
October 1971 25p
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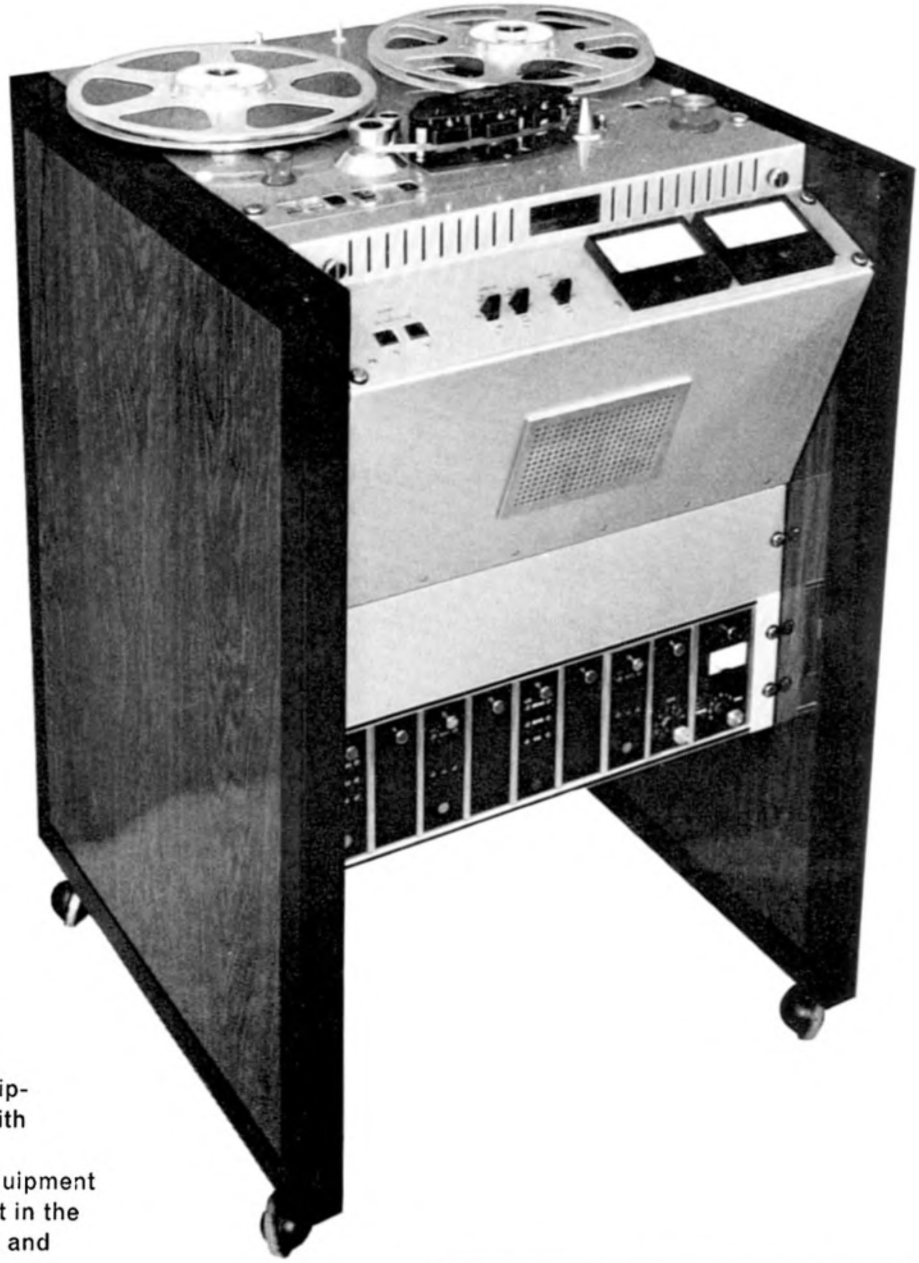

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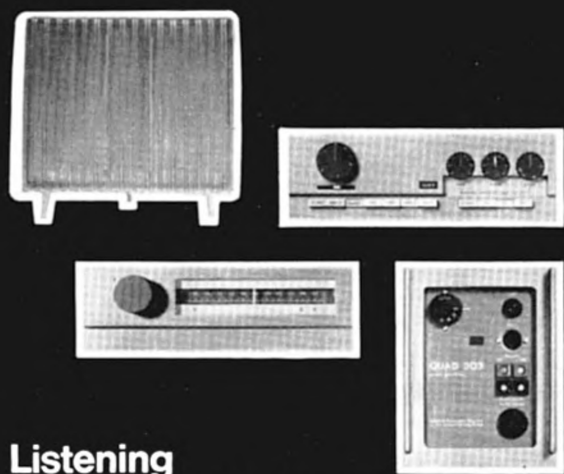

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When we listen we become engrossed in the music and, with good equipment, we can often obtain the same satisfaction that we would enjoy in the concert hall. Of course, there are differences between the real and the reproduced. Many of these we recognise as such; we come to terms with them and they do not intrude.

More serious perhaps are the distortions which we do not consciously notice but which are nevertheless continuously producing a contradiction between the actual and the imagined. They produce listening fatigue, a condition detrimental to the true objective. These distortions have little to do with the popular conceptions of HI-FI or LO-FI sound; on the other hand they have much to do with good or bad engineering.

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studio sound
INCORPORATING TAPE RECORDER

OCTOBER 1971 VOLUME 13 NUMBER 10

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

FEATURE ARTICLES

REGULAR COLUMNS

'HOW DO I get into the recording industry?' This query is often raised in letters from readers and until recently has been a difficult one to answer. The industry lacked anything resembling a training scheme, until a few months ago, 'eaving potential applicants to their own devices. One school-leaver, we noted in last month's 'Situations Vacant', resorted to a classified advertisement. Others, on our advice, initially approach the BBC Engineering Department. There are many doors into the BBC and an intelligent individual with an interest in music and recording stands a fair chance of acceptance. The traditional BBC reliance on formal qualifications (A-level Physics and Maths or a Daddy in the Department) is no longer followed so rigidly by the Corporation, which could account for some strange Prom balances broadcast this season.

Broadcasting House and environs offer a gentle cloistered existence which attracts many employees for life; others find the community dull and leave for the brighter lights of commercial broadcasting or recording. The BBC thus represents a stepping-stone to the recording industry or a worthwhile career in itself.

Another way into recording is by circulating letters to as many studios as writer's cramp will allow (a duplicated circular being an effective passport to the wastepaper basket). If he can sell himself in a letter, and if the letter arrives at an opportune moment, an applicant stands a fair chance of gaining an interview. If this procedure fails, he can try further volleys of letters. And if the interviews, once granted, prove negative, the applicant has probably misjudged his temperament and should turn to other industries.

Many of today's studio employees, particularly the younger staff, entered the recording business after a more-or-less unsuccessful musical career. This has produced a wide gap between so-called 'musically-minded' operators and engineering staff, sometimes enabling a competent one-man concern to do an altogether better job.

All of which is either haphazard or healthy competition, depending on your attitude to life. Recently the situation changed and a youngster with his/her eyes on sound recording can now steer an education towards that target. The basic qualifications for the *Tonmeister* Course are A-level Music and Physics GCEs, an unusual combination in a world where people tend either towards the arts or to the sciences. Sussex University are running the course which promises a valuable brood of musically-minded engineers.

SUBSCRIPTION RATES
Annual UK subscription rate for STUDIO SOUND *is £3 (overseas £3·30, $8 or equivalent).*
Our associate publication Hi-Fi News *costs £3·12 (overseas £3·66, $8·64 or equivalent). Six month home subscriptions are £1·50* (STUDIO SOUND) *and £1·56* (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.*

BINDERS
Loose-leaf binders for annual volumes of STUDIO SOUND *are available from Modern Bookbinders, Chadwick Street, Blackburn, Lancashire. Please quote the volume number or date when ordering.*

CORRESPONDENCE AND ARTICLES
All STUDIO SOUND *correspondence should be sent to the address printed on this page. Technical queries should be concise and must include a stamped addressed envelope. Matters relating to more than one department should occupy separate sheets of paper or delay will occur in replying.*
Articles or suggestions for features on all aspects of communications engineering and music will be received sympathetically. Manuscripts should be typed or clearly handwritten and submitted with rough drawings when appropriate. We are happy to advise potential authors on matters of style. Payment is negotiated on acceptance

News

IBC Call For Papers

THE 1972 INTERNATIONAL Broadcasting Convention will be held at Grosvenor House, Park Lane from September 4 to 8. Contributions are invited on all aspects of television and sound broadcasting, including operational experience, studio design, origination equipment, recording (including cassettes), signal distribution systems, transmitters and transposers, aerials, receivers, propagation and service planning, films, satellites, automation aspects of broadcasting, digital techniques in broadcasting, and engineering management.

An exhibition prospectus and a copy of the rules and regulations are available from The Secretariat, International Broadcasting Convention Exhibition, c/o EEA, Leicester House, 8 Leicester Street, London WC2H 7BN. For further information about the convention, registration forms or the publishing of papers, write to: The Secretariat, International Broadcasting Convention, IEE, Savoy Place, London WC2R OBL.

Industrial Equipment Retailer

REW EARLSFIELD, recently appointed sole UK agent for the Dolby B Ferrograph, are expanding their Charing Cross Road premises as part of a new exercise in audio/visual retailing. Long established in the domestic hi-fi market, REW are also equipped to demonstrate, sell and service Sony and Akai video systems, repairs being reportedly child's play for REW's ex-Ampex engineers. REW are now opening a basement room for demonstrations of industrial sound equipment. They will initially be handling recorders in the Ferrograph and Revox industrial category, studio microphones, mixers and monitor loudspeakers. The range of their stock will depend largely on the co-operation of manufacturers and importers.

REW consider themselves in an ideal position to cope with the problems often incurred with small scale industrial orders. They instance the case of a microphone importer who lost two days of a representative's time advising a theatrical producer for the sale of just four microphones.

Aldwych Theatre Sound System

JOHN MOORE, sound consultant to the Royal Shakespeare Company, has designed a new sound system flexible enough to meet the demands made by some hundreds of different sound cues being set and reset every week. The equipment consists of four two track Revox tape units plus one spare, which are fed into six Elcom preamplifiers, and eight Elcom pan faders. Each of these have six TMC switches for channel selection. Two auditorium channels and three on-stage channels are provided by six Westrex 120W amplifiers. Two sets of identical speaker switches with a relay crossover switch enable the operator to preset difficult cue sequences while other tapes are in use. Four auxiliary Elcom pan faders can be patched independently into any amplifier for specific effects. The speaker patch panel allows any speaker to be plugged into any amplifier. Full test facilities with tone generator and VU meter allow the input and output of the console to be checked and monitored. Two six-way Westrex microphone mixers can be substituted for the fourth Revox by means of a patch panel which can also be used to connect four recorders and transcription turntable in any combination for recording and dubbing.

Speakers used are twin Goodman's *Axiom* 300 mm units with Westrex High Frequency horns using the 100V line method to avoid volume variation when switching speakers in or out.

Obituary: Wilhelm Franz

WE ANNOUNCE with regret the death of Wilhelm Franz, founder of Elektromesstechnik (EMT). Born in Bremen in 1914, he first worked for an American-owned company in Berlin. He set up his own company there in 1939 with his brother as partner from around this time, the association continuing through the war years and the relocation of the firm at the Black Forest, until Wilhelm died on April 10 this year. He leaves a wife and four children.

SNS Launch PA Equipment

SNS COMMUNICATIONS of Bournemouth have entered the field of pop-group electronics with a range of amplifiers and speakers. Heart of the system is a 125W amplifier which can be used in conjunction with either a PA preamplifier or an instrument preamplifier. The PA preamp has six high-impedance channels, with two jack inputs per channel. Each channel also has independent volume, bass and treble controls. The mixer output from the 12 inputs can be further adjusted by master bass presence and volume controls and a reverberation depth control. The instrument preamplifier has a plethora of tone controls which include hitherto unheard of items such as '*baddle*' and '*preddle*' as well as the usual bass, presence and so on. There are also three sturdily constructed loudspeakers in the range, designed to take a belting and to sound reasonable as well. The system is completed by 125W and 50W slave amplifiers which are basically the same as those used in the main power amplifiers, minus the controls. Three notable features of the units are the use of slider controls throughout, completely interchangeable plug-in circuits—including the output power transistors—and a patented triac-protected output stage that enables the amplifiers to be driven quite happily into short or open circuits. For further information concerning this and related matters contact: SNS Communications Ltd, 851 Ringwood Road, Bournemouth, Hants.

AES Lecture Programme

THE BRITISH SECTION of the AES announce their lecture programme for 1971/72. Lectures will take place, unless otherwise stated, on Tuesdays at 7.15 p.m. at the Mechanical Engineering Department of Imperial College, Exhibition Road, London SW7.

October 12 'Developments in Audio Instrumentation'—J. Kuehn, B & K Laboratories.

November 9 'A Variety of Approaches to Audio Power Amplifier Design'—David Rees, Audix Ltd.

December 14 'Sound Transmission in Structures'—Dr C. L. S. Gilford, University of Aston.

January 11 'Distortion in Loudspeakers Caused by Low Frequency Signals'—H. D. Harwood, BBC Research.

February 8 'Matrix Systems for Four Speaker Stereo'—Michael Gerzon, Mathematical Institute, Oxford.

March 14 'Alternatives to Frequency and Time in Audio System Design and Analysis'—Dr D. M. Leakey, GEC-AEI.

April 4 'Control of Acoustic Feedback by Room Equalisation'—J. H. Kogen, Shure.

May 9 'Recent Developments in Electronic Music Technology'—Professor T. Cary, Royal College of Music.

June 13 'Transformers and the Audio Engineer'—P. J. Baxandall.

Polycourses

TWO COURSES of possible interest to readers start this autumn at the North London Polytechnic. The timetable for the 1971/2 series of lectures 'Audio and Acoustic Measurements' is as follows:

October 28 'Parameters and Standards of Measurement'—R. N. Baldock

November 4 'Measurement of Microphone Performance'—H. D. Harwood BSc, BBC Research

November 11 'Electrical and Mechanical Measurements in Tape Recording'—R. L. West

November 18 'Measurements in Professional Recording'—A. McKenzie

November 25 'Electrical and Mechanical Measurements on Disc, Pickups and Accelerometers'—S. Kelly

December 2 'Measurement of Loudspeaker Performance'—R. L. West

December 9 'Measurement of Loudspeaker Performance'—R. C. Driscoll

December 16 'Measurement of Studio Characteristics'—R. C. Driscoll

January 13 'Measurement of Noise Transmission'—J. Moir

(*continued on page 502*)

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A CCIR to DIN Adapter

An easily constructed circuit equalising CCIR tapes to replay on modern DIN equipment

by Arthur Garratt

WHEN I conducted a field test on the Ferrograph *Series 7* (STUDIO SOUND October 1970), I had two particular criticisms of the machine. The first was that switching the machine from pause to play caused an electrical surge which produced an audible click at the output. The second was that one could not play CCIR tapes at 19 cm/s with correct equalisation. The first objection, the click on starting, is probably due to the fact that the left-hand motor is switched off and a resistor substituted, so there is a breaking of a fairly large inductance. If this happens at a voltage peak, it is almost impossible to suppress the click.

To solve this problem, my mind ranged over a number of possible solutions: slugged relays and transistors biased to cut off with a large capacitance so that they would not conduct until the click was over, so to speak. I finally solved it in a very simple way. I fed the Ferrograph output into a switched potentiometer. At the point where it switched, the attenuation through the pot is more than enough to push the click below threshold. The switch operates the machine start through the auxiliary socket (**fig. 1**). Now, to play in a tape, the machine is set at pause with the pot closed and the switch therefore open. A quick rotation of the pot then starts the machine and fades up the signal in under half a second. It can be made even quicker if you like to fit a quadrant fader unit on to the pot, but I have found that a simple rotating pot works quite satisfactorily.

The second problem, a suitable equaliser to correct from DIN (which at 19 cm/s is fortunately identical to NARTB equalisation) is a rather more formidable job. It is fairly easy to design either a DIN or a CCIR equaliser, and quite difficult to design the DIN *to* CCIR circuit.

A playback equaliser for a DIN recording has two time constants (see Appendix); one is 50 μS to lift the bass from a turnover frequency (3 dB lift) of 3.18 kHz, and the other is 3/18 μS to attenuate the bass at a turnover frequency of 50 Hz. The CCIR equaliser, on the other hand, has one time constant (100 μS) which lifts the bass with a turnover frequency of 1.59 kHz and, of course, there is no bass attenuation.

To get the required response curve of the conversion equaliser, you have to subtract one curve from the other and then choose a frequency, like 400 Hz, at which you make the two the same. Not having plots of the two curves that I could really trust (it is really amazing the discrepancies between different books) I sat down at a calculating machine and worked out the required characteristics from first principles. The relevant corrections to play a CCIR tape on a DIN machine are as follows:

Frequency	Required lift (dB)
50 Hz	3
400 Hz	0
1 kHz	1
3.18 kHz	4
5 kHz	5
10 kHz	6
15 kHz	6

To get the lift at each end of the audio spectrum with a passive network would mean an insertion loss of at least 10 dB, which I did not want. So I decided to have two stages of gain which would give me 20 dB and start from there. I wanted to have as little distortion as possible and it was convenient to use the +50V supply line from the Ferrograph auxiliary socket. So I started with these parameters.

I am a great believer in the theory, put forward by an American professor of electrical engineering, that the best way to design an amplifier is to copy a good one. I could not expect to find an amplifier which provided the necessary equalisation—if I could, I wouldn't be writing this article. So I decided to take a flat characteristic amplifier and modify it to meet my requirements. I turned to that very good little book published by Mullard, 'Transistors and Audio Circuits'. The obvious starting point was the amplifier with high voltage output on page 126. I didn't need the high voltage but I did need very low distortion

(continued on page 502)

FIG. 1

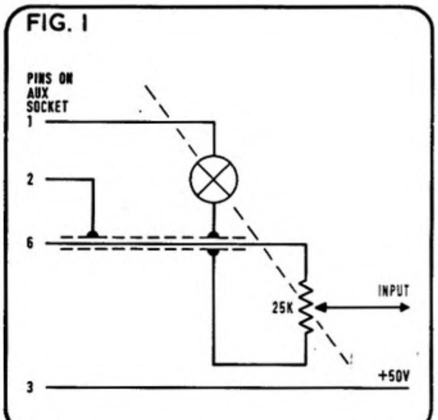
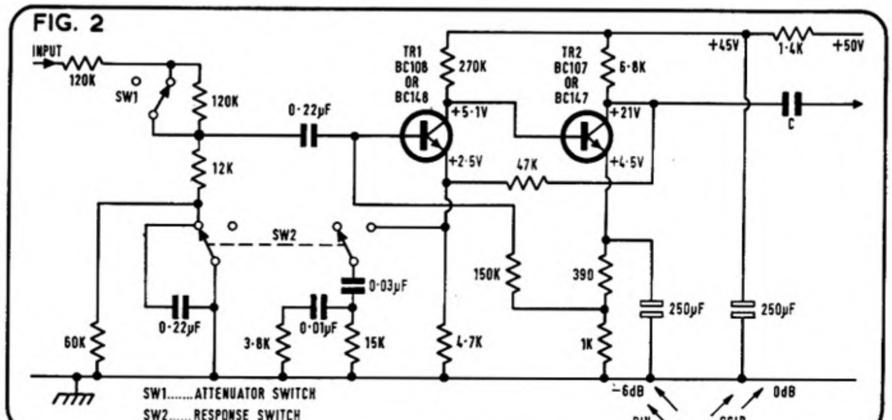


FIG. 2



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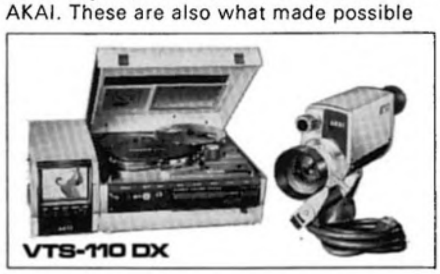

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Rank Aldis-Audio Products, Rank Audio Visual Ltd.: P.O. Box 70, Great West Road, Brentford, Middlesex Tel: 01 568-9222 at about 1V, and the distortion quoted is 0.1% at this level. It also has the advantage, associated with the low distortion, of operating at 45V which is fairly close to the 50V line. So this was the basic circuit. Now I needed the rather curious top lift and a straightforward 6 dB per octave bass lift. The bass was easy and I did this at the front end with a simple network. I also incorporated a switch here to give me either 0 dB or –6 dB; this can be eliminated if you have no need for it.

The top lift is much more complex. The best place to put the equalising network is in the feedback link from the collector of the second transistor to the emitter of the first. This type of circuit has been analysed by S. W. Amos ('Negative Feedback in Transistor Amplifiers,' *Wireless World*, January 1971), and he shows that the gain of the total amplifier is defined by the ratio of these two resistors. So we can ignore the effects of the variable feedback on the gain of the first transistor but we cannot ignore the phase changes. So the calculation becomes rather horrifying, needing a calculating machine, familiarity with operational algebra, and plenty of courage. I used a mixture of all these plus some experimental evaluation—what detractors of this powerful technique call 'suck-it-and-see'. The results showed I needed a double lift circuit, one to nudge the response up at about 1 kHz and the other to boost the higher frequencies, though without any significant boost above 10 kHz. The values in the complete circuit (**fig. 2**) meet these requirements very well. Strict analysis at 15 kHz gives a lift of 6.6 dB. This was confirmed by a test of the finished amplifier using an audio oscillator and a valve voltmeter. The experimental results are within ±1 dB, and these were confirmed by a test tape which was within ±1 dB from 40 Hz to 10 kHz, the limits of the tape. At 400 Hz the total gain is 0 dB, and this falls to –5.5 dB with the gain switch set at –6 dB. Switched to DIN, the gain is –1.5 dB, which is not significant. Noise at such signal levels is unimportant and distortion is virtually unmeasurable.

