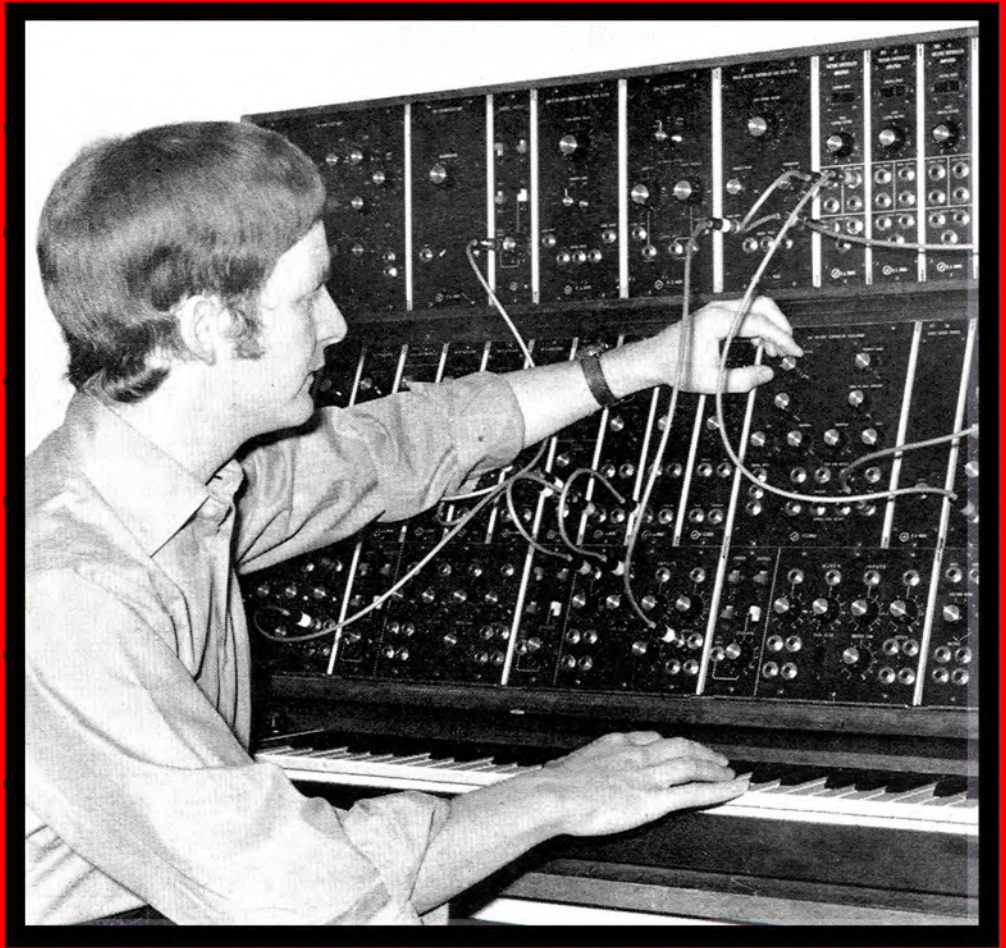
STUDIO SOUND

OCTOBER 1970 3s (15p)



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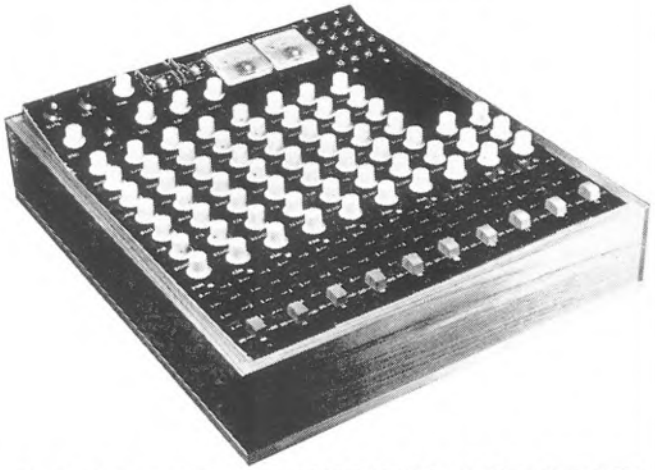

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The rest of the specifications are as you'd expect in a tape recorder of this quality: low harmonic distortion, good signal-to-noise ratio, minimum wow and flutter, excellent speed stability with the classic three-motor design.

In its standard version, the PRO 12 allows for twin-track stereo, twin-track mono and dual-track mono on $\frac{1}{4}$ inch tape; an alternative version allows for quarter-track stereo or mono.

It also has separate heads and separate amplifiers for both recording and playback at either of its speeds, $3\frac{3}{4}$ or $7\frac{1}{2}$ ips, and provides before and after tape (A-B) monitoring either visually or aurally.

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

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Studio Sound

AND TAPE RECORDER

OCTOBER 1970 VOLUME 12 NUMBER 10

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COVER PICTURE

Mike Vickers (ex-Manfred Mann) at the keyboard of his Type 3 Moog electronic music synthesiser.

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.

IT IS FREQUENTLY suggested (by Leonard Bernstein for a start), and equally often denied, that pop is an exciting step forward in the evolution of music. There can be no question that pop has contributed at least to the evolution of recording techniques, introducing to the public the wonders of compression, flutter-echo, many electric musical instruments, electronic tremolo, phasing, multitracking and (with doubtful success in several Beatles' compositions) reversal. Not to mention fuzz —deliberate distortion.

Originally the latter was applied to the electric guitar, introducing random wave patterns into the tedious simplicity of the pickup output. Since then, engineers, performers, or the inbetweens, have extended this treatment to the electric organ, relieving the boredom of its tone with varying degrees of success. With the arrival of *Blood, Sweat and Tears*, the public was offered fuzz, like chips, with everything. 'Listen to its glorious coarseness' your pop performers could be heard to say. Recently we heard a demonstration tape which took 'glorious coarseness' up a few dB into the realms of inglorious grit. 'No,' we were assured, 'it's not a faulty dub. The trouble with *B, S and T* is that their fuzz is too professional, too clean.'

Pop's flirtation with studio gimmicks is laudable up to a point: many of us remember the pleasure of hearing the *Sergeant Pepper* (phasing) songs for the first time. But when performers bog themselves down en masse in a single gimmick, following that uniformity cult which dictates their hairstyles and clothing, they create a monotony which serves only to damp public interest.

We are inclined to think that pop is running out of steam when, in the light of the considerable success enjoyed by the Moog synthesised *Switched-On Bach*, the 'exciting step forward' crowd answer back with more fuzz, more phasing, and that supreme bore—the electric violin. A few groups have toyed with the Moog, yet even The Beatles kept it so far in the background that they seemed to fear being overshadowed by it.

The Moog has proved a disappointing solo instrument in televised pop. Multitrack facilities are needed to achieve the polyphonic music in which the synthesiser excels, offering a limitless source of accompaniments to more conventional pop instruments and voices. The voltage-controlled circuitry which made the Moog possible can in turn be applied to human voice signals and to any acoustic or electric instrument. Heaven knows how many guitars have been passed through compressors and equalisers; who will be first to modulate the operating levels of the latter devices with the output of a second instrument?

If not running out of steam, could it be lack of financial resources that keeps pop so firmly in the rut, or simply lack of ideas? If the latter, it is time pop performers exploited *pre*-echo, examined the myriad of new tones available from unconventional instrument tuning, slackened their guitar strings while playing, explored slurring, merged pre-taped sound effects into their music, and (one or two groups have cottoned on to this) tried the effect of echoed slow percussion. Perhaps then, when they can afford it, they'll push the lot through a Moog.

Teldec's recently announced Video Disc offers the prospect of 18-hour capacity gramophone records, assuming that 12 minutes of 3 MHz occupies the space of 20 hours 30 kHz. The system does not permit lateral modulation so stereo may reduce storage capacity to ten hours (two-channel) or five hours (four-channel). It will be interesting to see whether this can be exploited by the audio industry. Not least of the problems is the fact that few pop groups have a large enough repertoire for a five-hour stint.

studio diary

FIRST DOLBY-B CASSETTE RECORDER

THE FIRST Dolby-B cassette recorder to be offered on the domestic market was demonstrated on August 12 by Kellar Electronics. Production of the *DTA50* commences in September, retail distribution starting through selected outlets in October. The recorder incorporates a 25 W per channel power amplifier and has a claimed 40 Hz to 12 kHz ±3 dB frequency response (1 μm head gap), with 2.5% overall distortion at 0 VU. Signal-to-noise ratio is 52 dB with Dolby in, 47 dB with Dolby out, at 0 VU. Wow and flutter total 0.15% peak, CCIR weighted, and bias frequency is 105 kHz. Price will be £50 including tax. Stanley Kelly and Sidney Larholt, joint managing directors of the new company, are backing the unit with 'an unqualified five-year guarantee'. They believe themselves to be the first to offer this for domestic tape equipment. Kellar Electronics Ltd is based at Maryland Works, 9 Brydges Road, Stratford, London E.15.

SUTTON MOVE

THE SUTTON Sound premises in Soho Square are about to be demolished and the company have moved temporarily to 23 Redan Place, London W.2 (Tel. 229-0100). This accommodation has been provided by Sound Associates.

GEMINI RE-EQUIP AND RE-DECORATE

CLOSED FOR alterations from July 27 to mid-August, Gemini Studios, 15 Cricklewood Broadway, N.W.2, are now offering special introductory rates of £3 10s per hour. Their new equipment includes an Allen & Heath mixer, Teletronix compressor/limiters, TRD stereo recorders, Binson echo, Grampian reverberation and Tannoy monitor loudspeakers. Studio dimensions are 7 x 5 m, which 'has been known to hold eight musicians, six spectators and three cats'.

SONY MOVE

SONY UK Ltd moved early in August to Pyrene House, Sunbury Cross, Sunbury-on-Thames, Middlesex. The company's VTR Division remains at the existing Bedfont premises.

MARQUEE EXPAND

A 16-TRACK Ampex, complementing their existing eight-track *MM1000*, and a 24-channel mixer built to Helios design were among improvements made during August to Marquee Studios. The Richmond Mews premises was closed for a £35 000 development scheme, re-opening on September 1. The control room has been doubled in capacity by merging with an adjoining tape store.

R.A. MOOG AT AUDIO FAIR

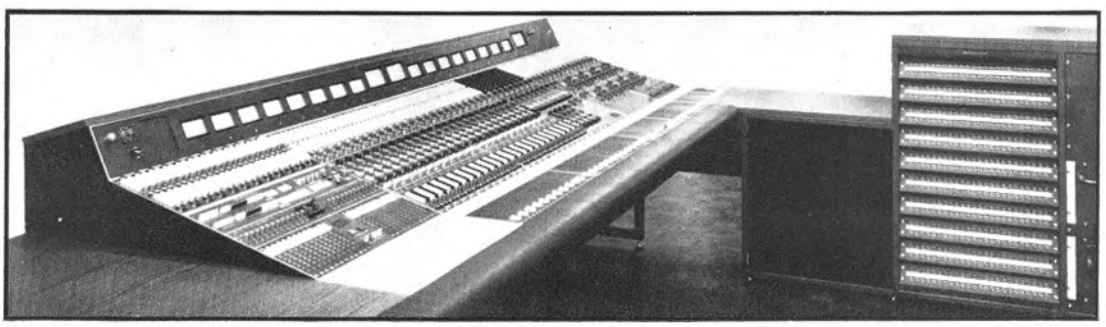
THE INVENTOR of the Moog electronic music synthesiser, Dr R. A. Moog, will visit London in October to demonstrate his developments at the International Audio and Music Fair. A talk entitled 'The Progression of Electronic Music Synthesisers' will be given on Tuesday October 20 at 4 pm, repeated the following day at 8 pm.

JACQUES LEVY

REPORTING HIS visit to Spot Productions (August issue), Keith Wicks stated that the company's managing director, Gary Levy, is a cousin of APRS chairman Jacques Levy. The latter has since informed us that he has no blood relationship with any member of the British recording industry.

KAYE RETIRES FROM PAINTON

AFTER 20 years service, J. B. Kaye has retired from Painton & Co Ltd. He joined the company in 1950 as chief engineer and later progressed to general manager, joint managing director and vice-chairman. Earlier in his career he worked for International Standard Electric and Philips.



The most elaborate Neve console to date, recently installed at Whitney Recording Studios Inc., Hollywood.

PYE TOUR EASTERN EUROPE

SIXTY REELS of Dynarange *202* and an eight-track Mincom recorder were carried by the Pye Mobile Recording Unit during its 24-day tour of Rumania, Yugoslavia and Poland recently. Also on board were an eight-output Neve mixer and 20 microphones. Recording engineer Vic Maile and maintenance engineer Tony Cary taped nine concerts by the American Blood, Sweat and Tears group.

RECORD REVIEW AND HI-FI NEWS MERGE

THE LINK House Group magazines *Record Review* and *Hi-Fi News* are to merge with effect from the October issue. *Hi-Fi News Incorporating Record Review* will cost 3s 6d and carry 20 more pages of editorial matter than the existing *Hi-Fi News*. It is hoped that the new publication will appeal equally to audio enthusiasts and gramophone record buyers. Peter Gammond becomes Music Editor.

NEXT MONTH

IN THE NOVEMBER *Studio Sound*, Angus McKenzie undertakes a detailed comparison of 11 professional recording tapes: Agfa *FR4*, *525* and *555*, Ampex *434*, BASF *SP52*, *LGR30* and *LR56*, EMI *H57* and *815*, and Scotch *202* and *206*, reaching some surprising conclusions. Keith Wicks visits Trident. In 'The Gentle Art of Busking', Bob Auger replies to critics of multi-mike techniques. Reviews: Dolby-B and the Koss *ESP-6* electrostatic headphones.

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

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

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

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We want you to have the best.

PHILIPS

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RECORDING STUDIO TECHNIQUES

PART TEN PORTABLE STEREO MIXERS

BY ANGUS McKENZIE (Roundabout Records)

IN the design of mixers for location recording, the most important considerations are ease of connection and use. To avoid carrying enormous quantities of equipment, it is helpful for microphones to plug straight into the mixer itself, and the output from the mixer to connect direct into the tape recording system, which may or may not include a noise reduction system. Most mixers also incorporate not only loudspeaker monitoring but also a talkback system with desk-mounted microphone. A 20 dB mute is normally applied to the monitor speakers when the talkback key is depressed. It is also useful if the talkback microphone can be injected on the master tape for take identification. All the microphone inputs should be balanced and the input impedance recommended is 1 K for 200 ohm capacitor mikes. The amount of gain in the mike preamps should be controllable, however, by a pre-set potentiometer or an attenuation switch. As transistors do not have anywhere near the overload characteristics of valves, the preamp gain should be so attenuated as to allow the main channel gain to be used at least halfway up. A maximum sensitivity of −60 dBm into the microphone input stage is quite adequate for capacitor microphones under normal conditions. For classical recording, peak outputs from capacitor microphones can be as high as −20 dBm and occasionally even higher, while in pop recordings still higher inputs can be encountered, showing the advisability of providing gains as low as only 20 dB in the preamps, and also 10 and 20 dB input attenuators.

It is always useful to have at least treble and bass equalisation available on each mike channel, and a mid-frequency presence control is also useful. The mixer should have the facility of pan potting all or most of the inputs to various positions from extreme left to extreme right. This is usually done by splitting the output of each mike fader into two isolated channels and adjusting the gain independently of the two feeds with a potentiometer having full gain on both channels in mid-position, reducing the gain to zero on one or other channel when rotated to either extreme position. This permits any microphone to present its output anywhere from extreme left to extreme right. The output level metering should be taken from the main output of the mixer and should be capable of being switched to the output of the tape recorder, coming back into the mixer for monitoring purposes. A key switch increasing the meter sensitivity by 20 dB simplifies bias and equalisation setting of the tape recorders. To avoid the necessity of taking a lot of test equipment to a session, a simple tone oscillator is essential, incorporated in the mixer, and I recommend switching frequencies of 60 Hz, 1 kHz, 10 kHz and 15 kHz with a potentiometer, the oscillator output being switchable to either or both channels at any required level. I consider it an advantage to have the microphone channels in pairs using stereo vertical slide faders with independent control of left and right, whereas it is advisable for the master gain control to be permanently ganged.

All input and output connectors should be of the same type so that time is not wasted locating leads. For simplicity, low cost and weight considerations, I use three-pin locking DIN plugs throughout as connectors with chassis mounted sockets on the mixer and ancilliary equipment, although Cannon XLR connectors are in more general studio use because of their ruggedness. Provided that fairly short leads of not more than 9 m length are used between mixer and recorders, unbalanced connections are safe. In this case the socket pin not in use should be earthed, providing an unbalanced feed to the balanced input of other equipment.

Various standards

Various standards for peak recording level are in use but, now that transistorised circuitry has been in use for so many years and high power line out stages are simple to design, studios are adopting +8 dBm for peak recording level, or alternatively +4 dBm out for zero VU or NAB level. It is most important to have good overload margins throughout the mixer, allowing the master gain control to be used well below maximum, and also allowing a considerably higher output than the peak recording level for transients that even the PPM may not show. I consider an overload margin of 16 dB important for the master gain control, and a minimum of 8 dB (preferably 12 dB) above the nominal peak output level of the mixer.

On a mixer used for pop recording, it is essential to have the facility of jacking in limiters and more complex equalisers to any mike or fader channel since it is often required to set limits at different levels on different mike outputs. It is more convenient to use tip, ring and sleeve jacks for this purpose in which case both the send and return signals can be carried on the same cable, provided the impedance at the jacking-in point is kept low. It is preferable for send and return to be independent. Some excellent sub-miniature screened balanced jacks are available, allowing quite a lot of connections to be made in a comparatively small space, and a number of studios are using these. The provision of echo send and return circuits in portable mixers may also be of importance, and it is a matter of opinion whether the echo output from each microphone channel should be taken from before or after the individual microphone channel gain controls. Several mobile mixers I have encountered included an extremely interesting echo send control in which the percentage of echo to direct sound is controlled by the position of a potentiometer with no independent echo volume control provided, the main microphone channel gain being used. The echo output from each channel can be provided with a switch selecting any echo device or combination of devices and it is usual also to have a main echo send gain control. The echo return circuits normally return to the direct feed immediately before the main overall gain control, and usually have an independent echo return gain. If one desires to use more than two tracks for recording, it should always be possible to use the echo send circuits as feeds to the other tracks, in which case echo can be added when reducing back in the studio.

As previously explained, I infinitely prefer PPMs to VUs, and it is essential for either of these to be in the mixer itself. It is useful to have, on more comprehensive mixers which might be termed 'transportable', pre-fade listen and metering circuits. The outputs of every mike channel are taken from immediately before the channel fader to a multi-position

(*continued overleaf*)

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David Robinson

PART FIVE
FURTHER CIRCUITS

WITH three articles published, there has now been sufficient time for queries and comments to stream in. So to start this month's article, I propose to cover some of these in detail in the hope of helping those who have not yet put pen to paper.

Firstly, in Part Two reference was made in **fig. 9** to a Preh fader; this is distributed by G.E. Electronics, whose address was given at the end of that part on page 320. Part Three produced two circuit errors, the less serious being in the mike amp, **fig. 22.** C12, the capacitor which forms an RF short-circuit at the input, should be returned to the OV line and not to the junction of R1 and R9. Connecting it as shown will not affect the audio performance of the amplifier but will degrade the rejection of RF interference signals. The other error is more serious. C2 in the bridging amplifier **(fig. 20)** should be connected to the collector of Tr2 (shown as Tr6!) and not to the junction of R5 and R6. Obviously with the component values for unity gain there is no difference, but I hope those readers who have tried to obtain gain from the circuit will not have wasted too much time puzzling over the constancy with which it provided a gain of one, independent of the value of R5. The printed circuit cards do not have these errors.

While discussing the cards, apologies to readers who have not yet received their orders. Demand was so heavy that initial supplies were rapidly exhausted, and new supplies were held up at holiday time. In general, cards take two to three weeks to arrive after an order is sent to me via Link House.

Other points: the magnetic cartridge input, **fig. 23,** was printed without the transistor type information. Tr1 and 3 are *BC109*, Tr2 is a *2N4062*.

