more detail, we shall suppose here that the roll-off is that given by two identical RC roll-offs; this type of filter has advantages which will be apparent later. This 'double RC' roll-off causes the difference of the two mike outputs to have a maximum amount of bass boost at the frequency f at which the double RC filter is 6 dB down. If this frequency f is regarded as the 'cut-off' frequency of the filter, then the spurious Blumlein output will be at least 10 dB below the sum signal at all frequencies if $\frac{1}{2}(\varepsilon c)/(2\pi df) = 0.32$, i.e. if $f = (\varepsilon c)/4d)$. Thus if the microphone sensitivities differ by 1 dB, then the bass cut-off frequency of the Blumlein output should be $f = 0.03c/d$, which equals roughly 400 Hz for a microphone separation of 2.5 cm.

FIG. 26 BLUMLEIN DIFFERENCE TECHNIQUE WITH PHASE COMPENSATION



Using a double RC roll-off in the Blumlein output means that the microphones need be accurately matched in the frequency range from $1\frac{1}{2}$ octaves below the cut-off frequency to $1\frac{1}{2}$ octaves above. As the matching need be accurate over only 3 octaves or so, it should be

(*continued on page 541*)

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SPECIFICATIONS

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

People the world over agree there's something about a Sanyo possible to use preset gain controls to ensure this, and it should be easy to obtain sensitivities matching to within 1 dB in this range. With many microphone designs, a matching to within ½ dB should be possible, which would allow a cut-off frequency one octave lower to be used (say 200 Hz for a mike spacing of 2.5 cm).

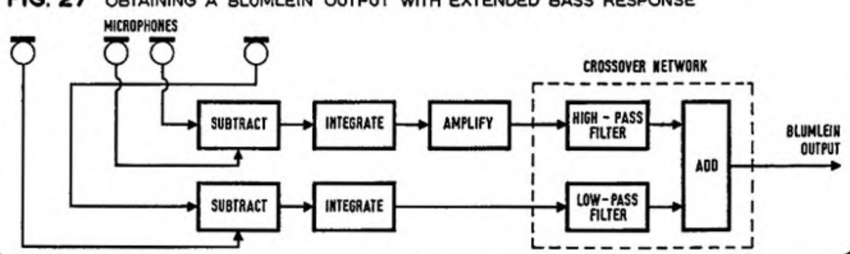
The action of the bass roll-off filter in the Blumlein output S causes phase shifts to occur in the bass. The 'sum' signal M does not have any such phase shifts and, as a result, when S is added to or subtracted from M, the relative phase shift between S and M causes a loss of stereo separation and a poor directional characteristic, even above the cut-off frequency. The directional chracteristic and stereo separation in the bass can be considerably improved by subjecting the sum signal M to 'phase compensation', i.e. by introducing phase shifts in the signal M to match those present in the signal S, thereby making the two signals in phase with one another. This is done by passing M through either of the *all-pass* circuits of **figs. 24** and **25** (which both have the same effect on signals). The all-pass circuit has a flat frequency response, but has a phase response identical to that of a double RC bass roll-off whose cut-off frequency is $f = 1/(2\pi RC)$, where R and C are the values of the marked resistors and capacitors. The block diagram of the Blumlein difference technique with phase compensation is given in **fig. 26.** Of course, other types of bass roll-off filter and corresponding types of all-pass circuit could be used, but the double RC filter is the simplest for which exact phase compensation can easily be achieved.

technique must be found. This is also important when one wishes to obtain a highly directional mono microphone whose polar diagram is completely frequency-independent. The simplest way of obtaining an extended bass response for the Blumlein output is to use two pairs of identical microphones placed along a straight line, one pair spaced close together to provide a high-frequency Blumlein output, and one spaced farther apart to provide a low-frequency Blumlein output, along with a crossover network. In order to avoid phase errors, the centres of each of the two pairs must coincide. As a pair of identical microphones provides a good Blumlein output over a range of four octaves or so, two pairs should be capable of providing a Blumlein output over about eight octaves, i.e. most of the audible frequencies. The outer pair of microphones should be spaced about 16 times as far apart as the inner pair. The technique for deriving the composite Blumlein output is shown in **fig. 27.** Care must be taken to get all the frequency and phase responses right; this will be the case if the high and low pass filters in the crossover network are both double RC circuits with the same cut-off frequencies and if the 'sum' signal is passed through one of the all-pass circuits illustrated in **fig. 25.**

Such complexity

Of course, such complexity is only justified when there is a good reason to maintain a good ultra-directional chracteristic right down to the extreme bass. This will be the case, for example, when mono or stereo recordings are being made live with distant microphones, and where the bass reverberation characteristics of the concert hall require a high degree of bass directionality.

FIG. 27 OBTAINING A BLUMLEIN OUTPUT WITH EXTENDED BASS RESPONSE



According to the experiments of Donald S. McCoy[1], stereo sound is not greatly degraded with a roll-off frequency as high as 300 Hz when the difference signal is rolled-off in the lower bass, as long as phase compensation is used. It should therefore be possible to obtain good stereo using the Blumlein difference technique. McCoy's results for roll-off of the difference signal with no phase compensation show that such stereo is much less acceptable to the listener, underlining the importance of using phase compensation. Very much more critical experiments by other researchers[2] show that *experienced* listeners under good listening conditions can hear even small losses of stereo separation in the extreme bass on *some* programme material.

For this reason, methods of extending the bass performance of the Blumlein difference

Having seen that it is possible to obtain microphones possessing a high degree of directionality in the bass, the experienced recordist will immediately wonder what happens to the bass response of sounds coming from a source close to the microphone. It is well known that, while omnidirectional microphones give a flat frequency response even on close sounds, such sounds suffer from an unpleasant bass boost when figure-of-eight or cardioid microphones are used. As may be suspected, ultra-directional microphones will suffer from this fault even more.

It should be emphasised that the bassiness of close sounds caused by directional microphones is not just a defect of the particular method (the Blumlein difference technique) that we have chosen to use to obtain the directional characteristic. It is a direct consequence of the laws governing the propagation of sound that for sounds whose distance exceeds the physical dimensions of the microphone, the amount of bass boost obtained on close sounds depends only on the microphone's directional characteristic, not on the particular method used to obtain it. Thus the large amount of bass boost on close sounds obtained with the Blumlein difference technique would also occur with any other type of microphone having the same directionality, whether this be obtained electronically, by diffraction or reflection of sound, or by mounting the microphone in a baffle, box or horn.

Fig. 28 shows the amount of bass boost experienced at different frequencies by a sound 1 m from the microphone, for omnidirectional, figure-of-eight and clover-leaf microphones. If the sound is twice as close, then the bass boost would occur one octave higher; if it is twice as distant, then the bass boost would occur one octave lower. It will thus be seen that, while a speaker can be as close as 1.1 m before a figure-of-eight causes a 3 dB boost at 50 Hz, he cannot approach closer than 2.4 m before a clover-leaf gives this bass boost. Moreover, while the rate of bass boost of a figure-of-eight is only 6 dB/octave, that of a clover-leaf is 12 dB/octave. Other second spherical harmonic polar characteristics (discussed in last month's appendix B) have the same amount of bass boost on close sounds as the clover-leaf.

Other microphone directional characteristics obtainable with the Blumlein difference technique, such as the cardioid and the unilobe, are combinations of the above directional characteristics. As a result, the bass boost caused by such composite microphones is a combination of the bass boosts illustrated in **fig. 28.** As the relative proportions of a microphone's sensitivity due to its omnidirectional, figure-of-eight and clover-leaf components will vary with direction, this means that the amount of bass boost on close sounds will also vary with the direction. In combining the bass boosts of **fig. 28,** it must also be recognised that the boosts are accompanied by phase shifts identical to those caused by simple circuitry with the same frequency response.

By way of example, **fig. 29** illustrates the bass boost obtained on axis at a distance of 1 m from a cardioid; the same bass boost also occurs for a sound 45° off-axis 1 m away from a unilobe. On the axis of a unilobe, much more bass boost occurs in the extreme bass at a distance of 1 m, due to the 12 dB/octave clover-leaf component, as shown in **fig. 29.** However, the higher bass of close sounds on the axis of a unilobe is subjected to a much gentler boost, because of partial cancellation of the omnidirectional, figure-of-eight and clover-leaf components, with their differing phase shifts.