The isolating capacitor, C, in **fig. 2** is chosen to suit the input impedance of the amplifier following the equaliser. If this is 250 kΩ, a 0.22 μF capacitor is suitable.

Veroboard construction

The unit was built on Veroboard and fitted into one of those useful die-cast boxes. Input is through a standard jack, output through a jack-plug on a flying lead. The 50V supply comes in through a coaxial plug, but you can use any convenient plugs and sockets to suit yourself. I used toggle switches for the attenuation (a single-pole, double-throw) and for the DIN/CCIR switch (double-pole, double-throw). No on/off switch is needed as it gets its supply from the Ferrograph.

In my case, I was only interested in a signal from the upper track, but obviously the amplifier can be doubled up as a stereo unit—the only differences being that you need ganged switches for the DIN/CCIR changeover and the 1.4 kΩ voltage dropping resistor should then be 700 ohms with 500 μF smoothing. You need this smoothing as the Ferrograph output is not absolutely hum-free.

I use the 600Ω output from the Ferrograph and take this from the auxiliary socket, together with the 50V supply and the remote switching. It might be possible to get a stereo output from this socket, but I found soldering in the four leads I needed sufficiently traumatic. The output line is single screened (its capacitance has no significance at 600Ω impedance); the 50V line and switching line are ordinary twin flex. The screening is a common earth, avoiding any possibility of a hum loop.

The anti-click pot switch can be fitted into the unit if desired; I have this on my mixer panel for convenience. I chose a value of 25 kΩ for the pot. This is not important, provided it is well in excess of 600Ω, but a high value makes it possible to use either the 600Ω line output or the so-called 'low-level' line if other equalisation is needed, when the Baxandall tone control system of the Ferrograph can be used.

Although this equaliser was designed for the Ferrograph Seven, it can obviously be used with any DIN or NARTB standard machine to play CCIR tapes into another amplifier. All that is needed is a 50V positive rail supply. The input impedance of the unit is about 250 kΩ, which is high enough for any recorder. Output impedance is 200Ω, so this will feed almost any amplifier satisfactorily.

The equaliser can also be used the other way round, in the sense that it can be used in the *input* to a CCIR recorder so that the recorded tape has DIN/NARTB characteristics. This requires the response switch to be in the CCIR position, of course, otherwise the equaliser gives a flat response.

The equaliser should preferably be inserted at a voltage level of about unity. Some care may be needed to make sure the recorder is not overloaded at the higher frequencies, remember there is a lift of 6 dB at 10 kHz, but the lift is never greater than this. And, of course, the level indicator on the recorder will take account of this high frequency lift. Probably the only time it might be a hazard is when checking the response with an oscillator!

Summing up then with this equaliser and a DIN/NARTB machine operating at 19 cm/s you can play back tapes recorded to CCIR standards while with a CCIR machine you can record to DIN/NARTB standards, again at 19 cm/s of course.

Appendix

The normal bass lift necessary for any replay amplifier is at 6 dB/octave. A simple way of defining this is to express it as the time constant of a capacitor and resistor in series. The time constant is defined as the product of resistance and capacitance, the units being ohms and Farads. To avoid the rather intractable Farads, the capacitance can be expressed in microfarads and the time constant in microseconds.

The impedance of a capacitance and resistance in series is: $Z = \sqrt{R^2+X_c^2}$ where X_c is the impedance of the capacitor at the frequency under consideration.

Then $X_c = \dfrac{1}{2\pi fC}$ where f is the frequency and C the capacitance in those beastly Farads.

The turnover frequency, that is the frequency where the lift is 3 dB, is when $R=X_c$ or $f = \dfrac{1}{2\pi RC} = \dfrac{1}{2\pi T}$ where T is the time constant in microseconds.

This gives the following turnover frequencies:

T (microseconds)	Turnover frequency (Hz)
35 μS	4540
50 μS	3180
70 μS	2270
100 μS	1590
200 μS	795

The bass attenuation condition is specified by a capacitor and resistor in parallel. Then

$$Z = \frac{RX_c}{\sqrt{R^2 + X_c^2}}$$

In exactly the same way as in the series case, the turnover frequency is given by $f = \dfrac{1}{2\pi T}$

So for a time constant of 3180 μS the turnover frequency is 50 Hz.

The quoted characteristics are as follows (Reference Ferrograph Handbook):

Speed	Characteristic	Time constants
38 cm/s	CCIR/IEC/DIN	35 μS
	NARTB	50 μS
19 cm/s	DIN/NAB	50/3180 μS
	IEC	70 μS
	CCIR	100 μS
9.5 cm/s	DIN/NAB	90/3180 μS
	IEC	140 μS
	CCIR	200 μS

A little algebra shows that lift can be expressed for the series condition as

$$\text{Lift} = 20\log\left[\frac{\sqrt{4\pi^2f^2T^2+1}}{2\pi fT}\right] \text{ in decibels}$$

where T is in seconds. And the bass attenuation, parallel condition, gives the following expression:

Attenuation $= 20\log\sqrt{4\pi^2T^2f^2+1}$ in decibels.

January 20 'Assessment of Noise Nuisance' —J. Moir

January 27 Visit to AIRO Laboratories, Hemel Hempstead—G. Berry

February 1 'Amplifier Measurements'—P. J. Baxandall

February 10 'FM Reception'—R. S. Roberts

February 17 'FM Measurements'—R. S. Roberts

February 24 'Developments in Audio and Acoustic Measuring Instruments'—J. Khuen. B & K Laboratories

The courses are held on Thursday evenings from 6.30 to 8.30 p.m. and the fee is £6.30. The other course which starts on October 28 is 'Sound Studios and Recording'. This will be held every Thursday afternoon from 2.30 to 4.30 p.m. and will continue until January 13, after which there will be an examination in May; the course fee is £10.50. The syllabus includes principles and practice of studio acoustics, recording techniques, studio control equipment, signal distribution, design and testing and power supplies.

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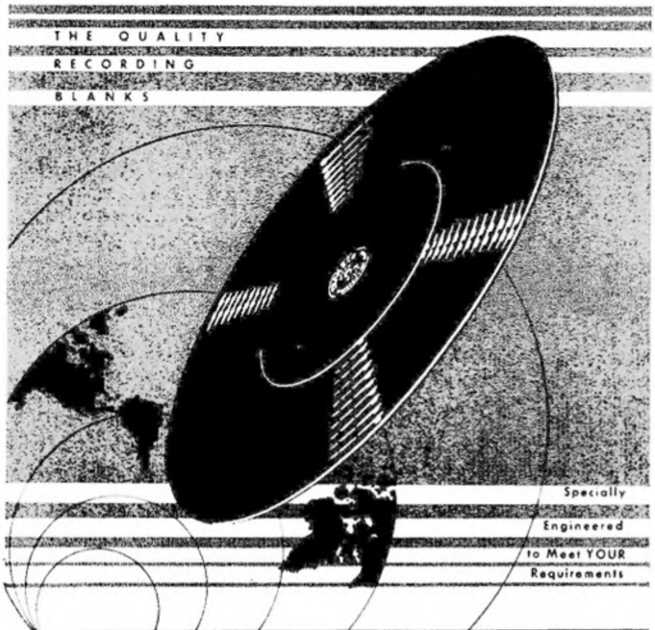

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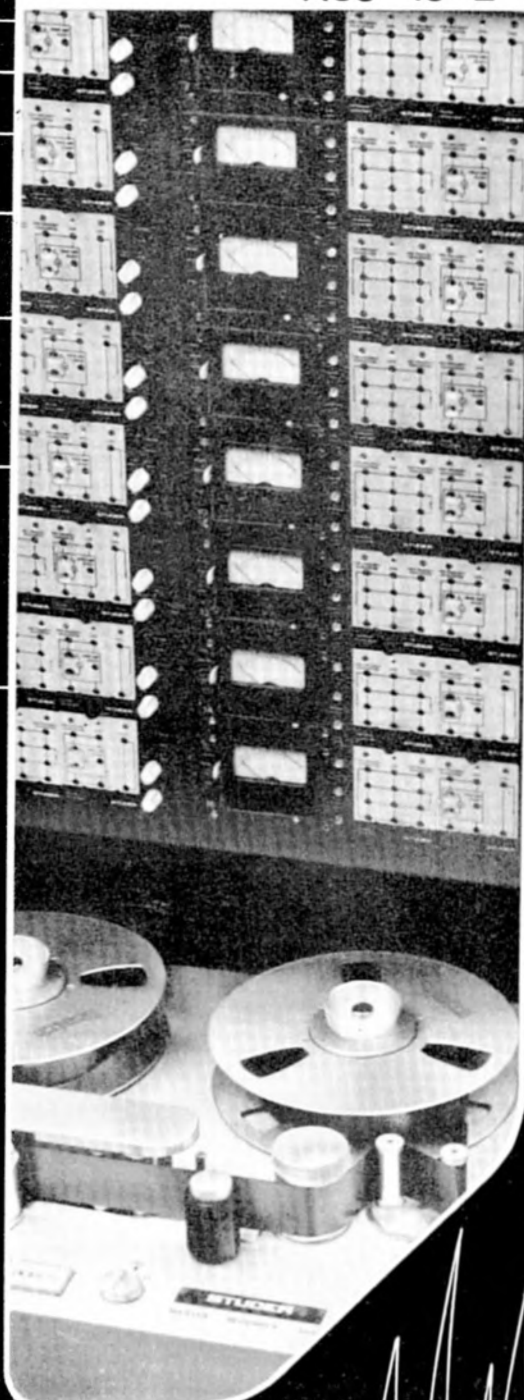

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Studio Diary

BY KEITH WICKS

FIRST, a correction. Contrary to the statement in the August edition, the current Fairport Convention album (Angel Delight) was recorded at the **Sound Techniques** Studio for Island Records, and engineered and co-produced by John Wood, who has engineered all previous Fairport Convention albums. Geoff Frost, managing director of Sound Techniques, asked me to make this clear as I had reported in error that Fairport Convention had been working at Trident. I have since found that someone booked 'Fairport Convention' for a morning session 'because he didn't have a name for his artists'. The engineer confirms that the artists who turned up were not in fact Fairport Convention. All very strange, and my apologies to Sound Techniques. I am sorry that Sound Techniques feel that an error of this kind 'fully justifies our worst fears and suspicions' about the accuracy of this studio column. Every reasonable effort is made to ensure accuracy, but there is obviously a limit to how far one can go in checking information. I should like to make it clear that there was never any intention on the part of Trident to claim credit for work they had not done.

Other information received from Sound Techniques concerns the activity of their engineers. Due to shortage of studio time at Chelsea, it is not unknown for Sound Techniques' engineers to be seen working with their clients at many other major studios, such as Olympic, Morgan, AIR, and Island. John Wood is doing a great deal of production work at the moment and has just finished a Sandy Denny album. This was recorded at Sound Techniques and Island Studios, remixed at Vanguard Studios in New York, and mastered at Sterling Sound, also in New York.

Although Fairport Convention have not been in, **Trident's** engineers have been kept very busy this last month. Aubrey Small, Johnny Mathis, New Seekers, David Bowie, Sean Phillips, Ditch Cassidy, John Kongas, Linda Lewis, Tremeloes, Atomic Rooster, Audience, Bernie Taupin, Raymond Froggatt, Colin Scott, Ralph MacTell, T. Rex, Van der Graaf Generator, Indian Summer, Keef Hartley, Osibisa, Mary Hopkin and Nazareth have all been booked in to the studio in the last month. Lucky Trident, because a lot of studios are once again finding work rather hard to come by.

Intersound have been recording a variety of material including a Jewish radio play, Scottish country dance music, and Greek baszuki music. Colin Hare has just finished his album *Page Full of Hits* for the Larry Page Organisation, and more Rediffusion Reditune recording has been carried out.

On August 6 1969, work started on the construction of the **De Lane Lea Music Centre.** It is now complete. A total of £770,000 has been spent, resulting in one of the most impressive studios to be seen, and there is every reason to suppose the results will be as good. Managing director, Dave Siddle worked closely with Geoff Frost of Sound Techniques on this massive project, and they seem to have thought of everything, operation of the equipment being simplified by the extensive use of logic circuitry. There are three studios, capable of accommodating 130, 35 and 20 musicians respectively, and provision has been made for film work as well as records. Film can be projected into Studio One, a telecine machine enables 35 mm or 16 mm film to be piped to monitors around the building, and one, three, four and six track film recording facilities are available.

John Vine, DJ member of the **Roger Squire Studio** staff, recorded his first half-hour *Be My Guest* show in the Chalbert Street studio. This was transmitted on BBC Radio Medway and went down very well, so the BBC have asked John to do another. Stewart Marx is another DJ having success with the aid of the Roger Squire Studio. He recently made a recording simulating the sound of a discotheque, for use during a BBC Z Cars episode.

The commercial radio scene is getting more lively as the months go by. A representative of a large organisation, likely to obtain a licence to broadcast, has approached Roger Squire 'with a view to having a tie up of some sort'. Stay tuned for further information.

Sound Developments have been recording various commercial and sales conference tapes. They recently had Jonny Hawkesworth in for a film music session, and are now completing an album of electronic music for the Dante Agency.

At **Wessex,** Jesse Peterson has been recording more pop-religious material for the States. A fast worker, Jesse recorded no less than eight albums in a week. The Flirtations have been doing voice dubbing, and Don Hunter has been in for the Gem Record Company producing Milkwood albums and singles. John Worth produced a couple of album tracks for Chapter One artist Julie Sullivan, and guitarist Vic Flick is also doing production work for the small company. Besides looking after his own orchestra, Vic Flick Sounds, he has been producing for the group Putney Bridge. The Royal Life Guards marched in again recently, this time accompanied by a dozen violins, to record popular classical pieces.

Pye recording star Lonnie Donegan recorded *Don't Blame the Child*, a ballad written by Frankie Lane. Apparently Lonnie heard Frankie singing this song in cabaret in the States, liked it, and obtained permission to record it. Backing was by rhythm, brass and strings and engineering by the studio manager Adrian Ibbetson. Two members of the Bournemouth Bach Society spent two days recording an LP of classical harpsichord and violin. Alan Price and Georgie Fame have been completing an album co-produced by themselves and Mike Smith for CBS. Other work for CBS has included two albums, produced by Arthur Frewin, one a 'pub sing along type thing', and the other a collection of past hits. The Keith Mansfield Orchestra have been recording album material for CBS, as have the Andy Ross and Alan Tew Orchestras. Mike Batt of Belfry Productions has been in to record tributes to Simon & Garfunkel, and Elton John. Latest Wessex news is that harmonica man Tommy Reilly is about to record an LP for Polydor, which will be produced by his son David on behalf of their own company, Dasi Music.

The recent B. B. King album which featured 'just about everybody including Ringo' was recorded at **Command Studios** in Piccadilly. See 'Studio Diary' next month for important news from this studio.

Recent work at Clapham's **Majestic Studios** has included the completion of a Helene Francois LP for Proclaim Records, with producer John Hawkins, and the continuation of cover versions of pops for Avenue Recordings. The 35 piece Bury St. Edmunds Silver Jubilee School Orchestra have been in to record, and impressed the engineers with their high standard of performance. Don Marchand produced a single with Bootleg Alley, and Chas Pete produced a new TV theme for *Father, Dear Father* on behalf of Belsize productions. Other work for Belsize included a Colonel Bagshot album produced by Martin Hall, and engineered by Roger Wilkinson. Studio owner Mike Morton continued work on his *Non Stop Top Twenty* album.

Alan Grandy has left Majestic Studios to concentrate on songwriting and production, rather than engineering, and we wish him every success.

The **Tooting Music Centre Studio,** which has been in operation for nearly a year, has gone four track with the installation of a new TRD machine. The studio holds up to a dozen musicians, and three guitar amplifiers, a drum kit, and a Hammond organ are all included in the hourly charge of £5.25. Dragonmilk have been in to record a single due for release soon on the Brecon label.

The Music Centre also does mobile work and recently recorded the Western Echoes at the Nashville Rooms, Kensington.

Another low-priced four track studio is **Gooseberry,** the £5 hourly charge being particularly surprising as the studio is in Gerrard Street in central London. Georgie Fame and Mark Bolon have used the studio for demo work, and Robert Mellin Music had some session men in to record *Here Comes My Baby* on which studio manager Peter Houghton eventually became the vocalist. Peter is constantly trying to further his singing career and volunteered to vocalise when the session musicians found he provided the 'breathy' type vocal required. The record is to be released on the Pye label.

Gooseberry started as Studio 19, three years ago, and has since been equipped with a Richardson Electronics desk which works very well. PPM monitoring is used, as Peter finds these meters extremely accurate, and says he can get far more signal on the tape before distortion because he always knows exactly what is happening.

Why is the studio so cheap? Peter Houghton explained that he kept charges low by doing all the work himself and sees no reason why the big studios should charge the high rates they do. Gooseberry will go eight track as soon as Peter finds someone to lend him £5,000. Any offers?

Eden Studios in Kingston, Surrey, also charge £5 per hour. *Come And Have A Good Time*, a number published and produced by the studio, and recorded there by Hampton Wick, is soon to be released on the Philips label. Some other numbers are now under way, and Eden hope to have five or six releases during the next 12 months. The studio does a variety of work, recording opera, plays, soul, and pop, and running a tape-to-disc and pressing service.

A Long Time Old, recorded a few weeks ago at **Mayfair Studios** by Steve Arlan and produced by John Shakespeare, has now been released on the Square record label. Pete Brown and Piblockto made a self-produced single for Pathe-Marconi (Paris). Danny Doyle, in for EMI with producer John Drummond, also made a single.

John Hudson tells me that Dave Maynerd and himself have built a new 12 channel eight track console for **Trend Studios** in Dublin. It converts easily to 20 channel 16 track, has two foldback systems, two echo sends, and foldback and echo facilities on the monitoring. The electronics of this desk were all designed by Dave. It is possible that the Mayfair engineers will now start building desks for other studios.

At **Sound** (Maidenhead), classical accordionist Lorna Martin has been laying down material by Bach, Buxtehude, Pacheldel, and contemporary English composers William Byford and John Dowland.

Sixteen track facilities with Dolbys are now available at **Maximum Sound** for £24 per hour, night or day. The new machine, a Scully *M100*, was installed because of the constant demand for 16 track by groups.

Maximum have been recording Arthur Brown and Richard Barnes, both for Gerry Bron, and Luan Peters, the *Golden Shot* girl, has made a single. Manfred Mann has been in doing possible singles, and Mike Hudd has been completing his first album, described by studio manager Dave Hadfield as 'very soft, but not slush—very pleasant'.

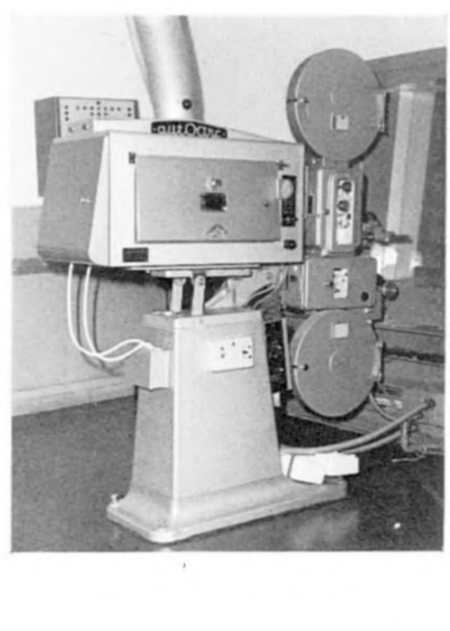
The **Jackson Recording Company** has been very busy. War Horse, a splinter group of Deep Purple, have been in as have local girl Julie Felix, and a 15 piece soul band called Beef Bayonet, and described by Malcolm Jackson as 'very hairy'. Regular customers at the studio this month included Doug Flett and Guy Fletcher, and Reflection. The Jackson Company made history by recording the first Punjabi album made outside of India.

Malcolm tells me he is buying a new noise reduction unit which is better than the Dolby. It has a four position switch, but the rest is much better described in Malcolm's own words: 'If you put someone in front of a mike, and leave the studio door open, you've got traffic, birds singing, howl-rounds, footsteps, amps humming, mixer noise, and crackling pots. The first switch position cuts out the birds and hiss. The second cuts out amplifier hum, tapping feet, and things like that. The third position is for things like traffic, and makes a sibilant mike less sibilant. It also cuts out crosstalk between instruments—it will chop drums off the vocal mike, for instance. The fourth position is really hefty—it can cut out howl-rounds and everything. There's no deprocessing with this system; you use it at the end of your reduction and you've got a perfectly clean tape.' I hope to be permitted to reveal the identity of this magic machine in the near future.

Fedco Audio Laboratories is an American company specialising in eight and 16 track remote recording. This summer, Fedco is equipping a house in Marblehead, Massachusetts, overlooking the Atlantic, as a 16 track studio, where producer George Martin and engineer Bill Price will spend seven weeks recording Seatrain and the Paul Winter Consort. Mixing will most likely be done in London.

Lastly, the **Jack Clement Recording Studios** in Nashville have had sessions for Dot, Capitol, Heartwarming, Word, Fraternity, Kravel, Barnaby, Mega, Jamie and Electra companies. Artists included Stoney Edwards, Reba Rambo, Ken Hill and the Triple Threat, and Duffy's Plantation Band.

Frontage and 35 mm projection equipment at De Lane Lea.