Finally, there have been several queries on the input stage of the mike amplifier, fig. 22. Readers wanted to know for what microphones the circuit is suited, and why the input was apparently not balanced. Microphones are designed to feed a higher impedance than their nominal impedance, so that the maximum signal-to-noise ratio can be realised. Most microphones are designed to give a flat frequency response when so terminated. Thus the input labelled 600 is in fact nearer 1.5 K; and a '600' microphone is nearer 100 ohms. The 600 ohm input is thus suitable for all microphones of 100 ohms up to 1 K; the 60 ohm input for all low impedance (e.g., ribbon '30 ohms' and similar).

The question of balanced lines was discussed in an article by Anthony Eden in the June 1970 issue—the same as Part One of this mixer series. The 600 ohm input is wound symmetrically so that it is effectively well balanced by the symmetry (of winding and stray capacitance). The lack of a centre tap is a positive advantage, completely isolating equipments from each other. Thus there is no possibility of earth loops, for example.

Single tap

The 30 ohm input is not balanced but is of course still fully isolated. In practice there have been no problems or disadvantages in the use of a single tape rather than a separate winding which would introduce switching complexities. The final advantage of either 30 or 600 ohm isolated input is, as Mr Eden points out, that either balanced or unbalanced inputs can be used with no modification, the switching being automatically effected by the input plug.

The final error in the mike amp concerns the price of the input transformers. The quoted price was from two years ago, since when the price of Mu-metal has increased considerably. The present price ranges from £2 6s for one through £2 2s for two to £1 12s for 25; and there is a minimum order charge of £2 10s. Home Radio of Mitcham can also supply the transformer at £2 4s each, with no minimum charge but no quantity discounts.

As important as the amplifying and routing facilities in a mixer are the monitoring arrangements, which are both audible and visual. The monitor output is about 1 V RMS and is designed to feed external amplifiers whose power will depend on the size of the monitor room or, if studio playback facilities are used, the size of the studio. The output can be any one of three signals as shown in **fig. 36/37:** mixer signals, the tape replay, or a talkback facility to the studio. The outputs from the power amplifier are brought back into the mixer for the necessary switching; the talkback signal for example must not appear on the control room loudspeakers to avoid acoustic

(continued overleaf)

FIG. 36 MONITORING ARRANGEMENTS

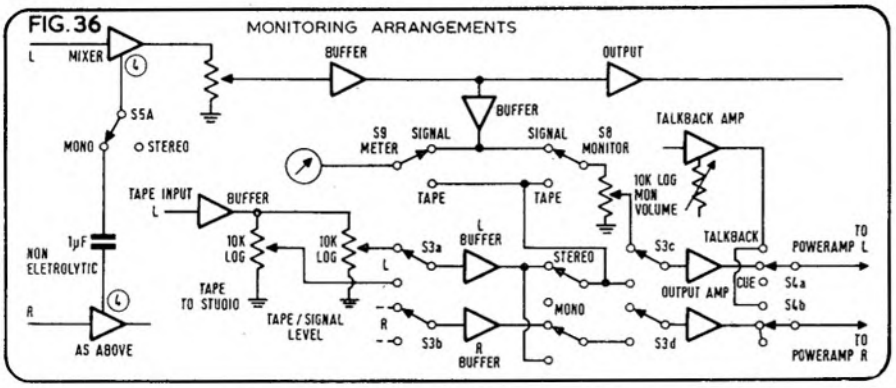
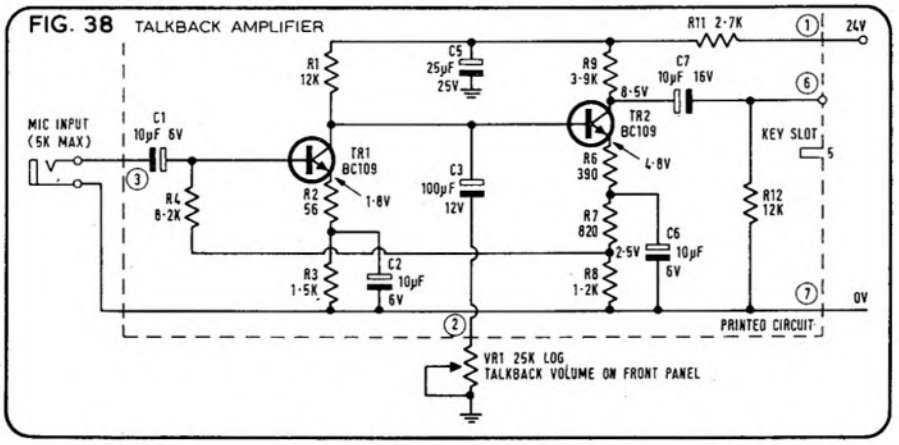


FIG. 38 TALKBACK AMPLIFIER



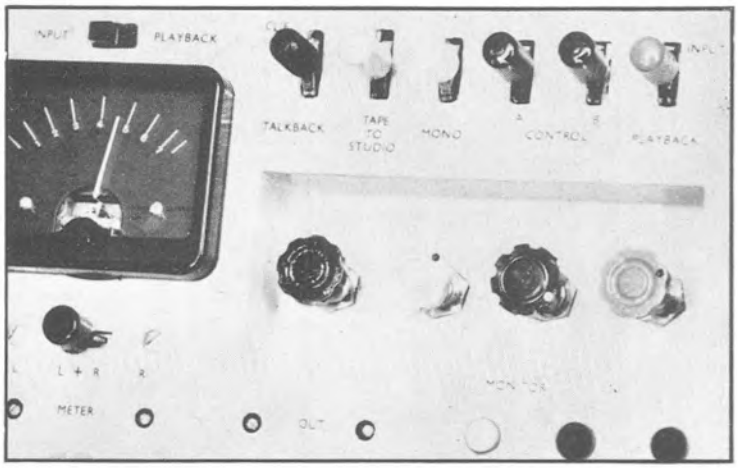


Fig. 39-*Front panel layout*

feedback. In a studio mixer the monitoring arrangements are naturally much more extensive, with circuits to give clean feed to the speakers (pressing one button on the channel input to give only that channel on the monitor speakers), foldback to the various points in the studio (sending to earphones on one of the performers the sound of everyone but himself) and switches to allow checking of post-fade and pre-fade, and post-echo and pre-echo signals. In the design I have been describing, these extra facilities are not necessary and have been omitted. It is obviously an easy matter to add whatever circuits are required for any particular requirement since, by the liberal use of buffer amplifier stages, all monitoring points can be fully isolated from each other. Readers are also referred back to the buffer amp, last month's **fig. 31.**

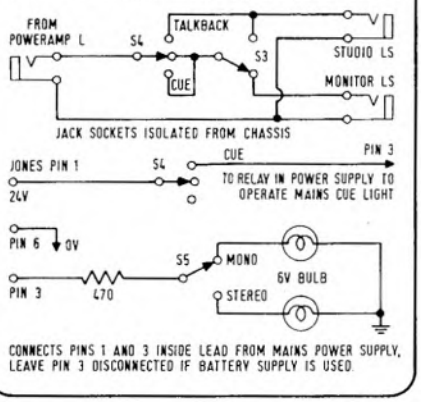
The first amplifier to be described is the talkback amplifier, which enables the operator to talk to the studio to stop a bad recording, or announce the various 'takes'. When the key is pressed, the output from a general-purpose low quality microphone is amplified and fed to the studio loudspeakers only—the monitor loudspeakers are cut to avoid acoustic howl-round. A separate volume control is fitted. The circuit is shown in **fig. 38** and will be recognised as being similar in design to previous units; the use of DC feedback pairs provides a very useful stable building brick which can be adapted for many purposes, and readers will have noticed that they form the backbone of the mixer. The first transistor, a low noise type, is DC stabilised by a feed from the emitter of the second. Since the feedback is negative, a very stable working point is reached. Local feedback is applied to each amplifying stage by using undecoupled resistors in the emitters. Overall gain is controlled by varying the AC collector load in the first transistor. The input impedance is about 5 K which means it is suitable for any 600 ohm microphone, or for any of the cheap, imported types, about 1 to 5 K, now on the general market.

Panel layout

Fig. 39 shows the layout used on the front panel. In the prototype, only one of the volume controls was labelled since the remainder are colour-coded to the row of keyswitches above. The extreme left-hand switch is the talkback cue control, coloured red, and the control for the talkback volume is underneath the switch and is also painted red. Tape-to-studio and the second volume control from the left are coded yellow, the extreme right-hand volume control and switch being green. This last is the tape level control. The other volume control is labelled 'monitor' and is the level adjustment for the monitoring amplifiers and speakers in the control room. The mono-stereo switch connects the two mixing stages together for AC signals, and was made rather stiff to operate so that it could not be accidentally moved instead of one of the adjacent keys. This was painted white. The control keys are black, and connections from these are wired to suitable sockets on the rear panel. The object of these is to control the simple stop-start function of up to two recorders. Since different machines use different systems for this, no further details are given, each constructor being left to wire these to suit his own machine. A complete remote control unit for suitable tape recorders can of course be installed instead of this simple arrangement.

There remains one more monitoring circuit to discuss, that dealing with metering arrangements. For most of the time it is the incoming or recording signal that is monitored, but there are occasions, such as the initial line-up of the recorder, when it is useful to switch the meter to the tape playback. Using the oscillator which is built into the mixer, this enables the frequency response of the machine to be checked at the upper frequencies. Switch S9, above the meter (**fig. 39**), is included so that the inputs to the meter circuit can be switched. The metering logic is to read the signal before the output amplifier, which is not always as satisfactory as measuring the true output. However, this was done for simplicity. The meter was required to read both tape return and signal out, and before the output amplifier these signals are at the same level. It can also be extended to reach echo send and return easily. The switching strategy is considerably increased if the output is measured, especially if the optional balanced line system is used—immediately an extra pole must be introduced. The best (and most expensive) method, as used in studios, is to have a meter permanently connected across every output line (main, tape return, echo, etc.) and perhaps a roving switched meter for measurements inside the unit. This is obviously far too expensive for the amateur, and so compromises have to be made.

FIG. 37 MONITORING ARRANGEMENTS(2)



Which meter?

The next decision that has to be made is that of which type of meter to use—PPM or VU; this has been the subject of many articles and all I propose to do is to cover briefly the differences between the two systems, leaving the choice up to each constructor. If a VU is the choice, then for operational convenience two meters are best for stereo, although it would be satisfactory to use one switched between left and right. If a PPM is selected, there is a further option open; there is the choice of having either two independent meters and drive amplifiers, or having electrical switching to one. In a correctly balanced system, any difference between the two channels must be intentional so that a single meter which reads the greater of the two signals is satisfactory. This system is considerably cheaper than two meters, and was the method in the prototype. The mixer has a three-way switch so that the meter can be switched to read the signal level on the left channel only, right channel only, or a centre position, which is the normal mode, where the greater of either is read. This last position is labelled rather unfortunately on the prototypes as 'L+R' which is quite wrong, since the one thing that it must not do is read the sum of the two channels! A computer-language symbol for 'L or R, whichever is the greater', would be ideal.

If two meters are chosen, the PPM user has the option of either having two separate movements, or using a twin pointer instrument, which is two movements in one case with superimposed needles. This last makes it extremely easy to read stereo signals, but it should be noted the case is larger than that shown in the diagrams and photographs of the prototype mixer.

Next month will open with a brief discussion on the two-metering system, and include simple circuits for either type.

Component Suppliers

Talkback Amplifier Printed Circuit *Ref 107-2*, 6s from the author c/o Link House.
Home Radio (Mitcham) Ltd, 187 London Road, Mitcham, Surrey.

impressions

BY JOHN SHUTTLEWORTH

FOUR CHANNEL STEREO

QUADRAPHONIC sound, sound in the round, four channel Stereo, or whatever other name it goes by, is very much in the news, particularly after the demonstration at Sonex 70 by A & R and Rogers. I was able to attend these demonstrations early enough to listen in a comparatively quiet and relaxed atmosphere.

The extra two channels reproduced through two speakers behind the listener certainly add something to the sound but I am not sure whether I like what they add.

I think we ought to be careful at this stage not to repeat the mistakes many of us made when stereo was first introduced. At that time the hi-fi brigade seemed to be split into two camps: (1) the defendants of mono who, having heard some of the ping-pong stereo of that time, stoutly maintained that stereo was not worth the extra expense, and (ii) those of us who realised that it was an exciting and very worthwhile step forward to more faithful sound reproduction. It was interesting at Sonex 70 to hear the reactions of those at the demonstration, in general exactly duplicating the reactions of their predecessors when stereo first arrived.

The average enthusiast with a limited budget may feel that the extra expense is not justified; and his wife may not want to find room for two more speakers in the living room, There is consequently bound to be a resistance to change from the consumer, until the new system catches on sufficiently to impress the Joneses.

I would like to try to put these considerations aside, and examine the system as far as possible on its merits. As quadraphonic sound is still very much in its infancy, and still at the experimental stage, no-one can talk about it with much authority, My own experience is limited to three demonstrations and some minor experiments.

Some of the best two channel stereo gives a sound picture that suggests a concert hall the other side of the two speakers and that the room in which we listen is just outside the hall, a sort of large luxurious box completely soundproofed from the hall on all sides except the one behind the speakers. If chamber music is properly recorded and reproduced, the effect is remarkably realistic, and can give the impression that the room has been extended beyond the speakers, and that the artists are playing in the extension.

This illusion can be reinforced by hanging an acoustically transparent curtain across the room just in front of the speakers; we then get the impression that the performers are just behind the curtain.

While good two channel stereo can give remarkable realism in this way, it can't make any sound appear to come in front of a line joining the two speakers, and so it can never 'put us in the concert hall'; if I read the literature correctly, this is what quadraphony aims to do.

I understand that the theory behind the idea is that, in a concert hall, one hears not only the sound from the performers but also the sound reflected from the walls of the hall (why not the ceiling and floor?) and that these sounds come from all directions. It therefore seems reasonable to try and record all these sounds and allow the listener at home to hear them as they were in the hall, from the same directions.

It is claimed by the advocates of quadraphony that four channels are a minimum requirement and that any increase beyond this is not worth the extra expense. If we accept this and try reproducing our sound using four loudspeakers, two in front and two behind the listener, it seems to me that the best we can hope for is to obtain the illusion that the side and near walls of the living room have now become acoustically transparent and look out into the concert hall. My own experiments have shown me that the placing and relative volumes of each speaker is very critical and I prefer it if no speakers are behind me but are at the side instead.

This is very effective when reproducing chamber music and gives the impression that the performers have moved from behind the front speakers to a position between but just in front of them. Care has to be taken in choosing the speaker units and in adjusting the volumes and the best results are obtained when it is not possible to tell that the side speakers are on until they are switched off.

My first experiment on these lines was merely to connect a pair of Goodman *Maxim* speakers in parallel with two Lowther Acoustas. The very efficient Lowthers were used as the front pair with the inefficient *Maxims* giving just the correct volume for the side pair. Friends asked to listen to this arrangement and to comment on the sound quality all wondered what they were supposed to be hearing until the *Maxims* were switched off, when it became quite obvious. All preferred the effect of the *Maxims* on.

The main fault in the system is that, with the side speakers pointing directly at the listener (and this seems to give the best effect) the *Maxim* tweeters or sibilants occasionally give the impression of spitting in the listener's ear on high transients.

My next experiment was to introduce a little delay into the sound from the side speakers by recording the original on a 38 cm/s Ferrograph and listening to the tape replay through the side speakers while listening to the original through the two front ones. Quad *303* amplifiers fed Tannoy York speakers for the front and the Ferrograph *Series 7* fed a pair of *Spendor* monitor speakers at the sides, the latter with their own amplifier. This arrangement was very effective for some music recordings, especially where the original recording had a 'dry' acoustic, but fell down badly on speech.

It seems likely, however, that using a short or possibly variable delay could give very satisfactory results. (The Danish engineer Rorbaek Madsen has published some experiments on these lines which look promising.)

Neither of these experiments could be called quadraphony by any stretch of the imagination but they give some idea of what we will get from record manufacturers in the form of pseudo quadraphony made from two-track stereo masters. Since they can't resist issuing pseudo-stereo made from mono masters, I fail to see how we can escape this. These early experiments did show me two things, however; first that one can't get away with inferior equipment in any part of the chain, either front or side (or back) and secondly that the extra speakers do improve the sound picture.

To get back to real quadraphony as demonstrated at Sonex 70, I did not like the feeling of being in a sort of acoustic vacuum, in the centre of a circular sound stage, though I do agree that the sound was richer with the rear speakers on than with them off; but I did not feel any more 'in the concert hall' than I do with good two-channel stereo.

We must remember also that any noise in a system is multiplied when we use more amplifiers and speakers. I find it bad enough to listen to hiss or surface noise from 2 speakers in front of me; being surrounded by it would soon become intolerable.

I understand that some tapes I heard were recorded by placing four microphones in the concert hall at the corners of an area marked out to represent an 'average size living room', and that the front two microphones were cardioids facing the orchestra while the rear two were omnidirectional

I can't see the logic of this arrangement and would have thought that two back-to-back coincident stereo pairs would give better results.

The results from the arrangement used gave me a confusing picture at times, with occasional curious effects such as one orchestral passage where the tympanist seemed to leap to the back, bash a couple of notes and leap to the front again.

I also found (and this is confirmed by my own experiments) that curious results are obtained if the rear speakers are mounted high in the room. At Sonex 70, one of the speakers in the A-R demonstration was mounted in a top corner by the door behind the listeners. I felt the sound from this speaker to be distracting and unreal.

Theoretically, I would have thought that there might be some justification for the method used by Granville Cooper in his experiments at Guildford recently, in which he tried placing speakers at the corners of a tetrahedron, thus giving height as well as 360° lateral information.

But of course the art is in its infancy, and there is the Hafler system to consider—as noted by the Editor last month (page 371).

Ferrograph stereo amplifier F307

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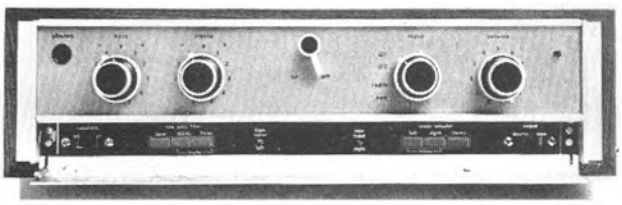
In appearance, the F307 amplifier continues the uncluttered lines of the Ferrograph Series 7 recorder, the two making an ideal combination which is matched both visually and technically. But the amplifier is equally compatible with most other good recorders and hi-fi installations, suits innumerable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

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



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Ferrograph

Recording a Children's Choir

By Stewart Orr

IT all started about 16 years ago when I was a member of the school choir. Occasionally, when we sang something very well or took part in some unusual service, the choirmaster would, with due pomp and electronic ceremony, produce an enormous machine boasting an envious array of knobs and coloured lights. This would be connected via about a mile of cable to the nearest power socket, and then be attached to a large globular microphone covered with wire mesh. The result was always enthusiastically received by us but, because of the age of the machine and the microphone, left much to be desired from a technical point of view.

Now I see these recordings from a totally different viewpoint, as I have recently returned to the school to teach rather than learn. Also, as an enthusiast, I have taken over the technical side of recording sessions from the choirmaster.

The first recording session took place one Sunday afternoon in the gymnasium, this building being selected because of its reverberant acoustics. I duly set up the Ferrograph, mixer and two Reslo mikes on stands, and soon the session was under way. All sounded fine through the monitor headphones, after we had moved the mikes a little closer to the choir, and I sat back, happily expecting a recording of good quality. At the end of the final work I rewound the tape and it seemed that my optimism had been well founded—all sounded well-balanced and at about the right level. When I returned to the school and played it over a Quad system, however, all the imperfections I had missed earlier stood out in bold relief. Half a dozen times there was overmodulation of a high treble note, although the meter had never shown anything like this when recording. Rustling of sheet music, in unison, spoilt another almost perfect take, and throughout there was that bane of all recording engineers, the phantom foot-tapper. The second two faults, fortunately, were not my department, and I merely passed them on to the choirmaster. The first, however, was more serious, as it appeared that my record amplifier was playing up. I tried dozens of test recordings of various musical instruments and voices at different levels but, even with the meter showing a gross overload, no apparent overloading could be heard on the tape. The fault was finally discovered in the mixer—merely a matter of reducing the gain on the microphones which were overloading the mixer second stage, and increasing the Ferrograph gain slightly to compensate.