An unwelcome side-effect of the close-talk properties of wide-range ultra-directional microphones is that they will be exceptionally sensitive to the lower frequencies of wind noise, which is heard by the microphone as a very close sound. For this reason, they will be unsuitable for outdoor use. This defect can be minimised by making the microphones less directional at very low frequencies, which, as we have seen, is not difficult! It is this lack of directionality at low frequencies, so often cursed, that makes parabolic reflectors and gun

(continued on page 543)

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BASF	—	20/-	26/-	31/-	8/9	17/6	25/-	28/6	41/-
BASF round pack	8/9	15/3	20/3	23/6	6/9	13/6	20/3	23/6	34/9
EMI	9/6	18/-	24/6	30/-	8/6	12/6	24/6	30/6	42/-
PHILIPS	—	18/6	24/6	28/-	8/-	13/6	20/6	26/-	36/6
SCOTCH	—	16/-	21/-	26/6	7/-	11/-	21/-	26/6	38/-
SCOTCH Dynarange	—	19/6	26/-	33/-	—	—	25/6	32/3	45/3

	DOUBLE PLAY					TRIPLE PLAY				
Reel	3"	4"	5"	5¾"	7"	3"	4"	5"	5¾"	7"
ft.	300	600	1200	1800	2400	450	900	1800	2400	3600
BASF	10/9	20/-	28/-	40/6	49/-	17/-	24/-	40/-	49/-	61/-
BASF round pack	8/6	15/3	23/6	34/9	43/6	13/6	20/3	34/9	43/6	55/9
EMI	12/6	21/6	36/-	48/-	66/-	19/6	32/6	56/-	—	—
PHILIPS	10/6	19/-	29/6	42/6	59/6	17/-	30/6	50/-	—	—
SCOTCH	12/9	19/-	31/8	42/-	58/6	18/6	30/-	—	—	—
Dynarange	14/-	22/6	36/-	47/3	66/10	—	—	—	—	—

microphones usable outdoors without unbearable wind noise.

Conclusions

This series of articles has shown how microphones with new directional characteristics can be obtained from conventional microphones by means of the Blumlein difference technique, in which the integrated difference of the outputs of two identical microphones, placed side-by-side, is added and subtracted to the output of one of the two microphones.

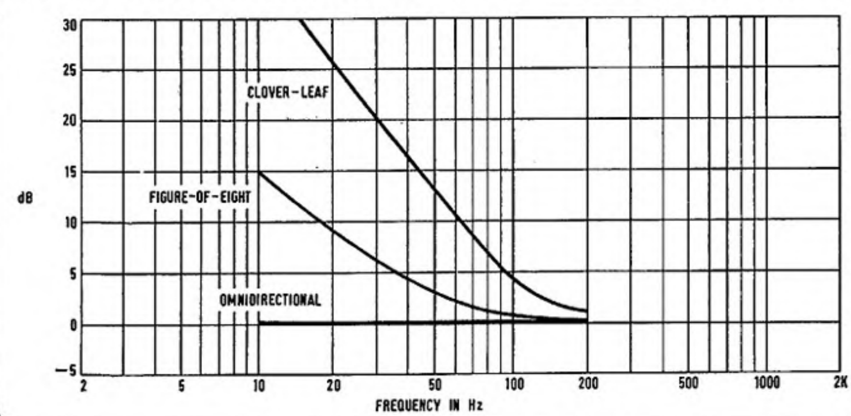
Two directional characteristics thus obtainable have been examined in some detail, the *clover-leaf*, obtained using a pair of forward-pointing figure-of-eights, and the *unilobe*, obtained from a pair of forward-pointing cardioids. Many other new directional characteristics are obtainable, notably the extremely directional one derived by applying the Blumlein difference technique to a pair of sideways-pointing figure-of-eights.

In the first part of this series, it was shown how variable-characteristic capacitor microphone capsules can be used in conjunction with the Blumlein difference technique to obtain the signals for various types of quadraphonic recording. The second part of the series investigated the high-frequency deficiencies of the Blumlein difference technique, and included proposals for ameliorating these in which a third microphone is used for the 'sum' signal. The third part of the series discussed the low frequency performance, and showed how this can be improved by using phase compensation and extra microphones. It was shown that microphones which are ultra-directional in the bass suffer from a high degree of bass boost on close sounds.

By using some or all of the techniques described in these articles, it should be possible to obtain a wide range of potentially useful directional characteristics which remain stable over a frequency range of several octaves. This should prove especially useful for recordings in which distant microphones have to be used, for suppressing reverberation, and for applications such as 4-channel recording where conventional coincident microphones do not give enough directional information.

The Blumlein difference technique thus meets some of the needs of modern recording, and would prove particularly convenient to the recording engineer once microphones particularly adapted to its requirements are developed. While it is perfectly feasible to use present commercial microphones in this application, the best results can only be obtained if small capsules are made available having the various different conventional directional chracteristics, notably figure-of-eight and hypercardioid. It should be possible to develop commercial microphones in which several capsules and the required circuitry are integrated into a single housing, thus creating a two or four-channel microphone as convenient in use as conventional capacitor microphones. For this reason, the technique is worthy of further study by microphone designers as well as recording engineers. As far as the author is aware, there exist no modern patents which would impede the exploitation of this technique.

FIG. 28 BASS BOOST GIVEN BY MICROPHONES AT A DISTANCE OF 1m FROM SOUND SOURCE



Appendix C The directivity factor

The most commonly used measure of how directional a microphone is, is its *directivity factor* γ, defined as the number by which the energy output of the directional microphone has to be multiplied so as to equal the energy output of an omnidirectional microphone whose sensitivity equals that of the directional microphone in its direction of maximum sensitivity, if both are placed in a uniform noise field. γ clearly measures the ability of a directional microphone to suppress sounds such as reverberation coming from directions other than that of maximum sensitivity. Mathematically it is defined by

$$\gamma = \frac{4\pi}{\int_0^{\pi}\int_0^{2\pi} \tau(\theta,\phi)^2 \sin\theta \, d\phi \, d\theta}$$

where $\tau(\theta, \phi)$ is the amplitude sensitivity of the microphone at an angle θ off axis and at an angle θ round the axis, and is made to take a maximum value 1.

An omnidirectional microphone has a directivity factor $\gamma = 1$, cardioids and figure-of-eights both have a directivity factor $\gamma = 3$, and the most directional conventional microphone is a hypercardioid with 6 dB front-to-back ratio, with $\gamma = 4$. A clover-leaf microphone is not quite so good, with $\gamma = 3.75$.

The term 'ultra-directional microphone' may with justice only be applied to microphones with a directivity factor greater than 4, which is the highest obtainable with conventional microphones. The unilobe has a directivity factor $\gamma = 4.9$, and so picks up 2 dB less reverberation than a cardioid. While the unilobe is not all that ultra-directional, it does have compensating characteristics. It is easily derived from widely available cardioid microphones, it has an excellent suppression of sounds from the rear, its horizontal directivity is particularly good (which is important for good stereo separation), and a simple microphone arrangement sufficies for stereo.

A way of increasing the directivity factor is to apply the Blumlein difference technique to a side-by-side pair of identical forward-pointing hypercardioids, taking care to adjust the amplitude of the Blumlein output S so that the left and right polar characteristics point 45° to the left and right respectively.

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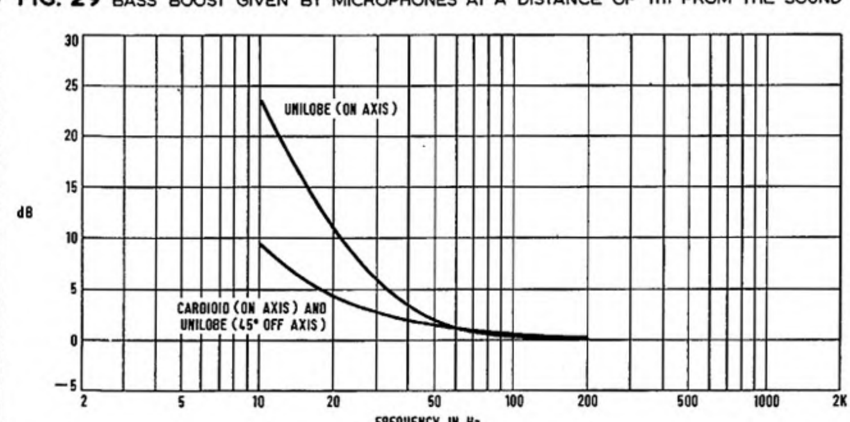
1) Donald S. McCoy, 'Distortion of Auditory Perspective Produced by Interchannel Mixing at High and Low Audio Frequencies,' Journal of the Audio Engineering Society Vol. 9, p 13-18 (1961).
2) F. K. Harvey and M. R. Schroeder, 'Subjective Evaluation of Factors Affecting Two-Channel Stereophony,' JAES Vol. 9, p 19-28 (1961).

FIG. 29 BASS BOOST GIVEN BY MICROPHONES AT A DISTANCE OF 1m FROM THE SOUND



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PHILIPS ACCESSORIES

BY H. W. HELLYER

LAST month we headed the article, 'Philips *N4308*'. This month, we come to the 'etc'. Many readers have asked for details of add-on amplifiers, power packs and other ancillary equipment.

In the previous article, I mentioned the *EL3787* stereo preamplifier, and promised further details. Herewith such information as I can glean, Sirs.

The circuit shows that it is a very straightforward three-stage design, taking the signal from the unused head winding of a stacked-head machine and amplifying the signal to Line level. Switching is fitted, giving the correct equalisation for 19 or 9.5 cm/s. Another switch position makes the preamplifier suitable for synchronous or sound-on-sound recording—Duoplay or Multiplay, to use the terms that Philips themselves employ.