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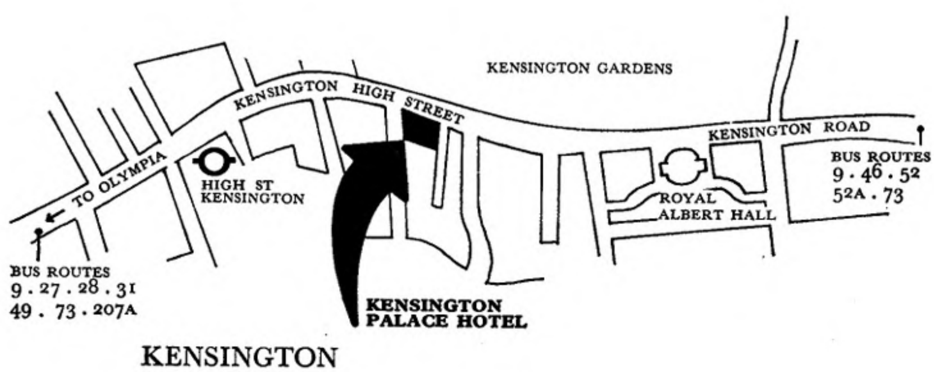

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BUILDING YOUR OWN

John Fisher considers the practical problems of constructing one-off equipment

THERE can be great satisfaction in building your own equipment, in deciding the details of layout and finish, and in using the end product. Building your own can be one way of saving money, of getting precisely what you want and of knowing the equipment inside out. When a fault occurs, you are not at the mercy of incompetent distributors or tardy manufacturers. You can also gauge with more certainty, sometimes, the limits and potentials of your own assembly than of the prefabricated item.

Using or adapting a published design is normally the most time saving way of going about things and it is worth filing a way even the most obscure circuits that might one day prove useful. However, before pouring money into a project, ask yourself whether you understand sufficiently what is going on in the circuit. Are the components readily available, and what substitution of components is necessary or possible? What test equipment will be needed to make the circuit work properly?

Understanding the circuit, or the basic principles, is fundamental. Any text accompanying the circuit is likely to give some idea of what is going on but it may also assume that the reader is conversant with general principles and the form of circuit involved, leaving him to read the circuit for much of the detail. As a background to such articles, this journal has published articles on the principles of semiconductors and the elements of audio circuits which are well worth reading if your knowledge of the subject is sketchy.

Assuming you know what is going on, and are sure that a particular circuit will do what you want, the next problem may be components. Generally, as many readers find out, it is pretty hopeless trying to build from spares available at the radio shop round the corner. Unfortunately some people who find this difficulty then assume that the components are not available, and even go so far as to reproach the editorial office for publishing designs using 'unobtainable' components when in fact such components are readily available through large specialist dealers and mail order firms.

In the hope of making it easier for readers to obtain supplies of components, I have drawn up a table (1) of component suppliers and another (2) of what they can supply. The list is in no sense comprehensive. It is a short-list of suppliers I have used and who have given satisfactory service. All supply by mail order, some over the counter as well. The components listed as available from the firms in question are ones which I immediately knew to be

(continued on page 509)

	Precision resistors	Miniature histab resistors	other resistors	electrolytic C's	close tolerance C's	other C's	silicon transistors	F.E.Ts	germanium transistor	diodes and rectifiers	Zener diodes	mains transformers	audio transformers	Veroboard	hardware	chassis, etc.	switches	preset resistors	potentiometers	meters	plugs and sockets	valves	speakers	other remarks
Alpha Radio	1	2	2	2		2	1		1	2	1	2	1	2	2	1	2	2	2	2	2	2	2	
Duxford		3		3	2	2	1		1	1				2			1	3	1					
Electrovalue	1	3		3		2	3	1	1	1	1							3	1					
H. L. Smith		2	2	1		1						1	1		2	2	1		2	1	1		1	
G. W. Smith	1		2	1		2				2		2	1	1	2		2	1	1	2	2	2	1	
Transformer Equipment Ltd													3											made to specification
Drake Transformers													2											Delivery approx 12 weeks
Samsons												2												from stock
Z & I Aero	1		2	1		2				1												2		obscure components
Henry's Radio		2	2	2		2	2	2	2	2	2	1					1	1	2	2	2		1	
Ernest Turner																				2				Manufactured 'specials' and special calibration
Amatronix							1	1																
Rastra							2	2	2															

1 = stockist   2 = good range   3 = exceptional value

obtainable from them, in most cases through having purchased such components from that source at one time or another; most of the firms, except obviously the specialist manufacturers, could in fact supply a wider range of components than those indicated and the selection is a purely personal one. With that, I hope we will not be besieged with requests for addenda! I have in one or two cases indicated where the components supplied seem to offer particularly good value.

Substitutions

With individual components, the simplest points sometimes give concern: for instance capacitor values. Decoupling capacitors can often (but not always) be increased in size without ill effect. Subject to the dictates of space, capacitors may be paralleled to make up values, or higher voltage rated types used. It is generally preferable in low noise stages *not* to put undecoupled resistors in series in noise conscious positions to make up required values, but this may if necessary be done elsewhere. Diodes of higher voltage or current rating may normally be used unless specific reasons are given for choosing a particular type. Transistors in particular tend to be given a holy reverence that is quite unwarranted; there are ample equivalents for most transistors in most applications. In many cases, provided some basic requirements are met, a vast range of dissimilar transistors may be substituted for specified types with good results. Unless particular reasons are given for choosing a particular transistor from many similar types, it is likely that the specified type was one conveniently available when the circuit was designed and has been found to be satisfactory.

With the proviso that it may lay the circuit open to RF pick-up if carried to excess, in general it is possible to use a higher frequency transistor in place of a lower frequency type. Provided there is no risk of introducing noise, transistors with higher voltage, current or power ratings may be substituted for transistors with lesser ratings, and low noise types may be used in place of general purpose types of similar ratings. One really needs to look at the circuit and see whether the transistors are p-n-p or n-p-n, germanium or silicon, and then what the obvious requirements of it in that configuration are. That done, it is usually a fairly simple matter to choose a suitable substitute if the type shown is difficult to obtain. Many manufacturers and distributors provide substitution data. Retailers are rarely the most helpful or reliable sources of information, and I heard recently of a well known London dealer telling one customer that it was all a great racket: there were two basic types of transistor, p-n-p and n-p-n, and that this apart they were all the same. This, I think most readers would agree, is carrying interchangeability a little too far!

Test equipment

On the subject of test equipment, the very least one can begin with is a multimeter. For the poverty stricken, there is a fair choice between DIY article (Heathkit for instance) and one of the better Japanese multimeters. To begin building circuits without a meter is a complete waste of time and money, as one will inevitably become bogged down when something doesn't work first time or subsequently fails. It is surprising how readers will sometimes write in asking for help with a piece of equipment they are building and will casually admit in the same breath that they have no means of making measurements on the circuit to see what is happening. One is always delighted to try to help, but this is hopeless!

For several years I have been using a very reliable Japanese multimeter, a Nakagawa *NH-201* which has a DC sensitivity of 30 k/V and AC sensitivity of 12 k/V, which cost me under £6 at the time. Eagle are selling an attractive range of meters from an insensitive 1 k/V to an excellent 50 k/V, some including overload protection devices and a range of accessory leads. They seem to offer good value even in these days of import surcharges. The range is available from Alpha Radio (Eagle Catalogue 25p) and G. W. Smith can also supply quite a variety of useful Japanese meters.

Mail Order Component Suppliers

- Alpha Radio Supply Co, 103 Leeds Terrace, Wintoun Street, Leeds 7. Tel. Leeds 25187 *(Catalogue available)*
- Duxford Electronics, 97/97A Mill Road, Cambridge. Tel. 63687 *(Catalogue available)*
- Electrovalue, 32A St Jude's Road, Englefield Green, Egham, Surrey. Tel. Egham 5533 *(Catalogue 7½p)*
- H. L. Smith & Co Ltd, 287/289 Edgware Road, London W2. Tel. 01-723 5891 *(also retail)*
- G. W. Smith & Co (Radio) Ltd, 3 & 34 Lisle Street, London WC2. Tel. Ger(rard) 8204, 9155 *(also retail)*
- Transformer Equipment Ltd, Railway Place, Wimbledon, SW19. Tel. 01-540 1186 *(manufacturers)*
- Drake Transformers Ltd, Billericay, Essex *(manufacturers)*
- Samsons Electronics Ltd, 9 and 10 Chapel Street London NW1. Tel. 01-262 5125 *(also retail)*
- Henrys Radio Ltd, 303 Edgware Road, London W2. Tel. 01-723 1008/9 *(Catalogue 37½p plus 10p p.p.)*
- Ernest Turner Electrical Instruments Ltd, Chiltern Works, High Wycombe, Bucks. Tel. High Wycombe 30931/4 *(manufacturers)*
- Amatronix Ltd, 396 Selsdon Road, South Croydon, Surrey CR2 0DE
- Rastra Electronics Ltd, 275/281 King Street, London W6. Tel. RIV 2960

Some of the London shops sell certain models below the list price and these are worth looking out for. The higher the sensitivity (ohms/volt rating) the better; 10 k/V should be regarded as the minimum if the meter is to be of more than limited use.

An oscilloscope is a luxury but, after a multimeter, a variable tone source is virtually essential. The output amplitude must be stable and flat over the frequency range and some form of sensitive high impedance dB meter or valve/transistor voltmeter is a very useful accessory to it in checking frequency responses. Other items such as the oscilloscope, distortion meters, transistor testers, and wobble meters are very nice to have around but must inevitably come lower in the circuit-builder's priorities. A good pair of ears is the best complement to a multimeter and tone source and, as the final arbiters of one's handiwork, quite irreplaceable.

Experimental Tetrahedral Recording

TABLE 1 Matrixings converting standard skew tetrahedral signals of fig. 1b into other tetrahedral systems.

1a: Conversion to Cooper system.

$$\begin{bmatrix} L_C \\ R_C \\ A_C \\ B_C \end{bmatrix} = \begin{bmatrix} \cdot354 & \cdot854 & \cdot146 & \underline{\cdot354} \\ \underline{\cdot354} & \cdot146 & \cdot854 & \cdot354 \\ \cdot146 & \cdot354 & \underline{\cdot354} & \cdot854 \\ \cdot854 & \underline{\cdot354} & \cdot354 & \cdot146 \end{bmatrix} \begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}$$

1b: Conversion to mirror-image skew tetrahedron.

$$\begin{bmatrix} L_R{}^* \\ L_F{}^* \\ R_F{}^* \\ R_R{}^* \end{bmatrix} = \begin{bmatrix} \cdot500 & \cdot500 & \underline{\cdot500} & \cdot500 \\ \cdot500 & \cdot500 & \cdot500 & \underline{\cdot500} \\ \underline{\cdot500} & \cdot500 & \cdot500 & \cdot500 \\ \cdot500 & \underline{\cdot500} & \cdot500 & \cdot500 \end{bmatrix} \begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}$$

1c: Conversion to Bruck system.

$$\begin{bmatrix} T_B \\ L_B \\ R_B \\ B_B \end{bmatrix} = \begin{bmatrix} \underline{\cdot303} & \cdot803 & \underline{\cdot014} & \cdot514 \\ \cdot663 & \cdot544 & \cdot245 & \underline{\cdot452} \\ \underline{\cdot044} & \underline{\cdot163} & \cdot952 & \cdot255 \\ \cdot683 & \underline{\cdot183} & \underline{\cdot183} & \cdot683 \end{bmatrix} \begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}$$

1d: Conversion to 'sword of Damocles' system.

$$\begin{bmatrix} T_D \\ L_D \\ R_D \\ B_D \end{bmatrix} = \begin{bmatrix} \underline{\cdot183} & \cdot683 & \underline{\cdot183} & \cdot683 \\ \cdot544 & \cdot663 & \cdot254 & \underline{\cdot452} \\ \underline{\cdot163} & \underline{\cdot044} & \cdot952 & \cdot255 \\ \cdot803 & \underline{\cdot303} & \underline{\cdot014} & \cdot514 \end{bmatrix} \begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}$$

TABLE 2 Matrixings rotating skew tetrahedral signals

2a: Horizontal clockwise rotation by θ.

$$\begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}_{out} = \begin{bmatrix} \frac{1}{2}(1+\cos\theta) & -\frac{1}{2}\sin\theta & \frac{1}{2}(1-\cos\theta) & \frac{1}{2}\sin\theta \\ \frac{1}{2}\sin\theta & \frac{1}{2}(1+\cos\theta) & -\frac{1}{2}\sin\theta & \frac{1}{2}(1-\cos\theta) \\ \frac{1}{2}(1-\cos\theta) & \frac{1}{2}\sin\theta & \frac{1}{2}(1+\cos\theta) & -\frac{1}{2}\sin\theta \\ -\frac{1}{2}\sin\theta & \frac{1}{2}(1-\cos\theta) & \frac{1}{2}\sin\theta & \frac{1}{2}(1+\cos\theta) \end{bmatrix} \begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}_{in}$$

2b: Rotation about ears' axis by θ upwards at front.

$$\begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}_{out} = \begin{bmatrix} \frac{1}{2}(1+\cos\theta) & \frac{1}{2}(1-\cos\theta) & -\frac{1}{2}\sin\theta & \frac{1}{2}\sin\theta \\ \frac{1}{2}(1-\cos\theta) & \frac{1}{2}(1+\cos\theta) & \frac{1}{2}\sin\theta & -\frac{1}{2}\sin\theta \\ \frac{1}{2}\sin\theta & -\frac{1}{2}\sin\theta & \frac{1}{2}(1+\cos\theta) & \frac{1}{2}(1-\cos\theta) \\ -\frac{1}{2}\sin\theta & \frac{1}{2}\sin\theta & \frac{1}{2}(1-\cos\theta) & \frac{1}{2}(1+\cos\theta) \end{bmatrix} \begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}_{in}$$

2c: Rotation clockwise about front-back axis by θ.

$$\begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}_{out} = \begin{bmatrix} \frac{1}{2}(1+\cos\theta) & -\frac{1}{2}\sin\theta & \frac{1}{2}\sin\theta & \frac{1}{2}(1-\cos\theta) \\ \frac{1}{2}\sin\theta & \frac{1}{2}(1+\cos\theta) & \frac{1}{2}(1-\cos\theta) & -\frac{1}{2}\sin\theta \\ -\frac{1}{2}\sin\theta & \frac{1}{2}(1-\cos\theta) & \frac{1}{2}(1+\cos\theta) & \frac{1}{2}\sin\theta \\ \frac{1}{2}(1-\cos\theta) & \frac{1}{2}\sin\theta & -\frac{1}{2}\sin\theta & \frac{1}{2}(1+\cos\theta) \end{bmatrix} \begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}_{in}$$

In the previous two parts of this series, the method of making tetrahedral recordings was described. This last part describes the possible uses of such recordings in a wide variety of playback experiments.

If the precautions outlined in Part Two have been followed, the recording should consist of four coincident cardioid (or hypercardioid) signals pointing to the four corners of the cube shown in **fig. 1b:** L_R to rear left downwards, L_F to front left upwards, R_F to front right downwards, and R_R to rear right upwards. By matrixing these four signals, it is possible to obtain *any* conventional microphone characteristic output pointing in *any* direction.

A possible adjustable matrixing circuit, in this case with four inputs and two outputs, is illustrated in **fig. 2.** As many extra outputs as desired may be added, as long as the input impedance does not become too low for the input signals. The gain of each of the inputs on a given output is varied between +1 unit and −1 unit by means of the potentiometers VR and the phase controls S. While transformers are shown in the schematic of **fig. 2,** transistorised phase-splitter circuitry is cheaper and potentially better. A considerable loss of voltage is caused by the isolating resistors R (about 12 dB with four outputs) and it is recommended that an amplifying stage be incorporated at each output unless low capacitance signal leads are used. It is not recommended that the gain controls be placed between the + and − lines of the input transformers, although this would obviate the need for a phase switch as it would either decrease the input impedance or increase the non-linearity and interaction of the controls, or both.

By this or suitable alternative means, it is possible to derive any combination of the four input signals, and the coefficients of each input signal can be set directly on the controls VR. This allows the matrixing circuit to be adjusted instantly for any possible experimental requirement, as long as the coefficients that should occur in the matrix are known. For this reason, most of the rest of this article is devoted to giving the matrixings required to derive various different types of signals from the standard tetrahedral recording.

For reasons of space and convenience of presentation, we shall use standard matrix notation for this. For those not familiar with matrix notation, a given signal in the left column of these tables is equal to that combination of the signals in the right column with the coefficients in the given signal's row of numbers. (In addition, negative numbers have been indicated here by underlining instead of by the more usual minus sign.) Thus, for example, in **Table 1c,** the signal L_B is given by:
$L_B = 0.663\ L_R + 0.544\ L_F + 0.245\ R_F - 0.452\ R_R$ and in **Table 3** the signal A_6 is given by:
$A_6 = 0.483\ L_R - 0.483\ L_F + 0.629\ R_F + 0.371\ R_R$.

Table 1 gives the matrixings required to convert a skew tetrahedral recording with

Experimental Tetrahedral Recording

Part Three

by Michael Gerzon

signals L_R, L_F, R_F, R_R as in **fig. 1b** into a recording intended for reproduction via one of the other tetrahedral layouts. The matrixings given synthesise microphone outputs pointing along the relevant tetrahedral axes with the same microphone directional characteristic as used for the original recording.

The outputs L_C (front left), R_C (front right), A_C (rear above) and B_C (rear below) for the Cooper tetrahedral speaker layout of **fig. 1a** may be derived as in **Table 1a.** The outputs T_B (front top), L_B (front left), R_B (front right) and B_B (back) for the Bruck speaker layout of **fig. 1c** are derived as in **Table 1c.** The outputs T_D (top), L_D (front left), R_D (front right) and B_D (back) for the 'sword of Damocles' layout of **fig. 1d** may be derived as in **Table 1d.** The outputs $L_R{}^*$, $L_F{}^*$, $R_F{}^*$, $R_R{}^*$ for the skew tetrahedral system with speakers in the *lower* front left and right rear positions, and in the *upper* left rear and right front positions, may be derived as in **Table 1b.**

Those with a knowledge of matrix algebra should note that the matrices of **Table 1** are orthogonal, so that to convert the other way (e.g. from a Cooper to a skew tetrahedral recording), the inverse matrix may be obtained simply by writing down the transpose, i.e. interchanging rows and columns. Similarly, to obtain the matrixing from one of these systems to another (e.g. Cooper to Bruck), simply compute the matrix $B\,C^T$, where C is the matrix given in **Table 1** for the system (e.g. Cooper) which is being converted, and B is the matrix in table for the system (e.g. Bruck) to which it is being changed. To facilitate such computations, all coefficients have been given to three decimal places.

It may prove necessary to rotate the stereo image because of inaccurate microphone placement, or to bring sounds to the front of the listener. **Table 2a** gives the matrixing for the skew tetrahedral system that rotates the image horizontally around the listener by an angle θ clockwise. If θ is made negative, then the image is rotated anticlockwise. Note that a clockwise rotation of the image is also produced by an *anticlockwise* rotation of the original microphones. **Table 2b** gives the matrixing for the skew tetrahedral system that rotates the stereo image by an angle θ upwards at the front about the axis running through the listener's ears. This should prove useful with recordings made with high-up microphones. **Table 2c** gives the matrixing for the skew tetrahedral system that rotates the stereo image by an angle θ clockwise about the front-back axis. This should prove useful for correcting tilted microphones.

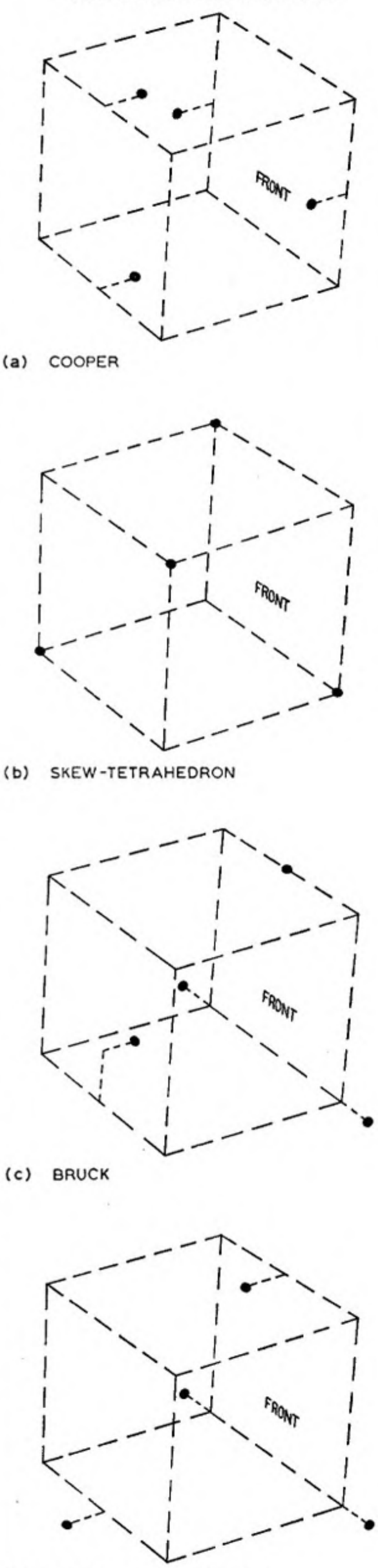
Again, by applying matrix algebra methods, it is possible to compute the method of rotating the sound for recordings made for the Cooper, Bruck or Damocles layouts. For example, if H is the matrix corresponding to the desired rotation in **Table 2,** and if B is the conversion matrix corresponding to the Bruck system in **Table 1c,** then the matrix producing the same rotation for Bruck-system recordings is BHB^T.

Besides tetrahedral methods of playback, the four-channel 'tetrahedral' recording can also be used for playback over more complex loudspeaker layouts. For example, the sound can be played over a cube of eight speakers, placed at the cube corners of fig. 1b, by feeding to them the eight signals L_R, $L_R{}^*$, L_F, $L_F{}^*$, R_F, $R_F{}^*$, R_R and $R_R{}^*$ (see **Table 1b**) in the obvious manner (see also ref. 1).