The next recording was to be taken on location in a parish church in the heart of rural Norfolk. This time I had a couple of helpers—boys who were pleased to come along if only to change the daily routine slightly. We arrived in good time and soon the tape recorder was plugged in and ready. Mike positioning was fairly obvious as the choir faced the organ in the chancel: one on the organ side took care of the choir while one on a window ledge above the choir would increase the organ level if necessary.

While I was setting the mikes up on their stands one of the helpers, Fred, unwound the cable and left the end ready for me to join to the mike lead. He had spent 20 minutes painstakingly hiding the cable under mats and behind pews in the chancel, and the rehearsal was just about due when I came to make the join and test the mike and its 50 m of cable. At that moment Fred appeared, smiling. 'I couldn't see how the two joined,' he informed me, 'so I left it to you'. Nor could I see how to join two plugs at one end of the lead and two sockets at the other! Out it came, despite Fred's insisting that it would be quicker to change the plugs using the soldering iron in the gadget bag (a precaution I always take with the home-made mixer). The cable was laid again in two minutes flat, although you could occasionally see it sticking out at odd places in the chancel, and the rehearsal started just as we had checked the continuity of both mikes.

The recording was a moderate success, although it had its awkward moments. The click suppressor capacitor had become detached from across the motor switch, with the result that every time it was started or stopped a loud click came through the three pairs of monitor headphones. Unfortunately young Fred often let out a high-pitched squeak of surprise when this happened and it was only by unplugging his phones before starting and stopping that 'noises off' were avoided.

On replay, the tape seemed quite acceptable, despite a few imperfections. The choir mike was placed nearest to the probationers, whose notes were the least certain. Recording was made easier by the fact that only the music was required, and thus no mikes were needed for a preacher. A firm choirmaster (or a stone floor) had exorcised the phantom foot tapper, and the relative mixer and tape recorder levels were correct.

Perhaps the biggest job I have done with this choir was in Westminster Abbey where I was to produce a master for LP copies. Preparations for this started a month ahead, and I purchased extra mike stands and extension cable to ensure that I would not be hampered by lack of any essential components. A couple of days before the recording I was checking equipment and connections when I realised that one of the Reslo ribbons had collapsed. Panic ensued and resulted in phone calls to London where all I could get was a good lady who repeatedly insisted that her name was not Reslo, and nor was her lodger's. After half an hour I gave up and, as a last resort, went to consult my local dealer. With the air of a bored conjurer he produced two spare ribbons that he had kept in stock for several years. I took both as a precaution and all looked ready for the great day.

The next day we started off by coach for London with the choir and a few parents who lived locally. After an uneventful journey, we arrived in Westminster and unloaded the choir and the equipment, one of the vergers taking care of it in the switch room under the screen. Meanwhile the choir had gone to robe and prepare for a preliminary practice.

Our first job was to find the electrician and discover the position of power sockets. Unfortunately the electrician would not be back until about half past two and, as no one else had been detailed to deal with us, we had to wait. However, the time was well used in planning where our mikes would go and routes for the cables.

In due course the electrician arrived and shattered all my hopes by pointing out that, as the woodwork of the choir had recently been regilded, I could not suspend my mikes above the singers. He would not allow individual mikes to be set up for the minor canons taking the service, because of cable route problems, but suggested that I used the tape recorder output from the public address system for recording.

I used two Reslos on floor stands, to east and

(continued on page 433)

SPENDOR AUDIO SYSTEMS

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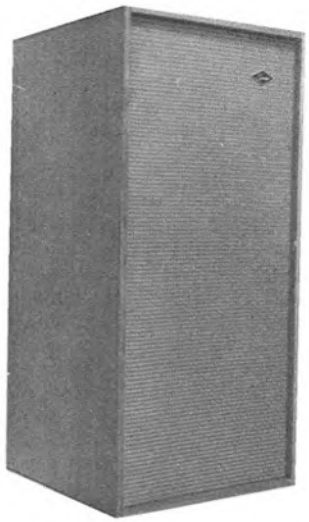

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Fitted with the SPENDOR 20 WATT POWER AMPLIFIER M20/9, this combination provides a portable powered loudspeaker which is the finest of its type at present available.

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west of the choir. This gave some control over the strength of the accompanying organ: the choir were facing slightly west so the east mike picked up mainly organ, and the other mainly choir. The problem of the canons taking the service was solved by the Abbey PA system, the output from this being fed to the mixer via a 600 ohm mike transformer. The electrician switched the various PA mikes in when required.

The recording did not pass without incident. The 21 cm metal supply spool had somehow become bent between Norfolk and Westminster, causing the tape to catch in the flanges as it fed out. Immediate first aid was effected by pushing the tape over with a pencil so that it came off the spool sideways and did not catch. This was supplemented during the first lesson by stopping and bending the spool. Apart from this the recording was uneventful.

At the end of the service I left the machine running to record the final voluntary on the east mike, and started to dismantle the near one, and recoil its cable.

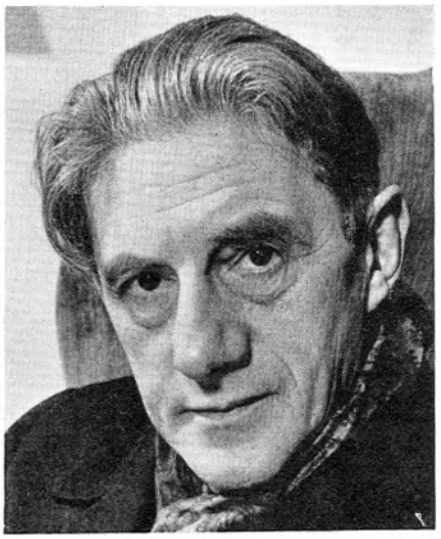
On arrival back at school we took over the staff room to listen to the recording. It was mainly satisfactory except for the introit where the bent spool had left its mark, and the final voluntary, where a parental congratulation boomed out over the organ.

Next day the touchy job of editing was started as soon as a safety copy had been made. Editing was fairly straightforward, mainly trimming the start and finish of each section and timing the start of the second side of the disc. All was going well, and it seemed that the master would be ready to catch the afternoon post, when the mains voltage suddenly fell and the machine ground to a halt. This drop lasted 20 minutes, until the power was cut completely for the rest of that day. Eventually, however, the tape was edited, and 74 LP copies were pressed and circulated to parents and staff.

The recording that has been the most effective, and also the least trouble technically, was taken in the school hall one Sunday afternoon. The choir had recently been practising a short Bach arrangement *Jesu, Joyance of my Heart*, and I was asked to record it during their regular practice time. The choir of about 20 were positioned on the stairs, trebles at the back, with altos, tenors and basses (all boys under 14!) in front. One mike was placed on a fully extended stand in front and above, whilst the other, again on a stand, was placed on the floor of the hall with the soloist. The organ had no separate mike but was sufficiently picked up by the other two.

The problems here were mainly musical and need not concern us, but nonetheless we got our musically perfect recording on the third take, which was very lucky. The only thing that went wrong (human error again) was that, just as the last chord was being held, a couple of hooligans came out of an upstairs room and, after slamming the door, carried on a conversation in loud voices along the landing overlooking the hall. Time was against us and a further recording was not possible. Out came the splicing tape, and the finished product consisted of the first two verses of the last take and the last verse of the second take. Volume levels did not quite coincide, with the result that a slight rise in volume is detectable during the final verse. If anything, this tends to enhance the musical effect.

The recordings mentioned are just the most interesting of those I have come across during my first year of teaching at the school. For impending projects I am investigating the possibility of using the cellars as an echo chamber but so far all I have got for my pains is a recording of the coke boiler.



Sir John Barbirolli

A Technician Remembers

By Bob Auger

I FIRST encountered John Barbirolli and the Hallé Orchestra in September 1943 at their first concert together, in the Victoria Hall, Hanley, when the newly constituted orchestra was only a few weeks old. The strong impression that the occasion made on me at the time may be realised by the fact that I still remember quite clearly their performance of the Brahms *Second Symphony*. The conductor was no stranger to me, since I had among other of his recordings a performance of the *Swan Lake* suite with the London Philharmonic Orchestra and his *Wedding Cake Caprice* with Yvonne Arnaud. I was also aware that the dynamic young conductor had been summoned to New York in 1936 by Arturo Toscanini to become his successor with the New York Philharmonic. Barbirolli had just spent an exhausting period auditioning candidates for the Hallé and had personally selected every single musician in the new orchestra. During the remaining war years and the ten years following, I attended many Barbirolli concerts, both with the Hallé and BBC orchestras, out of London and at the Royal Albert Hall and Royal Festival Hall.

In 1956 I was pleased and somewhat overawed at being invited to participate in Pye Records' first recording sessions with the Hallé Orchestra and Sir John Barbirolli, as he now was. This 'crossing the footlights' on my part was not carried out without trepidation, but I was very soon put at ease by the great man, who proved one of the most co-operative artists you could wish to meet.

The somewhat autocratic platform presence was rarely to be seen in the control room, where he was very much a member of the recording team. Occasionally we were a little naughty and took this rather for granted. I well remember, during a tape playback in the middle of a session, going out on to the stage in Manchester and moving bodily the entire horn section of the orchestra to the opposite side of the platform. I inadvertently omitted to inform the conductor of the operation, with the consequence that, on the second take of the piece being performed, he gave a dramatic cue in entirely the wrong direction. The orchestra contained themselves very well but Sir John was considerably put out for a few bars. During the lunch break he called me over to one side of the hall, away from everybody else, and said in his characteristic gruff voice: 'I don't care where you put 'em, but for God's sake tell me before I go out!'. The fact that he took the trouble to mention this in confidence was very much appreciated. He would have been quite justified, of course, in bawling me out in front of the full company.

Daniel Barenboim has remarked on Sir John's penchant for little secrets with his friends. He always liked to have his little private jokes in Italian with the recording producer, Douglas Terry, who shared Sir John's fluency in the language. When he was rehearsing and I was standing beside him making a few notes prior to recording he would make stage asides with large facial gestures and flashing eyes—very reminiscent, I always thought, of a baritone villain in provincial Italian opera.

He was, of course, very fond of debunking musical authority and the critics. Once when I crept into the back of the town hall at Cheltenham to listen to a morning rehearsal of a new piece, somehow or other he came to realise that I was in the room. When the tea-break was called in the middle of the rehearsal, he shouted down the length of the hall for me to come up to the platform. While I was still 25 feet or so away, he demanded to know what I thought of the piece. I have no doubt that the earnest query was prompted by the fact that sitting in various parts of the hall there were upwards of 30 or so critics.

I have not been fortunate enough to work with Sir John for some time now, since our ways parted when he returned to EMI, but I did manage to meet him on many occasions at London concerts and he was always as charming as ever. I would like to express the gratitude and admiration of all the technicians who found JB such an appreciative artist and colleague, not least as one who remembers that in the darkest days of the war Barbirolli returned to the country to raise our morale and uplift us spiritually when others saw fit not to enlighten us with their presence.

ultra-directional microphones

Applications of Blumlein difference technique

by Michael Gerzon

THE standard microphone directional characteristics are omni-directional, cardioid, hypercardioid and figure-of-eight, and it is not possible to obtain any essentially different directional characteristics from conventional microphones. Even the best of these characteristics is not really very directional. It is true that one can obtain highly directional 'gun' microphones, but these have one overwhelming defect for high quality use: the directional characteristic varies greatly with frequency. This means that, for sounds a little off the axis of a gun-mike, the frequency response is not flat, and the treble rolls off sharply. In particular, if several 'coincident' gun-mikes are used for recording stereo, the reproduced stereo width will be very frequency dependent.

However, it would be very useful to have ultra-directional microphones whose directional sensitivity did not vary much with frequency, especially over the important frequency range 1 kHz to 5 kHz. This article will discuss the theory of high quality ultra-directional microphones, and will show how such microphones may be obtained by means of an almost forgotten 40-year-old technique invented by Alan Blumlein. It should prove possible to obtain reasonable ultra-directional microphones using an arrangement involving available commercial microphones, but the best results would undoubtedly be obtained using purpose-designed capacitor microphone capsules which have not yet been developed. One intriguing consequence of the techniques to be described is that it should be possible to use two suitable microphone capsules, such as those in the AKG *C24* or Neumann *SM2c* stereo mikes, to obtain the *four* signals required for either a conventional (box format) or tetrahedral four-channel stereo recording.

Blumlein's famous 1931 stereo patent (see reference 1) described, among many other things, a simple and ingenious method of getting genuine stereo out of two almost-coincident omnidirectional microphones. As we shall be referring to his technique for doing this frequently, it is convenient to give it a name, and call it the 'Blumlein difference' technique. In this technique, Blumlein placed two omnidirectional microphones next to each other, only a few centimetres apart, as illustrated in **fig. 1.** A circuit then subtracted the output of one microphone (say B in fig. 1) from that of the other. This subtracted signal was then integrated (i.e., subjected to a bass boost and treble cut of 6 dB per octave). The resultant signal, which we shall call the 'Blumlein output', is the output that would be given by a sideways-facing figure-of-eight microphone, as explained below (see **fig. 2**). The Blumlein output can thus be used as the difference signal S of a stereo recording in which the output of one of the omni-directional microphones is used as the stereo sum signal M, in a sort of M-S technique. Thus the two stereo outputs may be obtained by respectively adding and subtracting the Blumlein output to one of the omni-directional outputs.

To understand how subtracting the two microphone signals gives a sideways-facing figure-of-eight output, refer to fig. 1. If a sound comes from directions II or IV, then it arrives at both microphones simultaneously, and the difference of their outputs is then zero. If a sound comes from direction I, then it arrives at microphone A before it reaches microphone B. As a result, for sounds from direction I, the output of microphone B is a slightly delayed version of the output of microphone A. The sound amplitude at microphone B will thus have changed slightly over the period of time taken in travelling from A to B, and so the difference of the outputs of the two microphones will be non-zero for sounds travelling from direction I. Similarly, for sounds travelling from direction III the difference between the two outputs will also be non-zero,

but of opposite polarity, as the time delay is now the other way round, with sounds reaching B before A.

Thus the difference of the outputs of the omnidirectional microphones A and B is zero for sounds from the front and back, and non-zero, but of opposite polarities, from the two sides. This indicates that the directional characteristic of the difference of the two outputs is a sideways-facing figure-of-eight. However, the frequency response of the difference of the outputs is not flat. This is because low frequency sound waveforms change more slowly than high frequencies, and so in the time taken in travelling between the microphones, the magnitude of the change of the low frequencies, as a proportion of their amplitude, is smaller than at high frequencies. Thus at low frequencies the difference between the two microphone outputs will be smaller than at high frequencies, and a 6 dB per octave bass boost and treble cut is required to flatten the frequency response.

The Blumlein output thus derived corresponds to the pick-up of a sideways-facing figure-of-eight, and may then be added to and subtracted from the omnidirectional output of, say, microphone A to obtain left and right signals that correspond to the sound pick-up of left- and right-facing cardioids (see **fig. 3**). This will give quite a good stereo separation, albeit with a lot of sound pick-up from behind.

It would seem that, by this means, one can obtain two perfect cardioid microphone outputs from two closely spaced omnidirectional microphones. Unfortunately, the frequency range over which this can be done properly is in practice restricted both in the bass and in the treble. The above theory holds properly only if the wavelength of the sound in the air is substantially larger than the distance between the two microphones. For instance, if a sound frequency whose wavelength is precisely the distance between A and B originates from direction I in fig. 1, then the resultant sounds picked up by the two microphones will be identical, and the difference of their outputs will be zero. At that frequency, the directional characteristic of the Blumlein output will be as illustrated in **fig. 4**, and this is certainly not a figure-of-eight! In practice, one may take the highest frequency at which the Blumlein difference technique works reasonably well to be $\frac{1}{2}(c/d)$ where d is the distance between the mikes, and c is the speed of sound in air.

The speed of sound c in air is about 340 metres per second, and if the microphones are placed a distance d of 2.5 cm apart, then the highest frequency at which the Blumlein difference technique works reasonably well is $\frac{34.0}{2 \times 2.5}$ = 6.8 kHz. This illustrates that it is important to space the microphones as close to one another as possible, to obtain an accurate figure-of-eight in the extreme treble. Available small microphones allow spacings of 1.5 cm to 3 cm to be used.

In theory, one should be able to get a figure-of-eight response right down to the lowest bass frequencies. However, the above discussion assumed that both microphones have precisely the same sensitivity. In practice there are bound to be differences in the sensitivities of the two microphones. When the output of one microphone is subtracted from that of the other, there is therefore going to be an unwanted residual output due to the slightly different sensitivities. In the treble this is all right, as the wanted difference signal will be much larger than the unwanted residual output. However, in the bass, the figure-of-eight signal will be so weak that it will be swamped by the residual difference signal caused by the differing microphone sensitivities. This spurious signal will be even more objectional once the 6 dB per octave bass boost is applied, and for this reason it will prove necessary to roll off this boost at and below that frequency in the bass at which the residual component starts being troublesome. If the difference in microphone sensitivity is 1 dB, then this bass roll-off should start at a frequency of about $\frac{c}{30d}$ which will be a frequency of about 453 Hz for a microphone spacing of 2.5 cm.

Note that the spurious component of the Blumlein output caused by the sensitivity differences will be troublesome even if the sensitivities of the two microphones are different for sounds from only certain directions. A difference in sensitivity for sounds from the sides is quite likely, as each microphone will tend to obstruct the sound heading towards the other. It will also be seen that, with the Blumlein difference technique, it is necessary to point the two microphones in precisely the same direction if they have a tendency to be directional at some frequencies. This contrasts strongly with the requirements of conventional 'coincident microphone' stereo technique.

The advent of high quality cardioid microphones made the Blumlein difference technique obsolete, as they do not suffer from the frequency limitations described above. However, the available range of high quality microphone directional characteristics is rather restricted. This has been emphasised by the advent of four-channel stereo, in which coincident microphones can provide only three essentially independent signals to feed the four speakers placed horizontally around the listener. This means that the use of coincident conventional microphones inevitably causes crosstalk between the four channels (see reference 2).

This is a pity, because coincident microphone techniques are generally admitted to be more realistic than other techniques. To reduce the crosstalk between the four channels, one would wish to use more highly directional coincident microphones for each channel. The Blumlein difference technique was originally used to create moderately directional microphones (cardioids) out of completely non-directional microphones. It is therefore logical to try using the Blumlein difference technique with conventional directional microphones in the hope of obtaining completely new directional characteristics.

Suppose that, instead of being omnidirectional, the microphones A and B used in the Blumlein difference technique were identical forward-pointing figure-of-eights as illustrated in **fig. 5.** Then one can take the difference of their outputs and apply a 6 dB per octave bass boost and treble cut as before. Once this is done, one will no longer get a sideways-facing figure-of-eight, but a new microphone directional characteristic which has no response at

(continued overleaf)

FIG. 1 BLUMLEIN'S PLACEMENT OF OMNIDIRECTIONAL MICROPHONES (NOT TO SCALE)

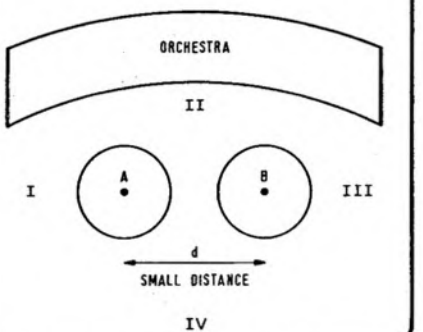


FIG. 2 OBTAINING A SIDEWAYS-FACING FIGURE-OF-EIGHT FROM TWO OMNIDIRECTIONAL MICROPHONES

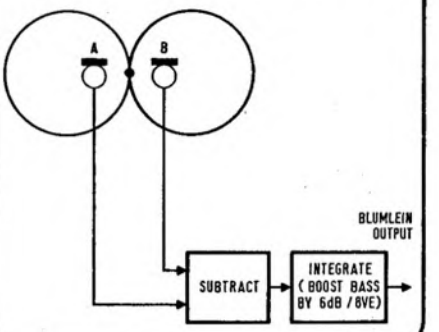
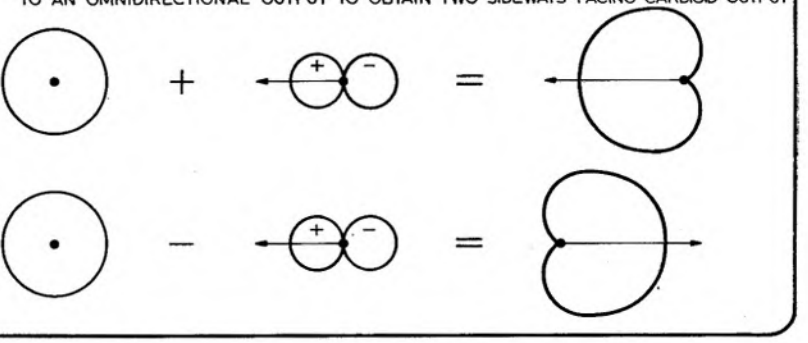


FIG. 3 THE ADDITION AND SUBTRACTION OF A SIDEWAYS FIGURE-OF-EIGHT OUTPUT TO AN OMNIDIRECTIONAL OUTPUT TO OBTAIN TWO SIDEWAYS-FACING CARDIOID OUTPUT



the sides (as microphones A and B have no response at the sides), and no response at the front or back (due to the subtraction of outputs), but a fair response in all directions at 45° from the front or back, as illustrated in **fig. 6.** Because of the shape of its directional characteristic, a microphone whose sound pick-up (polar response) is as in fig. 6 is called a *clover-leaf* microphone.