Specification is as follows:

Function	Impedance	Sensitivity	Pins	Connector
Inputs				
Play (Stereo)	3 K	260 μV	1–	5-pin DIN
Diode	20 K	1 V	1–2 and 3–2	5-pin DIN Socket 2
Outputs				
Headphones	10 K	200 mV	1–2	Socket 1
Line	20 K	1V	3–2 and 5–2	Socket 1 Socket 2
Supply				
22 V			5–2	5-pin DIN

Note that the plug on its short flylead goes to the 'Stereo' socket of those tape recorders so equipped, where the 22 V supply for the preamplifier is picked up as well as the required signals. But, of course there is no reason why this supply could not be provided externally, and the same circuit used for alternative purposes. Current consumption is only 8 mA. Using the preamplifier on equipment without the take-off facility is still possible, provided there is a stereo take-off point. Then, a flylead from the second socket will enable the equalised recorder signal to be fed through for application to a stereo amplifier. The output from this second socket is suitable to load, for example, a high impedance 'Gram' socket on a stereo radiogram or amplifier.

In the normal playback mode and (as in **fig. 1** where the *EL3787* is shown switched to 19 cm/s), head signals from pin 1 of the plug (with pin 2 common return line) are applied via a 10 μF electrolytic capacitor to the base of the OC59. Pin 4 on this plug is an earth connection, free until the plug is inserted. It should be joined to pin 2 if the preamplifier is to be operated free-standing.

The signal passes from the collector of T1 to the second stage and also to the feedback network, which in the 'normal' mode is an R-C-R chain straight across the output. At the output of T2 we find an adjustment, a form of preset gain which affects the bass end of the frequency range. Before we adjust this one, it is necessary to adjust the top end of the band. The appropriate control is part of a negative feedback path from T3 collector and T2 emitter. It is adjusted for best response at 14 kHz, in the following way:

With the speed switch at 9.5 cm/s and a generator applied to pins 1 and 2 via, a 2 : 1 divider consisting of a 100 ohms resistor in series with pin 1 and another 100 ohms resistor across pins 1 and 2, feed in a 1 kHz signal at 220 mV. Read off the output at pins 1 and 2 of Socket 1 and adjust the generator output to give a reading, at this socket, of 650 mV. Then adjust the treble preset, R16, for 310 mV when the frequency has been increased to 14 kHz.

After this, we can go back to the bass preset and adjust it for a reading of 750 mV with a 60 Hz signal applied. This gives us the bass boost to compensate for the 'natural' treble increase that is obtained from a replay head—the theoretical 6 dB per octave slope.

This depends, as you would expect, on a correct power supply. More accurately, it depends on the output stage being set up properly, and there is another present, R21, in the base bias circuit of T3, which sets the collector current. The collector-emitter voltage is read off and R21 adjusted to obtain 7.3 V.

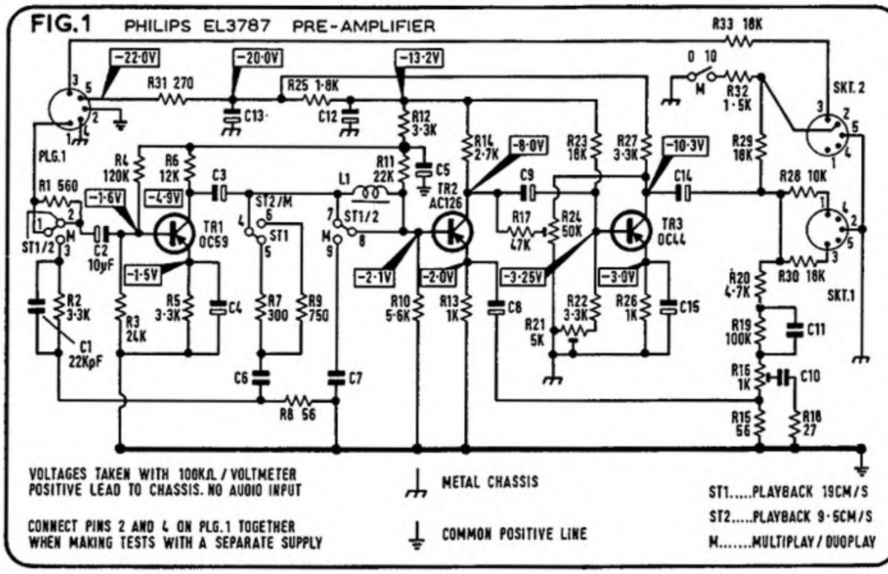
One of the arguments I have heard from old hands reluctant to rethink themselves into the semiconductor era, which their juniors accept and take in their stride, has been that transistor equipment 'always has so many variables'. Here is an example: in a comparable piece of valve equipment the output stage would be left to settle itself comfortably around an operating point determined by the designer and obtained by selection of components. What if the HT voltage wandered a bit? What if the emission went down over the years? What if resistors, objecting to their heat cycle, climbed up into the Meg range? The elasticity of valve equipment would take care of all that. Things had to get pretty bad before we noticed any difference . . . or so the argument goes. But against this we say that transistorised gear can be very precise, is capable of some accurate adjustment and not subject to the same sort of deterioration. All the other arguments, cost, weight, lower temperatures, voltages, etc., are so well known as not to need repeating. But this point, of accurate setting and precise operating conditions, is too often overlooked.

And now I shall brush the frogs from my rusty typewriter, sit back and wait to hear what my friend Mr Bastin has to say about that!

The output circuits are interesting. From T3, the signal is passed to Socket 1 for headphone output and also as a suitable feed to match the right channel of a main amplifier. From the same take-off point we can see a similar feed to Socket 2, pin 5, and note that this gives a stereo signal to match the straight-through diode signal from pin 3 of the plug, which picked up its feed from the tape recorder. This gives us stereo playback from a mono machine, provided it is a ¼-track model.

Looking at this same point of take-off from T3, we note a switched resistor shunting across

FIG.1 PHILIPS EL3787 PRE-AMPLIFIER



the output, its value quite low. This switch is part of the Multiplay function, and the object of R32 is to attenuate the output for re-application to the tape recorder. It we are recording Track 1 and intend to mix the signal already recorded on Track 3, this must be attenuated. Also, the input is taken into a higher impedance by the inclusion of R1 as the first section of the switch opens. The other function of this switch is to insert the C1, R2 filter to reduce the bother of HF bias breakthrough. This is made even more certain by L1 being inserted in series with the base of T2, and preceded by the shunting action of C7.

The only other alteration is a reduction of resistance in the feedback loop for the higher speed playback, which is done by substituting R7 for R9.

These simple circuits appear to be the kind of thing that the average enthusiast knocks up between times, but the styling of the made-up version makes it a worthwhile buy for the chap who owns the associated equipment—Philips, Cossor and Stella models particularly—and who wants to extend his scope. The idea could easily be adapted to more efficient, less noisy circuitry, using up-to-date silicon transistors, or even one of the ICs that are beginning to influence the market. No prizes offered—think of the satisfaction you will get when it works!

Apropos this: I did a review of a piece of test equipment, a very stylish little signal tracer, the Grundig *SV2*. This is a perfectly plain, four-transistor circuit and I commented to Geoff Pople, their Chief Engineer: 'Seems the sort of thing the average workshop would make for itself.'

'Yes,' he said, 'But would they?'

Another piece of equipment it would not be so easy to knock up, although the circuit, reproduced in **fig. 2**, is extremely simple, is the slide synchroniser which Philips call the *EL1995*. The snag here would be the physical mounting of the head and tape path, though this is most certainly not beyond the ingenuity of the average handyman.

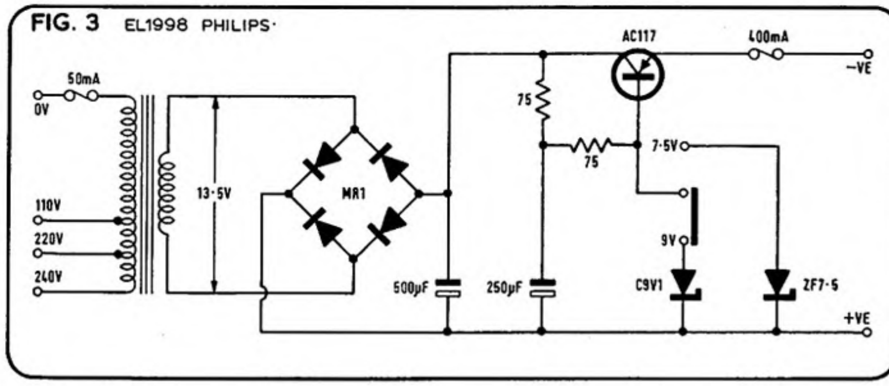
The slide synchroniser has a 9 V supply, either from its internal battery or from one of the power packs we shall be considering later. Its three-transistor circuit puts pulses on the tape during recording, then reads these pulses off during playback and uses them to trigger a relay. The relay is in the circuit of the slide projector's remote control switching, so every pulse causes a slide change. In this case, the pulse is really a chain of pulses, as long as the operating button is held down, instigated by S2. The pulses can be heard, lying in the frequency band from 800 Hz to 1 kHz, so if a four-track tape is prepared for slide commentary, the pulses will be an audible buzz on track four and, unless erased, will cause some bother when the tape is inverted, making this track 1.