Another method of playback is over six loudspeakers arranged to form a regular octahedron around the listener. While there are many possible octahedral speaker layouts, the best stereo image will be obtained only if all six speakers lie at the same angle off the axis through the two ears of the listener. This suggests that the octahedral loudspeaker layout of **fig. 3** should be used (or else its mirror-image). The signal fed to each loudspeaker will be the signal that would have been picked up by a cardioid microphone pointing in its direction. If the six loudspeakers are labelled A_1 to A_6 as illustrated, then their signals may be derived from the usual skew tetrahedral recording by the matrixing given in **Table 3.**

(continued on page 513)

FIG. 1 REGULAR TETRAHEDRAL LOUDSPEAKER LAYOUTS SHOWN EMBEDDED IN A CUBE WHOSE SIDE LENGTH EQUALS THE HEIGHT OF THE LAYOUT



(a) COOPER

(b) SKEW-TETRAHEDRON

(c) BRUCK

(d) SWORD OF DAMOCLES

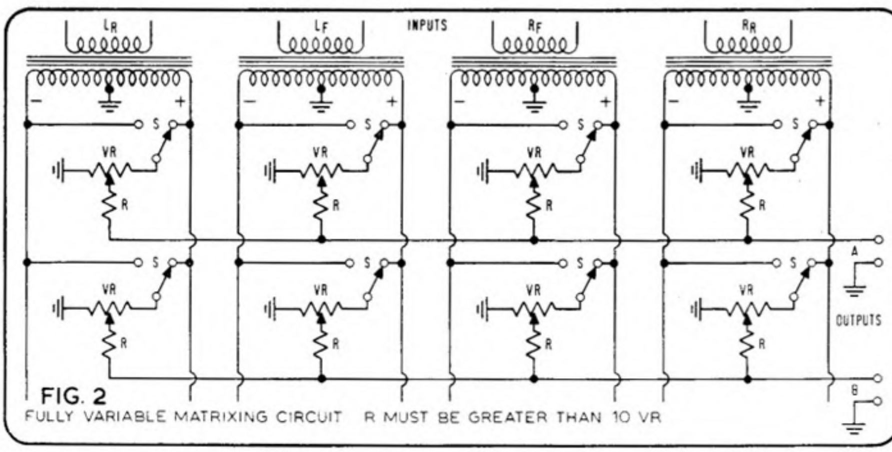


FIG. 2
FULLY VARIABLE MATRIXING CIRCUIT R MUST BE GREATER THAN 10 VR

With the possibility of such loudspeaker layouts, it will be seen that the name 'tetrahedral stereo' is rather a misnomer, for the only way that a tetrahedron enters into such recordings is in the tetrahedral axes that happen to be chosen for the signals fed to the four tracks of the tape. There are many possible ways of storing the four parameters of information that determine the three-dimensional direction effect around the microphones, of which an alternative method would be to record the outputs of an omnidirectional microphone and that of three mutually perpendicular figure-of-eights. Because tetrahedra are involved only in describing the *way* the information is stored on the tape, and have nothing to do with the *content* of this information, the author has proposed that systems of recording the full directional effect around the microphones, including height, should be called *periphonic* systems (*peri*-, around, Greek).

The reader will see that, in principle, any regular or almost regular loudspeaker layout can be used for periphonic reproduction—tetrahedron, octahedron, cuboctahedron, dodecahedron, icosahedron, or even 62 speakers placed on the 31 axes of icosahedral symmetry. I do not propose to give the matrixing for the latter here. Perhaps the most important area of research is to determine methods of reproducing the correct directional effect over non-regular loudspeaker layouts, as only such irregular layouts stand a chance of fitting conveniently into a wide variety of domestic furnishing schemes.

All the matrixings of **Tables 1, 2** and **3** have the effect of converting four signals picked up with four identical cardioid or hypercardioid microphones pointing in four different directions into new signals which are effectively picked up by the *same* cardioid or hypercardioid characteristic pointing in four (or six) new directions. It may be desired to change the shape of the microphone pick-up characteristic to reduce overlap (see Part One). In this case, one uses the matrixings given in, or computed from, **Tables 1, 2** and **3**, except that a small constant is added to or subtracted from every coefficient in the matrixing. For example, if one wishes to convert from cardioid to 135°-null hypercardioid, while performing one of the operations described in tables 1-3, one uses a matrixing in which every coefficient is 0.073 smaller than it would be if a cardioid characteristic were retained. Similarly, if the original recording is made with four 135°-null hypercardioids (possibly due to pre-record matrixing) then 0.104 must be added to each matrix coefficient to restore cardioid outputs. To convert a cardioid recording to, respectively, 150°, 135° and 125°-null hypercardioids, one must subtract 0.033, 0.073 and 0.107 from every matrix coefficient in **Tables 1, 2** or **3.**

It is possible to rematrix tetrahedral recordings to throw away the height information (see ref. 1). This may be useful if it is desired to determine the subjective importance of the height information, and the relevant matrixing is given in **Table 4a.**

There is the related problem of playing 'conventional' four-channel recordings via a

(*continued on page 515*)

TABLE 3 Conversion from the skew tetrahedral system of fig. 1b to the octahedral system of fig. 3.

$$\begin{bmatrix} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \end{bmatrix} = \begin{bmatrix} \cdot854 & \cdot146 & \underline{\cdot354} & \cdot354 \\ \cdot017 & \cdot983 & \underline{\cdot129} & \cdot129 \\ \cdot629 & \cdot371 & \cdot483 & \underline{\cdot483} \\ \underline{\cdot354} & \cdot354 & \cdot854 & \cdot146 \\ \underline{\cdot129} & \cdot129 & \cdot017 & \cdot983 \\ \cdot483 & \underline{\cdot483} & \cdot629 & \cdot371 \end{bmatrix} \begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}$$

TABLE 4 Matrixings for reproducing 'conventional' recordings via skew-tetrahedral and octahedral speaker layouts

4a: Suppression of height information in tetrahedral recordings.

$$\begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}_{out} = \begin{bmatrix} 1 & \cdot333 & \underline{\cdot333} & \cdot333 \\ \cdot333 & 1 & \cdot333 & \underline{\cdot333} \\ \underline{\cdot333} & \cdot333 & 1 & \cdot333 \\ \cdot333 & \underline{\cdot333} & \cdot333 & 1 \end{bmatrix} \begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}_{in}$$

4b: Matrixing for tetrahedral playback of 'conventional' 4-channel recording.

$$\begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}_{out} = \begin{bmatrix} 1 & \cdot414 & \underline{\cdot172} & \cdot414 \\ \cdot414 & 1 & \cdot414 & \underline{\cdot172} \\ \underline{\cdot172} & \cdot414 & 1 & \cdot414 \\ \cdot414 & \underline{\cdot172} & \cdot414 & 1 \end{bmatrix} \begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}_{in}$$

4c: Matrixing for octahedral playback of 'conventional' 4-channel recording.

$$\begin{bmatrix} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & \cdot172 \\ \cdot121 & \cdot707 & 0 & 0 \\ \cdot121 & \cdot707 & 0 & 0 \\ 0 & \cdot172 & 1 & 0 \\ 0 & 0 & \cdot121 & \cdot707 \\ 0 & 0 & \cdot121 & \cdot707 \end{bmatrix} \begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix}_{in}$$

4d: Surround-sound reproduction of 2 channels via a skew tetrahedron.

$$\begin{bmatrix} L_R \\ L_F \\ R_F \\ R_R \end{bmatrix} = \begin{bmatrix} 1 & \underline{\cdot414} \\ 1 & \cdot414 \\ \cdot414 & 1 \\ \underline{\cdot414} & 1 \end{bmatrix} \begin{bmatrix} L \\ R \end{bmatrix}$$

4e: Surround-sound reproduction of 2 channels via an octahedron.

$$\begin{bmatrix} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \end{bmatrix} = \begin{bmatrix} \cdot888 & \underline{\cdot460} \\ \cdot674 & \cdot214 \\ \cdot674 & \cdot214 \\ \cdot460 & \cdot888 \\ \underline{\cdot214} & \cdot674 \\ \underline{\cdot214} & \cdot674 \end{bmatrix} \begin{bmatrix} L \\ R \end{bmatrix}$$

skew-tetrahedral speaker layout so that all sounds come from a horizontal direction. This also entails throwing out the spurious height information, but the matrixing of **Table 4a** cannot be used in this case, as it would cause undesirable out-of-phase images because conventional four-channel recordings are not properly 'conditioned' for the requirements of tetrahedral playback. The matrixing of **Table 4b** is a compromise that may allow conventional four channel recordings to be reproduced tetrahedrally. **Table 4c** gives a matrixing that may allow a conventional four channel recording to be reproduced over the octahedral layout of **fig. 3.**

We may play two channel stereo recordings via the skew tetrahedral or octahedral layouts by using the matrixings of **Table 4b** or **4c**, treating the stereo signal as if it were the front two channels of a four channel recording. Hafler-style surround-sound reproduction of two channel recordings is also possible. **Tables 4d** and **4e** give matrixings that may produce approximately horizontal surround-sound reproduction of two channels via the skew-tetrahedral and octahedral layouts.

Besides experiments with surround-sound and periphony, the other main use of tetrahedral recordings is in the study of ordinary two channel stereo microphone techniques. A tetrahedral recording made with coincident microphones contains within its four tracks sufficient information for any conventional coincident microphone recording to be reconstructed by matrixing. Thus, for the first time, it is possible to perform repeatable objective comparisons between the different microphone techniques, something which has not been done up to now as far as I am aware.

Table 5 gives the matrixings required to derive the left (L) and right (R) signals of various two channel recording techniques from a skew tetrahedral recording. Thus such a recording provides all the advantages of variable characteristic microphones, except that adjustments can be made after the recording, and a greater variety of adjustments are possible.

If a tetrahedral recording has been made with microphones that are spaced apart significantly, then much of the above matrixing will no longer work, and one is restricted to reproduction via one particular loudspeaker layout which may well prove to be non-optimum. Slightly modified matrixings could well give adequate results if the microphone spacing is moderate. A disadvantage of highly coincident microphones is that they tend to interfere with one another acoustically at high frequencies, but this is considered to be a relatively small price to pay for experimental flexibility.

The above account has only indicated a few of the many possible experimental uses of tetrahedral recordings, but nevertheless indicates just how much information is contained in the four channels. In a precisely definable sense, tetrahedral recording makes much more efficient use of four channels than any other current proposal. So great is the system's flexibility that a full appreciation of its uses and possibilities requires a more profound analysis than is possible in these pages. This flexibility is equally great whether coincident or multimike recording techniques are used (see ref. 1). A great deal of experimental work remains to be done before the system is ready for domestic use, as is apparent from the very large number of possible playback methods.

The intention of this series of three articles has been to set out the requirements and possibilities involved in tetrahedral recording, so that others should be encouraged to experiment with this technique. Like any new technology, the new recording system requires some unlearning of old tricks and the learning of new ones. With the extreme newness of even 'conventional' four channel stereo, it is hardly surprising that many of the old methods that worked with two channel stereo are still being applied erroneously to four channel systems. It is hoped that a study of ref. 1 and of this series of articles will have given some understanding of the special requirements of periphony. Finally, one must acknowledge the value of the pioneering tetrahedral recordings of Granville Cooper (ref. 2), whose hard-won experience has proved so useful in formulating the problems in doing experimental recordings.

References

1. Michael Gerzon, Principles of Quadraphonic Recording, Part Two, STUDIO SOUND, September 1970
2. Granville Cooper, Tetrahedral Ambiophony, STUDIO SOUND, June 1970

TABLE 5 Matrixings deriving the outputs L and R of various 2-channel coincident microphone techniques. The skew-tetrahedral recording is assumed to have been made with cardioids, and the stereo pairs are horizontal and forward-pointing.

(i) 90°-angled figure-of-eights:
$L=L_F-R_R$, $R=R_F-L_R$

(ii) 90°-angled cardioids:
$L=0{\cdot}250L_R+0{\cdot}862L_F+0{\cdot}250R_F-0{\cdot}362R_R$
$R=-0{\cdot}362L_R+0{\cdot}250L_F+0{\cdot}862R_F+0{\cdot}250R_R$

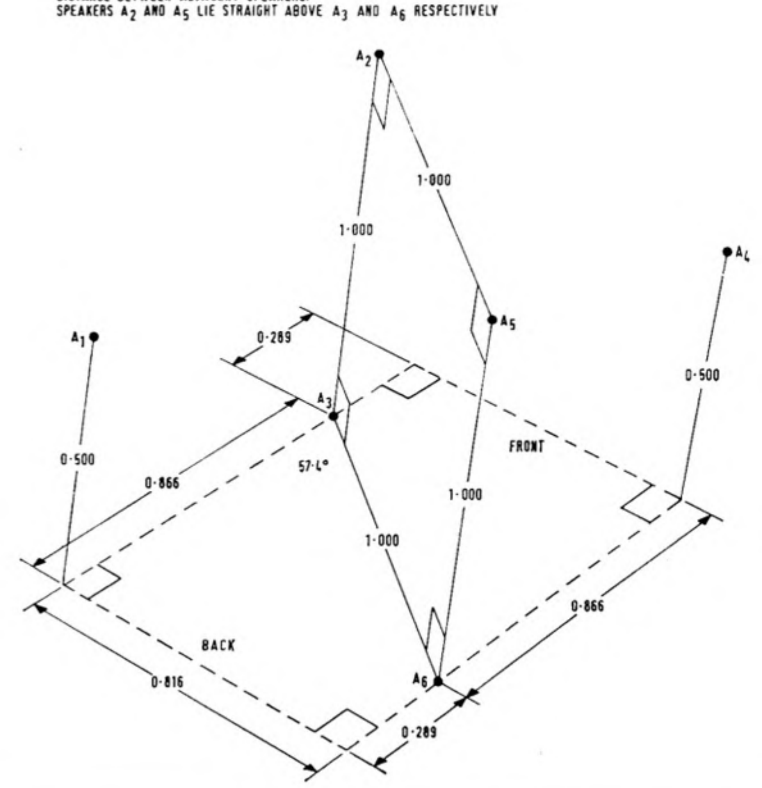
(iii) 120°-angled cardioids:
$L=0{\cdot}408L_R+0{\cdot}842L_F+0{\cdot}092R_F-0{\cdot}342R_R$
$R=-0{\cdot}342L_R+0{\cdot}092L_F+0{\cdot}842R_F+0{\cdot}408R_R$

(iv) 150°-angled cardioids:
$L=0{\cdot}556L_R+0{\cdot}780L_F-0{\cdot}056R_F-0{\cdot}280R_R$
$R=-0{\cdot}280L_R-0{\cdot}056L_F+0{\cdot}780R_F+0{\cdot}556R_R$

(v) 180°-angled cardioids:
$L=0{\cdot}683L_R+0{\cdot}683L_F-0{\cdot}183R_F-0{\cdot}183R_R$
$R=-0{\cdot}183L_R-0{\cdot}183L_F+0{\cdot}683R_F+0{\cdot}683R_R$

(vi) The matrixing for θ°-angled 150°-, 135°-, 120°-, or 105°-null hypercardioids can be obtained from that given here for cardioids by subtracting, respectively, 0·033, 0·073, 0·125, or 0·185 from all coefficients.

FIG. 3 OCTAHEDRAL LOUDSPEAKER LAYOUT
ALL DISTANCES SHOWN AS A MULTIPLE OF THE STRAIGHT-LINE DISTANCE BETWEEN ADJACENT SPEAKERS.
SPEAKERS A_2 AND A_5 LIE STRAIGHT ABOVE A_3 AND A_6 RESPECTIVELY



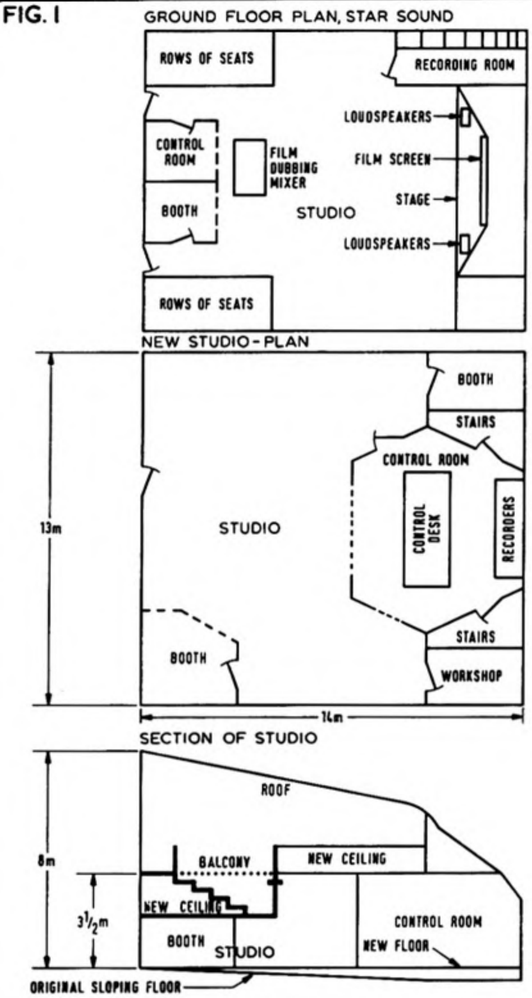
Around the Studios

BY KEITH WICKS

AUDIO INTERNATIONAL

LAST year, I visited Star Sound Studios in Rodmarton Street, W1. At the end of my report, which appeared in the March 1970 issue, I noted that the studio was about to be re-equipped and that some reconstruction was about to take place. This has now happened and the result is Audio International Recording Studios. Studio manager Richard Millard explained how the change took place.

FIG. I



RM *This studio was purchased by Radio Luxembourg on August 1, 1970. It was then decided that it would be a very good idea to go in with a record company on the project, so we invited MAM to join us, and this they agreed to do. Radio Luxembourg London Ltd and MAM each have a 50 per cent interest.*

KW I know what the studio was like when it was Star Sound and I can see there is virtually no resemblance to the old studio now. How did you tackle the conversion?

RM *I approached Sandy Brown Associates and told them what we wanted to do. We made a rough sketch of what was required in the way of facilities—control room, isolation booths, and so on. McLaren Ward & Partners were the acoustic consultants and Sandy Brown Associates the architects.*

KW Did you consider keeping the stage and the audience seating.

RM *No. I did originally suggest having the control room under the balcony but there was not enough height. I wondered if we could lower the floor, but investigation showed that we couldn't, so it was decided to put the control room where the stage was.*

KW What was your minimum height requirement for the control room?

RM *I think about three metres.*

KW I am surprised you had less than that under the balcony.

RM *Balconies are fairly low and you must remember there was a sloping floor. We had to raise the floor to level it off and a new suspended ceiling under the balcony further reduced the available height there. We couldn't do much to the balcony because of our tenancy agreement. We were not allowed to change the basic structure of the building.*

KW Would you have been able to build the control room up in the balcony?

RM *Well, it would have meant levelling off the balcony, with the result that the control room would have been very high relative to the studio floor.*

KW Why would you have had to level it off completely?

RM *We could have had it in tiers, I suppose, but it would have led to complications, and it was also a question of money. We had an awful lot to buy at that time.*

KW Can you disclose the amount of money spent on the conversion from Star Sound to Audio International?

RM *In excess of £100,000 altogether. We spent about £60,000 on equipment, and £40,000 on the conversion itself.*

KW The studio seems a lot smaller now.

RM *I don't think we've lost all that much in area. When this was Star Sound, they had a separate control room and voice booth underneath the balcony, and a tape machine room down one side of the studio. And then there were the audience seats. I think it just looked big because of the height more than anything. We should in fact have gained in area rather than have lost it.*

KW Why was it necessary to reduce the height so much?

RM *It would have been too live if we had not lowered the ceiling. Also, with a high ceiling, you tend to get a rather 'buckety' sound. We've tried to compromise, actually. We have two ceiling heights, and we can put groups under the balcony to get a tighter sound. Musicians like our studio. String players and brass players like the feel of the studio. What we sometimes do is roll back the carpet. We've got a concrete floor with linoleum on top which we can use to brighten up the sound.*

KW The new ceiling in the studio has meant a lot of wasted space upstairs.

RM *We can't really do anything about that. We may do at a later date, but it's a question of cost. It would be very expensive to insulate the upstairs area from the main studio.*

KW Equipment. Why a Neve desk?

RM *I've had two Neve desks before, and been very happy with them. Also there was the question of delivery dates. Neve were able to supply the desk in a reasonable time. It's different to the standard desks in that we have additional peaking frequencies on the tuned equalisers at 10 kHz and 350 Hz.*

KW Why these extra frequencies?

RM *We did experiments. We had a Pultec equaliser, and found that it's very useful to have 350 Hz to give a bit more guts to things like guitars, and to the voice as well. 10 kHz, I found, is rather nice for strings.*

KW Loudspeakers. You have Lockwood

cabinets with Tannoy units?

RM *Yes, Tannoy Golds. We prefer them to the Reds. We had other speakers in for evaluation, and we spent a long time listening to them, being thoroughly confused with what we heard. In the end, we decided that we preferred the sound of the Golds.*

KW How many of you came to this conclusion?

RM *Four, I think. All the engineers at Luxembourg. After a day listening to a lot of different material, the general consensus of opinion was that these had the least coloration.*

KW Interesting, because most studios seem to go for the older Tannoy Reds, rather than the Golds.

RM *Yes, I know this. We did A-B checks between the two, but we found the Golds were preferable. The bass was better. Lockwood made up special cabinets for us because I have a thing about cavity effects. I had the speakers mounted on the front of the baffles rather than behind them. I think that at one time Tannoy used to recommend this, but I never see it mentioned now.*

All our speakers are driven by H/H Electronic amplifiers, which we find most satisfactory. We have two speakers in the studio, and four in the control room. The control room ones are mounted on a rail so we can move them around.

KW At De Lane Lea's new Wembley studios, the speakers are on a rail round the room so you can put two round the back for quadraphonic work.