Thus the result of applying the Blumlein difference technique to a pair of forward-pointing figure-of-eights is to obtain a Blumlein output with a clover-leaf directional characteristic. Clearly, a clover-leaf does not resemble any conventional microphone directional characteristic, and this dramatises the fact that the Blumlein difference technique creates essentially new types of microphone. In fact, the clover-leaf is essentially the only new type of characteristic that can be obtained by this technique, as all of the other possible 'new' characteristics may also be obtained by adding or subtracting the outputs of clover-leaf microphones to those of suitable coincident conventional microphones. For example, the directional characteristic illustrated in **fig. 8c** may be obtained by adding the output of a clover-leaf microphone to that of a coincident hypercardioid microphone whose axis points 45° to the left, and whose null responses point behind and 90° to the right.

The clover-leaf microphone on its own is clearly unlikely to be of much practical use, and one could instead use a pair of microphones at A and B with some other directional characteristic. To illustrate the principle further, consider a pair of identical closely spaced forward-pointing cardioid microphones, as illustrated in **fig. 7.** The directional response of the Blumlein output (the integrated difference signal) will be as in **fig. 8b.** As in Blumlein's original arrangement, one can add and subtract this Blumlein output to that of one of the cardioid microphones (**fig. 8a**), to obtain respectively the left- and right-hand stereo channels. These channels are picked up with the directional characteristics illustrated in figs. 8c and 8d, if the relative gains of the cardioid signal and the Blumlein output are suitably adjusted.

It will be seen that the resultant microphone characteristics point in directions at 45° to each side, and each have the quite remarkable property of being very nearly just the positive lobe (without the negative lobe) of a figure-of-eight. For this reason, it is convenient to call this type of directional characteristic a *unilobe*. A unilobe characteristic has a response of less than −15 dB for all sounds more than 90° off its axis, and of less than −30 dB for all sounds more than 120° off axis. However, these figures only apply in the horizontal plane, as the vertical cross-section of a unilobe's polar response is somewhat closer to that of a cardioid. Of course, applying the Blumlein difference technique to a pair of cardioids only gives an accurate unilobe characteristic at frequencies substantially less than $\frac{1}{2}(c/d)$, for the reasons explained earlier.

For stereo work there are great advantages in using a closely spaced forward-pointing identical pair of cardioid microphones, and deriving a stereo signal by adding and subtracting the integrated difference of their outputs to the output of one of the cardioids. While this only works well within the frequency limits discussed earlier, a highly directional sound pick-up will be obtained at mid-frequencies, and at all frequencies one can guarantee a stereo sound with little sound pick-up from the rear, due to the insensitivity of the original cardioid microphones to the rear. The Blumlein difference technique, used with a pair of cardioids, should prove especially useful for obtaining good stereo separation without too much reverberation when the microphones are placed at a distance from the orchestra.

If two pairs of such cardioid microphones are used, one pair pointing forward and the other backward, then it will be possible to obtain a coincident microphone four-channel recording with excellent channel separation at mid-frequencies. To do this, one would normally have to use four separate microphones, and it is difficult to get so many microphones as coincident as one would wish. However, it is in fact possible to make each microphone capsule do the job of two microphones, thereby necessitating only two capsules for four-channel recording.

The secret behind this seemingly impossible trick lies in the observation that the capsule of a conventional variable-characteristic capacitor microphone is really two separate microphones. Without going into too many details, such capsules consist of two electrically conducting diaphragms placed one on each side of a central plate, often made of metal with holes drilled through it (see **fig. 9**). Each of the diaphragms separately is a pressure-sensitive device, and the central plate acts as a delay line for sound, so that the sound pick-up of each diaphragm is cardioid, pointing in opposite directions. Conventionally, by shorting the two diaphragms at audio frequencies (by capacitors C in fig. 9) and by varying their DC potentials relative to the central plate (by the potentiometer R), one can obtain any desired combination of the two opposing cardioid outputs, thereby obtaining a variable-characteristic microphone.

For our purposes we can instead treat such a capsule as two cardioid microphones pointing in opposite directions by wiring up each half of the capsule as a separate capacitor microphone, as in **fig. 10.** This double microphone will

FIG. 4 POLAR DIAGRAM OF THE BLUMLEIN OUTPUT OF TWO OMNIDIRECTIONAL MIKES WHEN THE WAVELENGTH OF THE SOUND EQUALS THE MICROPHONE SEPARATION

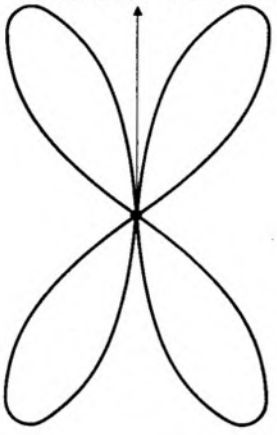


FIG. 6 THE CLOVER-LEAF POLAR DIAGRAM OF THE BLUMLEIN OUTPUT OF A PAIR OF FIGURE-OF-EIGHT MICROPHONES

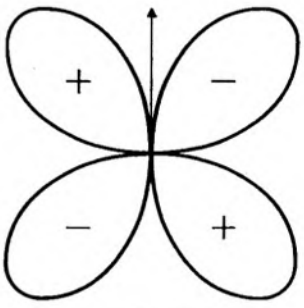


FIG. 5 (NOT TO SCALE)

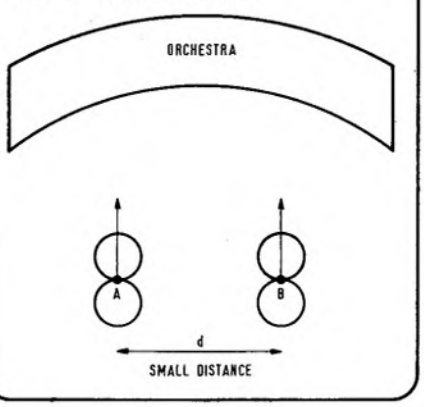
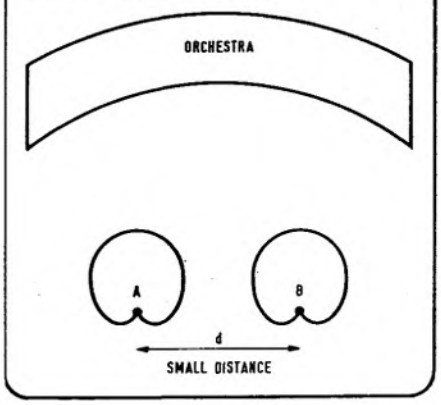


FIG. 7 (NOT TO SCALE)



ultra-directional microphones

consist of two back-to-back cardioids as illustrated in **fig. 11a,** although by adding and subtracting the cardioid outputs we may instead regard it as an omnidirectional and a figure-of-eight microphone in one capsule, as illustrated in **fig. 11b.** Unfortunately, two coincident capsules of this type are incapable of giving more than *three* independent outputs when only simple matrixing is used, as both capsules have a virtually identical omnidirectional output in common.

To get four independent outputs from two almost coincident double-cardioid capsules, the Blumlein difference technique must be used. For example, if two double-microphone capsules are placed side-by-side with both pointing forward, as in **fig. 12,** then the Blumlein difference technique may be applied to the forward-pointing pair of cardioid outputs, and to the backward-pointing pair of cardioid outputs, so as to obtain four unilobe outputs similar to those of figs. 8c and 8d. pointing in four horizontal directions at 90° to one another. Thus two double-microphone capsules placed next to one another can provide a coincident four-channel stereo output with excellent channel separation at mid-frequencies.

The Blumlein difference technique may also be used to derive the four signals for a tetrahedral (see refs. 3 and 4) three-dimensional sound recording using only two microphone capsules. In this case one uses two double-microphone capsules placed one above the other, with one capsule pointing horizontally 45° to the right, and the other pointing horizontally 45° to the left. The four cardioid outputs will provide a reasonable horizontal four-channel sound, and height information can be derived by obtaining the integrated difference of the *omnidirectional* outputs of the two capsules. This Blumlein output has a vertical figure-of-eight polar response, and may be combined with the four horizontal cardioid outputs to obtain a tetrahedral recording, as described in ref. 3. The advantage of using this method of tetrahedral recording is that the all-important horizontal information is derived with little spacing-effect, due to the vertical microphone separation. More conventional 'coincident' microphone techniques for deriving tetrahedral signals encounter difficulties because of the need to place four non-interfering microphones close together.

We have seen that the Blumlein difference technique used with double-microphone capsules enables various types of four-channel recording to be made using only two coincident microphone capsules, and allows a closer microphone spacing than would be possible otherwise. For conventional four-channel stereo, it enables new highly directional characteristics to be used, and for tetrahedral recording it permits the important horizontal sounds to be obtained with specially high quality. Such four-channel microphones should also prove useful for ordinary two-channel stereo recording, as by matrixing the four outputs, the engineer has a high degree of control over reverberation pick-up while avoiding the artificial effect of using distant reverberation microphones.

The main snag in all this is the limited frequency range over which it works properly. This is especially important in the treble, where a microphone spacing of under 1 cm should be used. This awaits the development of suitable small microphone capsules, and the next part of this article will examine in more detail the effect of using spacings around 2.5 cm.

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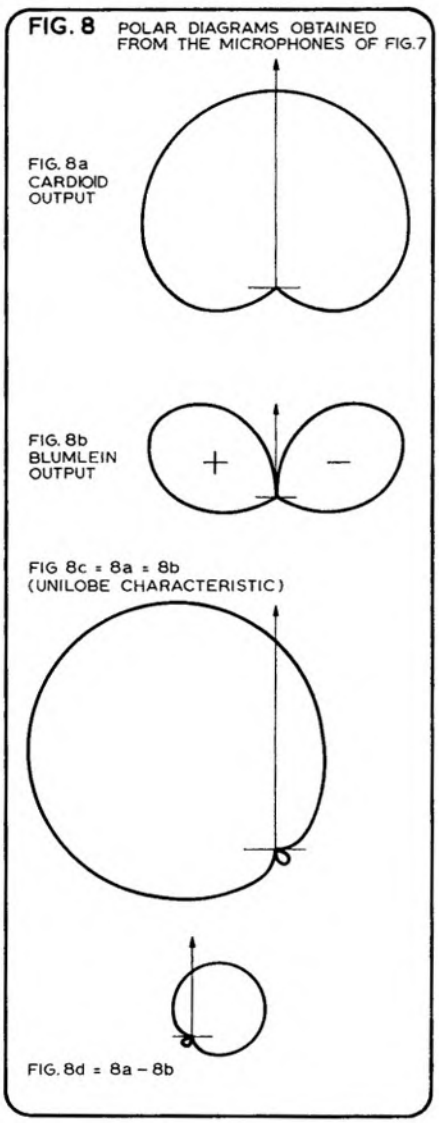
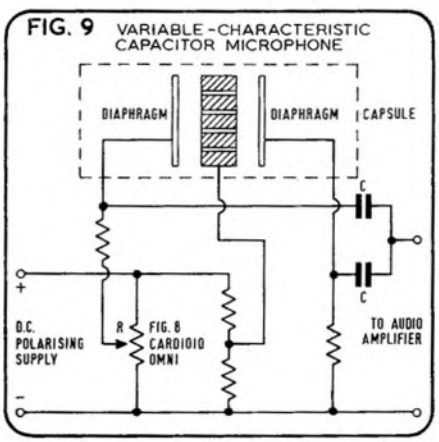
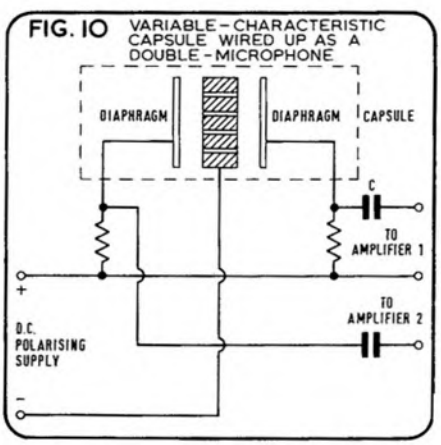
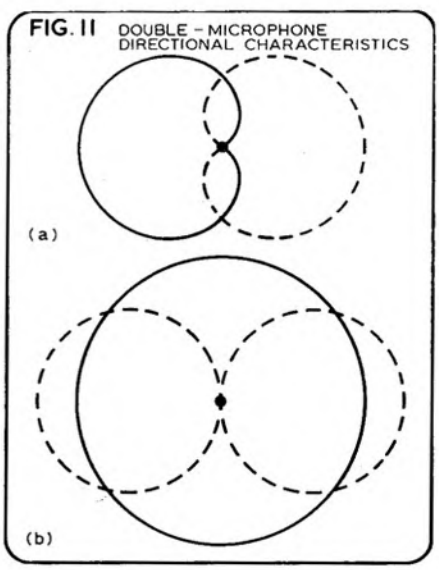
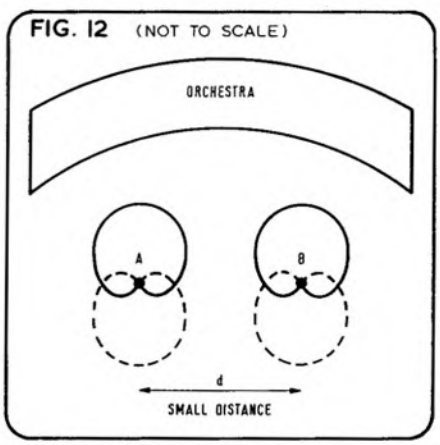
2) Michael Gerzon, The Principles of Quadraphonic Recording, Part 1, *Studio Sound*, August 1970
3) Michael Gerzon, The Principles of Quadraphonic Recording, Part 2, *Studio Sound*, September 1970
4) Granville Cooper, Tetrahedral Ambiophony, *Studio Sound*, June 1970











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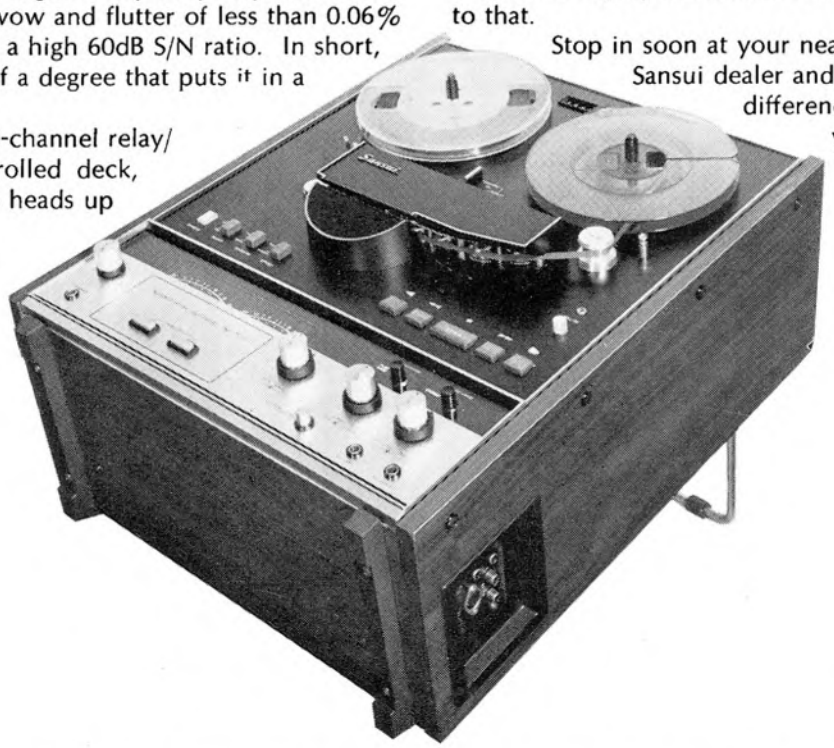

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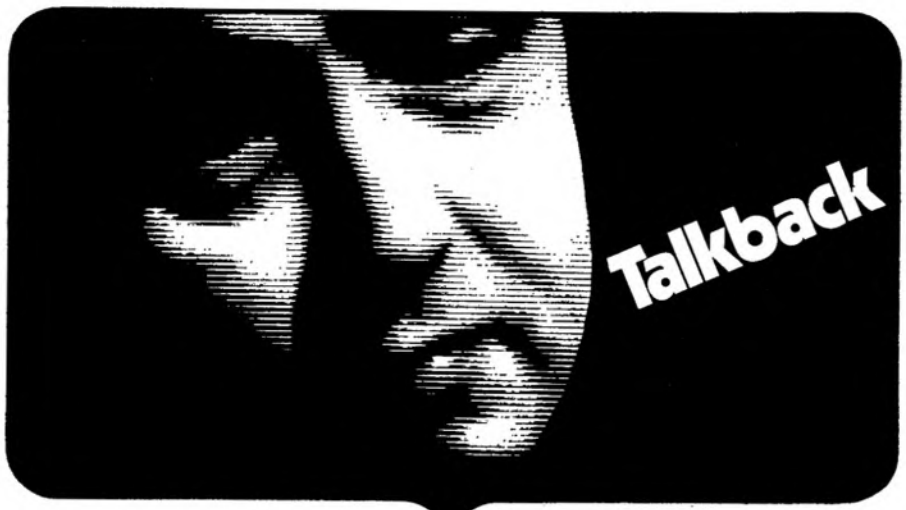


by Peter Bastin

ENJOYED DAVID Kirk's blissful lurch through metrication in the June issue. It opens up a vista as beautiful as Accrington on a wet Bank Holiday. One is hardly aware that he is, as he says, worried. He has clearly made a fairly thorough study of metrication (or decimalisation) problems, and (if I may make so bold) he has even tried to regard it with some humour. Which is more than I can do. His Kirkimalisations could surely be carried a stage farther. We could honour (?) the Decimalisation Board with a metric formula of their very own. 1 000 words=0.

IF YOU'RE sick of reading about four-channel stereo, this will make you sicker: Philips have demonstrated a four-channel system cramming *eight* tracks into the 3 mm tape width of a 4.75 cm/s Compact Cassette. Incidentally, one purpose of four-channel stereo is to recreate hall acoustics. Ideally this requires anechoic conditions in the control room which in turn could result in acoustically treated control consoles—hairy mixers.

INTERESTING, THE little things that crop up in print. Especially the odd little bits of candour which sometimes explode the great 'professional' myth. For example, the editorial in June boldly stated that professionals sometimes skimp on recorders but always use good microphones except when multi-miking. Alan Green (Folk Heritage Recordings) suggested that it is not so much the quality that matters as the finished sound. Someone else, might have been Arthur Garratt, said that studios are frequently cluttered and chaotic. I believe all these things. The disorder and apparent confusion in some BBC and ITV studios has to be seen to be believed. Nevertheless, the sound comes out. It may not be 'hi-fi' in the purist-writer's book, but it is the sound that was wanted. If you listen to most pop-music singles, you will find that the sound-quality stinks. But they still sell and they're still played on radio and TV. 'Quality' is all very well and very desirable but, faced with a problem of effect or quality, the average pop studio would elect for effect.

THE NOISE Abatement Society of 6 Old Bond Street, London W.1, offer, for the sum of £10, a noise level meter. This is designed to the Society's specification for use by the police, public health and factory inspectors, and the public at large. The instrument is 127 x 50 x 25 mm and measures noise on a scale of 70 to 90 dBa. It will register your pop group as a danger to mental and physical health.