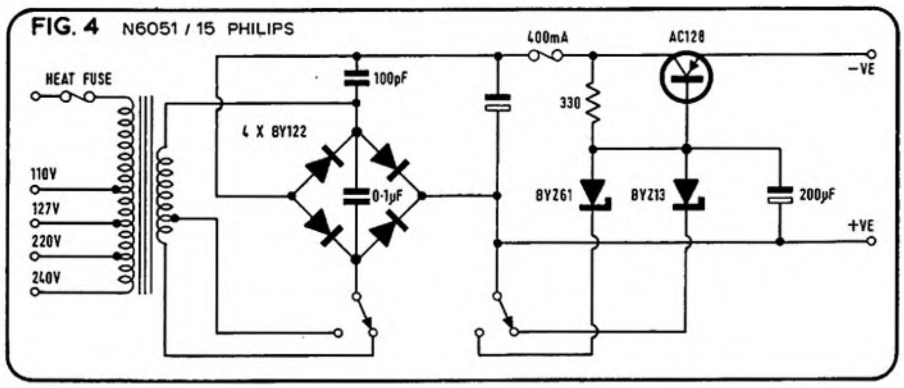
The circuit is dependent first of all on erasure of this bottom track, so when the S1 switch is closed and the 23/21 contacts of S2 are already closed, a direct current flows through the erase head K1. Limited by R12, R7 and R15, it should be about 2 mA. (Note that the switch function is a little misleading in the Philips diagram; the clue is the letters beneath the switch contact, which denote E-erase, R-Record and P-play. There are only two buttons, and S1 is operated to select erase, while the pulses are put on when S2 is operated; for playback, the two buttons are up, and this closes the contacts 2/1 and 7/8 of S1.)

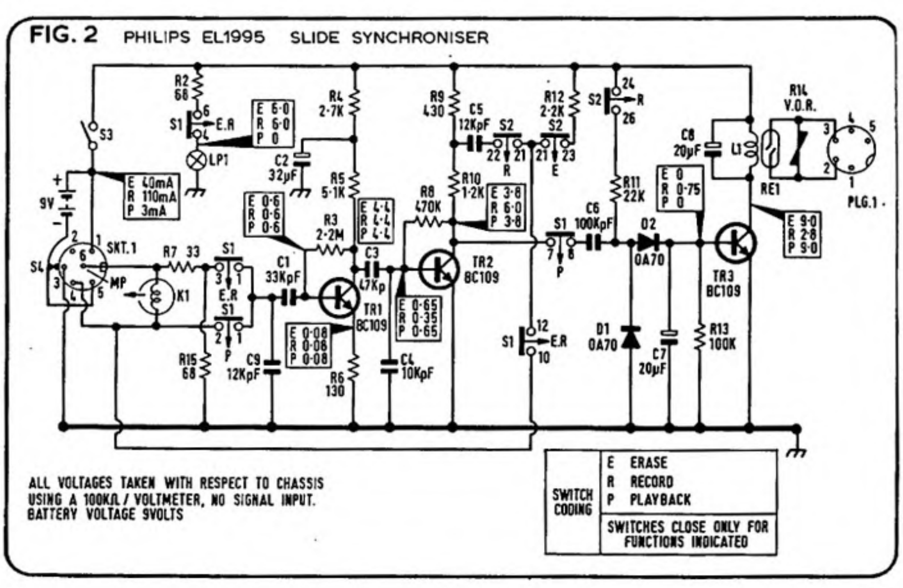
To record an impulse, the DC is removed from the head by the opening of S2 (21/23 contact), and the first two transistors form an oscillator, the feedback loop being C5 via the appropriate switches. At the same time, C7 is charged up and a positive voltage is applied to the T3 base via the series diode and the 22 K bias resistor. This transistor switches on and, as the relay coil is in the collector circuit, it is energised, closing the relay contacts and effectively short-circuiting pins 2 and 3 of Plug 1, completing the projector remote control circuit. Thus, when preparing the slide programme, one simply chats as necessary, then presses the button both to change the slide and record an impulse which will do the same job for us on playback.

This modulation voltage can be read across the head—a convenient test point being brought

(*continued on page 548*)







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Philips make a whole range of top quality tape recorders. One is bound to make somebody very happy.

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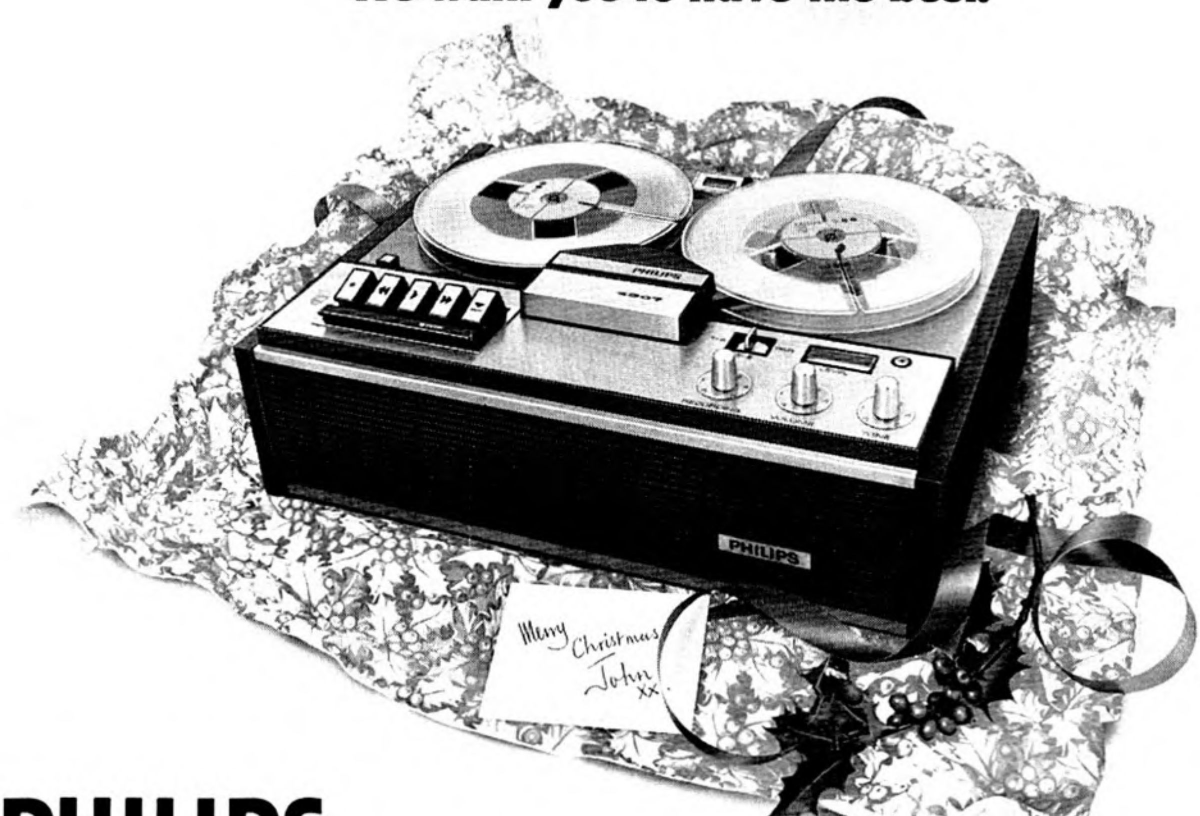


PHILIPS

PHILIPS

around the studios

SUTTON SOUND
by Keith Wicks

SUTTON Sound recently moved from Soho Square when their lease expired. They are now at 23 Redan Place, Queensway, occupying part of Sound Associate's premises. As a result of this move, they now have sound and (35 mm) picture facilities, a dubbing theatre being in the same building.

I visited the studio to hear a session featuring Welsh pop singer, Miec Stevens. Before recording started, engineer Mark Sutton showed me the equipment and facilities. The control room measures about 5 x 3 m and the desk is situated so that the engineer looks straight into the studio, which is about 9 x 6 m. There are 20 input channels and eight outputs, visual monitoring being provided by eight large VU meters. There are two small VUs for checking the level sent to the reverberation plates. Two EMT stereo plates are used, their associated remote control panels being on the right hand side of the desk. These allow the motor-operated damping pads to be adjusted, and meters show the reverberation times obtained. The main part of the desk is taken up by the input channel controls which are in line with their corresponding faders. At the right hand side of the desk are panels containing echo and monitoring facilities, a talkback unit, and the eight output faders. These can be mechanically coupled as required. Beneath the desk is a standard jackfield enabling the microphones to be plugged into any channel.

Sutton Sound have facilities for up to four track recording. As I mentioned in my report on Unitrack in September's *Studio Sound*, Sutton were going to purchase a *Uni-8* machine. They have now decided to get a Scully instead, and may possibly go 16 track instead of eight. A final decision has yet to be made but, whatever they decide, it is definite that Dolby A noise reduction will be installed. Mark considers this essential when recording classical music (particularly guitar or piano), using eight or more tracks. On the other hand, he says that their use is

(continued overleaf)

Above left: Ian Whiteman, piano.

Above right: Jenny Forward, tape operator.

Right: Miec Stevens, vocal and guitar.
Far right: Mike Evans, bass guitar.