RM *We were considering that, but we abandoned the idea because we couldn't get far enough away from the rear speakers. We are now experimenting with some smaller speakers behind.*

KW On the basis that they would only be used for ambience?

RM *Yes. Probably.*

KW There are two schools of thought, aren't there? I am thinking that the use of quadraphonics will be up to the individual record producers, and some of them will want to put musicians in all four corners. If quadraphonics comes to anything, that is.

RM *Well, it might do. I haven't been impressed with the results I've heard so far. And I just cannot see how it's going to be adapted to the living room, unless it's an ambiophonic system. It's all right where the rear speakers don't contribute anything to the main body of the sound.*

KW How did you decide which tape machines to use?

RM *I was familiar with Studer J37s and C37s, which I liked. They were engineer's machines. So for multitrack, I settled on the Studer, although I hadn't even seen it then. At that time, the A80 was in the process of development, and I'd only seen the specification. One thing I liked was that we could change the motors in a couple of minutes, and practically everything comes out as a separate unit, and can be replaced. Ease of servicing is very important in a place like this, where there is a lot of equipment, and a lot of money tied up in it.*

KW So how many machines have you altogether?

RM *Three A80s. One is a 16 track which can be converted to eight track in about ten minutes, and there are two two track machines. Our four track machine is a Scully which we took over from Star Sound.*

One of the advantages of the Studers is that you have a variable speed adjustment. You can vary the speed without having to have an external oscillator and amplifier. The Studers work on a different system to most other machines. They are driven by an internal oscillator, rather than being locked to the mains. It's like a Revox, actually. There is a toothed wheel, and a frequency discriminator which makes corrections accordingly.

KW But I presume you could in fact use a wide range variable speed unit with these machines if you wanted to, by plugging out the internal oscillator.

RM *That is what they are going to do. They are working on it so that you will be able to get up to about 20 per cent variation.*

KW Why do the meters on the desk go right into the red when you are recording?

RM *Well, unfortunately, the law of Dolby is that you work to a peak of 320 pWb/mm. With some of the modern high coercivity tapes, like LR56, PER555 and PER525, one can go up to 510 pWb/mm, or even more. We are using PER525 so we are working to 510 pWb/mm most of the time. So what we do is record into the red. Dolby tone is recorded at 4 dB below 320 pW/mm, which is about 185 pWb/mm. It doesn't matter that the meters peak right over, as long as the Dolby is working on the right part of the curve. That's assuming your mixer can take it. The overload margin on a Neve is considerable—I think it's about 18 dB now. The record amplifier must be able to work at about 4 dB above its normal peak recording level, but a machine like the Studer can cope.*

One of the nice things about the Studer is the ease with which you can change the parameters to suit a different tape. When we are doing an eight track non-Dolby recording, we just put in a new set of cards so that we can work to +4 VU, which is equivalent to 510 pWb/mm. This gives us an instant changeover.

KW The studio and control room areas are now working. What has still to be done?

RM *Our reduction room is not yet equipped. We'll do that at a later date when we see how things go, what future trends are going to be, and whether we are going to go to 24 or 32 track.*

KW Do you think that will come?

RM *Not at the moment. I think 16 track is the ultimate for the time being. What we are going to do is to get a disc cutter very soon.*

KW How many engineers do you have at the studio?

RM *There is our chief recording engineer, Bill Somerville-Large, Peter Rynston who has just joined us from Decca, and Rodney Harper.*

KW And yourself. How did you become involved in the recording business?

RM *I started as a development engineer for EMI, with Dr Dutton's advanced development group at Hayes record division. There were only about eight of us then, and we were doing work associated with the studios at Abbey Road. We did development work on tape, studio speakers, in fact anything to do with recording. I was there for two years, and I suppose my main concern was modulation noise. Our department was also responsible for launching stereo tapes. This was at 19 cm/s, twin track.*

Then, in 1957, I went to Recorded Sound. In those days, it was a smallish studio, mono, of course. I was running the recording side of that and did quite a few sessions there. In 1959, I went to Radio Luxembourg as chief engineer. At that time, they were doing a lot of outside recordings with a mobile unit. Everything was a bit run down, so I had to do a lot of work on the equipment. We did numerous audience shows, and also a lot of big band recording. Ted Heath, Cyril Stapleton, Joe Loss, the Big Ben Banjo Band, Ronnie Aldridge and the Squadronnaires . . . these were the big bands of that period.

KW Some of the recordings were done at Star Sound, weren't they?

RM *Yes. 'Take Your Pick' and 'Double Your Money' were, but we did a lot of work in town halls around the country. We've still got some of the old tapes, and the results are remarkably good considering we were using STC 4038s most of the time. We didn't have any capacitors.*

KW Are you saying you don't like *4038s*?

RM *No. It's just that one has got so used to capacitors. Ribbons are still used for brass quite a lot, but in those days we used them almost exclusively.*

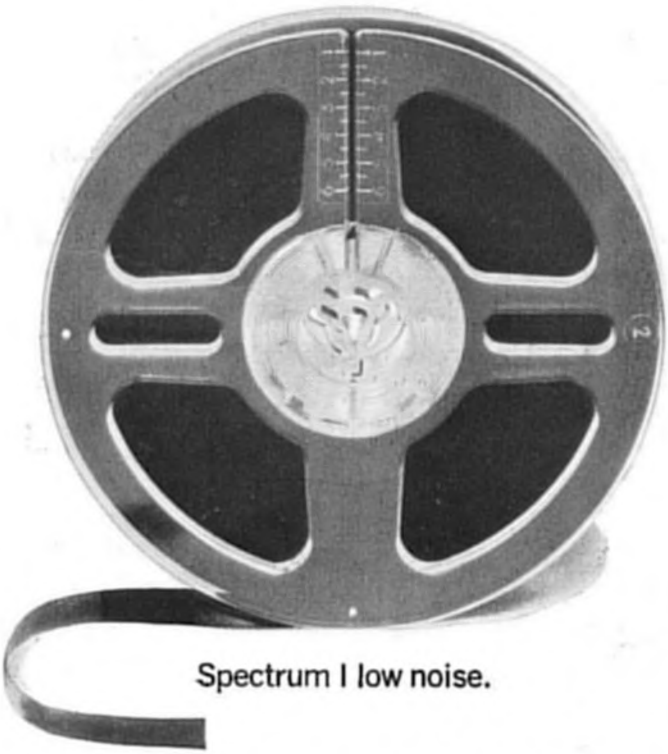
In about 1966, we were doing quite a lot of music recording for Luxembourg's use, and we also issued one LP of a small band, which was quite successful. We then decided to invest in some new equipment and bought a Neve desk with eight channels and two outputs, which was in fact one of Neve's first. Around 1967, we got a four track Studer, and did more and more records. We had a production company associated with Radio Luxembourg, and we recorded Joe Dolan's 'Make Me an Island', which got high in the charts. We were using a four track machine, but only had two mixer outputs, so we had to use the foldback and reverberation group outputs as well, and there was a Vortexion mixer stuck on the end. In 1968, we bought another Neve desk, a 16 in, four out desk, and we started doing work for a lot of other companies. We then decided to expand, and it was at this time we heard that Star Sound was on the market. So I came here with our general manager, and we advised the board that this would be a good investment. We bought the studios, converted them, and opened on June 8 this year.

KW What does it cost to use your studio?

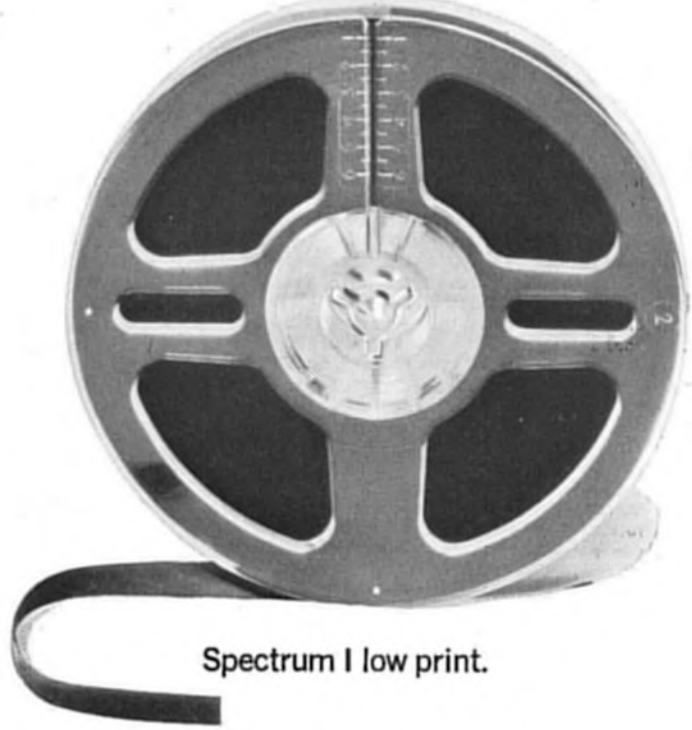
RM *Sixteen track costs between £24 and £42 per hour, depending on the time of day. It is cheapest after 9 a.m., and most expensive after midnight. The high rate also applies at weekends. Eight track is £20 to £36, and four track £16 to £30.*

Richard Millard

Pray silence for Spectrum I.



Spectrum I low noise.



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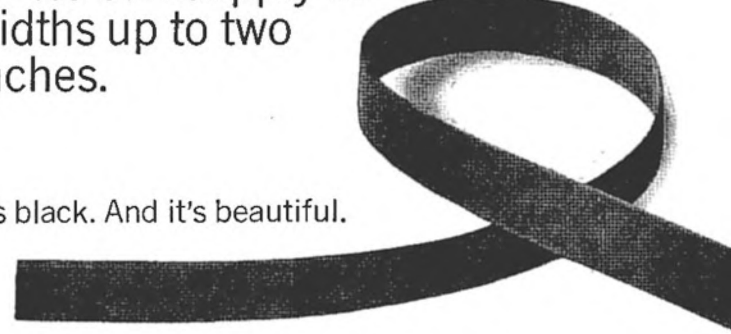

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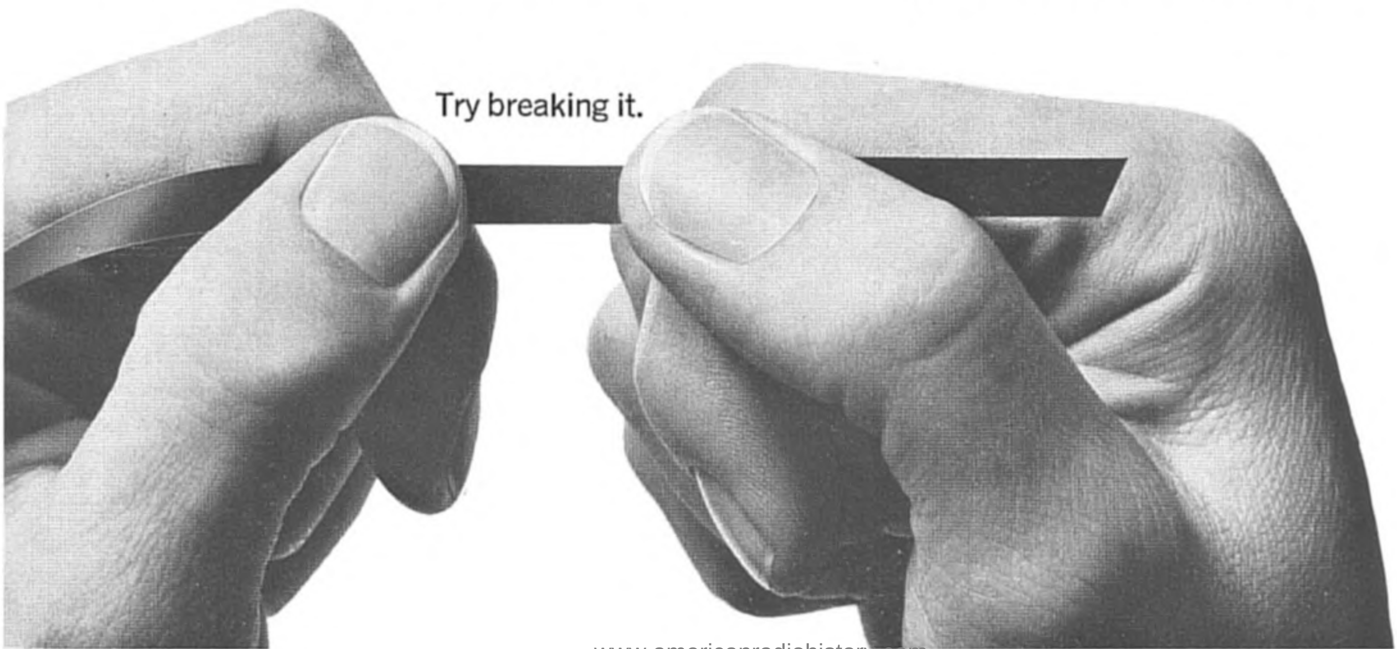

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PAN'S WIFE follows in tow with Pan to the occasional Trade Do. She's heard all the advice going—why *A* doesn't do this, why *B* shouldn't do that, why *C* and *D* ought not do the other, and why *E* would sound/look/run better if it didn't something else. Negative advice. Mrs Pan has produced an all-purpose answer to the all-purpose negative question you are probably dying to ask: Why *Pan?* Why not?

SOMEBODY RECENTLY wrote a book about recording the voices of the dead, and somebody else published it. Nothing new about this; record companies have been doing it for years. It would seem that the best thing an up-and-fading pop star can do for himself is die—in the most exciting possible way—leaving behind the bundle of demo tapes without which no pop musician is complete. Pan is still striving for the Top Ten, waiting for the day when pipes, shorter hair and nudity come back into fashion. When I reach Number One, I shall be seen to expire at the end of an all-nite rave and retire to the solitude of the Channel Islands.

A PROBLEM FOR anyone engaged in the mass-media business is that of knowing your audience. The latest BBC Television Moon Ritual wasn't meant for me. Nor, judging from Certain Conversations Subsequently Overheard on British Railways, was it meant for the general commuting public. Every opinion I have heard on the subject echoes my own irritation at the banal and immature manner in which the Apollo 15 journey was presented. Chairman Burke contributed a faltering soliloquy of devalued superlatives: fan*ta*stics, sophisticateds (?), experts, incredibles, and all the rest of it. As for the 'experts', residents Moore and Nicholson seemed to be drying up after so many Moon Missions. The usually ebullient Moore was reduced to demonstrating an Emmett creation, bolstering the overall impression that the presentation was intended for kids. Perhaps the producers think the public doesn't know an umbilical from a LEM's left legs. They are mistaken; most people alive enough to follow Apollo 15 must have seen 11, 12, 13 and 14 and would consequently know the superficial moontalk backwards. It is not a BBC tradition to pander to the lowest intellects in the community; BBC news broadcasts, particularly on radio, are a model of intelligent communication. In some fields, notably sport, finance and politics, the Corporation leaves my poor intellect far behind. Five minutes of union/management polylogue on the state of the goat's milk industry leaves me in a state of grey open-eyed sleep.

H. W. HELLYER BECAME rather steamed, last month, over the use and non-use of the Pond. This is defined as the pressure corresponding to a weight of one gramme, the gramme being a unit of mass. Or mess. Its natural abbreviation is a plain p which could lead to some interesting misunderstandings with our post-denary coinage. Happily, the Pond became officially defunct when the cgs system of units gave way to the mks (metre, kilogramme, second). Which presumably leaves us with the kilopond?

DEBATING WITH a colleague what an all-pass filter might be, we came up with a new idea in noise reduction—*total* noise reduction. The Panbox would be smaller and much cheaper than a Dolby and could be used at any reasonable programme level (900V flashpoint). The only controls would be a switch and a fader, labelled as shown in the block schematic. We recommend about 8 dB above −8 dB ref. level for tapes modulated to 64.4 microwebers per furlong.

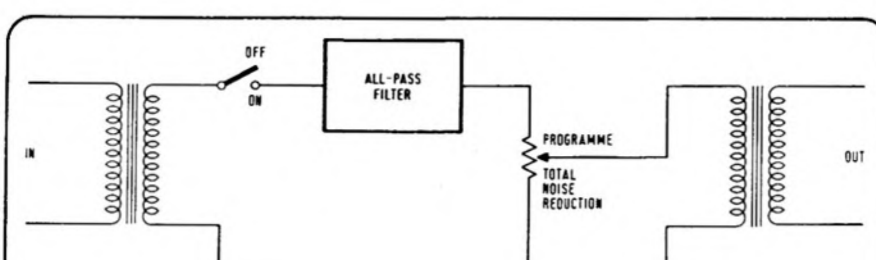
HOW DO YOU define 'stereo'? Careful now, because the word has nothing inherently to do with two-channel systems, hence the legitimate references to four-channel stereo. The original Greek *stereos* meant 'solid', which seems to leave us without a word. I hesitate to suggest *biophony* since like monaural (one-eared), it carries shades of human dissection. *Biphony*, perhaps, or *duophony*. My own favourite would recognise the pioneering genius of Alan Blumlein: *Blumphony*. 'Tetrahedral ambiophony' is unlikely to go down well with the consumers; my standards committee and I recommend defining related apparatus as a *Gerzophone*.

THOSE WHOM it concerns at Broadcasting House are quite impressed by chrome dioxide tape. At least they would be, I am told, if it were given sufficient chance to show itself to advantage. As one engineer put it: 'It's better tape all right. Trouble is, our amplifiers weren't designed for it and they crack up before reaching anywhere near optimum modulation level'. This, coupled with the fact that the tape is more abrasive than most, means the net result of using chrome at BH is faster head wear.

IF YOU THINK Angus McKenzie is the sole fount of all wisdom, you haven't read *The Electric Telegraph* (Popularised) by Dionysius Lardner, published in 1855. We all risk being called upon, at some time in our lives, to erect an Indian telegraphic line. Thanks to Dr Lardner, the practical problems are on record:

'By experiments thus made, Dr. O'Shaughnessy found that the wires employed in Europe would be quite inadequate to the Indian telegraph. In England, where the lines are carried along railways, and where there are no living obstacles to contend with, the thin iron wire, called No. 8 gauge, answers its purpose well; but no sooner were the iron rods (being the only obtainable materials) mounted on their bamboo supports in India than flocks of that largest of all birds, the adjutant, found the rods convenient perches, and groups of monkeys congregated upon them; showing clearly enough that the ordinary wire would be insufficient to bear the strains to which these telegraphic lines would be subjected. It was found also that not only must the wire be stronger, but that it must be more elevated, to allow loaded elephants, which march about regardless of roads or telegraphic lines, to pass underneath.'

Arsenic is advocated for white ants with an appetite for underground cables.



Where it goes

THERE is more than one way to shave a sheep but some methods are more likely than others to kill the creature. There are likewise more ways than one to record a musical instrument. Some just don't work very well.

My purpose here is not to lay down a law for each situation but rather to show the frame of mind I feel should be adopted when approaching an unfamiliar beast. If anyone cares to disagree, or can add anything I have missed, I shall be pleased to hear from him.

Harpsichord and piano

The harpsichord seems an appropriate subject to begin with, having been subjected to more foul treatment by manufacturers and recording engineers than any other surviving instrument. There is a tradition in the recording industry that you approach a harpsichord the way you would milk a cow, by getting underneath. Most 20th-century instruments have open bottoms, for reasons I will shortly explain, and sub-soundboard microphones have the advantages of being fairly close to the strings and yet out of sight (though how the latter helps in a studio I am not sure). Unhappily, this placement produces a very poor signal-to-wood ratio since the microphones are ideally positioned for recording action noise. This is particularly aggravating in harpsichord solos, many modern recordings displaying an accompaniment of deep bass explosions produced each time a jack rises or falls. Record reviewers do not seem to have noticed the effect. Perhaps their hearing aids need adjusting.

I would record a solo harpsichord in the same way I would a piano, with a coincident pair of ribbons or capacitors angled down towards the mid-treble and bass strings respectively. Not that this solves everything. A recent commercial disc recorded in this way (judging from the absence of action thunder and the well balanced room acoustics) included at no extra charge a few motor cars driving past Fenton House. This is inexcusable; the passages affected should have been retaped and edited into the master. Alternatively, instrument, instrumentalist, recorder and recordist should have taken themselves to a quiet part of the country. I'm told there still is one, about 20 minutes north of Inverness.

I often wonder what proponents of the milkmaid approach do when confronted by an Italian instrument. These, and four subsequent centuries of European harpsichords, incorporated a resonance chamber beneath the soundboard, its vent being the more or less elaborately decorated rose. Several modern manufacturers take the trouble to build a thin soundboard and a resonance chamber but do not bother to cut a vent, claiming that you can't hear the difference. Since the rose of a harpsichord is barely accessible for the following experiment, place your hands over the f holes of a cello guitar after plucking the six strings. If you can't hear the difference, join the queue for a hearing aid.

Early pianos were based on the same thin soundboard and resonant cavity structure of Italian harpsichords. The hammer action was simpler, and I am told more effective, than the complex transmission used today. Then the rot set in. Competing with the piano, harpsichord makers such as Tschudi and Kirckman fitted every imaginable contrivance to increase the dynamic and tonal flexibility of their instruments. Piano makers reacted, using longer and heavier strings in three-fold unison and at higher tensions to increase their loudness ceiling. This necessitated stronger casework and, they decided, a thicker soundboard. Which made the structure heavier and more rigid, adversely affecting the tone—particularly at the treble end. The strings wasted more energy trying to vibrate larger wood thicknesses so the devolutionary cycle was repeated. The resonance vent was closed and then the bottom removed, supposedly to let the sound out in both directions. Iron frames were introduced and the soundboard was now so heavy that its acoustic value fell almost to nil. The modern grand piano, with its 30-ton string tension, has more in common with a Sherman tank than with its delicate parent, the fortepiano. Which is fair enough because the modern piano has tonal beauties of its own. What is unfair is that piano makers devoted the same indelicate cares upon the harpsichord, hence the absence of a resonant cavity and the mammoth soundboard construction. The large multi-manual multi-stop instruments produced in this fashion are much quieter than the products of 14th-century workmen, and tonally less interesting.