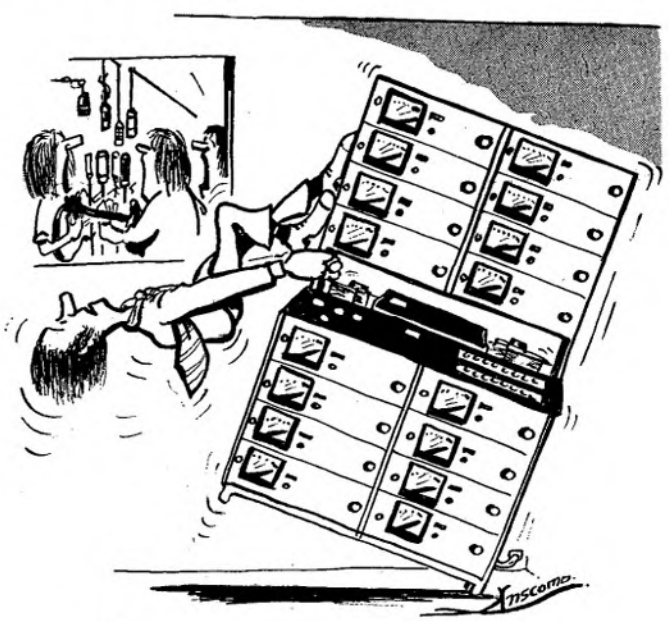
HAVE YOU ever noticed what sloppy Joes some tape-recorder operators are? I often get tapes without leaders, usually having to chop off a chewed-up lump of recording tape at the beginning. A chap I was talking to the other day told me he is compiling 31 items of music so he can play one on each day of the month. That's OK, but he ruined the whole thing by saying that he *couldn't stand* wow and what could he do to get rid of it at 4.75 cm/s?

DON'T LOOK now (try 1971) but yet another domestic telerecording system has been developed: Cartrivision. For £380, Cartridge Television Inc will sell a VTR built into a wide-screen colour receiver. A supporting video library will be organised, full facilities being offered for 'home movie' recording. Maximum cartridge duration is two hours. Sounds very promising.

SHOULD LIKE to know what holds those four-channel headphones, pictured in August *Studio Diary*, on the listener's head. Araldite or anti-gravity?

TOSHIBA HAVE brought out a CCTV unit which will undoubtedly create a market of its own. The complete pack costs £168, is marketed by ADM Business Systems, and comprises a mini-camera with tripod, monitor set and 10 m cable. Both camera and monitor are completely mobile and need only a power point. The camera has a standard 16 mm lens with focus and can be obtained with wide-angle lens for an extra 14 quid. The monitor, no bigger than a standard telephone, has a 130 mm screen. You can, if you wish, hire the whole thing for 5s a day.

H. W. HELLYER complains (September *Studio Sound*) about phono plugs and sockets, 'having seen so many melted inners and rusted outers'. A few months back, Angus McKenzie was similarly worrying about GPO jack corrosion. One pictures these gentlemen seated at their rusting typewriters, water dripping from the ceiling, froggy things swimming round the table . . . Personally, I think a connector should be ruled out of court if it breaks when you tread on it.



SPECTRAFONIA

Bob Auger* describes the preparation of the most ambitious audio-visual project ever undertaken

PERHAPS the most ambitious audio-visual project this year is the *Spectrafonia* installation which has been built into one of the Expo 67 pavilions in Montreal as a contribution by the City of Montreal itself towards the 'Man and his World' exhibition, scheduled to last throughout this summer.

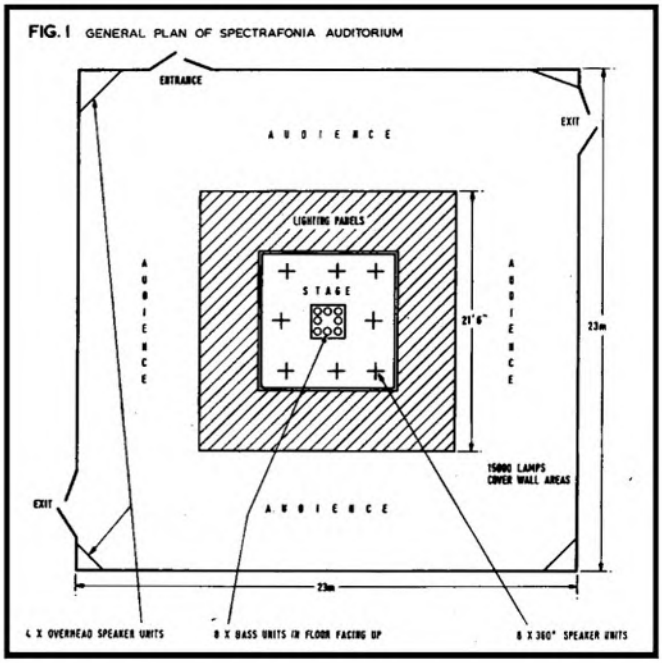
After a short briefing on the telephone by the project consultants, I realised that the installation was to be unusual to say the least, and could possibly live up to the claims of the designer that it would be 'the greatest hi-fi installation in the world'. 'Great' it must be, high quality it should be, and a mind-blower it has to be, since the equipment includes a 16-track, 50 mm (two inch) tape, 3 M professional recorder, programmed with 12 tracks of music feeding a multi-speaker playback system, the other four tracks being utilised for pre-programmed lighting effects, augmented by random lighting effects generated by the frequency and amplitude of the music.

The designers of the pavilion are attempting to create a complete environment which will enfold (maybe engulf would be a better word) the visitor in a couple of kilowatts of sound plus several thousand points of light emanating overhead from a veritable forest of cables. The audience are seated on a kind of theatre-in-the-round, or circus format. The diagrams will give the reader some idea of the basic design of the pavilion but remember that the stage, which is only 7 m square, contains eight stacks of loudspeakers arranged so as to give 360° dispersion of sound. These are augmented by eight LF speaker units, flush-mounted in the centre of the stage, which carry bass from all the tape channels mixed together for reinforcement purposes, plus enough cable to carry 15 000 separate light points.

Great care has been taken by the scheme's acoustic consultant, David Wilson, to ensure that the pavilion provides an almost completely negative environment from the sound point of view. The whole of the auditorium has been acoustically analysed and the reverberation time brought under control. It can be reduced to something under 400 mS. All peculiarities regarding resonances and variations in frequency response have been eliminated or compensated for in the electronic circuits of the sound installation. When I point out that the acoustic consultant also took considerable trouble to analyse the acoustics of the recording venue and that he felt able to negate even these peculiarities it will be seen that something unusually detailed has been attempted. The object of all this acoustic research, or 'acousta-voicing' as it is now called, is to attempt to present music 'in the air', so to speak, and in an almost disembodied manner. Since this is probably the first time such a presentation has been attempted the technical reservation has been made that, if this did not turn out satisfactorily, the negating adjustment in the playback system which had been inserted to remove the sound characteristics of the recording studio could be removed. Up to the time of writing I have not heard from the pavilion designers which method of playback has been adopted. It is interesting to note that, even with all the painstaking research and care that has gone into this side of the project, it still seems to depend on a se ies of subjective tests by a committee of people to decide which system is best.

The sound equipment installed in the pavilion includes the 50 mm tape playback system mentioned earlier, the audio tracks of which are fed into Dolby *A301* units and thence via a series of power amplifiers into Altec *604* speaker assemblies. Thirty-two speaker cabinets are arranged round the perimeter of

FIG. 1 GENERAL PLAN OF SPECTRAFONIA AUDITORIUM



Bob Auger* describes the preparation of the most ambitious audio-visual project ever undertaken

the stage in stacks of four, so that each stack covers all the audience. Each cabinet can be individually set for volume level in order that the speakers farthest away from the audience can be played at a higher volume than those nearby. The centre of the stage contains a specially constructed Altec speaker assembly with the eight units handling bass frequencies only. A further four Altec speakers are mounted in the corners of the ceiling facing down towards the audience.

The orchestra is divided into eight sections and heard from the stage perimefer installations, the chorus and ambience tracks being fed into the ceiling-mounted units. The nature of the music chosen for the first recording (Berio *Sinfonia*) is fragmentary, with various sections of the orchestra quickly alternating. Being generally interspersed with the chorus, the playback images are continuously moving and it is doubtful whether a more suitable piece of music for the initial experiment could have been found.

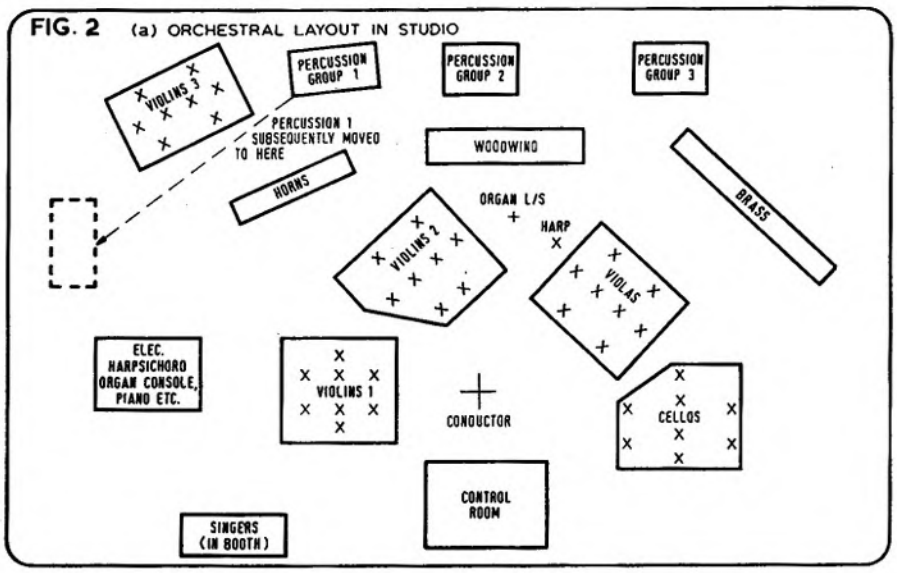
During a planning meeting with the organising consultants it became apparent that considerable control would be needed at the recording sessions in order to avoid unnecessary spillover of musical instruments from one orchestral track to another. Since this could not be avoided altogether, care was taken to plan the geographical layout of the orchestra in the studio and to relate this problem to the physical layout of the loudspeakers on the pavilion stage. In other words, where bad separation was unavoidable (i.e., loud brass being picked up on the microphones of the lower strings) this has been taken into account in the playback installation, as can be seen in **fig. 2,** which relates orchestral layout to loudspeaker placement. Since acoustic separation could become a problem in the recording studio it was decided not to record in one of the normal classical venues (i.e., Walthamstow, Watford or Barking Assembly Halls) but to use a studio large enough to accommodate a symphony orchestra and small chorus with enough extra space to lay out the orchestra while leaving large gaps or aisles between the sections. It was finally decided that Anvil Studios at Denham would be ideal for this purpose, particularly as the studio had been recently equipped with a 24-channel eight-group output Neve mixing desk. When this equipment was augmented by a second Neve console brought in by Granada Recordings, together with no less than 16 Dolby *A301* units and a 3 M 16-track recorder, we were home and dry.

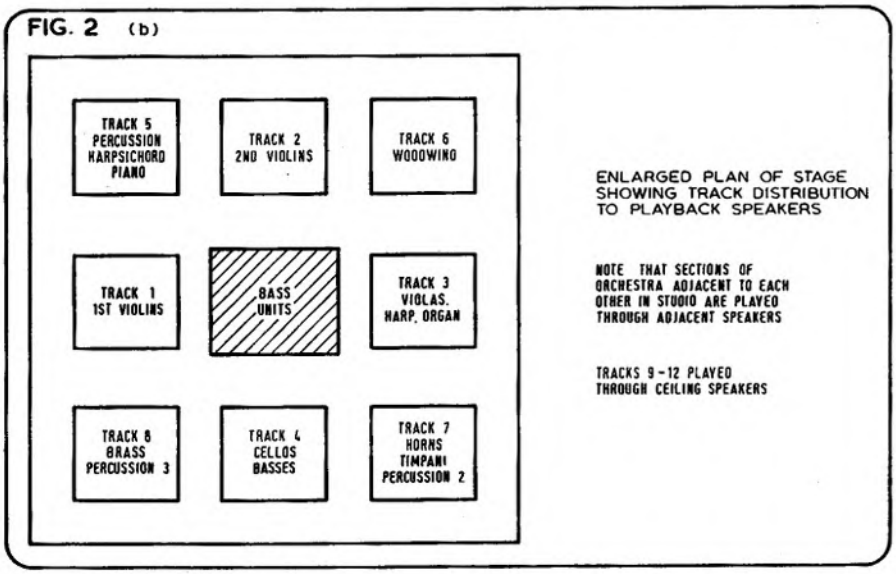
Granada Recordings

We realised at an early stage that it would be difficult to achieve a precise balance between the tracks at the recording sessions for optimum playback at the exhibition, and that a subsequent master tape would have to be dubbed for the purpose. Consequently, once the decision was made to produce such a master, it was agreed that we might as well make use of all 16 tracks on the original tape to provide maximum flexibility of rebalancing during the dubbing operation. Having decided to utilise all 16 tracks for audio at this stage we were able to arrive at the following track layout:

1. First violins
2. Second violins
3. Violas, harp, Hammond organ
4. Cellos, double basses
5. Percussion group 1, electric harpsichord, piano
6. Woodwind
7. Horns, timpani, percussion group 2
8. Brass, percussion group 3
9. 10, 11, 12. Swingle Singers—two singers to each track
13. Ambience—south-west corner of studio
14. Ambience—north-west corner
15. Ambience—north-east corner
16. Ambience—south-east corner

(continued on page 443)





Ferrograph
Series 7 tape recorder

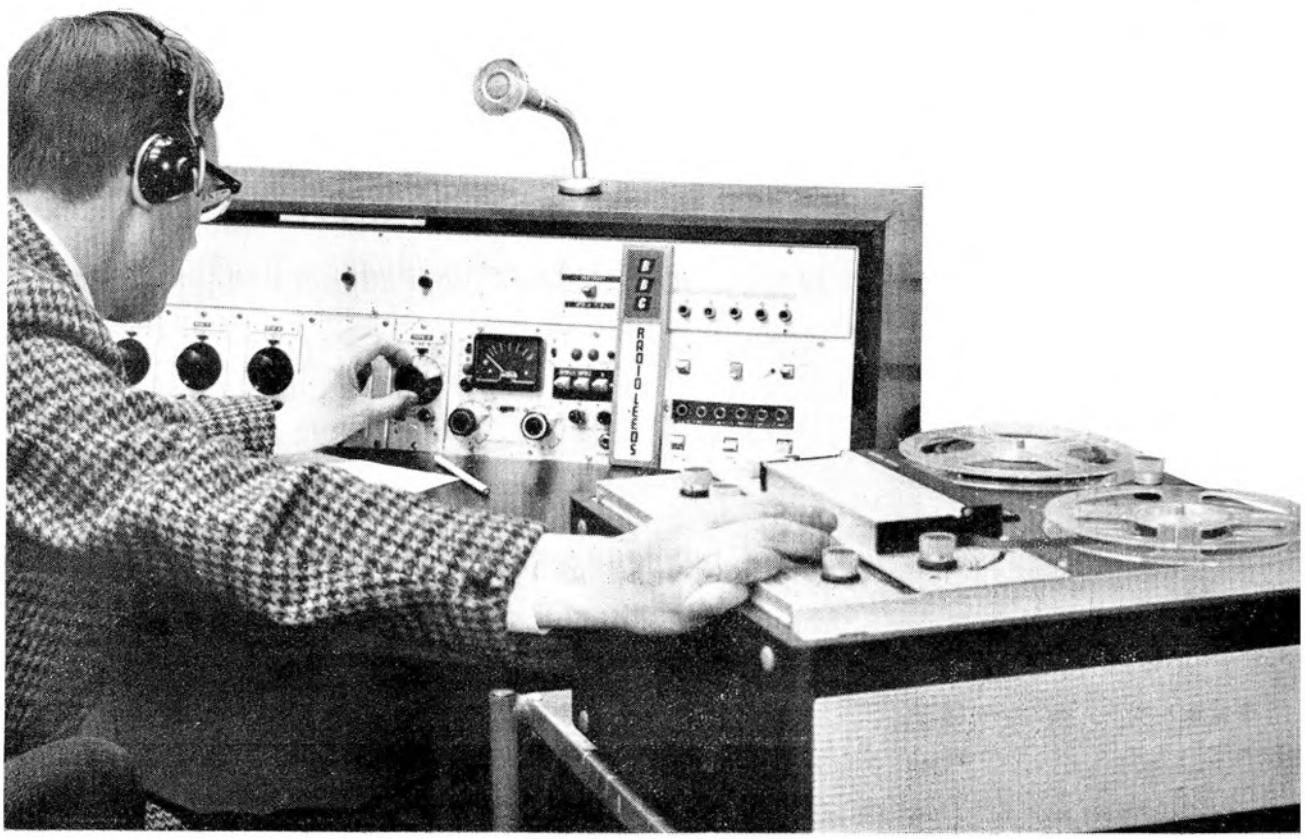
Where a tape recorder must be good and reliable, you'll find Ferrographs. In a radio station, for example, tape recorders are in constant use. Technical performance is all-important; absolute dependability and split-second control are essential. So Radio Leeds uses Ferrograph recorders.

Ferrograph Series 7 tape recorders are British made, available in mono and stereo, with and without end amplifiers. All instruments are solid state, three speeds. All incorporate an unrivalled range of facilities, including two inputs per channel with independent mixing, independent tone controls on each channel, endless loop, signal-level meters for each channel on playback and record, re-record on stereo models, and many others. The output is 10 watts per channel. Ferrograph recorders are available in elegant hardwood or in a vinyl case to suit any decor and method of use.

Follow the professionals; choose the recorder you know will serve you best at home and in your work: Ferrograph. Your local Ferrograph specialist will be pleased to demonstrate it to you. Alternatively, please write or ring for details and address of nearest stockist. The Ferrograph Co Ltd, The Hyde, Edgware Road, Colindale, London NW9 Tel: 01-205 2241, Telex: 27774

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

Ferrograph

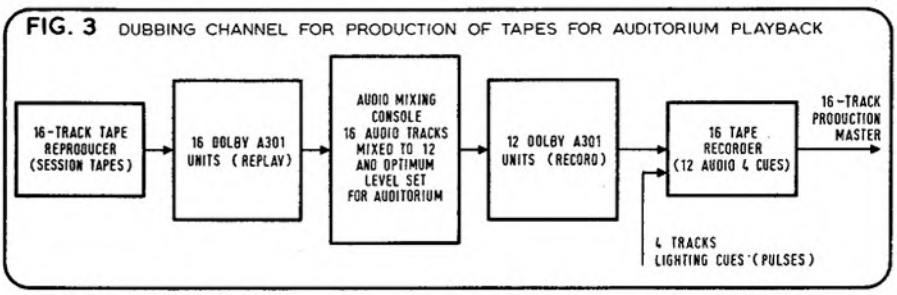


It should be mentioned that the score of *Sinfonia* contains as a frontispiece a very elaborate diagram of the composer's intended concert layout, and this differs completely from that arrived at, for technical reasons, on the sessions; I would like to pay tribute to the composer at this point for his ready acceptance of what must have seemed to him to be a complete contradiction of all he had carefully planned. It is not common in my experience to find a contemporary composer who, having carefully calculated so many effects in his score, is so willing to co-operate with technicians under such disturbing conditions. Some of the general stress felt at the time can be judged from the accompanying illustrations.

The music recording was produced by Harold Lawrence and some idea of the concentrated effort and co-operation between the various parties can be judged from the fact that the complete recording was achieved with considerable time to spare on the final session.

The 16-track tapes were subsequently taken to Montreal where a complete dubbing suite had been set up with the chain of equipment shown in **fig. 3.** At this stage any idiosyncrasies in recording levels can be ironed out and the final balance between the various orchestral tracks set to match the playback levels on the auditorium stage. At the same time the four tracks containing the chorus were mixed together in pairs with the four tracks containing the ambience and third violins, resulting in a 12-track audio master leaving four tracks available for the pre-programmed lighting cues.