Mark Sutton at 20-input desk.

around the studios

'rather a luxury on heavy pop material'. At the moment they have a Studer (four track 25mm), stereo *TR90*, a bay mounted Ampex (mono), and two track Ampex and Philips recorders. These are all situated in the control room, to the side and in front of the control desk.

Finally there are two 380mm Tannoy speakers housed in Lockwood cabinets, and the quality of the material I heard was good. I mention this because, in a previous report, I said that a studio had rejected their Lockwoods for being too 'harsh'. This may possibly be so in some rooms, or perhaps with certain types of music, but everything seemed fine in this particular case. Mark told me that he uses the older Tannoy speakers in preference to the 'Gold' series, for they have a smoother top response, and can handle more power.

The session started at about 11.30 pm. The group included Miec Stevens, Mike Evans (bass guitar), Ian Whiteman (piano) and Roger Powell (drums). A Neumann *U87* microphone was used for the piano, and another for the lead guitar, the latter being positioned directly in front of the guitar amplifier. The bass amplifier was pointed towards a wall to prevent too much of it being picked up by the other microphones. A Neumann *U67* was placed between the amplifier and the wall. The drums were situated in a small cubicle in the side of the studio. AKG microphones were used for these, a *D12* for the bass end, and a *C28* for the top. Two *U67s* were used for vocals, and a Neumann *KM84* for Miec's acoustic guitar.

After indulging in some light ale, wine, Guinness and cider (the last two mixed and definitely not my favourite drink), there were a few rehearsals, and then the recording itself. This was done on the four track Studer, operated by Jenny Forward.

Rounded up

When the time came to add the vocal, everyone in the vicinity was rounded up. Miec sang the verses, while the rest (friends of the group, the record producers, Jenny's boy friend, and yours truly) provided choruses of la-la-la's. For this Miec used one *U67* and the rest of us stood around another. After several rehearsals, takes, and retakes, alternated with cups of Beaujolais I decided it was time to go.

I enjoyed the session very much. It was produced by Lyn Jones and Ronnie Williams of Cwmni Cyhyrchu Cymru Ltd. (Welsh I believe.) Their hospitality left nothing to be desired. The group were very friendly, and Mark Sutton was most co-operative.

The rates for recording at Sutton Sound are cheaper than many comparable studios in London—£12 per hour, regardless of the number of tracks, and in my opinion, a bargain.

TAPE RECORDER SERVICE CONTINUED

out to the centre pin, pin 6, of the main socket. When the record impulse button is pressed, there should be about 29 mV at this point. With the white button up and only the red button down, i.e., in the erase mode only, a reading of about 225 mV is obtained at this spot.

Turning to the other end of that circuit, we find that there must be some limits to the switching ability. After having had one slide synchroniser ruined because it had been unwittingly connected to a slide control circuit that switched the main supply, I am always most careful with this warning. In this instance we have a 25 W limit. More precisely the *EL1995* will switch 30 V at 800 mA and that is pretty good. The voltage dependent resistor across the output is some protection, but has its limitations, and more complete protection would be an expensive proposition.

A little earlier I mentioned the power supply circuits, and have supplied one or two typical designs, again from Philips, to demonstrate the simplicity and effectiveness of this type of accessory. Quite often, mains power packs like this are made of an equivalent size to the battery they are going to supplant. In all cases they are pretty small. The amount of regulation such a simple circuit can provide is meagre, but often sufficient for the job in hand.

Simplest of these is the single series transistor circuit of the *EL1998*, with the base voltage crudely clamped by a zener diode of appropriate value and a 400 mA drain. It had several practical drawbacks. The output was taken to a Roka plug—a type of small coaxial connector, moulded on to the cable. The wire had a nasty habit of fracturing just at the entry, and there was no way of overcoming this except a cable change. Life being what it is, for a long time the replacement leads were not available. Another problem we met was the need for fuse replacement which required that the plastic case, fitted like the two halves of an Easter egg around the flopping transformer and printed circuit, should always have to be removed. Almost invariably, the pillars through which the long screws were inserted broke away from the body of the case.

Up-to-date version

But enough happy memories . . . we come to **fig. 4**, a more up-to-date version, the Philips *N6501*. It also has two zener diodes, a slightly more refined smoothing and protection circuit, a 400 mA loading and a heat-fuse built into the transformer. It was physically smaller and neater, but not so widely employed. Its successor, the *N6502/15* is much better, with three voltage tappings and a two transistor circuit, although designed for a much smaller current drain. The use of a full-wave rectifier circuit instead of a bridge, the change to one zener diode and resistive determination network, and again a neat physical construction are features of this and other power units. It is no great difficulty to rig up something similar: let's hope this month's contribution has given a few ideas.

RECORDING STUDIO TECHNIQUES

PART TWELVE DUBBING 78s ■ FAKE STEREO

BY ANGUS McKENZIE (Roundabout Records)

FOR many years record companies large and small have issued LPs of dubbings from old 78s, some of which were very well engineered whilst others have sounded quite appalling. Dubbing 78s is not as easy as might first appear. Among factors to be taken into consideration are the size of the groove, the state of wear and the recording characteristic of the original.

The speed of early 78 recordings has been found to vary from as low as 70 to as high as 90 r.p.m., though the majority lie between 74 and 82 r.p.m. It is most important to know either the speed of the original recording (often difficult to ascertain) or the pitch (not necessarily to the standard as we now know it). It is therefore essential to have a turntable with wide variable speed facilities. The Lenco *88* is very suitable, though modifications may be necessary to achieve a very fast speed. Unfortunately some older turntables that would otherwise be suitable had poor hum suppression.

Groove sizes have varied enormously, particularly in the early days, and to play 78s satisfactorily it is important to have several playback cartridges with different tip radii varying from 65 to 90 μm. Some early discs have a considerably lower hiss level when played with a 90 μm point, though later recordings suffer a degree of high frequency loss and slightly higher distortion than when a smaller tip radius is used. It is therefore important to use the smallest tip radius possible, provided that the hiss level is not degraded. At this point it is worth mentioning that fibre and thorn needles are not recommended for normal usage since the lower conductivity of the material causes the point of such a stylus to assume quite a high temperature when tracking and tends to burn the groove, usually worsening the hiss level. Fibre or thorn played 78s frequently sound better when a larger tip radius diamond or sapphire is used. Discs played infrequently with steel needles in a good quality arm on an electric gramophone are less likely to be worn.

Any discs in for dubbing should be cleaned very carefully first with suitable solvents but care must be taken not to dissolve any of the surface shellac. The position of the hole should be carefully examined as swinging causes wow. Modern cartridges track quite satisfactorily at 5 gm or so. In many cases it is possible to go back to the original master or stamper and produce vinyl pressings which can then be dubbed with a corresponding decrease in surface noise.

A characteristic suitable for playing most 78s is one having a bass boost of approximately 63.6 mS. This time constant should be left in permanently and all corrections made afterwards. Many people have said it is better to copy 78s without any correction at all, apart from the main time constant, leaving the listener playing back the LP to add his own correction. I do not agree with this policy since record companies have more effective filtering and other electronic circuitry than is available in the majority of homes. Using a B & K third-octave filter to check the upper limit of recorded passages on older 78s, I found that very rarely are any frequencies above 6 kHz recorded on the oldest discs. Around 1936, 9 kHz was the limit although, in a few years before the introduction of LPs, Decca in particular had a frequency response extending considerably higher. My measurements have shown that the apparent presence of HF on old discs is in fact harmonic distortion introduced either when cutting the master or in playing back, particularly if recordings are worn. It is therefore recommended that a fairly steep cut filter be used, preferably non-inductive to minimise ringing.

A number of interesting electronic circuits have been used over the years to give a subjective improvement in quality. One of these was developed by H. H. Scott, and called the Dynaural Noise Suppressor. This device reduced the frequency range of reproduction both at the bass and treble ends in quiet passages and had a threshold device controlling the point below which suppression was effective. It tended to be audible in operation, however, although a modern version using transistor circuits might give improved results.

Successful attempts have been made to use the Dolby system unconventionally, by adjusting the law and sensitivity controls separately on the different frequency bands. Greatly improved results have been obtained using two channels back-to-back with equalisers and filters between the units. As a brief experiment I suggest setting a Dolby in the playback mode and withdrawing the module containing the two LF compressors, altering the settings on the other two compressors as desired, and feeding in a peak input signal to the Dolby several dB higher than the normal peak signal. Do not, however, exceed the normal maximum allowable input of approximately +17 dBm as distortion will occur.

Many companies dubbing 78s have been using a click suppressor and this basically consists of a main circuit chain delayed by a few milliseconds and a sidechain containing very heavy treble boost with an arrangement to mute the main chain for a short duration just before, during and after a click or spit, allowing sufficient time for the stylus to stop any resonating caused by the sharp transient.

It is useful to have a graphic equaliser available to improve the sound further and remove cutter resonances which frequently occur near the upper limit of recorded treble frequencies. A considerable improvement in reproduction of acoustically recorded 78s can be achieved by a carefully controlled amount of bass lift. It will frequently be found that the hiss level on early vocals is surprisingly low, as is the hiss level on early British Columbia issues pressed on a paper filled shellac with a much improved silent shellac surface.