A good modern copy of an Italian harpsichord—with a 5 mm case thickness—also holds in tune far longer than the slabsided iron-framed instrument put out by piano-influenced makers.

A final point before leaving the harpsichord and its hammering mate, the piano. Don't rely too heavily on the acoustic properties of the wooden 'reflector'. This device originated as nothing more than a dust cover, part of the decorated case from which Italian harpsichords were usually removed to be played.

Violin

This instrument occupies an altar in many minds. To be worth hearing, we are told, it must (a) have been made by Stradivarius during the period he used that cunning varnish formula, and (b) be played by a virtuoso with a lifetime's experience of the instrument. Alas, a solo violinist, virtuoso or not, accompanied or unaccompanied, is my idea of purgatory. The violin possesses neither the acoustic interest of a plucked instrument—where every note has a life cycle of its own—nor even the dynamic guts of that other great bore, the organ. Having said this, I will try to placate the reader by acknowledging the unearthly beauty of violins in concert. Plucked, scraped, blown or thumped, any two sound generators have greater tonal appeal in unison than singly, due to the greater harmonic complexity. If this were not the case, the world would not pay whole groups of orchestral violinists to play the same musical line; the sound level alone could be duplicated, if that were all that mattered, by one violinist and a respectable PA system.

I have long doubted the value of the soundpost squeezed between the upper and lower panels of the violin resonance chamber. A colleague suggested that the post transmitted string vibration to the lower panel, aiding sound transmission. Leopold Mozart's guess (*Violin Playing*) was that it counteracted the downward string tension which might otherwise crack the body. Fair enough but why locate the post right under the bridge, where it displays maximum effect in damping bass vibration? Perhaps because an early manufacturer *wanted* just such an LF filter. When the soundpost was removed experimentally (*Scientific American*), the change in tone

One man's views on microphone placement By David Kirk

left the violin sounding rather like a guitar. In other words, the harmonic complexity was increased, probably adding to the beauty of the solo instrument. What chances, I wonder, for an international campaign to remove violin soundposts?

I mention these points to illustrate that you are defeated before you start where the solo violin is concerned. However careful you are, the resultant sound is unlikely to appeal to more than a tiny minority of the record buying public. So what do you do? Devise your own means of increasing tonal interest by using natural reverberation to create a ghost accompanist. I emphasise *natural* since the three-dimensional air motion in a hall can create more complex reflection patterns than a two-dimensional plate or a one-dimensional spring. In practice this means a coincident pair up to 4m back from the performer. With a piano accompaniment you have extra problems. The answer here is *not* two stereo pairs, nor is it a spot microphone, either of which would ruin the stereo picture unless you were (a) very skilful or (b) very lucky.

Recording violins in concert—which inevitably involves other members of the orchestra—is most easily achieved by placing a figure-of-eight stereo pair on a centre line in front of the performers, back half the effective soundstage width. This leaves the overall balance largely in the conductor's hands, which is where it should be, though you have a job to do it if he puts a feeble voiced soloist at the extreme left of the stage. The extreme right audience may not hear her (that's realism), nor may your microphones (that's a bad recording).

Guitar

My favourite guitar recordings are those which capture the lot: the low bass, the middle, the treble and the high treble action noise. Sad because most self-respecting guitarists—and I don't mean electrics—try hard to minimise bridge squeals. A solo Spanish guitar is an easy subject since the instrument has a sweet enough tone to come across dry. Additional reverberation, to my ears at least, only spoils perfection. One vital point if stereo pairing a solo guitar: if you go in close, encourage the performer not to swing about or the stereo will wander wildly. But then you know that!

Flute, oboe and clarinet

These instruments, at least the ones I've sat in front of, possess rather wild frequency responses. A previously well-behaved flute will suddenly resonate through your head, despite cerebral damping, and wrap the meter needles round their stops. If you work with VUs and monitor before tape, you risk unpleasant surprises when playing back this family. These instruments should be bathed in reverberation if recorded singly, though, like two or more violins, several flutes in unison or harmony can be very pleasant.

Organ

I once tried to classify a few friends as Organ Types or String Types (considering myself a String Type) though the majority confused the issue by claiming to be Best of Both people; nice for them. I explain my attitude by pointing out that the first hundred milliseconds of an organ note (or chord) is virtually the same as the thousands of milliseconds that usually follow it. When you've heard the first half second of a note, you've heard it all. Now air is vibrating in a fixed pipe, now it's not. In contrast, each note of a plucked or struck instrument has a life of its own, to the extent that no two Middle-Cs from a harp, harpsichord, fortepiano or guitar are ever the same. The attack, sustain and decay rates may vary, so more-or-less may the dynamics and the mechanical effect on other undamped strings.

Organ pipes extrude sound in the strangest places—everywhere, it seems, except within balanced earshot of the organist. A trial run through the various manuals and stops will reveal any your eyes failed to find. Be prepared for high microphone suspensions. A pair of capacitors and a 10m stand will handle most locations though a preliminary pilgrimage is advisable. The classic mistake is to close-mike each bank of pipes, only to wonder where the reverberation has gone and where the hiss came from.

Electronic instruments

At the present state of the art, I classify divider organs, voltage-controlled synthesisers, electronic piano/harpsichord/clavichords under the group heading 'buzz boxes'. At an exhibition one year, I heard a Lowther *Organino* synthesising a harpsichord and it sounded just like a harpsichord. The following year I heard it performing the same trick, and it sounded just like a Lowther *Organino*. That's experience. During the month EMS let me play with their *VCS3*, I found a control setting which produced a fairly realistic cello over a limited pitch range. Varying the frequency of my 'cello' waveform over more than a quarter octave, however, betrayed its electronic origin. I regard the synthesiser as a healthy step towards electronic instruments capable of equalling the harmonic complexity of acoustic instruments. They have a long way to go.

The divider organ is to me the worst horror instrument-manufacturers could inflict, entirely appropriate to introducing telly quiz shows. The fact that some divider organs come close to some wind organs is more a condemnation of the latter than a tribute to the former. And how to record them? Usually by plugging them into an equaliser with bass cut to reduce any hum. With VC synthesisers, top cut may be the only way to reduce control-oscillator clicks, assuming the filters in the synthesiser are otherwise occupied.

Voice

Lastly, the human voice. En masse it presents no problems: a stereo pair half the stage-width back on the centre line, a fairly live hall, and success is guaranteed.

Singly, matters are more difficult; few humans can croon straight into a microphone and get away with it. They require reverberation to a degree inversely proportional to their talent. A powerful voice may be captured more successfully by a stand-mounted microphone a metre or more from the artist. Note tendency of artist to move nearer microphone. This can be overcome by the mean trick of suspending the microphone above the singer's head. Guaranteed to eliminate blasting.

Last time I pointed out the danger of allowing condensation between the plates of a capacitor microphone, STC's Bob Fisher came up with the news that he keeps his in the loo. Which suggests that STC microphones incorporate a moisture seal. Many better capacitors don't and, if BF keeps these in his loo, BF will have hiss—due to the random movement of charged water particles between the plates. The moisture problem must be considered whenever a capacitor is used for close singing. A *D202* dynamic would be more appropriate to this condition.

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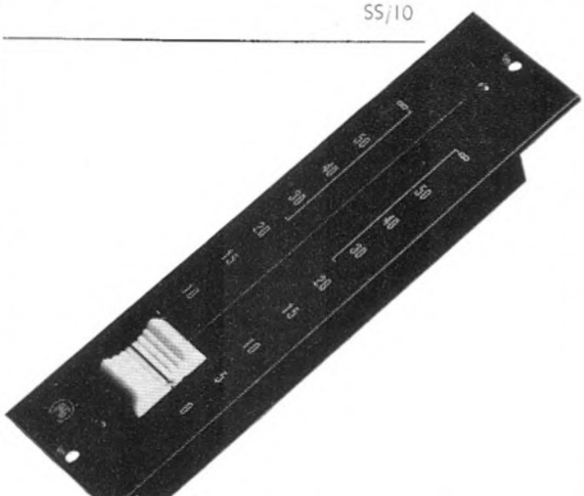

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PART FOUR INPUT CIRCUITS

THE microphone amplifiers described in last month's section can now be considered in relation to the rest of the mixer system that we set out to describe. It will be helpful if we take a look at the diagram which was printed in the July issue as **fig. 1**. It should now be possible to recognise the part that we have dealt with in the previous two articles as the portion between the attenuator switch and the equaliser section.

Phase change

Beginning at the microphone input terminals we come first to the phase change switch. This is needed because when many microphones are in use in a complicated set-up, it is quite likely that the phase difference between the electrical signals coming from two different microphones will cause signal cancellations when they are mixed together. The result might be that the level falls very dramatically when an instrument plays a certain note, resulting in the almost total absence of the signal from the final mixed output. Such problems can be temporarily overcome without the need to rearrange all the microphone placements, by being able quickly to reverse the connections to one of the microphones. This could be of great assistance in situations where there is no possibility of a rehearsal, as would be the case where a public concert was being recorded.

I must point out at this juncture that I have absolutely no personal experience of using a mixing desk to make a recording and I have to rely on the good advice of sound engineers as to the requirements of the mixer. When I am told something about the problems in using a mixer, I try to convert what sometimes seems like folklore into physics. The artistry in the use of a mixer is something that can turn what seems to me a defect into a positive advantage. Such is the case with the use of a phasing switch —clever manipulation of this can give very interesting aural effects in the finished product and the final result is what counts. I hope more knowledgeable readers will forgive me if I say something that they find to be artistically unsatisfactory.

It is usual to ensure that the phasing of all the microphones in one's possession is known. **Fig. 1** shows a dynamic microphone being affected by an atmospheric pressure variation. A compression is shown as a movement in the X direction while Y indicates a rarefaction. The pressure variations cause the diaphragm to move the coil in the magnetic field and a voltage is produced between the lead-out wires A and B. The sense of this voltage will depend on the direction of movement of the coil in accordance with the laws of electromagnetic induction. If we connect an oscilloscope between points A and B, we can observe how the voltage of A varies with respect to B as the pressure variations occur. In the diagram we have shown A moving positive with respect to B as the compression cycle occurs. If we have two microphones, each being affected simultaneously by the same sound pressure signal, it is possible to identify the leads A and B on both microphones. We can thus ensure that the two electrical signals produced have their positive and negative half cycles occurring at the same time. When this happens, the microphones are said to be in 'phase'.

There is a simple technique for checking this without an oscilloscope, as follows. The two microphones are placed close together at an equal distance in front of a loudspeaker which is emitting a constant note. This test is best done out of doors to avoid the problems caused by standing waves. The leads from the microphones are connected into the mixer and the mixed result observed, perhaps on a level indicator. If the level reading is higher when both microphones are connected than with one microphone connected, the microphones are in phase. If the combined reading is lower, the microphones are out of phase and the connections of one should be reversed. One of these original pairs should now be marked and used as a phasing standard against which all the other microphones should be checked.

Attenuator

Following the phase change switch, we have the attenuator switch. After all that was said in Parts Two and Three about not reducing the signal level before the first amplifier, here we are doing just that. The reason is that our mixer will be called upon to accept the input from various types of microphone. Most popular in studios these days is the capacitor microphone. This type has an internal amplifier and the basic sensitivity would be about 1 V/μB. This is five times as much output as the dynamic type and, if our criteria are to be observed as far as dynamic range is concerned, we must reduce this signal level to the same as the dynamic microphones. We have calculated that the maximum input level we would expect a microphone amplifier to need to handle would be about –20 dBm. It is a fact however that a capacitor microphone can produce outputs up to 0 dBm—especially if stuck up the bell of a trumpet!—and thus we provide a switched attenuator of 20 dB loss ahead of the microphone amplifier. The resistor values are selected so that the impedance presented to the microphone remains at 600Ω as does the impedance seen by the microphone transformer. The attenuator is arranged as shown (it is called an 0 or box attenuator for obvious reasons) because in this form it preserves the balanced nature of the input to the microphone transformer.

Equaliser Section

We can define an equaliser as a means of altering the frequency characteristic of an input signal. The equaliser can be used either to correct for deficiencies in the input signal or to modify the sound in accordance with the artistic judgment of the balance engineer.

The word 'filter' is sometimes used synonymously with 'equaliser' but I think of a filter as a means of removing rather than adding something. By my own definition, this is still an equalising operation.

I would like to consider the different types of equaliser that might be encountered in mixer design, or any audio engineering field for that matter. The first point is concerned with terminology—what do we call a particular kind of equaliser? Does **fig. 2** show the response curve of a bass-lift equaliser or a treble-cut equaliser? Without more information it would

(*continued on page 527*)

FIG. 1

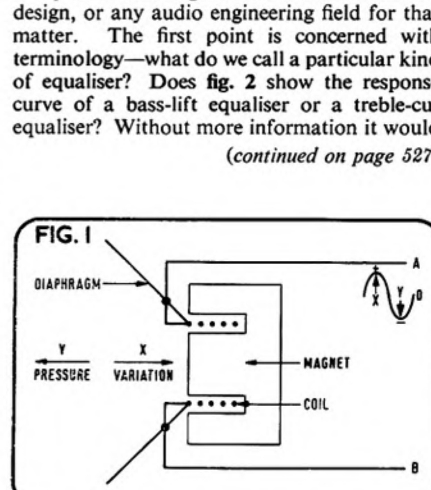
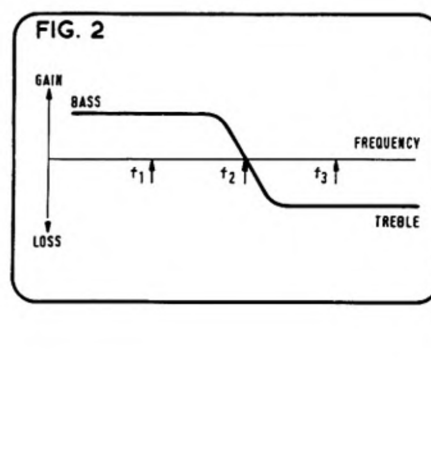


FIG. 2



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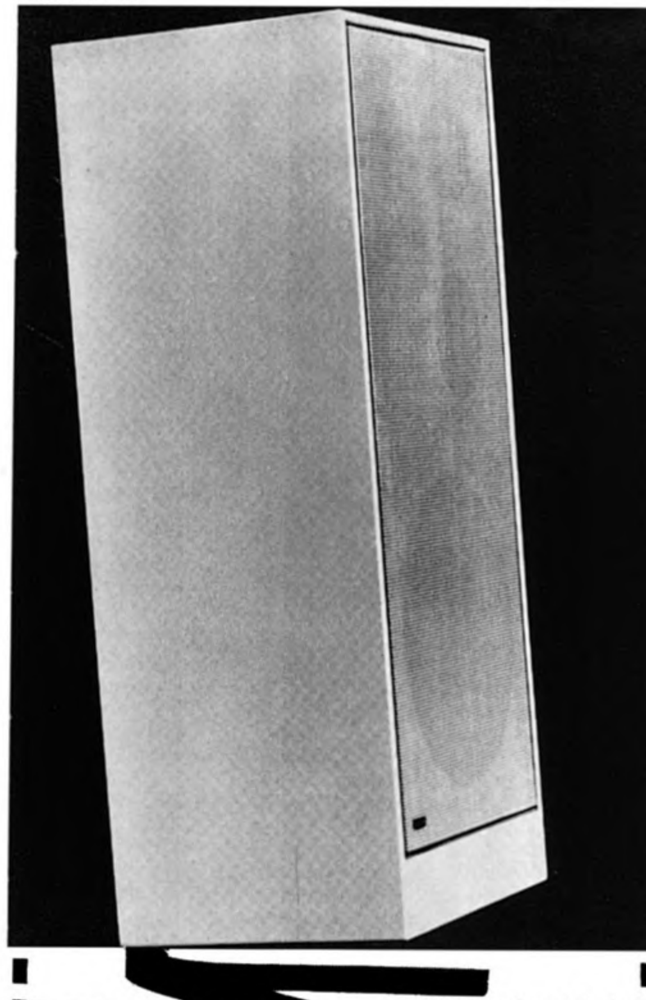

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Send to: **Dept. SS, Acoustico Enterprises Ltd, 6-8 Union Street, Kingston-upon-Thames, Surrey** Tel: 01-549 3471/3 (3 lines) be impossible to say. We have to work using conventions and agreed reference points, just as we did in the case of decibel calculations. I would approach the problem this way: suppose this curve is generated by a circuit which can be switched in or out of circuit at will.

Insertion Loss

Most equalisers, particularly passive equalisers (passive networks of resistors, inductors or capacitors), have what is known as 'insertion loss'. This means that, in order to achieve the equalising action, some gain has to be sacrificed at frequencies in what we will call the reference range. This expression will be explained below. The gain sacrificed is called the insertion loss and this loss can be made up by the use of an amplifier. We shall assume that **fig. 3** consists of a passive equaliser and a compensating amplifier so that its gain is unity or 0 dB in the reference range.

If we pass a low frequency signal, say f1, through this system, we can operate the switch and observe the output signal on the meter. Let us further suppose that the meter reads the same, no matter whether the equaliser is in or out of circuit. We now can set the oscillator output to f3 and will observe that, with the equaliser switched in, the reading on the meter is lower than without the equaliser. This circuit would then be known as a 'treble cut' equaliser because it has no effect on low frequencies but reduces gain at high frequencies. When seeking a title for an equaliser, therefore, we determine the frequency range over which the equaliser has unity gain—over this range it makes no difference whether the equaliser is in or out of circuit. Any frequency within this range can be used as a reference and the equaliser will be named according to the effect it has on frequencies outside this reference range. We can call this other range the 'effective range' of the equaliser.

It should be now clear that there are two main classes of equaliser that we may come across. The first and simpler type is that which divides the frequency band into two portions. **Fig. 2** illustrates such an equaliser. We have decided by the test above to call this a treble cut equaliser and we have seen that the frequency band is divided into the reference range and the effective range. The changeover between these two conditions occurs at about f2, the reference range being to the left or low frequency side. This frequency is known as the transition frequency and can be abbreviated to ft. The second and more complex type of equaliser, illustrated by the curve in **fig. 4**, divides the frequency band into three portions, two reference ranges on either side of an effective range. There are two transition frequencies: ft 1 and ft 2, and another frequency where the equaliser has greatest effect. This can be called the peak frequency or fp. The effective range in this case clearly lies between ft 1 and ft 2.

Type One Equalisers

We often read the statement in amplifier literature or mixer specifications that 'the bass control gives plus or minus 10 dB at 50 Hz' or something similar. **Fig. 5** shows why this is a very unsatisfactory way of describing such an equaliser because two different equalisers could give this result but the audible effects would be very different. Example (b) equaliser (broken line) has a much higher transition frequency than (a), but (a) has a greater slope rate which continues below 50 Hz while that of (b) shelves off. We clearly have to include much more information in our specification if we are to get the same audible effect from this same set of figures. **Fig. 5** illustrates the necessity to consider a subdivision of Type One equalisers. We can call Type 1a *sloping equalisers* and Type 1b *shelving equalisers.*

To specify an equaliser of Type One completely then we need to know:

Transition frequency.

Slope rate.

Whether it shelves or not and, if so, the maximum deviation from reference.

Transition frequency has been mentioned above and we need to have a method of determining it. We can say perhaps that the transition frequency is that frequency at which an equaliser becomes significantly effective. How significant is 'significantly effective'?

Audio engineering is basically a commonsense technology and something significant is 'what can be heard to be significant'. It is of course obvious that the cumulative effect of several phenomena in themselves undetectable to the ear may be quite audible and therefore significant. Thus it is necessary to have some means of deciding, by measurement, where an equaliser becomes effective. Experience shows that in practical cases the effect of an equaliser becomes apparent very gradually as the frequency band is explored. In the end we have to accept a convention when specifying the point at which the equaliser can be said to be effective.

In Part One we talked about the unfortunate effect of cable capacitance on the frequency response of an amplifier. Here, we are using exactly the same effect as a useful tool rather than as a burden that must be shed as far as possible.