FIG. 3 DUBBING CHANNEL FOR PRODUCTION OF TAPES FOR AUDITORIUM PLAYBACK



The pavilion planners were able to concentrate initially on the music balance, since the lighting cues could be worked out independently and recorded one at a time by the same post-synchronisation process used for building up a normal multi-track audio master during pop recording. Naturally enough the Dolby system was again used during the preparation of the 'production master' tape so that the highest signal-to-noise ratio could be maintained throughout the project.

Whether or not the planners' dreams to produce the greatest audio system in the world have been realised remains to be seen, or heard, but certainly the venture was a major step forward both in the ultimate use of the current quadraphonic development and also as an early important venture into the field of audio-visual entertainment.

Producer Harold Lawrence (left) listens to a playback with Bob Auger (centre), during production of 'Spectrafonia', with music by Luciano Berio.

tape recorder service

FERROGRAPH SEVEN CONTINUED

By H. W. Hellyer

ONE of our customers has an under-guarantee model *713*. Its counter drive, a flexible steel wire with nipped ends, had snapped and he had, to quote his expressive phrase, got his 'cogs in a twist'. The noise that the geared drive made during fast winding was nobody's business, but there was really very little wrong. We removed the whipping loose end of wire, retrieved the lonely nipple (grub-screw secured to the counter shaft) and then sent them back to South Shields for a free replacement.

Our customer resigned himself to a ten-day or so wait, but did not worry about robbing the piggy-bank to pay for his repair.

It only took Ferrograph a week to reply and instead of the new cable—which would have arrived in a small envelope—we found ourselves unpacking a well-stuffed package with much the same emotions the youngsters suffer at Christmas. And not without justification, for the goodies, unwrapped, turned out to be a sparkling new digital counter, a turntable hub, and a belt.

A belt! A Ferrograph with a belt, forsooth. But that is the modification lads, and we shall have to learn to live with it. The only snag is that for the privilege, the makers charge us nearly 30 bob. Our customer has not been told about that yet, and no doubt expects his repair to be done for nothing. Cost of extra time installing the new kit will have to be absorbed by us. Here's what it involves:

After removal of on/off and speed selector knobs and the top plate, remove the take-up reel carrier. This is secured by a grub-screw (Allen key needed here) and the only precaution is to retain the packing washer beneath it. The gear bracket on the hub spindle is held by two screws which can be removed by inserting a screwdriver through holes in the top plate. Remove this item, then unhook the 'reset' lamp, at lower left of the existing turns counter.

At the rear of the counter mechanism, in the middle of the deck, the deck support pillar will be seen. This has to be unscrewed with the aid of a 4BA spanner. Look out for the rubber insert, the solder tag and the washers associated with this assembly, and let the 'ON' lamp holder float free. The counter and its drive can be slid rearward and removed.

To fit the new one, locate the tongues in slots under the record button, fit the support pillar, with washers, rubber piece and 'on' lamp as before and align the turns counter with the cut-out in the temporarily fitted top plate before tightening. Ensure that the lamp is in the right place. Then replace the other lamp.

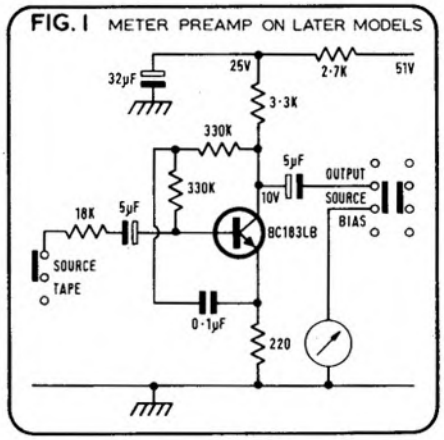
To fit the belt, slide it down through the hole in the motor top plate so that it sits around the spindle—don't fit it to the turns counter first, or you will stretch it in the final operation. When it is loosely looped into place, the new reel carrier can be fitted, using the same spacer washers, adjusted exactly for spool height, and finally the belt looped around its, and the turns indicator's, pulley.

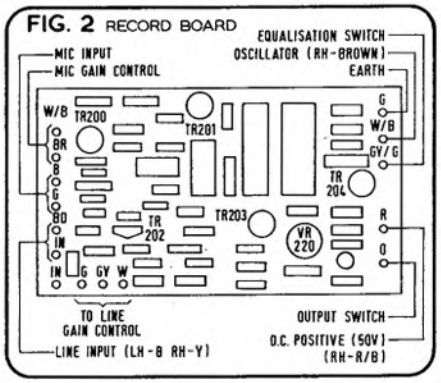
It can be seen that the new system allows more spool height adjustment, and it is easy to do this wrongly. The method used by Ferrograph, once the reel carrier is screwed to the motor spindle correctly, seating on its packing washers, is to limit the end float of the motor armature with a bracket and cup arrangement mounted on an adjustable arm. The arm is permanently fixed in a resilient mounting at the rear end and has a long screw going through it at the other end. The long screw, adjustable through the top plate, has a limited movement by the position of a locknut down its length and by the clamping action of a nylon gripnut at the bottom. It is spring loaded. The trick is to align the arm with a standard spool so that the lower flange sits clear of the side deck supports by about 1.5 mm, making sure that the range of movement of the adjusting screw is such that at this setting it is roughly in the middle of its travel. Some fine adjustment is then available to allow for odd thickness spools. If there is any doubt about spool thicknesses (and there certainly seems to be in the minds of manufacturers) the standards can be found in a recently published British Standard: *Specification for Magnetic Tape Recording Equipment*, BS 1568: Part 1: 1970. Available from the BSI, 2 Park Street, London WIY 4AA.

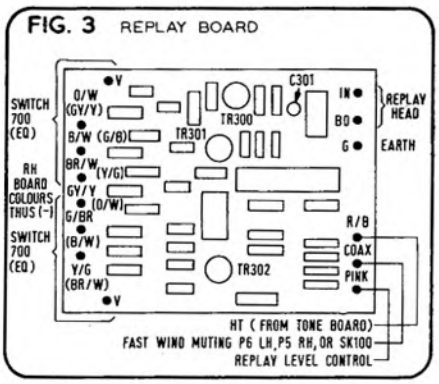
Which is where we came in . . . last month we promised a run down on meter setting, bias adjustments and overall response checks. Noise and distortion measurements should occupy our attention also, if space permits.

Meter setting differs somewhat on the models with serial number subsequent to 75 000 as there has been a switching and preamplifier change. The meter can now read Tape, Bias and input Source signal. In other words, as well as an aural A-B test, we can, with some careful setting up, carry out a complete A-B regulation.

The meter in these models is a conventional VU, but with certain differences as can be seen from **fig. 1.** The meter switching allows complete setting up which very few machines permit without some such alteration. Ferrograph provide the matching up of levels to the indicator circuit by adding a single amplifier.







This source reading is incorporated to allow the level of the signal passing through each recording to be selected and indicated regardless of the position of the output switch, which selects the 'off-tape' or 'straight-through' path of the signal. So the meter reads either the replay signal or the source signal, as well as the bias. It needs only the addition of a tone generator in the latest Ferrograph circuitry to bring this development into line with modern studio practice.

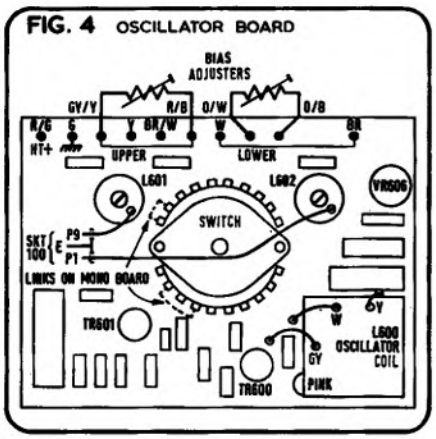
Setting up and adjustment are fairly straightforward with the Ferrograph, as we saw in its initial stages last month. One of the really important procedures is setting bias and the adjustment of the meter circuits to a given

standard. No use employing the presets to read 0VU, or whatever figure you choose, if the meter is not set, so we need a signal generator and a millivoltmeter. Pump in 1 kHz at the line input and read off signal across the 600 ohms output. Use one of the tapes formerly stipulated (the makers naturally recommend 'Ferrograph B') and be sure that stereo machines are set to stereo: false results can be obtained with stereo machines set to mono and adjusted for optimum bias.

Record the 1 kHz tone and read off the recorded signal (output switch to 'Tape') and adjust the signal generator for a reading of 200 mV. Then adjust the bias preset (marked B) for a maximum reading on the millivoltmeter. Only after this can we set the Ferrograph's meter, and this is now done with the machine paused. The appropriate controls are on the top panel of the amplifier block, down behind the vertical bracket with the motor start capacitor. These are not easy to adjust and I have made a habit of putting knobs on those I may have to use fairly frequently—as may have been spotted in one of last month's photographs. The 3 mm spindle flatted knob fits neatly. In my case, because of availability, the volume control knob of a Philips *EL3542* was employed—but don't tell Uncle Malcolm!

The two preset controls are used to bring the meter up to 0 VU for optimum bias. The same logicality prevails for positioning, i.e., all upper

FIG. 4 OSCILLATOR BOARD



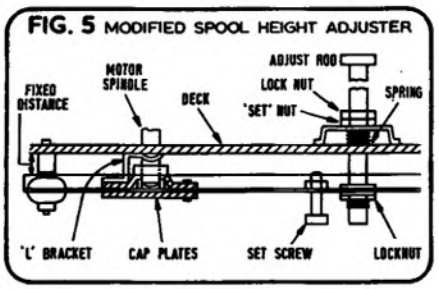
track settings, components, boards, etc., are to the left, viewed from in front. With the machine still set up in the record mode and in stereo, adjust the bias traps. The millivoltmeter is transferred to the collector of *VT203* on the record board (upper channel) by clipping to the can of the transistor. For position, see fig. 2. The coils L601, L602 are tuned through the oscillator board (see fig. 4) for a reading of below 300 mV. Repeat for the other channel. For stereo models, it is wise to go back over each adjustment, checking that the other channel has not been affected. In making these tests, there will always be the temptation to switch from track to track. Easily enough done, with the mode switch, but deprecated by Ferrograph on the grounds that switching from upper to lower while recording magnetises the record head. The temptation can be withstood, but if your particular function necessitates such a switch action the problem could be overcome with an additional switch-bank, with make-before-break contacts and a bias attenuating resistor network.

There is one other adjustment on the oscillator board, and this is *RV606*, for matching bias indication on each channel. Don't attempt to adjust this one until all the other settings have been checked. Its position can be seen on fig. 4.

Frequency response checks are quite detailed. As can be seen from the equalisation board (fig. 6) there are six preset adjustments for a stereo machine and, what is not always so obvious, an equal number of precise adjustments that entail the alteration of component values. I do not propose to go into the precise details of these alterations but they are available if wanted. Just write.

I must emphasise that such alterations are rarely needed. After replacing major parts, or a printed circuit board, some trimming up will be needed, but a factory set machine should never need this kind of treatment. There is no harm in checking the frequency response, and this can be a useful exercise for the audio buff. On this machine, keep the input down for a

FIG. 5 MODIFIED SPOOL HEIGHT ADJUSTER



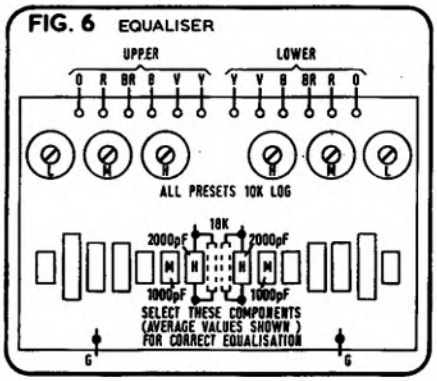
200 mV reading at the 600 ohms output socket. This should be 20 dB below maximum recording level. You will have seen the specification of the machine and, with the aid of the signal generator and millivoltmeter, it is possible to make a check in a reasonably short time. The only adjustment that matters after this is the take-off level from the record board, shown as RV220 in fig. 2. On later models, with the three-position meter switch and the meter preamp shown in fig. 1, the setting of this preset to give the same source and tape reading is quite important, but again, should not be done until the major settings have been made.

There are several other tests which can be carried out but which it would be pointless to describe as the user can do little by way of adjustment. But in the matter of noise control, some testing and perhaps adjustment can be done. You know and I know that our ears are the final arbiters. But if you want to check noise properly, and have access to adequate equipment, there are several tests that can be made.

Ensure first that there are no earth loops—especially through odd pieces of gear. After this, short across the two pins of the replay head connection (see fig. 2) and test with the millivoltmeter with the machine in the pause position and note that the reading should be less than 1.5 mV. Opening the head short should not bring the reading up to more than 3 mV for half-track machines. Then erase a portion of tape and check the s/n ratio between that which gives full modulation, and the erased portion, which should be better than 55 dB down. In direct figures, a reading of less than 3.56 mV.

If these figures cannot be bettered, look to the input transistor *VT300* (see fig. 3). You may have to go through several *BC214LB* transistors (or BC154, as fitted on earlier models) but, before doing so, take a look at C301. This component is a low-noise tantalum capacitor, specially chosen for the purpose. But it seems that Ferrograph have had the same problem we have met on other equipment

FIG. 6 EQUALISER



—that of a special component proving the most troublesome. I note that on replacement boards lately, a Siemens capacitor has been fitted in place of the little tantalum that was there before. I have not had to change one yet, and pass on the news without comment. The lads at South Shields know what they are doing.

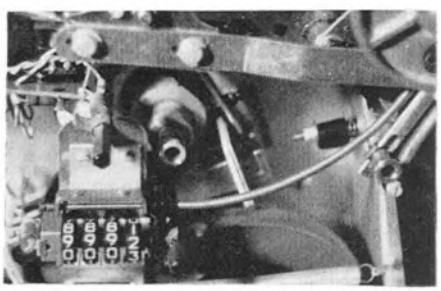
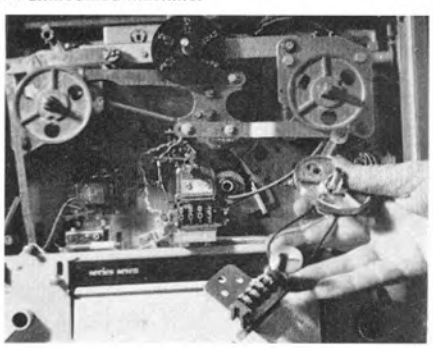


Fig. 7 Original cable-and-nipple drive was superseded by a sheathed cable but still gave trouble so . . .

Fig. 8 . . . a belt drive has been introduced, parts seen here against an unmodified machine.



RADON'S DL6CM MIXER

Designed for Professionals at unprofessional Prices

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

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

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

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

Also Available

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

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

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

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

LEVEL CONTROL EQUIPMENT

Superb Performance—moderate cost

F600-M Mk 2 Limiter/ Compressor

A Mk. 2 version of the well established F600 unit. Gain within the system is normally 25dB with output level of 0dBm (+8dBm to order). Compression ratio better than 25:1; variable attack and release controls with auto network. Noise –70dBm. Response: 10Hz–50kHz for –3dB. Distortion: 0.1% for 25dB reduction at 1kHz.

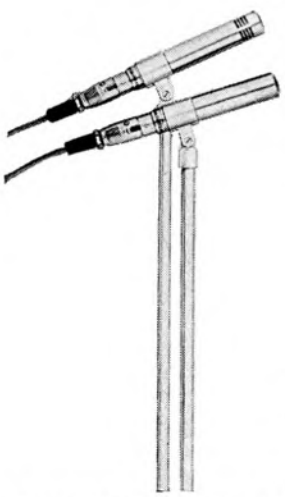
also available

F700 Compressor/Limiter and E800 Equaliser

Audio & Design (Recording) Ltd

10 Lower Rd., Cookham Rise, Maidenhead, Berks.
Tel: Bourne End 22231 (STD. 06825-22231)

CALREC TRANSISTORISED CAPACITOR MICROPHONES



THE 1000 SERIES MICROPHONES OFFER ALL THE FACILITIES DEMANDED BY THE PROFESSIONAL USER AND, BEING OF BRITISH MANUFACTURE, CARRY NO IMPORT DUTY.

CM 1000 OMNI-DIRECTIONAL
£76 16 0 complete

CM 1050 ACCURATE CARDIOID
£81 6 0 complete

- Phantom Power— Balanced Line
- Cannon Plugs and Sockets Throughout
- Multi-Power Packs Available

The prices quoted are recommended retail and include power units, connecting leads, windshield and stand clip. Generous trade and professional discounts are available. For further details of the 1000 series, 800 series (miniature) and 600 series (unbalanced) please contact:—

CALDER RECORDINGS LIMITED

REGENT STREET, HEBDEN BRIDGE, YORKSHIRE
PHONE 2159

going mobile

STEPHEN COURT DESCRIBES RECENT DEVELOPMENTS IN PORTABLE RECORDING EQUIPMENT

OVER the last 10 years, a tumultuous advance in mobile recording equipment has taken place. The two fields of location recording, film and straight audio, all derived their equipment from the studio. When the word came to go mobile, apart from all hell letting loose, it required gangs of soundmen, great piles of equipment, miles of cables, wires, plugs, sockets, tools, and any amount of gadgets that each sound engineer had made to make his job easier.

Watching an old film, one often wonders how on earth they managed to get any sound at all, when even today you can see great bulbous microphones, mixers, whose valves you could read a book by, and a proliferation of audio antiquity that would fill a removals lorry. The great advantage of recording in those days was the fact that the sound came from the mikes, through the mixer and straight on to an optical track or wax disc.

Nowadays, that removals lorry has been replaced by the sound mixers' car, usually an estate car, a Nagra, a small mixer and a pair of headphones. In the case of straight audio recording, usually a three or four track recorder, a mobile mixer, maybe 10 to 20 channels, and one or two monitor speakers. We once did a mobile at the Festival Hall, where the output of an Ampex recorder was monitored on Goodmans *Maxims*, and you can't get any smaller than that!

Starting at the front end, microphones have improved tremendously in the last few years but it is still common to see expensive capacitor mikes on a music set-up and an old 1936 ribbon on the brass, where any amount of correction won't beat that particular combination. Each engineer has his own preferences in this respect but, until recently, capacitor microphones were used on and off location, for their quality. Nowadays, there are some dynamic mikes on the market with extremely good frequency responses. Not requiring power supplies, these are more reliable—a must for location recording—and have a generally better overload characteristic. Microphones such as the AKG *D224*, and Sennheiser *MD421* and *MD211* are all dynamic mikes with very clean responses and can be used alongside capacitors without much worry.

I prefer to use capacitors as their quality is coupled with a higher output, and the Sennheiser *405* is the mike I have been using mainly in the last couple of years. The power supply is about the size of 10 cigarettes and runs off two miniature 9 V batteries—a far cry from the heavy mains-run units, and very useful for location recording. On film work it can be put into the Nagra side pocket and, on location music recording, taped to the mike stand or hidden behind the mixer.

You have probably read the *Studio Sound* survey on mixers, showing the types currently on the market. Usually, an engineer prefers to build his own mixer, or at least have it made to his specification. I have been using the German Sennheiser mixer which is one of the few professional mixers available for less than £500. Basically intended for the film industry, it comprises four basic inputs but extra units can be added by doubling up. Switchable mike amp gain, equalisation, a PPM and quadrant faders—not bad for a mixer the size of a portable typewriter!

At the other extreme, this country does not do a vast amount of mobiles, compared with say Germany and the United States. As I said earlier, when the call came for a mobile, it was generally necessary to load all sorts of equipment into a van, drive to the location, find a suitable place for the equipment, and set up there. That means, invariably, somewhere completely unsuitable for a control room. In Germany, some time ago, I saw what must have been a sound engineers' dream—a huge Mercedes truck, acoustically treated, monitor speakers in each corner, fully transistorised four-track recorder and a 20 channel mixing desk. All on a deep pile carpet, with seats for the engineer, producer and one other person. Cables ran out on drums from the side, similar to a TV outside broadcast unit, and with talkback to the assistants and artists, all the work was done from there. I couldn't find the cocktail cabinet, but I'm sure there was one!

With the increasing use of mobile VTR in television, slowly superceding film in some cases, there are now companies setting up such outfits, with the camera unit in the main truck, vision mixing and monitoring facilities. This camera truck tows a sound trailer of similar construction.

The great advantage of CCTV monitoring is that the engineer can mix, however far he may be from the artists, It is becoming increasingly popular even on conventional mobiles, as the engineer can see what's going on, without, as I had on one location, having to run out of the church vestry every few minutes to look around for himself!