American 78s were frequently recorded with a different recording characteristic and may well require a higher frequency bass turnover and a degree of treble cut. Many Toscanini recordings given very poor reviews in their day can sound better when played back with the correct characteristic. It is worth noting that Decca *ffrr* discs should be played back with a 25 μS treble-cut to achieve best results since this amount of boost was added on recording over the normal British curve, which in fact had no HF pre-emphasis at all. When joining sides together it is an advantage sometimes to add a small amount of reverberation over the join to make it less obvious. Unless the original recording was very dead, I find any addition of reverberation normally rather objectionable since it tends to cloud the sound which is usually already rather muddy at mid frequencies in old recordings. I must make a plea for engineers not to cut too much mid-top by applying roll offs from too low a frequency.

Many budget LPs in the last few years have contained wording to the effect that the record is 'electronically enhanced to give a stereo effect'. Up to the implementation of the Trade Descriptions Act some such discs were simply labelled 'stereo', as bold as brass. Almost all the fake stereo I have heard has for me been rather ineffective and in most cases I have preferred the original mono. Some companies, however, have achieved excellent results recently and a brief history of attempts at fake stereo may be of interest.

Early fake stereo was usually done by simple frequency division, channelling high frequencies to the left and low frequencies to the right. The resultant sound can be quite ludicrous, particularly when an attempt is made to reproduce a bass voice: the singer's tonsils are heard waggling in the left speaker while his stomach rumbles in the right one, to put it crudely. One German company applied artificial reverberation as well, making the sound even worse. Later efforts were more promising and included the use of graphic equalisers allowing additional HF bands through on the right while some medium LF

(continued overleaf)

bands came through from half left. By applying a mono signal to an echo plate or chamber and taking a low level stereo output which did not therefore have point sources, and mixing this in with the equalised direct signal, still better sound sometimes could be obtained. Unfortunately there has been a tendency for too much reverberation to be added giving a swimming bath effect in the centre of the sound stage.

Some companies have managed to keep away from the tendency for most of the sound to come from in between the loudspeakers by introducing a 90° phase shift in one of the channels after equalisation with respect to the other channel. This greatly improves the separation of middle frequencies, but such a phase shift device is very complex and extremely expensive to build. I understand that one company has a large black box containing inductances, capacitors and resistors in order to achieve this phase shift over the frequency spectrum.

Another useful device is time delay introduced in one or other channel, such a delay being in the order of a few milliseconds. A transient will tend to be heard from the channel not possessing the delay. There are many other pieces of electronic gadgetry available and I am currently working on some equipment which can achieve quite startling results by automatically controlling the instantaneous balance at different frequencies between the two channels.

Great caution must be taken if it is necessary to pan pot during the making of fake stereo tape and an example of the misuse of this is the violent moving of a harpsichord from extreme left to right during recitatives in a certain fake stereo issue of an opera. Perhaps even more amusing is the movement of an entire chorus between left and right several times in a fake stereo issue of a work by Carl Orff. Bearing these examples in mind, therefore, the engineer must remember that the sound must be musically reasonable, whatever faking he may attempt. In many cases it is better not to attempt a stereo effect. Near miracles, however, have been worked on one or two recent Decca *Eclipses*, though I find that most of the earlier issues are not as good as the original mono.

One word of warning; if the original recording contains an excessive amount of tape hiss, placing the higher frequencies on the left only will give an objectionable sound of hiss from that channel only. In general it would appear that chamber music and orchestral music (both pop and classical) are most effective in fake stereo, with vocal music (including opera as well as solo voice) least effective. A study of the recent *Eclipse* reissue of Bach cantatas originally recorded before 1950 should prove interesting since the sound is remarkably good, with vocalists surprisingly steady, while the chorus spreads quite well from left to right.

Recording fake stereo is a very lengthy business if it is to be done properly. It may appear defeatist for me to conclude on this note, but if the process cannot be done really well, it is better not attempted.

equipment reviews

REVOX Mk I To Mk 2 ADAPTER KIT

PRICES: Metal spool carriers: 17s. 6d. each. Left-hand roller guide with top and bottom plates: £1. Complete head casting with swing arm and roller: £12 10s. Tension device: 5s. Metal deck plate with head cover and knobs: £6 6s. **DISTRIBUTOR: Revox, 90 High Street, Eton, Windsor, Berkshire (Tel. 95-63388).**

WHEN initially introduced, the Revox *A77* was considered by most engineers to be the best machine available in its price range. There were minor criticisms concerning the scratch-prone plastic deck plate and also the somewhat sluggish rewind facilities. The wow and flutter figures have tended to become those by which other machines are judged, with consistent 19 cm/s readings of 0.06% to 0.07% (DIN weighted) being obtained.

Revox found that even better figures could be obtained by fitting a roller bearing in place of the static guide on the left of the head block. Also, to cut down any slight loops formed when starting the machine, they designed a damped swing arm to replace the fixed pin on the far left of the head block. All machines now being produced have these two modifications as well as improved fast spooling, and metal spool carriers. An aluminium deck plate with matching knobs and head cover is now available.

All these improvements can be incorporated in an older machine, everything being interchangeable with all the necessary parts being available from Revox UK.

The machine chosen for conversion had quite an early serial number and, although having been used extensively by the authors, was in good mechanical and electrical condition. Wow and flutter was just better than should be expected, averaging about 0.06%.

First, the spooling modification was attempted. Following the instructions supplied with the parts (one length of wire, clip and resistor), the modification went without a hitch. One point not made clear in the instructions is that the 'reel motors' switch should be viewed from the back, front down, when determining left and right connections. The shorting link between the left and right tags is extracted and the black wire on the right tag is moved over to join the other black wire on the left. A purple wire is then soldered to the vacant right tag and connected with the clip provided on to the third tag down (DJ1) on the power supply board. The white wire connected to the fourth tag down (DF3) is removed and clipped on to Tag One which is vacant on the servo control board. The 820 ohms 10 W resistor on the logic board is replaced with a 1.5 K 10 W.

With the machine resting upside-down on the deck plate and the front facing away, the connections DJ1 and DF3 lie on the farthermost vertical edge of the power supply board which is mounted just to the right of the mains transformer. The servo control board is mounted just behind the mains transformer and the vacant tag is on the extreme right of this board. The logic board is slightly to the left of the servo control board and approximately 10 cm farther back.

Some early machines have this modification already, while others have different rewind motors. It is necessary first to check the motor lettering as the modification is only suitable for motors with the letters EOK stamped on their sides. Motors with EOM must not be modified.

The result of this modification was a reasonable spooling tension, accelerating a full NAB spool successfully with either of the two spools fully loaded.

The next modification was the replacement of the entire head casting. When a new-design casting is ordered, this is already fitted with the damped swing arm and the roller bearing.

After removing the swing-down cover, note should be made of the head and tape sensor connections. The record and replay heads are mounted on a common base plate and this should be removed, taking care not to alter the azimuth and height adjustment screws. The tape sensor bulb holder should be unclipped and the erase head and photocell removed. The bar linking the pressure roller arm to the tape withdrawal pin and hum shield is disconnected. The pressure roller arm is loosened with an Allen key from its shaft and is lifted clear; avoid bending the linking bar. At this point the motor should be lowered by loosening the four supporting screws. The motor wiring need not be disturbed as the new head block fits over the capstan without the need to remove the motor. The capstan is very vulnerable at this point and you must ensure its polished surface does not get scratched or scored in any way. The head block may then be removed, care being taken not to damage the pressure roller arm pivot.

Fitting the new head block is a complete reversal of the aforementioned procedure. All the mating surfaces must be clean to preserve head alignment. Ensure that all screws fit freely before tightening, although it is unlikely that such a robust casting could distort. The tape guide on the immediate right of the replay head should be tightened last and the actual height of the guide should not be touched—this is preset. Some juggling with the pressure roller arm was necessary on our own machine but a small line cut across the top of the shaft and on to the arm before removal will avoid this. Finally, degauss the whole assembly, especially the heads, and clean.

Taking very careful wow and flutter readings, the improvement was astounding. The average reading was 0.025% to 0.03% at 19 cm/s with absolute peak readings of 0.04%. These readings were taken on a Miniflux wow and flutter meter, weighted to DIN specification.

Revox UK have also made available the roller guide by itself. This produces a very significant drop in wow and flutter and can be fitted on the existing head block very simply. All that is necessary is to loosen the screw holding the left-hand static guide from underneath the machine with a long screwdriver. This guide is then replaced with the roller and new top and bottom plates. A decrease of up to 0.02% or even more can be achieved just by replacing this guide. This modification may also be carried out on the older *736* machines with equally good improvements in wow and flutter figures. Great care must be taken, however, that not too much pressure is applied to the top nut as over-tightening can easily cause the top and bottom plates to bend and jam the roller.

Anyone attempting to modify the *736* would be advised to fit spacers of some kind in order to avoid the bending of these guide plates. Some experiment will be necessary as this is not a standard modification. The results, however, are still well worthwhile.