Fig. 6a shows a simple equaliser made using only resistors and a capacitor. A switch is included which enables us to bypass R_2. With R_2 shortcircuited we can plot the frequency characteristic of the equaliser. This is done by starting off with a low frequency and observing the output across C with the meter. The oscillator output can be adjusted to give a reading of 0 dB on the meter and this will be our reference level. It will be found that if R_1 is short circuited while the frequency is low,

(continued on page 529)

FIG. 3

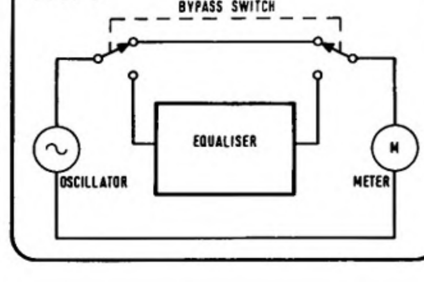


FIG. 4

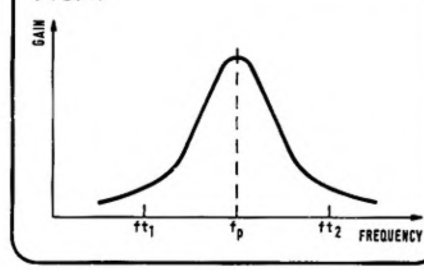


FIG. 5

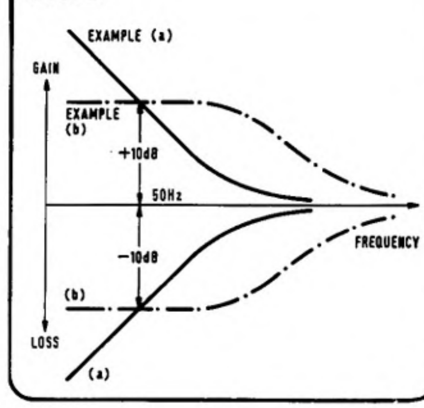
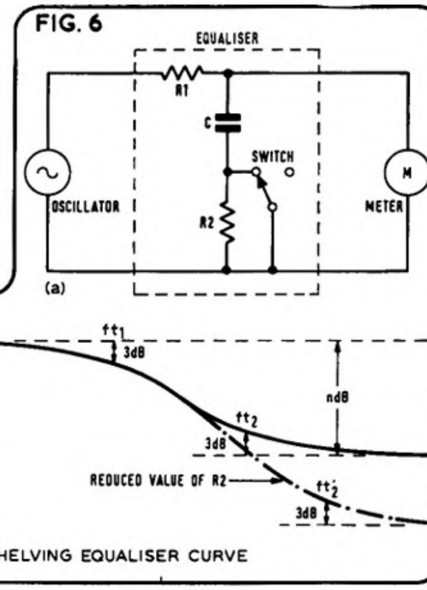
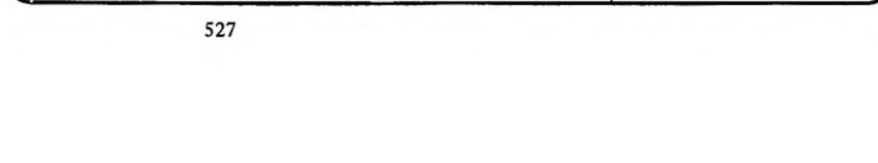


FIG. 6





(b) SLOPING EQUALISER CURVE (c) SHELVING EQUALISER CURVE

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effectively bypassing the equaliser, the reading on the meter will be unaltered. This is provided that the output impedance of the oscillator is very low compared with R_1 and that the input impedance of the meter is very high compared with R_1. The frequency of the oscillator can now be increased in convenient intervals, the reading on the meter being noted and written down in a table alongside the corresponding frequency setting. The readings should be made in decibels and in this case they will be negative readings relative to 0 dB. Finally, the results can be transferred to graph paper and a graph similar to that in **fig. 6b** will be obtained.

Sloping Equaliser

This graph will illustrate two of the points we wish to know. A point on the graph will be found where the response has fallen to −3 dB and it can be shown mathematically that this is where the capacitive reactance is numerically equal to R_1. This point is taken by convention to be the transition point of the equaliser and is called ft. 3 dB is also just above that minimum change in level that the ear can detect and so this point is the minimum significant departure from the reference point. If the graph is continued it will be found that eventually it becomes a straight line sloping downwards. A constant slope rate has therefore been established and we can measure what this is by considering the loss at two frequencies an octave apart. (Slope rates are usually given in decibels per octave.) The two frequencies are shown by f and 2f on the graph and the difference between the two loss values is found to be 6 dB. The slope rate is therefore 6 dB per octave in this case. The slope rate and the transition frequency can both be altered in order to vary the effect of this type of equaliser on the audio signal and with practical circuits it is customary to vary one or the other, keeping one fixed.

Shelving Equaliser

Fig. 6c shows the effect of R_2 on the results. If we open the switch, a frequency will be reached where the reactance of C has fallen to a value which is comparable to that of R_2. When this happens, a limit is established to the loss that is possible because the effect of reducing the reactance of C as frequency increases is less important. The response curve will thus level out forming a shelf at some level depending on the ratio between the resistor values R_1 and R_2. The value of R_2 will also determine the frequency of the higher transition frequency ft 2. This will be the frequency at which R_1 is equal in value to the reactance of C. The dotted line shows what is the effect of reducing the value of R_2. With this type of equaliser it is not possible to alter the loss value without altering the transition frequencies.

One final point that should be made about these equalisers is that where the slope rate or shelf ratio is insufficient to allow a loss of at least 3 dB, the transition frequency becomes indeterminate. In the case of a sloping equaliser this does not matter very much because it is doubtful whether the effect of this type of curve could be detected. In the case of the shelving equaliser with a difference of 3 dB or less the transition frequency would perhaps lie on the centre of the sloping portion as illustrated in **fig. 2** by f2.

Sloping and shelving equalisers form the basis of the vast majority of what are known as 'tone controls' in domestic equipment. They are very useful for large scale alterations in frequency response but also useful are more precise equalisers which have their effect over a more limited range.

The first type we should consider is really a special case of the sloping equaliser, but here the aim is a very steep slope rate and a well defined transition frequency. These are used as high or low pass filters for limiting the frequency range of an audio signal to get rid of low frequency noise such as hum or high frequency noises such as hiss or whistles. The main point is to extend the reference range as far as possible and rely on a rapid loss of gain outside the reference range to get rid of the offending signals. Slope rates of 18 dB/octave are not uncommon with this type of circuit and active filters are becoming more and more popular for this application.

Peaking Equalisers

The second type of limited range equaliser is known as the peaking equaliser as illustrated in **fig. 4**. This type of equaliser is subject to the same lack of precision in specification as the Type One equaliser was. We often find them quoted as having so many decibels boost or dip at such and such a peak frequency. This amount of information is clearly insufficient to specify the equaliser performance since, as before, two equalisers could give this measurement but sound entirely different. **Fig. 7** shows why this is so. We can see straight away that the two curves indeed have the same height at the peak frequency. The difference lies in the distance between the transition frequencies. This is not the same as the bandwidth of a tuned circuit. If the curve were produced using the properties of an inductance capacitance resonant circuit, we could specify the bandwidth in the classical manner as the difference in frequency between the two points on either side of the peak where the response has altered by 3 dB from the value of peak frequency. This shape of response curve can be produced by many different means—for instance by using the combined effect of two Type One equalisers such as a bass cut and a treble cut—so this definition of effective band will not do. The method that I prefer is to specify the points at which the response curve has altered by 3 dB from the reference level as in the case of Type One equalisers. There would thus be a considerable difference between the two specifications of Curve One and Curve Two in **fig. 7** by this method which would give a more accurate idea of the audible performance of the circuit.

Summary

We have looked at the way in which the shorthand methods of describing the performance of equalisers can be very misleading. The reasons have been discussed and an attempt has been made to say what extra information is needed to give a more accurate description. We have also grouped together the various types of equaliser and given titles by which they are commonly known. The list below may help to tidy things up.

The following examples can be either of the above two types:

Bass Lift — Bass Cut
Treble Lift — Treble Cut

Type One Equalisers
- Sloping Equalisers
- Shelving Equalisers

The following are usually special versions of Type 1a:

High Pass — Low Pass

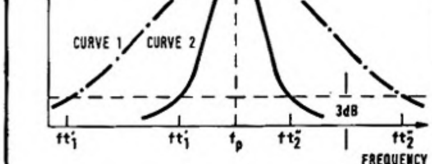
Type Two Equalisers
- Peaking equalisers
- Boost or Presence
- Dip or Absence

The 'Presence' equaliser is so called because the audible effect is to bring certain sounds forward towards the listener.

In the next article, practical circuits will be discussed and details given of a module which incorporates some of the features that have been dealt with here. It is also planned to go on to the mixing and routeing problems.

Errata (fig. 7): for ft_1' (curve 2) read ft_1''; for ft_2'' (curve 1) read ft_2'.

FIG. 7



The table below compares the performance of the MPA 1 and MPA 2 microphone amplifiers described last month.

	MPA1		MPA2	
Input terminals	1 & 3	4 & 5	4 & 5	
Input impedance	450	900	600	ohms
Supply voltage	30	30	30	volts
Supply current				
No signal	3·8	3·8	8·3	mA
Full output (see Note One)	7·7	7·7	12·0	mA
Maximum input before clipping (see Note Two)	−25	−22	−20	dB
Distortion (2 dB before clipping) (see Note Two)				
1 kHz	1·1	1·0	0·09	%
40 Hz	1·0	1·0	0·25	%

	MPA1		MPA2	
Noise output at full gain:				
Open circuit input	−62·5	−62·5	−68	dB
Input loaded with 600Ω	−59·5	−59·5	−67	dB
Noise output at minimum gain	−80	−80	−80	dB
Overall maximum gain	63	60	59	dB
Equivalent input noise				
Open circuit input	−125·5	−122·5	−127	dB
Input loaded with 600Ω	−122·5	−119·5	−126	dB
Frequency response				
HF −3 dB point	36	60	52	kHz
LF −3 dB point	3	*	2·5	Hz

Note One. Full output is +20 dBm

Note Two. The gain control is adjusted so that input and output amplifier overload at the same input signal level

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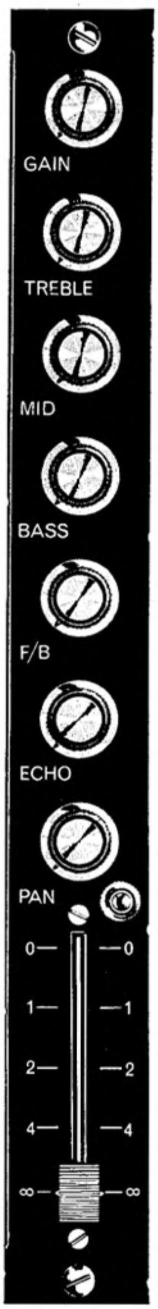

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SESSION MANAGEMENT AND EDITING

ON most recording sessions the chief recording engineer is not in charge of the session itself, this being run by the music producer. Engineer and producer must work together in close harmony rather than each keeping strictly to his own job. It is normal practice for the recording engineer to use the talkback at the beginning of the session while he is obtaining a satisfactory balance. During this time the producer may be in the studio itself discussing musical points, or giving advice in the control room. The engineer may well notice a musical point which has slipped the producer's ear, and the producer may hear an unsatisfactory point of balance which the engineer has not noticed. Both should sit in a good position between the monitors.

Although the interpretation and performance side of the recording is the producer's responsibility, being followed with a score, it is a considerable advantage for the engineer to have a wide knowledge of classical music, and to know immediately the sounds from different instruments and the different timbres of each instrument in different registers. Too often, the producer concentrates entirely on his music and the recording engineer alone has to decide the type of balance that will show the music off to its best advantage.

Since recording engineers have very considerable responsibility, they should attend live concerts as often as possible to remind them of the sound produced in a typical concert hall. I will never forget a year or so ago hearing that one engineer recording classical music had never been to a live classical concert. From what I was told, he balanced the musicians as he might have balanced a pop group, using echo chambers and much equalisation to overbrighten the sound. It is for this reason that the *Tonmeister* Course has been started at Surrey University, Guildford, requirements for the course being A-level Physics and Music. Although this may well keep out some very capable students, as a rule qualification in both aspects of the art will be of great advantage on sessions.

With pop music, I feel that it is just as essential for the engineer to be familiar with a group's style. A first class balancer can contribute significantly to a record's success. By the artistic use of gimmicks, a mediocre group can be made to sound very commercial. Since musicians have to be paid by the session, and clients obviously do not like to have to pay overtime, it is vital for all the equipment to be set up satisfactorily before the start of the session.

It is the producer's job to make sure the artists have rehearsed adequately before the recording, and to liaise with the recording engineer to discuss any difficult points of balance which may arise. The engineer should satisfy himself that the recording location is satisfactory, although he cannot be held responsible for external noise if the client has specified the location. It should not be assumed that the location is quiet if it is only heard on one day to be so. An example of this was a recent occasion when a recording was made on the Friday before a bank holiday, only to be continually interrupted by the greatly increased air traffic from Heathrow. On occasions such as this it is especially important to work with the musicians as a team, and I will not forget the co-operation of a string quartet who packed in perfect takes between take-offs.

Tact can also be of importance when, for instance, a member of the public starts repairing his car almost outside the location, revving up and running the wheels with the car jacked off the ground. This actually happened just before a session, the answer being to invite the chap in for a few minutes so that he could see what was happening, rather than simply asking him to stop.

Much has been said on the advisability of playing back takes to the musicians during a session. If the musicians are not working on a per-session basis, I usually like to play back quite a lot since it definitely improves the team spirit.

A number of different methods can be used to identify takes, one being to use a three-figure number, the first designating the tape spool and the last numbers the overall take number. Alternatively, the last number may be the actual take number on the particular spool.

Very clear note should be kept of all takes, including false starts, with the movement noted as well as the take number. It is probably best for the music producer to make his own notes although the tape machine operator would be wise also to make notes, which will assist in editing. He should note suitable editing points during the performance, while the recording engineer is concentrating on general sound quality. During a session he can help the producer by identifying the passage just before an edit point after a retake. When recording retakes it is important to start a few bars before the intended point for editing so that the music of the retake just before the edit point will create an overhang of reverberation in which to edit from the first take. This almost always allows an excellent transition. If an edit is carried out into a retake that starts at the edit point, the first second or so after the edit will sound slightly peculiar and dry, and will be quite obvious to more knowledgeable listeners.

Although the producer will be listening for incompatibilities of mood and tempo on retakes, the engineer too can be careful to listen for any discrepancies. It is by teamwork such as this that considerable time can be saved.

Many recording engineers allow the talkback to be directly injected on to the sound balance in the mixer for clearer identification during editing. Some engineers have also fitted a 40 Hz oscillator on their desks which feeds on to the tape when the talkback key is depressed. This allows the beginning of any take to be quickly identified during fast spooling.

For ease of editing it is essential that the tape path is as simple as possible with the front of the heads open allowing wax crayons to be used for marking the tape while it is resting against the play back head. I will never forget one colleague attempting to edit on a machine where the tape had to run, as he put it, 'once over the heads and twice round the gasworks' from the left to right spools.

An editor should have an adequate supply of empty NAB spools, and also the facility for playing the tape at half its normal speed to hear the edit in 'slow motion'. It is probably best when any take has been withdrawn from a spool for the remaining takes to be joined together in their original order so that they can be found again quickly if necessary. When an edit is perfect, my colleague often likes to join bad to bad as this helps to keep the takes in a convenient temporary order.

At the recording session some ambience should be recorded with all the musicians seated quietly. This can be used not only to lengthen gaps in the music but also for placing in the master between movements instead of leader tape if scrolls are not required by the producer. Leader tape can remove the intimacy of a record by withdrawing the listener momentarily from the recording. If scrolls are required the editor or producer has to be present when the disc is cut to tell the cutting engineer when to make them. Since traffic noise is most noticeable when musicians are not playing, as in a musical pause, these pauses can be edited out and quieter ambience inserted.

Sometimes a particular passage is repeated elsewhere in a piece of music, and where one section may be faultless the other may have a noticeable flaw. Although on musical grounds it is wrong to use the best performance for each section it is frequently essential and should be done by copying the master from another machine on to the machine that was used for the session. The greatest care must be taken in ensuring that the levels and equalisation are identical on the copying equipment, producing a copy as indistinguishable from the master as possible. Unfortunately this can only be done really successfully if the original recording is Dolbyed, otherwise any noise audible on the copy would be edited back into the original master.

If it is necessary to split a recording session over two or more days and in the interval the microphone setup and control desk settings have to be disturbed it is vitally important to make a note of all these positions. Even if an

(*continued on page 533*)

Studio Who

by Adrian Hope

IT was 10.30 a.m. on a rather misty spring morning. I was on Eel Pie Island in the Thames at Twickenham watching them demolish the old hotel there. On and off over the years, Eel Pie Hotel had been a venue for rock groups. When derelict, it ended up as a comparatively respectable commune. A while ago the order was given to pull it down and build houses instead. As I had half an hour to spare before visiting a private studio in the area, it seemed like a nice idea to see it for the last time. The fire brigade were already there and had wheeled a portable pump over the narrow footbridge to take water out of the river and on to a blaze which had broken out in the partly demolished hotel. Apparently there's a rule, law or tradition that says you can't just burn something and knock down what's left. You must first knock it down and then burn what's left.

On this occasion the smoke, flames and general excitement seemed fitting because the studio I was due to see belonged to Peter Townshend of The Who pop group. The group used to end their act by destroying instruments and amplifiers. Townshend let me spend some hours with him looking round the recording studio he has built in his home.

Why is it becoming more and more common for successful pop musicians to build a studio in their own homes? There are two main reasons. Firstly, the obvious one that groups can produce records under their own control without having to stir out of their own front door (notably the Paul McCartney LP of a year or so ago). The other and less obvious reason is that it enables a pop composer to produce his own demo discs of his compositions.

Townshend's father, Cliff Townshend, is well known and respected as a big band reed player and has graced the saxophone sections of most of the best British bands and studio groups over the last few decades. His son admits a feeling of disappointment that he never stuck at learning music the formal way long enough to become a sight reader.

Townshend writes most of the music the group plays. To present this in its best light to the group and to the people who record it (Glyn Johns, of whom he speaks very highly, and their producer Kit Lambert) Townshend must produce his own demos. Having heard a few of these, which he spends about a day each on making and which are built up by multi-tracking his own playing of all the necessary instruments, I began to wonder why he bothers to get the group together to re-record it. Both musically and technically the quality that Townshend produces in his tiny home studio really is astonishing. The reason the group does get together to re-record is the same reason why the group has stayed together all these years. In a nutshell they enjoy touring and then playing together in front of live audiences. The average length of their performances is some two and a half hours.

The studio is very small. Once a bedroom with an adjacent bathroom, the bedroom is now the studio proper and the bathroom contains racks of gear.

Townshend originally started making his own demos with a Vortexion *CBL* and it still stands in a corner. From there he went on to a pair of Revox *G36* hitched to Dolby *A301*. He then installed a 3M eight-track machine and now has in all five Dolby *A301* to cope with the total eight tracks and one stereo dub. An Ampex four-track machine was bought after the 3M eight-track for quadraphonic reduction and the nerve centre is a Neve studio mixer. For playback Townshend uses an American SAE amplifier which powers a pair of Lockwoods.

Among the drums, piano and various guitars in Townshend's studio, I noticed what looked like a Moog but wasn't. In addition to a *VCS3*, Townshend is now using an ARP synthesiser. This is something of an advance over the Moog in that, instead of using patch chords, it uses a matrix system of selection levers. With a matrix like this there is nearly, but not quite, the freedom from crosstalk that the Moog patch chords provide. But the main advantage of the ARP is that it plays up to six notes at a time (most synthesisers to date have been monophonic) and Townshend is impressed with the way his £5,000 of oscillators stay spot on in tune after initial setting. In his studio Townshend mostly uses Neumann capacitor mikes but has recently discovered the Sony *ECM 377* capacitor.

Townshend once recorded The Who for release on an EP but the project foundered. At least two LPs (other than the demos) have been issued, however. One is by Thunderclap Newman and the other to celebrate the eastern spiritual leader Meher Baba. The Baba LP is in a limited edition only and thus unlikely to be retailed. If you have heard it, I think you'll be impressed by what was done on a Revox *G36* with Dolby *A301*.

STUDIO TECHNIQUES continued

engineer thinks he could improve the sound with a different balance he is not advised to try, as he will probably be criticised for inconsistency.

Since it is easy to press the record button absent-mindedly after editing for several hours on some machines, it is advisable to have a switch on the back of the editing machine to disconnect the voltage supply to the bias and erase oscillator. If this is not possible valves should be withdrawn or the oscillator and bias printed circuit boards removed, preventing any accidental damage.

Studios do not generally use LP tape, particularly for live concerts or on mobile sessions. LP tape, let alone anything thinner, is very difficult to edit and tends to curl slightly when cut due to the differential stresses between oxide and binder, the plastic base of the latter being too thin to stop these stresses from causing a curl. Matt backed tapes are in general easier to edit because they are thicker.

As to the actual points where it is best to edit from one tape to another, the decision can really only be taken after considerable experience. As a rule, apart from obvious editing points, it is better to edit close to and immediately prior to a transient or the beginning of a note. Under these circumstances the editor must listen carefully to held notes by other musicians to make sure that the sound is the same. It can be very dangerous to edit during a held note since these usually not only vary in volume within themselves, but almost always will be at a different volume on another take. The ear will at once notice even a small sudden change in volume, but a gradual change is almost unnoticeable. If such an edit is essential it can be covered over if the edited tape is copied and very slight reverberation added over the edit which will tend to mask the level change. Many companies have used this technique when dubbing 78s to tape, covering the side changes with reverberation.

Editing is a very skilled art and it takes a great deal of experience before it can be done with consistent skill. Practice makes perfect, and I can only suggest practising with recordings from BBC broadcasts of speech, transposing words etc. Some of the news broadcasts are of particularly fine quality on Radio 4. It would probably make a good training to start such editing from recordings made at 19 cm/s, for if this is mastered 38 cm/s recordings will be found much easier.

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Directors: John Mosely, Denis Comper, M. S Gampell, T. Miller P. Nutting

General Information: Command occupies the premises once known as BBC Piccadilly One, two minutes walk from Piccadilly Circus. This studio was the home of the Allied Forces Network, and the place where Glenn Miller gave his last performance.

Studio One: Will accommodate up to 100 musicians, and seat an audience of 40. The total area is 223 m², the sound stage area occupying 176 m². This studio can be divided by three sets of curtains, has electrically operated main curtains, and theatre lighting with dimmer panel control. The average height is 7.5m.

Studio Two: Suitable for up to 35 musicians. A double tracked curtain can divide the studio in half. Floor area is 102 m². This studio is particularly suitable for heavy groups. The adjacent isolation booth also adjoins studio three, and can be used as a mini-studio in conjunction with any control room, or the copy/edit room. The area of this booth is 13 m².

Studio Three: The floor area is 84 m² and the studio holds up to 20 musicians.

All Studios: An isolated safety power supply is provided for electrical musical instruments. The colour and intensity of studio lighting can be varied to suit the mood of the moment.