The increasing use of 8 and 16 track recorders on mobile sessions makes life a lot easier as the engineer can concentrate on recording each group separately, then do the final mix back at the studio. As the location acoustics and ambient noise aren't always what they should be, the first time you can really hear the tape is when you return to the studio. I must admit the tape normally sounds faultless when you return from a location in the dark hours but in the morning, with fresh mind, any faults show themselves, and often call for hours of 'cooking' and very hairy editing!

At the other end of the scale, ultra mobile units using five or six microphones at the most, recording on to a Nagra recorder via a portable mixer, is still the most popular combination for mono recordings. The new Nagra *4* is a great improvement on the Nagra *3* but, as yet, I've still to see a *4* in common use on film location. I have used both but, for film work where reliability, portability and ease of operation are most important, the more rugged Nagra *3* is preferable. On music mobiles, one can sacrifice these advantages for the lower noise level and wider dynamic range of the Nagra *4*.

Another great improvement on the mobile side is the introduction of the Stellavox portable stereo recorder. Not very plentiful at the moment but the one I used was a very versatile and professional recorder. It seems a shame to me that they made it so small (about one third the size of the Nagra) and I can't help feeling those few centimetres were at the expense of some facility, although there was nothing lacking when I used it! The meters (two PPMs) are rather small and the maximum spool size is 13 cm, although larger NABs can be fitted. All the same, the prospect of stereo recording at 19, 38, and even 76 cm/s, with camera sync if required, is quite exciting for such a small unit. Four speeds altogether.

Another addition to the Sennheiser range is a studio monitor speaker with a built in 50 W power amplifier, equalised to give a flat frequency response and very clean sound. The unit is very compact but the very high cost in this country, about £200, is only justified by its mobility and quality, and the fact that it can be fed from the Nagra direct, or from the line output of a mixer. The speaker was so clean, when I played a Nagra through it, I heard things I didn't even know were on the tape.

I experimented with the Stellavox recorder, recording stereo through two Sennheiser mixers and *405* capacitor mikes, monitoring with the portable speakers, and the sound was amazingly clean, being kept to a minimum of equipment items. With equipment like this, there is a prospect of very light mobiles, with no need for compression or noise reduction on location, a very strong advantage where multi-track mobiles are not required.

At the present rate of technical development, one wonders whether all this will be out of date in a few years time. Location recording could come into its own in the seventies.

Model MR 939

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

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

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

SPECIFICATIONS

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

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

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

SANYO

People the world over agree there's something about a Sanyo

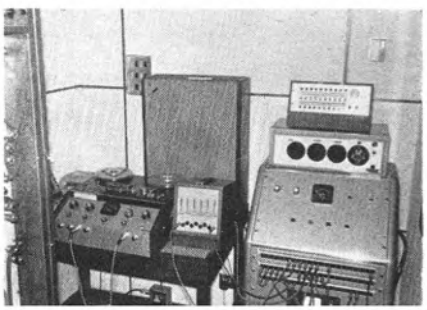
AROUND THE STUDIOS

independent television by keith wicks

WITH the International Broadcasting Convention just behind us, we now take a look at the premises of ITN in London, but with the emphasis on the sound side of the business.

The building is situated in Wells Street, W.1, and was designed for the change-over to colour which took place in the autumn of 1969. On arrival, I met Ron Newberry, the senior sound mixer on duty, who was to show me around. Seconds after we met, he had to take care of an unexpected report from an overseas correspondent, so we proceeded to the voice piece room. This consisted of a small cubicle for speech and an adjacent control room with recording facilities (**fig. 1**). A recording of a telephone conversation between the reporter and a member of the London news staff was soon under way. A Leevers-Rich graphic equaliser was connected across the incoming

(*continued overleaf*)



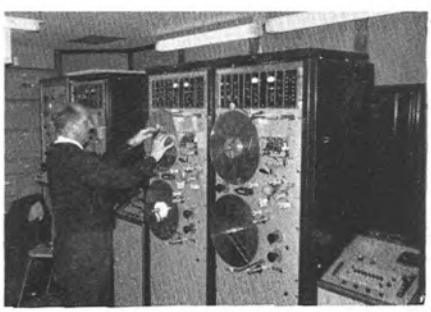


Fig. 1 (left): Voice piece room recording and control equipment—a temporary set-up

Fig. 2 (lower left): Dubbing mixer

Fig. 3 (bottom left): Sound control room

Fig. 4 (above): Tape and grams desk

Fig. 5 (top-right): Telecine control

Fig. 6 (above): Ampex videotape machines

Fig. 7 (bottom right): Engineer loading stripe recorder

line, a Westrex compressor used to keep the dynamic range within reasonable limits, levels being controlled on a four-channel Vortexion mixer. The main recording was made on a Gaumont Kalee 16 mm edge track machine and backed at 19 cm/s on a TRD recorder. A further recording was made on a Grundig *Stenorette* for transcription purposes. In the speech cubicle are a telephone, a ribbon microphone for the 'rear' voice, and a GPO telephone matching unit.

Dubbing mixer

I then had a look at the dubbing mixer. The desk (**fig. 2**), like most other sound facilities at ITN, was built by Elcom. There are 12 input channels, and the desk is equipped with rock and roll control circuits with automatic monitor changeover. As is usual in broadcasting studios in this country, PPM's are used for level checking. On the right is a jackfield to which most sources are fed via distribution amplifiers.

Behind the mixer is a tape and grams desk, containing one Vortexion tape unit and four Garrard *401* turntables. The pickups can be lowered by means of groove locating units which incorporate parallel tracking arms and a scale to indicate pickup position. They allow the required part of a 78 RPM effects disk to be found quickly and inserted accurately into the programme, which is what matters.

Fig. 8: Leevers-Rich recorders

I next visited the main vision and sound control areas where everyone was occupied rehearsing *News At Ten*. Ron Newberry is shown at the sound mixer (**fig. 3**) which has 24 input channels, all with individual equalisation and all switchable to any one of the three output groups. Compressors are widely used as the studio often has to deal quickly with material recorded under all sorts of conditions. Levels would be difficult to control if compression was not used. As in the dubbing mixer, there is a desk for tape and grams, and **fig. 4** shows the engineer playing a tape into the programme during rehearsal.

Fig. 9: News at Ten Studio

Other areas visited include telecine (**fig. 5**), videotape (**fig. 6**) and sound recording (**figs. 7** and **8**) where optical stripe and tape machines were in use. I had hoped to watch the news programme go out on transmission but time had beaten me, so I made do with a look at the empty studio (**fig. 9**). The microphones used are by AKG, mainly the general purpose *C451* and *D24* although, for such things as election programmes, *D109* neck microphones are used.

My thanks go to Norman King, head of sound, who made my visit possible, and to Ron Newberry and the other engineers who made it so interesting.

NEW equipment

SOUND/CINE SYNC SYSTEM

A COMPLETE synchronised sound system to suit 16, 9.5 and 8 mm film is now available from Farnell-Tandberg at £261 13s. (including tax). This comprises an *11-2M* battery recorder with separate audio and sync pulse tracks (£191 10s), FT-1 sync unit (£58 15s) and FT-2 tone generator (£11 8s). A reed switch is supplied to fit the projector.

Distributor: Farnell-Tandberg, Farnell House, 81 Kirkstall Road, Leeds LS3 1HR.

FM RADIO MICROPHONES

WIRELESS MICROPHONE systems are now being imported from America by Vega (European). Developed for professional applications, the *56* system comprises a 35 mW FM pocket transmitter, miniature moving-coil microphone, and a 230 x 170 x 95 mm receiver. Transmitter and receiver are both crystal controlled to a frequency specified by the customer. Claimed signal-to-noise ratio is 60 dB. The receiver can be mains or battery powered, typical link range being 10 m indoors and 800 m outdoors.

Distributor: Vega European Headquarters, 56 Queens Road, Basingstoke, Hampshire.

CROWN CONTROL UNIT

CARSTON ELECTRONICS are now importing a stereo control unit designed to suit the *DC300* and *DC40* power amplifiers. Two tape, two auxiliary, one tuner and two gram inputs are incorporated together with gain, loudness, balance, pan device, bass and treble tone controls, and LF/HF filters. Hum and noise are 90 dB below 2.5 V RMS into 600 ohms output. Panel dimensions are 430 x 135 mm and the price, with walnut finished cabinet, is £140.

Distributor: Carston Electronics Ltd., 71 Oakley Road, Chinnor, Oxfordshire.

MAGNETICALLY MOUNTED MICROPHONE

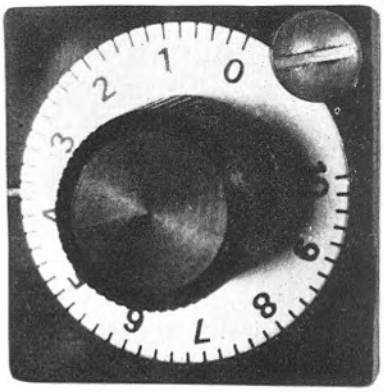
NOW AVAILABLE from S. G. Brown, the Classic moving-coil stick microphone is intended for speech communication and may be attached magnetically to most ferrous metal surfaces. Other mounts are available for non-ferrous surfaces and desks. Impedance is 300 ohms, frequency response rising by 10 dB per octave from 100 Hz to 2 kHz, nominally linear to 14 kHz, then falling rapidly. Output for normal speech is about 1 mV RMS, sensitivity being 85 dB below 1 V/Dyne/cm². Dimensions are 140 x 317 mm. A coiled lead is supplied, extending to 1.7 m.

Manufacturers: Hawker Siddeley Dynamics, Manor Road, Hatfield, Herts.

CUEMASTER CARTRIDGE UNITS

DETAILS OF *Cuemaster* cartridge reproducers and recorders have been sent to us by Consolidated Electronics who are currently seeking UK representation. Model *750* illustrated operates at 19 cm/s and achieves 0.2% wow and flutter with a correctly prepared cartridge. Start and stop times are less than 50 mS, remote control facilities being available. Record and replay heads are fitted (erase head is optional), to NAB mono or stereo configurations. Input requirements are 0 dBm to +20 dBm, bridging 600 ohms, output being up to +20 dBm into 600 ohms. Claimed frequency response is 30 Hz to 16 kHz ±3 dB for 60 dB signal-to-noise ratio. Total distortion is within 1.5% at +16 dBm, 1 kHz. Cue-to-programme crosstalk is 53 dB (150 Hz, 1 kHz and 8 kHz). Up to four units may be stacked and their outputs commoned. Models *640* and *650* are loaded from above and feature playback facilities only. All units may be obtained with IEC or NAB equalisation.

Manufacturer: Consolidated Electronics (Sales) Pty. Ltd., 505 Lygon Street, East Brunswick, Victoria, Australia.



LOCKING CONTROL KNOB

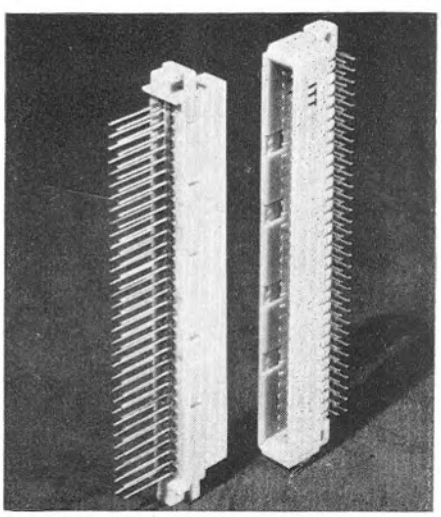
A LOCKABLE rotary control knob is now being produced by Argo, finished in anodised aluminium with a choice of graduation engravings. Model *LK25* is approximately 25 mm square.

Manufacturer: Argo Engineering, 54 Lemonfield Drive, Garston, Watford, Herts.

ENDLESS-LOOP TRANSPORT

AN ENDLESS-LOOP tape transport developed by Fitch Tape Mechanisms is claimed to have eliminated stiction problems. Adaptable to all cartridge formats, the mechanism may be mains or battery powered and permits full remote control.

Manufacturer: Fitch Tape Mechanisms, 7a Balham Grove, London S.W.12.



64-WAY CONNECTOR

IN A LENGTH of 94 mm, the *GO7* permits the connection of 64 poles and is designed for use with multilayer printed circuit boards. The contacts are arranged in two rows of 32, with a 2.54 mm pitch. A 96-pole version will shortly be available.

Manufacturer: ITT Components Group Europe, Edinburgh Way, Harlow, Essex.

The Grundig TK147 is a hush-hush job

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

But that's just the start. This superior design also keeps the distortion level low and frequency response and dynamic range high, whatever the conditions, the composition or the volume of the recording.
And how d'you like the sound of that?
You can get superb stereo playback results by connecting it to a Grundig Stereogram or external stereo power amplifier and loudspeaker.

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

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

GRUNDIG

Made Better to Sound Better

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

LEEVERS-RICH A501 GRAPHIC EQUALISER

MANUFACTURER'S SPECIFICATION. Seven band audio equaliser with switchable high and low pass filters. **Input:** 600 ohms balanced or unbalanced, bridging or terminating. **Gain:** Unity, adjustable ±10 dB. **Output:** Isolated, +20 dBm maximum into 600 ohms. **Frequency response:** 30 Hz to 20 kHz ±2 dB (controls at zero). **Noise:** below —60 dBm. **Centre frequencies:** 40, 100, 250, 630 Hz, 1.6, 4 and 10 kHz. **Control range:** ±9 dB. **Filters:** Off, 70 and 100 Hz (high pass); 7 kHz, 10 kHz, Off (low pass). **Dimensions:** 330 w x 135 h x 235 mm (in stove enamel cabinet with teak ends). **Power supply:** 200 to 250 V, 40 to 60 Hz, 12 W. **Price:** £195.
Manufacturer: Leevers-Rich Equipment Ltd, 319 Trinity Road, Wandsworth, London S.W.18.

THE Leevers-Rich Graphic equaliser was designed to meet the most stringent requirements for equalisation control of programme material, where far more comprehensive curve bending is required than the normal low and high frequency boost and cut provided by simpler equalisers. During the last decade, a number of firms have made graphic equalisers. These have not been entirely satisfactory since, when their different frequency band controls have been set to the centre position, in general they suffered from humps and valleys, giving an overall response often as poor as ±3 dB. Earlier models also tended to be rather hissy and possibly one of the most impressive features of the *A501* is the fact that, when all controls are set to the flat position with the equaliser switched in, the response remains ±0.5 dB throughout the audible frequency spectrum.

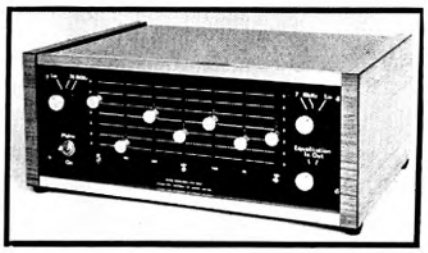
The *A501* has basically seven different frequency band controls. The ratio between each mid frequency and the next is 2.5 to 1, the bands being 40, 100, 250 and 630 Hz, 1.6, 4 and 10 kHz. Each band can be boosted or cut at will independently of the others in nine steps either side of the flat position, therefore giving 19 different positions for each control. The control levers are arranged in a horizontal line and the amount of boost or cut is controlled by vertical movement, allowing the user to see at a glance how much boost or cut is being given by examining the contour of the knobs, bass end on the left and extreme treble end on the right. At the top left corner of the facia is a bass steep cut control having its 3 dB point at 100 or 70 Hz when switched in, whilst at the top right is a steep cut treble filter having 3 dB points at 10 kHz or 7 kHz when switched in. An equalisation in/out switch occupies the bottom right. When the equaliser is switched out, the output is directly connected to the input. At the bottom left corner is the mains on/off switch, though I understand that in some models this is replaced by a panel light, in which case the unit is switched on and off externally. Inputs and outputs are connected by means of tip, ring and sleeve jack sockets on the back panel. A sensitivity switch allows the equipment to be used for overload points of +24 dBm or +4 dBm.

A preset potentiometer is also provided on the back panel to adjust for unity gain. The inputs and outputs are also duplicated on chocolate blocks but insertion of a jack plug automatically disconnects the chocolate blocks from the circuit. There is also provision for remotely controlling the equalisation in/out switch.

The equipment is available as rack mounting or in a teak table top case, the latter being the version reviewed.

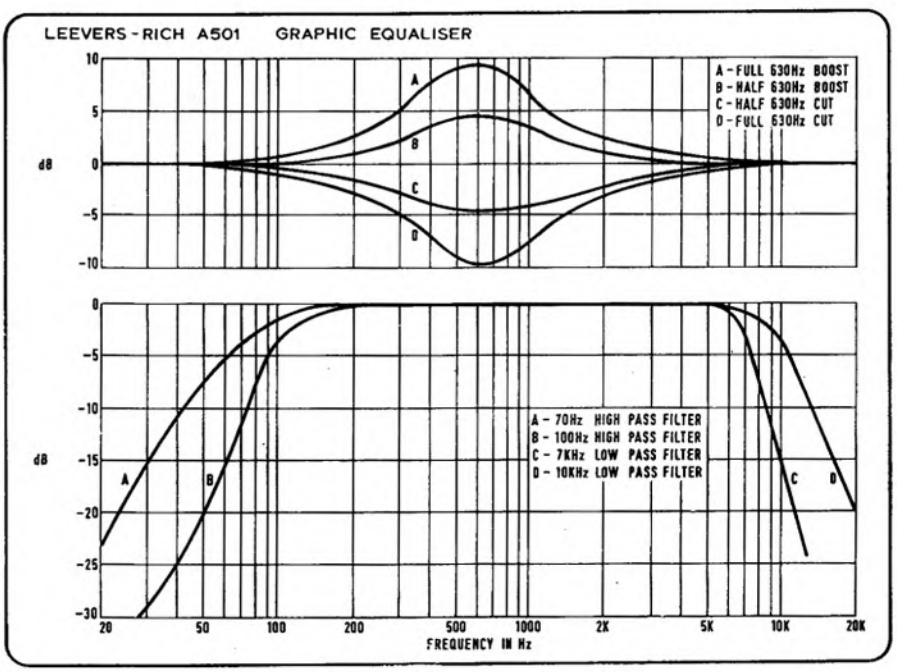
Input impedance is 10 K bridging and floating balanced whereas the output has a very low source impedance over the AF spectrum and is therefore capable of being loaded by any impedance down to 600 ohms, although a load this low cuts the extreme bass response slightly. The noise level was measured into a 600 ohm load resistor and found to be 73 dB down when referred to a peak level of +8 dBm and with top limiting applied to the meter above 15 kHz. With a 10 K termination, but without any weighting, the noise level was 70 dB below +8 dBm, and in the open circuit the unweighted noise equivalent figure was −68 dB. In the −20 dB sensitivity position, the noise level became −66 dBm unweighted. These noise figures must be considered excellent considering the number of complicated circuits involved, and should never be audible in practice.

Each equaliser can be boosted or cut by a maximum of 9.25 dB ±0.25 dB as measured and this should be more than adequate for all



purposes. The filter controls worked extremely well and the unit was tried for a number of applications, always performing excellently with a more than adequate range of equalisation available. The effect of using the equaliser between the line out of a tape machine and a Dolby deprocessor was tried. Most interesting changes in dynamics could be achieved in this way. The distortion characteristics were measured and, at all normal levels, the 3rd harmonic distortion was almost unmeasurable. The 2nd harmonic distortion reached between 0.1 and 0.15% over the range 60 Hz to 7.5 kHz. At an output level of +8 dBm the distortion reached a maximum of 0.4% over the audible spectrum. It is felt that these distortion figures would not be noticeable under all normal operating conditions. At normal operating levels, a 1 kHz square wave passed through the equipment extremely well with all the controls in the flat position, although a certain amount

(*continued on page 455*)



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of ringing was noticed by the output transformer, reduced when a load was applied. The frequency response was measured into 600 ohms, 2 K, 10 K and open circuit alternately. The bass response fell to −1 dB at 30 Hz and −3 dB at 20 Hz when a 600 ohm load was applied. Into open circuit the bass response was 1 dB down at 15 Hz while the extreme top remained absolutely flat up to 20 kHz, unfortunately rising to a most alarming peak of +21.5 dB at 100 kHz. This peak was only sufficiently damped when the termination resistor was as low as 2 K, which then slightly reduced the extreme bass response. It was seen, therefore, that the manufacturer's specification of ±0.5 dB from 15 Hz to 20 kHz was only achieved into open circuit. On the other hand, this specification is in my opinion unnecessarily good. I feel the manufacturer should make clear that the equipment should always be loaded to avoid a serious peak at around the bias frequency of most professional tape recorders, and that he therefore reduces the specification to be ±0.5 dB from 30 Hz to 20 kHz.