Returning to the *A77* modifications, Revox are now fitting metal spool carriers as standard. The effect of these, apart from a great improvement in appearance, is that all static buildup is eliminated when using metal spools. Also available, as extras for any machine, are a new design of deck plate and head cover. These are finished in brushed Dural and match the new spool carriers. The deck plate and head cover are supplied with four matching Dural knobs with knurled edges and an engraved pointer.

Some users may have experienced some initial wobble when starting the machine on record or replay. This can be greatly reduced by pressing the fast spool cue lever to the right of the head assembly. This brings the tape much closer to the head surface and consequently it has less distance to travel when pushing the play button. The fitting of the damped swing arm also decreases the wobble to a considerable extent. These two improvements in operation produce a virtually instant start even when replaying continuous recorded tone.

In more recent machines, Revox have also been fitting a different output transistor in the DC amplifier of the servo control unit. There is no direct improvement except in general stability and the longevity of the component.

All the improvements, taking into account the reel motor lettering, can be incorporated in the 38 cm/s version of *HS77*. Tests run on a modified high speed machine produced average figures of 0.015% with an absolute maximum of 0.025%.

One last point to remember when testing the machine out of its case; the remote control plug must be inserted for the relays to lock and the special mains disconnecting jack must be bridged. This is achieved by pushing insulated banana plugs into the two holes. Note that these two plugs must not under any circumstances be shorted together.

Angus McKenzie and Peter Self

field trials

SONY CV-2100 ACE VTR

MANUFACTURER'S SPECIFICATION. Helical VTR, recording 50 field monochrome at 29 cm/s nominal. **Tape width:** 12.5 mm. Spool capacity: 18 cm. **Recording time:** 40 minutes with 18 cm Sony videotape. **System:** British standard, 405 or 625 line. **Video inputs:** 1 to 3 V p-p, 75 ohms, unbalanced. **Video outputs:** 1.4 V p-p, 75 ohms, unbalanced. **Audio input:** · 65 dBm (600 ohms unbalanced). **Audio output:** 0 dBm. **Signal-to-noise ratios** (audio and video): 40 dB. **Heads:** Erase, audio/sync, two video. **Features:** Manual/AGC. Still frame. Compatible with other CV2100ACE machines. Tape duplication. Simple editing. **Price:** £395. 230 mm (diagonal) monitor: £126 7s 3d. **Cameras:** From £135.

Distributor: Sony UK Ltd, VTR Division, Ascot Road, Bedfont, Feltham, Middlesex.

AT the moment of writing, five companies are producing 12.5 mm helical VTRs for the UK market: National, Nivico, Sanyo, Shibaden and Sony. All but one employ a twin-head drum, Sanyo's *1000SL* being the exception with a four-head drum.

Sony were the first company to market a practical VTR for significantly less than £1 000. Their first model employed the field-skip technique currently used on the *CV-2000B*. This permits a virtual halving of tape speed, recording 25 of the 50 fields transmitted each second by European TV stations. On replay, the second head (dead during record) comes into circuit, causing each field to be scanned twice. One field occupies a full video track.

The *CV-2100 ACE* records and reproduces all 50 fields at a tape speed of 29.14 cm/s. It is more than a bare VTR. It permits single field freezing (scanning a stationary tape), video editing and sound dubbing. Supplied with the recorder were an *AVC-3200 CE* camera and *AVF-3200 CE* electronic viewfinder, both 625 line, a *CVM-90UB* 405/625 line monitor/off-air receiver (175 mm screen width), moving-coil stick microphone and two 18 cm reels of triple play Sony video tape.

A fairly detailed instruction book was included, quite adequate to guide an audio man through the unfamiliar territory of lacing a helical drum, adjusting camera aperture, video gain and monitor contrast. Camera and recorder are connected through six-pin DIN plugs, while an eight-pin locking connector joins the VTR to the monitor. The latter carries audio and video in/out.

My prior experience of TV equipment has been limited to adjusting aerial positions on or near The Box and noticing the critical difference

between a position giving good reception and one causing severe ghosting. I was agreeably surprised to find that nothing about the Sony VTR system displayed this 'fragility'. You can run a video cable over a mains lead, hang it or loop it in any way you choose without visibly affecting the picture.

The *AVC-3200 CE* camera is one of several models produced by Sony. Camera and viewfinder screw together, the latter being a small hooded monitor with contrast, brightness, vertical hold and horizontal hold controls. None of these controls influences the signal fed to the recorder. Screen width is 77 mm.

Camera controls comprise lens focus (calibrated from one foot to infinity) aperture (f1.8 to 16), on/standby/off, video/RF out internal/external sync and a threaded UHF coaxial socket in addition to the VTR DIN connector. The tripod, a very solid affair by amateur cine standards, incorporates a pan/tilt head and a height adjuster worked by a fold-away handle. Telescopic legs extend to three times their shortest length. The camera base may be mounted at almost any angle (including 90°) and any height between 50 and 135 cm. The tilt and height locks must be treated carefully to prevent jarring the camera and viewfinder.

Most indoor work, with normal household daylight or artificial light, required full f1.8 exposure. Difficult lighting conditions were improved by removing lampshades and exchanging the odd 60 W with a 100 W bulb. Recordings made under domestic electric light usually required maximum contrast on the reproducing screen.

The recorder employs a single motor for capstan drive and fast wind. A belt couples the head drum to the capstan. Leaving the feed spool (left), the tape passes over a back-tension brake servo, round a rotating guide, across the erase head (separate audio and video segments), then over a slightly skewed post which angles the tape down round the drum. Another post skewed at a complementary angle, another guide, audio and field-sync heads (two segments on one block), on through the capstan and pinch wheel to the takeup spool. The tape is not lifted from the heads during fast wind and the erase head was found to collect considerable amounts of dirt. The video heads were not unduly prone to dirt build-up and a routine cleaning and degaussing after every 10 hours running seemed to suffice, as with an audio recorder.

Two controls on the right-hand side of the cabinet govern video and audio levels, judged against a switchable meter. The pointer is much less active when reading video, only rising significantly when a white shirt walks on to the picture, or the sun comes out. (If you are interested in the technicalities, I recommend L. C. Showalter's book *Closed Circuit TV*, published by Foulsham at 45s.)

Pulled outwards, the video level knob switches on the video drum for single-field viewing. It is usually necessary to pull the tape forwards or backwards slightly to push inter-field picture breakup away from the centre of the screen to the upper or lower edges. No discernible damage was caused to the tape or the recorded image when replaying a frozen field unless the reels were pulled in opposite directions simultaneously. Video tape manufacture has improved very considerably in recent years. The material is now likely to suffer more at the hands of its operator than from the recorder. Unthreading in mid reel (if one wished to switch the tape to another machine without rewinding) could easily cause a fold. Two accidents in fast winding (the only ones during a two-month test period) caused such folds and their visible effect was a thick white line which passed from the bottom to the top of the picture in about a second. Both accidents were the result of switching straight from rewind through stop to play.

The drum rotates during forward and reverse wind, presumably because it would cost more to have a disengaging mechanism. Occasionally this results in an unsteady speeded-up picture being visible on fast wind and it is possible, when the picture finally breaks up, to 'tune in' at least partially by adjusting the horizontal hold and switching to a new line standard!

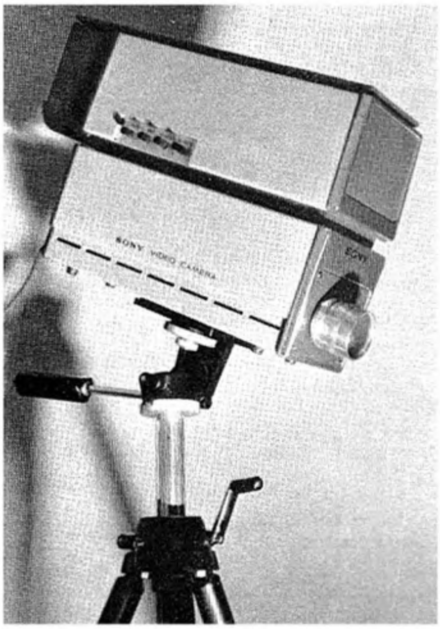
Two standard unbalanced jack sockets accept microphone and gram inputs, a third jack socket supplying audio for an external amplifier.

The Sony monitor/off-air receiver is a standard domestic set with normal 405 and 625 line facilities, brightness, contrast, horizontal and vertical hold. The only unusual feature was an adapter box on one side of the cabinet, housing the VTR connector and three UHF sockets, two being video inputs, the other a video output. The UHF connectors are duplicated by miniature jack sockets. A mini-jack on the main body of the receiver permits the connection of a separate 75 ohm aerial. A switch selects off-air or external monitoring.

Under no-signal VTR conditions (playing a bulk erased tape or with the video drum stationary), the monitor screen produces a random display of black and white smears. A few seconds recorded 'silence' (camera off or video gain at minimum) eliminates this distraction, a practice that should be followed as studiously as the cine crowd avoid flooding their screen with light between films or slides. It ain't professional.

Pictures may be faded in and out by carefully manipulating the video gain control. This would be easier with a larger control on the top of the recorder. Under low-light conditions, the camera aperture permits a limited degree of fade-out.

The camera was a pleasure to operate. Lens angle was wide enough to permit a very satisfactory piano recording in the cramped confines of an acoustically damped box room. Vertical and horizontal panning were jerk-free the electronic viewfinder showing exactly the picture being fed to the recorder—in shape at least.



The viewfinder picture is duplicated, when recording or setting up, on the monitor receiver. The latter makes an invaluable 'remote viewfinder' when you choose to take pictures of yourself.

Like most helical VTRs, the Sony requires several seconds to stabilise when switched from stationary to record or play. The picture jumps once or twice, then reforms for the duration of the scene. During the first 10 minutes the Sony is used, the picture may jump in mid scene. Certainly the video drum needs to warm up (preferably with no tape threaded, to conserve tape and head life). A run of a minute or two is enough to stabilise the horizontal sync of a cold machine.

The video edit facility on the *CV2100 ACE* overcomes the frame break-up problem that would otherwise occur between programme sequences. Mr Smith wishes to lecture upon his collection of stuffed birds. In the absence of a second camera and a vision mixer, you place him behind a table and record his entire 30 minute talk. You then rewind, point the camera at an owl and, guided by the sound track and digital turns counter, switch straight from playback into record. After a preplanned number of digits, you stop the VTR or pan to a new scene (avoiding Mr Smith who may now be negotiating a doughnut). This technique permits video inserts with no more picture break-up than a single field flash.

Audio inserts were technically possible, using a separate sound-record button in conjunction with the edit button. These two controls are normally out of sight under a sliding flap in the top of the deck. This facility was in fact faulty on the VTR I tested and a purchaser would obviously have had it repaired.

Video reproduction was very good and the only outstanding difference from 'live' was a white streaking effect which I initially attributed to dropout. In fact this is caused entirely by dirt on the drum slip rings. Cleaning tools are supplied and are completely effective.

Wow has no more effect on the picture than it has in a cine projector, the eye being relatively insensitive to variations in the 50 Hz frame speed.

My intention of inverting the tape to see the effect of scanning upside down was foiled by Sony's ingeniously simple idea of making the spools non-inverting. This is worth considering as a safeguard for audio applications, when the NAB and DIN committees next change their minds.

The Sony monitor contains a peaky tweeter particularly efficient around line-scan frequency (10.125 kHz on 405). The VTR's audio channel is quite capable of living up to a decent external amplifier and loudspeaker, as might be expected from the 29.14 cm/s tape speed (midway between 19 and 38). Wow was audible on piano and guitar but was mainly random, probably due to variations in back tension. I could not hear it on light music or speech, and in this respect the VTR is comparable with the kind of domestic audio machine you can buy for £100 or so.

Is the recorder worth £350? To an industry requiring a memory for existing CCTV equipment, it undoubtedly is. And in the (notoriously hard up) field of education, the prospect of preserving BBC Educational TV broadcasts and reproducing through a wide-screen monitor must be more worthwhile than the vastly more costly replay scheme offered by EVR.

Camera, recorder and monitor have limited potential as a home movie medium, because they are so rigidly confined to the home. A battery portable VTR represents a more promising medium for movie-makers, however, and I look forward to testing these units in coming months. **David Kirk**

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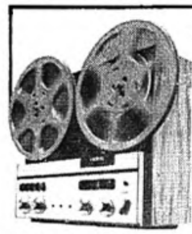

EQUIPMENT TEST REPORTS

By Hirsch-Houck Laboratories

REVOX A77 TAPE RECORDER

● IT IS a pleasure to report that the widely acclaimed, but no longer available, Revox G-36 Mk III tape recorder has actually been surpassed in performance by Revox's new Model A77. The A77 has fully solid-state electronics, a bias-oscillator frequency of 120 kHz (as opposed to 70 kHz for the G-36), and a new electronic motor-speed control. The A77 model we tested is a three-motor, four-track, two-speed recorder; however, it is substantially lighter and smaller than its predecessor.

The Revox A77 has its operating controls grouped into separate recording and playback areas. On the playback side are two rotary switches with concentric knobs. One switch establishes the playback mode—stereo, either channel through both outputs, or both channels combined for mono. Playback level is controlled by the concentric knob. The other switch connects either the signal input or the output of the playback amplifiers to the output jacks in the rear. Two playback-equalization characteristics are provided; NAB or IEC (for European tape recordings). The recording equalization is to the NAB standards. The knob concentric with this switch is a playback channel-balance control.

On the right side of the recorder panel are two VU meters with real VU-meter characteristics. Adjacent to each is a red button of the push-on, push-off type. Depressing either channel's button alone records both inputs on that channel. If both buttons are depressed, a stereo recording is made. These supplement a record-interlock button, providing a double safety against accidental tape erasure. Recording levels may be set up before the tape is put into motion. When the recorder is in operation in the recording mode, the selected channel's VU meter (or meters) is illuminated.

Under each meter is a recording input-selector switch, with a concentric recording-level control. There are inputs for high- and low-impedance microphones (with front-panel jacks in parallel with rear phono connectors), radio (via a rear DIN connector), and auxiliary inputs with connectors in the rear. In addition, each switch has a position for recording the output of that channel combined with any additional source onto the other channel.

The transport mechanism is operated by a row of five pushbuttons, activating solenoids to control fast speeds, stop, play, and recording. A connector in the rear permits the use of an accessory remote-control unit for these functions. The tape speeds (7½ and 3¾ ips) are selected by a switch that also controls a.c. power to the recorder. Each speed setting has two switch positions that set the tape tension to optimum values for 10½-inch or smaller reels.

The servo-controlled drive system of the Revox A77 is unique and effective. The tape-drive capstan is powered by an eddy-current motor that delivers a high torque, free of the pulsations that are inevitable with any motor having a pole structure. The speed of this motor can be adjusted by varying a d.c. control voltage, with relatively little torque variation. The motor has a built-in tone generator that produces an a.c. signal whose frequency is proportional to motor speed. This signal is amplified, limited, and applied to a discriminator, whose d.c. output is proportional to speed. This is further amplified and used to correct the motor speed. The change between 7½ and 3¾ ips is accomplished electronically by shifting the resonant frequency of the discriminator circuit. The chief advantages of this technique are independence from power-line voltage and frequency variations, as well as reduced flutter. Flutter of the A77 motor is inherently so low that the capstan can be driven directly from the motor shaft instead of through a separate belt-driven flywheel. According to the manufacturer, line voltage fluctuations of ±20 per cent cause a speed change of only ±0.05 per cent, and a change in the a.c.-line frequency of 50 to 60 Hz causes a speed change of less than 0.05 per cent. Thus, the Revox A77 is a truly universal machine, capable of operating from 110 volts to 240 volts, 50 to 60 Hz, by adjustment of a switch in the rear of the recorder.

When the full-width head cover is swung down, two more pushbuttons are revealed. One cuts off the signal to external speakers, and the other switches off the power to the reel motors. This is for convenience in editing. When the reel motors are turned off, and the recorder placed in a fast-speed mode, the reels may be turned by hand with the tape in contact with the playback head. At the desired point, the tape may be lifted from the heads and placed in the tape splicing guide which is molded into the fixed portion of the head cover. The only problem with this arrangement is the possibility that one may spill tape by forgetting to turn on the reel motors before placing the machine back into normal operation.

We stated that the A77 surpassed the older G-36 in performance. This is best illustrated by its phenomenally flat record/playback frequency response, measured with Scotch 203 tape, for which the machine's bias was adjusted. At 7½ ips, the response was within +0.5, −2.0 dB from 20 to 20,000 Hz. This has never been equalled by any other recorder we have tested. Perhaps even more impressive is the response at 3¾ ips, which was +2.5, −5.5 dB from 20 to 20,000 Hz. The high end falls off smoothly and is perfectly usable all the way to 20,000 Hz. The NAB playback response, with the Ampex 31321-04 test tape, was +1.5, −0.5 dB from 50 to 15,000 Hz.

The signal-to-noise ratio was very good, 51 dB at 7½ ips and 48.5 dB at 3¾ ips, referred to a 0-VU recording level. Noting that the distortion at 0 VU was a mere 0.65 per cent, we increased the recording level until the distortion reached approximately 3 per cent, which occurred at +10 VU for the higher tape speed and +9 VU for the lower speed. At these levels, the signal-to-noise ratio was 59 dB at 7½ ips and 54.5 dB at 3¾ ips, figures that closely approach true professional performance.

The transport worked smoothly and with complete silence. Except for the turning of the reels, one could not tell the machine was operating from a distance greater than about 12 inches. Wow was 0.01 per cent (actually the residual inherent in our instruments) and flutter was 0.09 per cent at 3¾ ips and 0.07 per cent at 7½ ips. In fast speeds, 1,800 feet of tape was handled in about 90 seconds, and the machine could be brought to a stop in about 2 seconds.

The Revox A77 is housed in a teak cabinet with a fold-away carrying handle. It is one of the handsomest, as well as best-performing, tape recorders we have seen. We have never seen a recorder that could match the performance of the Revox A77 in all respects, and very few that even come close. It sounds as good as it tests, which speaks for itself. The Revox A77 is offered in a variety of configurations. It is available with either half- or quarter-track heads, in either the teak cabinet or a portable carrying case. The price of the deck in a wood base is $569; the deck with built-in power amplifiers is $599.