The accompanying graphs show the frequency response of the 630 Hz control at the two extreme positions as a continuous line, with intermediate positions shown as further lines. The second graph shows the effect of the two positions of the bass and treble steep cut filters. Despite the fact that the different tone controls are in stages rather than continuous, they were completely silent in operation making it possible to adjust them continuously during actual use. It is recommended that the nominal 0 dB sensitivity be used, having the remarkable overload point of +24 dBm, rather than the −20 dBm position which overloads at +4 dBm and also has the poorer signal-to-noise ratio.

The equipment is very well built inside on circuit cards with each of the seven frequency band cards on a separate plug-in board, each being interchangeable with any other channel. The individual channel controls make contact internally with the various etched contacts on the edges of the boards and all the equalisation components are situated on a separate mother board. This allows great ease of maintenance. No operational faults occurred but it was found that the controls had to be set very accurately in a central straight line to achieve a flat response.

Angus McKenzie

TELEFUNKEN O 86 MONITOR LOUDSPEAKER

THIS unit is intended for use in outside broadcast vans and small control rooms with an air capacity of up to 50 cubic metres. The low frequency response can be modified by a four-way switch to suit various mounting positions. The settings are: *0* for placement away from all walls or corners, *1* for mounting on flat wall, *2* for mounting in corner away from floor or ceiling and *3* for mounting at the intersection of three room surfaces (i.e., corner near ceiling or floor). Such mountings give approximately 3 dB increase at frequencies below 100 Hz on an extensive wall, 6 dB in a corner and 9 dB in a corner near floor or ceiling. The switch should be set once and for all at the time of selecting the mounting position.

The loudspeakers used in the *O 86* comprise three 130 mm large-excursion low frequency units and two 100 mm units for medium and high frequencies. The HF speakers are set at an angle to the front face of the cabinet for the most efficient dispersion of the extreme treble.

To prevent intermodulation effects, the rear of each HF unit is sealed off from the low frequency air space by a small highly damped compartment.

The low frequency cones have high mass so that the resonant frequencies are kept low despite the high stiffness of the confined air space. The high mass reduces bass sensitivity but this is made good by feeding approximately 25 W to the LF units and only 5 W to the more efficient HF reproducers.

Electrical equalisation is used to smooth the overall electro-acoustic response. Parallel tuned rejector circuits are inserted between the input transformer and the input to the power amplifier. The first circuit is tapped and is connected to the four-position mounting switch mentioned earlier to give progressive attenuation at 150 Hz as shown in the lower curve of **fig. 1.** The other two dips are set at 2 kHz and 7 kHz respectively to correct small peaks in the HF response.

Simple single-section crossover networks divide the sound spectrum at 800 Hz and the output transformer carries separate windings for the LF and HF units so that optimum matching is possible with most of the power fed to the low efficiency LF units.

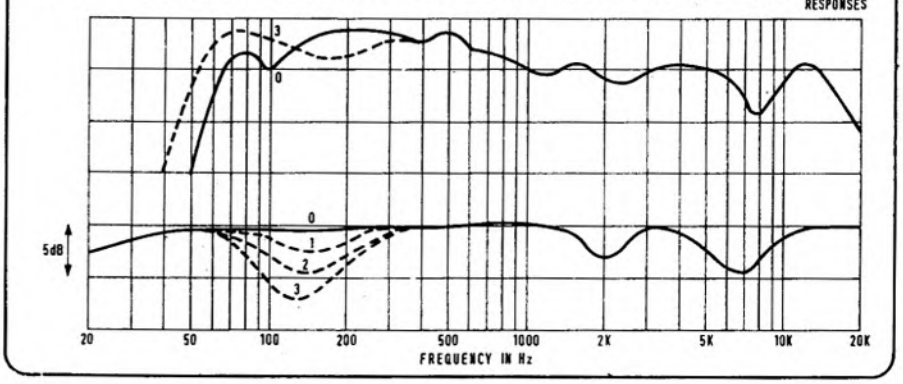
The solid curve of fig. 1 was taken in free space, clear of all walls and corners, with no reinforcement of extreme bass from room effects. The dotted part of the curve shows the degree of bass boost obtained from ceiling-corner mounting.

The first response was taken using one-third octave bands of filtered white noise as suggested

(continued on page 457)

MANUFACTURER'S SPECIFICATION. Small studio monitor loudspeaker with internal 30 W amplifier. **Input level:** 1.55 V maximum at 4 K. **SPL on axis at one metre:** 120 dB above threshold. **Frequency response (acoustic):** 80 Hz to 12.5 kHz ±1.5 dB. **Beam limits for 3 dB drop in HF:** ±30° horizontal, ±40° vertical. **Crossover frequency:** 800 Hz. **Weight:** 12 kg. **Dimensions:** 480 x 315 x 165 mm. **Price:** £175. **Distributor: AEG (Great Britain) Ltd., AEG House, Chichester Rents, Chancery Lane, London W.C.2 (Tel. 01-242-9944).**

FIG. 1 TELEFUNKEN O-86 STUDIO MONITOR LOUDSPEAKER ELECTRICAL AND ACOUSTIC FREQUENCY RESPONSES



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in the detailed test schedule provided with the speaker by Telefunken. Next a slightly more detailed response was taken using a B & K *1024* Sine-Random Generator which allows a narrow band of white noise to be swept over the frequency range 20 Hz to 20 kHz.

A B & K *2203* sound level meter was used to measure the sound output at a distance of one metre on the axis of the speaker.

Finally, full-range white noise was fed to the speaker and the sound output on axis at one metre was measured in one-octave bands making due allowance for the 3 dB per octave increase in level. This confirmed the step in response of about 3 dB below the crossover frequency of 800 Hz and suggests that a 3 dB increase in power to the HF units would vastly improve the balance of the *O 86* speaker system.

Comment

It seems silly to argue about a 3 dB change in response of a loudspeaker but, the nearer one gets to a level response, the easier it is to detect an unbalance of this order. My subjective impressions during careful listening tests on a variety of programme material was of a slight heaviness in the mid-LF range at all settings of the mounting switch and at a number of listening positions in three small well-damped rooms. According to the circuit diagram supplied with the *O 86*, taps already exist on the crossover choke, which is used as an auto transformer, and a further switch to provide a few different high frequency levels would almost certainly allow even closer matching to listening room conditions.

A. Tutchings

field trials

FERROGRAPH SERIES 7

MANUFACTURER'S SPECIFICATION (38 cm/s). 6.25 mm two-channel recorder with internal power amplifiers and side-facing loudspeakers. **Wow and flutter:** 0.08%. **Replay characteristic:** 35 μS (50/3180 μS at 19 cm/s). **Frequency response:** 30 Hz to 20 kHz ±2 dB. **Signal-to-noise ratio:** 55 dB unweighted including hum. **Oscillator frequency:** 100 kHz. **Microphone input:** 150 μV to 15 mV at 10 K (250 ohm to 2 K source). **Line input:** 75 mV at 2 M. **Line output:** 2.4 V (unloaded) at 600 ohms. **Auxiliary output** 300 mV into 10 K. **Loudspeaker output:** 10 W RMS into 8 to 16 ohms. **Amplifier distortion:** less than 0.25% RMS up to 10 W. **Stereo cross-talk:** 45 dB. **Lower track rejection:** 60 dB. **Tape speeds:** 38, 19 and 9.5 cm/s. **Weight:** 22.5 kg. **Dimensions:** 425 x 445 x 255 mm. **Price: £212 7s 6d** including purchase tax. **Manufacturer: The Ferrograph Co. Ltd, Mercury House, 195 Knightsbridge, London S.W.7.** Ferrograph Series 7 Manual with circuit diagram available separately at £1.

IT was with particular pleasure that I accepted David Kirk's suggestion that I field test the Ferrograph *Seven*. I have owned two of what H. W. Hellyer picturesquely calls the 'old battleship' Ferrographs for seven or eight years. One is a Model Four (19 and 9.5 cm/s) and the other a Model *88* Stereo (38 and 19 cm/s). For various reasons, the *Four* has done most of the work. And it really has worked, day in and day out, recording, playing tapes into features and, in particular, used for editing. You really cane a machine when you edit on it. Hour after hour it's switched forwards and backwards, Chinagraph marks get everywhere and bits of recording tape slip into the works. Well, apart from a couple of new heads, an indication of the work the old machine has done, and an odd smoothing capacitor that didn't really need changing, nothing whatsoever has been done to it, except, of course, regular cleaning and defluxing.

The old Ferrographs, reliable though they were, do show some signs of their age—after all the basic design is about 20 years old. Although they will still see most domestic machines off, by high-quality music standards the wow isn't quite good enough and neither is the signal-to-noise ratio of the microphone circuits. But probably the worst feature is the treble response. This lack of HF is to some extent due to a common record/replay head used up to *Series Five*. The gap requirements of record heads and replay heads are mutually incompatible, so you have to make a compromise and lose something on one or both of the functions.

So, with much experience of Ferrographs, I looked forward to getting my hands on the *Seven*. It arrived without the handbook; David wanted to see if I could negotiate the machine without instructions—I think he was really giving me an intelligence test. Well, for an hour or so, the intelligence didn't come up to standards because I didn't find the little flap that covers all the switching.

The first thing I did was to clean and deflux the heads, then give it a frequency check. First a NAB tape at 19 cm/s (Ampex *TT 01-31321-01*) and then two CCIRs at 38 and 19 cm/s (EMI *SRT 15* and *TBT 1*). On the 19 cm/s NAB tape, the playback response was 1.5 dB down at 15 kHz and 0.5 dB up at 50 Hz—otherwise it was within 0.2 dB. On the 38 cm/s test tape it was within 1 dB from 30 Hz to 14 kHz except for a curious, and unimportant, dip of 2 dB at 60 Hz. Above 14 kHz the output rose and there was a lift of 5 dB at 20 kHz.

Replay characteristics

So the replay characteristics were excellent, up to professional standards from these two tapes. The situation was not quite so good from the 19 cm/s CCIR tape. Ferrograph advise setting the treble at +4 and the bass at +3. This lifts both ends too much, and a better setting on the machine I had was treble +3.3 and bass +2. This brings me to my first minor criticism. I would prefer the system used on the *Series 6* with *switched* equalisation for CCIR and NAB playback, rather than the necessarily imprecise variable controls. And while we are about it, why not have switched NAB and CCIR recording characteristics? Kudelski do this although I must admit the prices of the two machines differ significantly!

Before I checked the record/replay characteristics, I checked the bias and here have a curious anomaly to report. I used standard play tape of various respectable makes like EMI, Scotch and Agfa. Very sensibly the VU meters (more about them later) can be switched not only to input and output, but also to give an indication of bias. Using Ferrograph's advised bias settings for the different tapes, all was well. But when I tried to set the bias in the usual way—by injecting tone (500 Hz) and bringing up the bias until the output had gone over the hump and dropped a decibel, I got into trouble. This consistently gave me too much bias, both compared with Ferrograph's figures and also in terms of the treble response which fell off. Not having the book at the time I thought this machine must be like the Uher on which you have to set the bias for flat response. But when the book arrived I found the method I was using was the advised one. Well, there you are, on the machine I had, it didn't work and I still don't know why. This,

(continued on page 459)

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of course, is not a criticism of the machine, but it's a bit odd. A good feature of the machine is that, if you set the bias at 19 cm/s, it is automatically adjusted to optimum at the other speeds.

I measured the record/replay response using Agfa *PE31* tape, setting the bias as recommended. At 19 cm/s it was within 1.7 dB total spread from 50 Hz to 15 kHz which is very good indeed on a machine of this price. In fact, if you correct for the slight variations on the playback response, the recording response was within 0.3 dB all the way. After this I looked at the machine with new respect. Here was a true professional, at least from the frequency response point of view.

I do not have a wow and flutter meter but set up an oscilloscope with the vertical plates fed from tone input and the horizontal from output. This test confirmed what my ears had told me—at 38 and 19 cm/s, audible wow and flutter were virtually absent. The Lissajou pattern on the tube did wander at *very low frequency*—about 2 Hz—which won't make any difference to anyone. At 9.5 cm/s I could detect wow.

Using a medium impedance microphone (200 ohms) straight in, the flicker noise was quite negligible. Even a 60 ohm microphone, without the matching transformer advised by Ferrograph, was quite acceptable. Here I think the Ferrograph Seven scores over any machine I've ever tried except the Nagra. Most home recorders are unacceptable on this score, but the Ferrograph FET inputs are beyond criticism.

There was only one test that the Ferrograph didn't pass with flying colours. I recorded some music at very high level, peaking over +3 VU. This played back without too much obvious distortion, but it did not erase fully first time through. So if you have a very heavily recorded tape, it is as well to use a bulk eraser or run it through the machine twice.

After these tests I used the machine for three months and really gave it a beating. At the end of this, I did another frequency run with similar results to the first, so there was obviously no significant head wear. As I probably used the machine in this time, particularly in fast wind, as much as an average user would in a couple of years, I feel that any fear of rapid head wear due to an absence of tape lifters is unjustified.

Now, what is the machine like to operate?

Editing

For editing, the machine is almost professional. The pressure pads can be cleared from the heads, making tape marking child's play. On pause, the tape can be rocked by hand, and there is the delight of variable speed spooling. The spooling control is not as sensitive as a *TR 90* or a Leevers-Rich but, with a little practice and the judicial use of one finger on the run-off spool, the tape can be spooled at just the right speed to be intelligible when trying to find a particular spot on it. This is easily the best non-studio machine I have ever used for editing. Of course it would be even better without pressure pads.

The Series Seven has another feature which is extremely useful. With it you can do what the BBC calls 'panel edits'. This means that if a speaker makes a fluff, you can wind back to just before the fluff and play back. Then, at a suitable point before the fluff, you cue the speaker and press the record button. With no click the machine switches to record and the panel edit is complete. Panel edits can be very useful for retakes because the speaker can listen to the material before the edit on headphones and so match his voice perfectly to the preceding material. I found when I did some programmes at Radio Moscow that *all* their edits are panel edits, they never cut and splice tape in the studio.

That's a good feature—but here is a bad one. The machine has an excellent pause control, which leaves the spool motors energized and the capstan motor running, so that flicking the function switch to 'play' gives almost instantaneous start-up. But the bad feature: this puts a click on to the output, probably from a poorly suppressed solenoid, and means that without special precautions you can't play a tape into another machine when making a feature. This nullifies most of the advantage of the 'pause' setting which, incidentally, can be operated by remote control. Please Ferrograph, do something about this click; there's no excuse for it.

Autostop Mechanism

A very good feature of the machine is the autostop mechanism. This is very ingenious: a right-hand sprung guide switches off the motors if it makes electrical contact with the frame. If a piece of stop foil touches it, contact is made and the machine stops. If the tape breaks, or comes to the end, the tension controller swings over and earths on a post. So the motors are switched off either by stop foil, breakage or run out. This works on spooling too, which is a very good thing.

If you want to run the machine without tape, it's very easy to slip a piece of sleeving over the fixed contact post so that the tension controller doesn't earth on it. A small point: the contacts need an occasional wipe, or oxide build-up on the tension controller prevents contact being made and the machine fails to switch off.

Having both a microphone input and a line input with separate gain controls you have a kind of poor man's mixer, for two sources, built in. There are three outputs, a genuine 600 ohm which doesn't mind being terminated by this impedance, a low level which feeds about 300 mV into 10 K or greater, and the speaker output (10 Watts into 8 to 16 ohms). The variable equalisers work on both low level output and speakers, but not on the 600 ohm output. This I found a nuisance because I could not play CCIR recordings out at 600 ohms, the playback being NAB. The gain control works only on the speaker output, which is good, because you can monitor off the speakers at whatever level you like while playing into another machine. The built-in power amplifiers are superb.

One or two minor criticisms. The small slide switches which can be set for Source or Tape look and behave like the nasty Japanese

(*continued overleaf*)

FERROGRAPH 7 FIELD TRIAL CONTINUED

switches on the Leak *Stereo 30*. Couldn't we please have something better? Another point, which I must say doesn't seem to affect the functioning of the machine in any way: it gets very hot and you can jump if you touch the take-up spool boss—Ferrograph warn you about this in the book. It only happens after several hours use, but I wonder why a solid-state machine gets hotter than the old valve models?

The recorder works equally well horizontally and vertically. I have used it almost entirely horizontally, as this makes editing much easier.

There is a tape transfer system so that you can record on one track and transfer to the other. I found this very useful when I was given a tape of a series of speeches recorded without any treble. I played it through and transferred it at the same time on to the lower track with full treble lift. I then transferred it back again, once more with treble boost. This worked very well and made the tape quite intelligible, although I wouldn't have liked to put it on the air after such treatment. The transfer is very useful for home movie addicts as it allows commentaries to be dubbed on to tape in sync with film without recording the noise of the projector. You first record a wild commentary with the projector running. Then you listen to this with headphones off one track to give correct timing, while you record on to the other track without the projector running and therefore without noise. Finally you can put it all back on to the first track using the transfer. By the way, you can cheat and use the transfer on the stereo twin-track machine to make what I call 'pseudo-full-track' recordings. If you record on the upper track, set the upper track switch to 'source' and the transfer switch at Upper to Lower, the machine will then record on both tracks in phase. If then played back on a full-track machine it will behave as a full-track recording, apart from the little bit missed down the middle. Beware, though, of doing this trick on tape previously recorded on a full-track machine as there will be mod on the middle bit that won't be erased on the stereo machine. Of course, like most machines with separate playback heads and amplifiers, there are ways of putting echo on tapes.

There is a useful auxiliary socket on the rear of the machine which takes a seven-pin DIN plug (I wish I could find a shop which stocks them—but Ferrograph will supply!). This feeds low level output and 600 ohm output on both channels, allows you to fit a remote control for starting and stopping, and also provides 50 V DC at up to 200 mA. This means that everything but the inputs can be wired up permanently if required. The tape counter works off the take-up spool and works very well, but of course it doesn't give an absolute reading like a tape driven elapsed time indicator.

Two useful things for me are that a standard EMI editing block sits nicely on the flap covering the switches, and the equalisation switch can be used to carry a reel of jointing tape. The lid, which has a peculiar arrangement for fitting, comes right off in use. The two quite adequate monitoring speakers are on the sides, so one can get some stereo effect from them, but of course for any serious listening you plug in external speakers—this automatically mutes the internal monitors. Apart from the auxiliary plug and the mains input, all connections are by standard jack plugs, which are perfectly satisfactory and easy to wire up, unlike phono plugs and DIN plugs!

All in all, I think the Ferrograph Series Seven is a fine machine with many features normally found only in professional machines. It is not perfect, but nothing is. I think there are one or two things Ferrograph could improve, particularly that click on starting. But I think they can be well satisfied with this new machine which compares favourably with anything else in its price range. If it proves to be as tough and trouble-free as its predecessors we need have no worries about foreign competition in the top class of amateur machines. I intend to buy one, and I can't praise it more than that.

Arthur Garratt

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Pioneer SE 30 ...	£12 12 0	£10 14 0
Pioneer SE 20 ...	£7 2 11	£6 2 0
Pioneer SE 2P ...	£6 15 5	£5 15 0
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Sansui SS 20 ...	£17 10 0	£14 0 0
Secom 650 ...		£3 12 0
Teleton SH 301P	£4 0 0	£3 10 0

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Eagle DM58 ...	£11 0 6	£9 13 0
A.K.G. D9D HL	£7 0 0	£6 3 0
A.K.G. D109 ...	£12 0 0	£10 10 0
A.K.G. D119 ES	£27 0 0	£23 12 0
A.K.G. D202 ES	£32 0 0	£28 0 0
Akai DM13 ...	£7 10 0	£6 11 0

	List Price	Cash Price
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Lux SQ1220 Stereo Amplifier	£124 10 0	£95 0 0
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Lux SQ505 Stereo Amplifier	£97 10 0	£65 19 0
Rotel 100 Stereo Amplifier	£45 10 0	£37 10 0
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Teleton SAQ 203E Stereo Amplifier	£27 15 0	£21 15 0
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