Control Rooms: All control rooms are identical in layout, physical volume, and equipment, so that the monitored sound is consistent from one to another. Built by Automated Process, the consoles have 24 inputs feeding 24 outputs, comprehensive equalisation, limiting/compression, and access to three different echo systems, including a natural echo chamber. There is full remote control of tape machines, noise reduction system, and sync facilities. Monitoring facilities include speakers mounted behind the engineer for quadraphonics. There are four separate foldback systems, and all studio headsets have individual programme selection and gain controls. Spare relay circuits are available so that, should there be any special or unusual requirements, compatible external equipment can be plugged up and brought into operation at the push of a button. There are three Scully tape machines mounted as an integral unit in each control room. Two provide one to four track facilities, and the third is for eight or 16 tracks, and can easily be converted to 24 track working. Varispeed control is available for running the recorders at precise non-standard speeds. The flick of a switch changes the console from record to reduction, and all consoles have VUs, PPMs, and phase-metering.

Master Control: All video, audio, and control lines are routed through this room, enabling all other locations to be linked in any combination.

Copy/Edit Room: Can copy anything up to four track. Eight or 16 track copying is done by linking control rooms.

Music Services: All studios are provided with grand pianos. Studio One has two Steinways. Any other musical instrument can be supplied to order.

Disc Cutting Room: This is equipped with a Scully/Westrex *3D11* mastering lathe which has automatic depth, pitch and spiralling controls. Full equalisation, limiter/compressors, and Dolby noise reduction systems are incorporated.

Video Facilities: The twin CCTV link in every facility can also be used for video recording.

Mobile Recording: Command's engineering staff will undertake location assignments.

Catering Facilities: Vending machines provide light refreshments and a fully equipped canteen can be used by special arrangement.

Parking Facilities: A list of 11 public carparks all within 500m will be supplied on request. Arrangements can be made to park orchestra vans all day every day outside the Jermyn Street entrance.

Hourly Rates

Studio One:	
Recording 1/2/4 track	£28·00
Recording 8 track	£30·00
Recording 16 track	£32·00
Studios Two and Three:	
Recording 1/2/4 track	£24·00
Recording 8 track	£26·00
Recording 16 track	£28·00
Reduction 4/8 track	£16·00
Reduction 16 track	£20·00
Copying/Editing 1/2/3/4 track	£5·00
Copying/Editing 8/16 track	£20·00

Tape Charges (per reel, 3M 202):

6·25 mm	£5·00
12·5 mm	£10·00
25 mm	£16·50
50 mm	£35·00

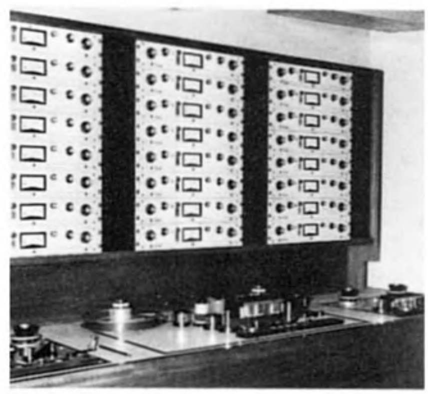
Disc Charges (Acetates):

33 rpm, 305 mm, single-sided mono LP	£7·00
33 rpm, 305 mm, double-sided mono LP	£9·00
33 rpm, 305 mm, single-sided stereo LP	£8·50
33 rpm, 305 mm, double-sided stereo LP	£12·50
45 rpm, 178 mm, single-sided mono SP	£1·50
45 rpm, 178 mm, double-sided mono SP	£2·13
45 rpm, 178 mm, single-sided stereo SP	£3·75
45 rpm, 178 mm, double-sided stereo SP	£5·50
45 rpm, 178 mm, single-sided mono EP	£2·50
45 rpm, 178 mm, double-sided mono EP	£3·50
45 rpm, 178 mm, single-sided stereo EP	£4·75
45 rpm, 178 mm, double-sided stereo EP	£6·75

Disc Charge (Masters—per side):

33 rpm, 305 mm, mono LP	£9·00
33 rpm, 305 mm, stereo LP	£14·00
45 rpm, 178 mm, mono SP	£6·75
45 rpm, 178 mm, stereo SP	£8·75
45 rpm, 178 mm, mono EP	£7·75
45 rpm, 178 mm, stereo EP	£9·75

Other Charges: There is a 25 per cent surcharge after 6 p.m. on weekdays, and a 50 per cent surcharge all day on weekends and Bank Holidays. Cancellations within 24 hours of the session are charged at 50 per cent, and those between 24 and 48 hours are charged at 33⅓ per cent.



Top: Denis Comper at 2/4 channel Scully.

Middle: Bank of 8/16 channel Scullys.

Bottom: Mixer close-up showing quadpots.

Servicing

BY H.W.HELLYER

FERROGRAPH SEVEN

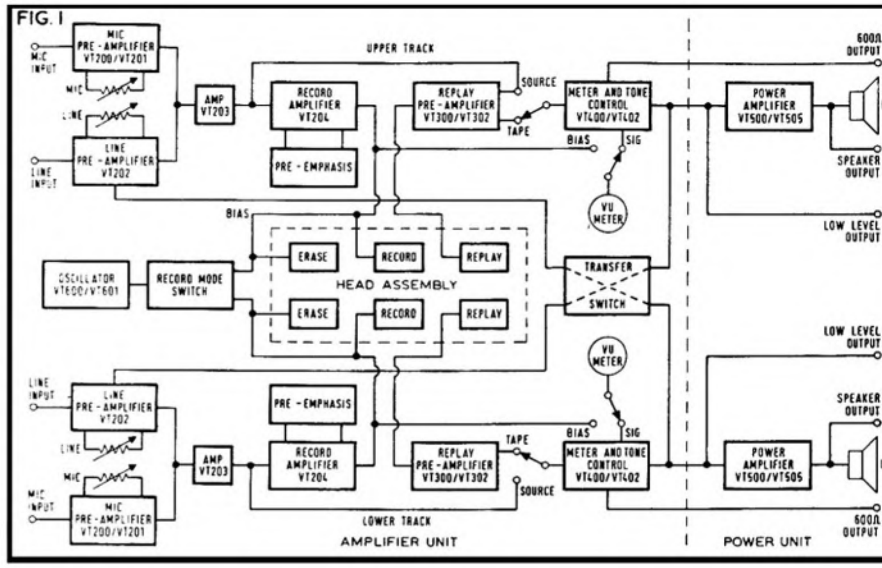


FIG. 1

A YEAR ago—for my sins, it seems—I promised to give details of the equalisation adjustments for any reader who wanted to know how Ferrograph ironed out some of the frequency response problems on the *Series 7*.

Anyone who has studied the service manual—a very comprehensive document—or had to service an ailing machine, will verify that attention to detail and meticulous thoroughness are hallmarks of Ferrograph construction. One of the facets of this fastidiousness is the adjustment—or at least, possible tailoring—of the record and replay response curves. Some alterations are within the control of the operator. Record gain can be preset as well as manual, bias can be altered and recording level set as desired. But frequency-conscious circuits have to be altered by changes in circuit time constants. This is done by altering components and adjusting presets within the machine.

Easiest way to understand the Ferrograph *Series 7* circuits is reference to the **fig. 1** block diagram.

Stereo models are duplicated mono as far as the electronics are concerned. Line and mike inputs have their own preamplifiers, with individual gain controls.

One or two differences have come about since Ferrograph issued the diagram. The transfer switch, for example, (not on mono models) takes a signal after the tone control amplifier. The replayed signal from one track is passed to the line input of the other track and rerecorded as shaped by tone controls. Early models did not allow this: tone controls were inoperative for the transfer signal up to serial 70,500.

That number is a crucial change point. Earlier models also had a centre position of the tape/source switch, labelled 'Normal'. A 48V relay in the power unit was energised by the same microswitch that energises the oscillator when the record button is locked on. This had contacts switching the record signal via the output switch to the VU meter. During fast wind, stop or play modes, the tape signal reached the meters, but if the record button was pressed the meter registered the source signal.

On later models, additional components were fitted for equalising and these are shown dotted in our **fig. 3.** We shall refer to this drawing again later, where differences between the *H* (high speed) and normal models will also be noted.

To get an idea of the way the equalisation is performed, it may be instructive to run briefly through the relevant parts of the circuit. Referring to **fig. 2a,** we find the replay signal from the head applied to the base of VT300 via an isolating capacitor. There are two components in this circuit worthy of note: possibly to give answers to some of those correspondents who complain: 'I continually get the Light Programme when I try to record . . .'

The important additions are R300 and C302, put there precisely to prevent such a mishap.

Equalisation is applied via a negative feedback loop over VT300 and VT301. Switch SW700 selects the RC combination for the appropriate speed. Treble response is affected by the three capacitors C313, C315 and C316, and to some extent by C314, C317. Bass response can be tailored by alterations to the series resistors R315 or R317.

The only significant difference between the circuit given and that of stereo models is a variable resistor, shunted with a capacitor (100 kΩ, 600 pF), between the emitters of the first transistor of each channel (VT300). The resistor is adjusted for minimum crosstalk.

Part of the equalisation circuit is switch SW700 1c, which varies the treble lift according to selected speed by varying the capacitance across the base of VT302, and thus the phase shift. The idea is to get a small treble lift and then a rapid fall-off, to reduce hiss by keeping the frequency response only as wide as it has to be, then to make it tail off rapidly.

One of the effects of this sort of tailoring is to guard against high frequency pick-up from the oscillator circuits. However much one may filter the feed to the recording head or the associated lines to the rest of the circuit (metering, monitoring and transfer links are common culprits here), there can be bias pick-up. If it is largely unavoidable, one gets rid of its effects by reducing the bandwidth. Reducing, that is, the unnecessary bandwidth beyond the specification, with a filter, or, in this case, a carefully tailored curve.

In **fig. 2a** there is one unexplained component. This is C312, whose function, in conjunction with R313, is to reduce the output from the replay preamplifier when the Ferrograph 7 is fast winding. The phenomenon of 'tweeter burnout' has been diagnosed as due to the high frequency energy generated when a tape recorder was rewound. Mid-frequency high amplitude tones become fierce HF shrieks, as our ears already inform us. The signal already at high frequency becomes supersonic and the tweeter goes haywire. Ferrograph protect users by putting C312 in circuit via the deck switching.

Digression . . . after having had to change many a loudspeaker unit through abuse I am always hopeful that loudspeaker protection will become more general. Manufacturers ought to concern themselves not only with circuits that prevent an amplifier from crumpling at the seams when its nominal 4Ω load sinks below half that value on deep bass, but also with devices that can protect loudspeakers from misguided attempts to click switches.

So far, we have discussed equalisation components in the replay preamplifier. Which is where you'd expect to find them. Right? Wrong. The components we have so far been discussing are mounted on the replay board and another board called the equalisation board (or, more correctly, 'pre-emphasis board') is mounted at the front of the amplifier section, carrying components we shall meet in **fig. 2b.**

The reason for this is the need to maintain a good noise figure by avoiding interlinking screened cables from the replay board. Components are mounted thereon and can be changed as the need arises, being suspended by their lead-out wires between raised pins. One can do quite a bit of fine adjustment to the replay curve by changes of value.

For now, let us note the required values, and here, of necessity, a table will be more helpful than pages of notes. There are high and medium speed versions, needing different resistors, mono and stereo versions (which, being duplicates, need not bother us at this point), and three production categories. These refer to machines from 70,000 to 70,499, 70,500 to 74,999 and 75,000 onwards. **Table 1** gives the values of the components in **figs. 2a** and **2b** that vary, and which are not specified in our circuits for this reason.

The equalisation components of **fig. 2a** are fixed. Some variation can be effected by direct component changes and by careful selection within the tolerances. The pre-emphasis, however, allows more immediate variation, with preset resistors RV711, 712 and 713 for the low, medium and high speed selection respectively.

A better understanding of how and why we should adjust these can be gained from a look at the sub-circuit of VT204, and its feed transistor VT203. From the collector load of the latter it will be noted that a take-off point is provided. This supplies the 'source' signal. Note that the take-off is via a bass-reducing circuit, C212 and R222. This is because the input to this stage from the matching impedance transfer stage, an FET with unity voltage gain, (signals to gate, follower configuration), has been bass boosted by the feedback circuit C210, R217.

RV220 is adjusted at high speed setting, to give the same output level at the '600 ohms output' socket when the tape/source switch is in either position.

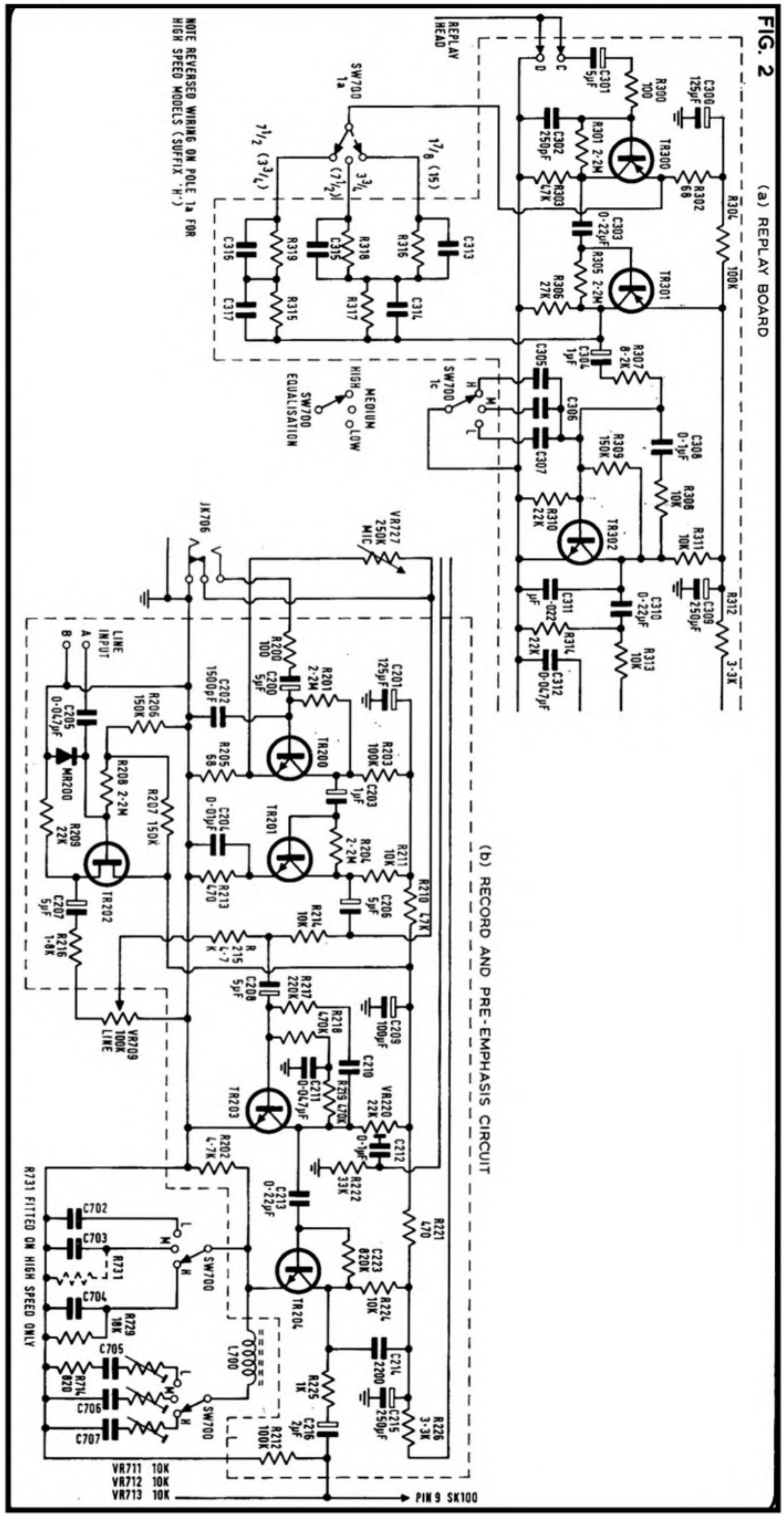
Heavy Feedback

The second take-off from the collector of VT203 is via C213 to the base of the record amplifier VT204. This amplifier has heavy negative feedback. To give the necessary high frequency boost to the signal applied to the record head, reduction of this feedback is needed, which can be done by varying the negative feedback, i.e., altering the C702 to C704 values.

A little twitch at the end of the high frequency response is given by the CR components in series with the inductor L700, these being across the emitter bypass capacitors previously mentioned.

Once again, a table could help to detail the various adjustments, but here we shall attempt a summary instead. The crucial frequencies are different for the different speeds of operation. At 38 cm/s we are interested in the bands 8 to 18 kHz and 18 to 22 kHz; at 19 cm/s 5 to 15 kHz and 15 to 18 kHz; at 9.5 cm/s, 3 to 10 kHz and 10 to 15 kHz. In each case, the capacitor in circuit is trimmed (shunted?) for adjustment at the lower of the two frequency bands, while the resistor takes care of the upper band, i.e., the twitch at the top.

(*continued on page 539*)



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The relevant components, again with regard only to the mono version, are from high to low speed respectively: C704, R713; C703, R712; and C702, R711. This coupling does not depend on whether the machine is a high or low speed version. The frequency response has to be checked overall. That is, first we trim up the replay response as necessary, using a test tape, for the following limits: 38 cm/s 30 Hz to 20 kHz ±2 dB; 19 cm/s 30 Hz to 17 kHz ±2 dB; 9.5 cm/s 40 Hz to 14 kHz ±3 dB.

Only when this is right can we check the overall record/replay response curve, and this also entails our having checked the bias setting. I have dealt with this before and cannot waste space repeating it. Please refer to the August and September 1970 issues.

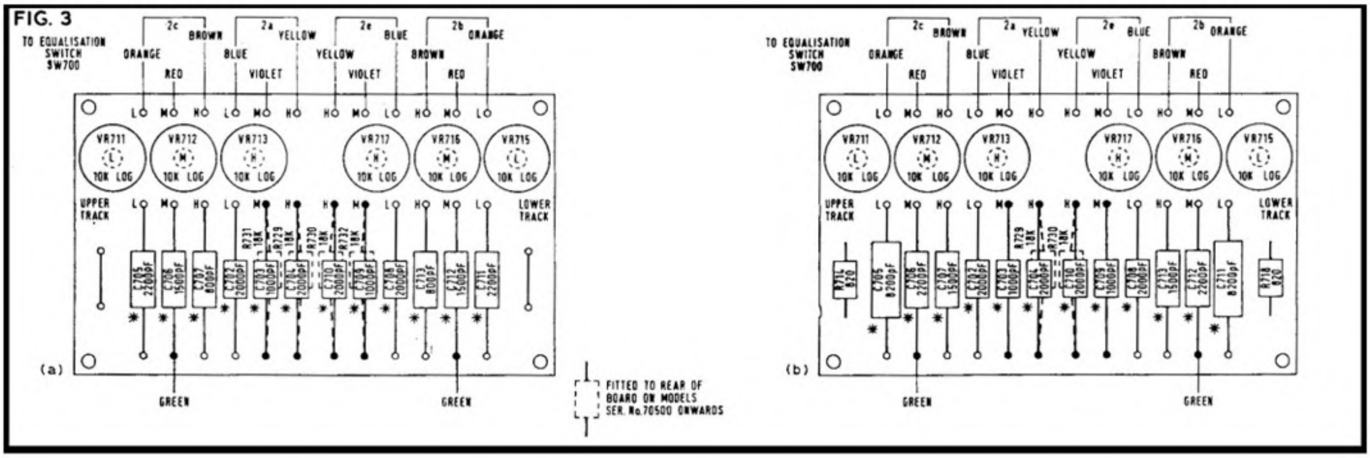
Recording tests are carried out with sinewave signals between 30 Hz and 17 kHz, at constant level 20 dB below maximum recording level. Aim to produce around 200 mV at the 600 ohms output and that should be as near right as is necessary. Frequency response limits will be as follows: 38 cm/s 30 Hz to 20 kHz ±2 dB; 19 cm/s, 30 Hz to 17 kHz ±2 dB; 9.5 cm/s 40 Hz to 14 kHz ±3 dB.

No doubt there will be a review of the Ferrograph *RTS1* in due course [*No doubt—* **Ed**]. Already, I have found it an invaluable aid to the workshop and adjustment can be done quickly and with confidence.

Serial No.	REPLAY BOARD C305	C306	C307	C313	C314	C315	C316	C317	R315	R316	R317	R318	R319	RECORD BOARD R714	R729	R731	R718
70,000 H to	·015µF	·022µF	·047µF	1500pF	·01µF	1500pF	1500pF	·01µF	68K	3·3K	120K	6·8K	18K	—	—	—	—
70,499 M	·022µF	·047µF	·15µF	1500pF	·01µF	1500pF	1500pF	·01µF	68K	6·8K	120K	12K	18K	820	—	—	820
70,500 H to	·015µF	·022µF	·047µF	1500pF	·01µF	4000pF	2000pF	·0068µF	150K	3·3K	120K	5·6K	15K	—	18K	18K	—
74,999 M	·022µF	·047µF	·15µF	4000pF	·0068µF	2000pF	4000pF	·01µF	120K	18K	150K	15K	5·6K	820	18K	—	820 stereo only
75,000 H on	·015µF	·022µF	·047µF	1500pF	·01µF	4000pF	2000pF	·01µF	150K	3·3K	120K	5·6K	10K	—	18K	18K	—
M	·022µF	·047µF	·15µF	4000pF	·01µF	2000pF	4000pF	·01µF	120K	5·6K	150K	10K	12K	820	18K	—	820 stereo only

Variable resistors RV711, RV712, RV713 all 10K presets. Record Board: C702=2000pF, C703=1000pF, C704=2000pF, C705=8200pF, C706=2200pF, C707=1500pF

FIG. 3



Patents Review

BY ADRIAN HOPE

IN BP 1,230,303, Wolf and Florian Freiherr von Hornstein, of Munich, West Germany, describe some of the problems of tape transport. The simplest decks are usually based on a three-motor system driving the capstan, feed and take-up turntables independently. Ask a designer for a cheaper arrangement and he will probably come up with a single-motor deck, transmitting the drive through a spider's web of steel wires, pulleys and bent tin. Cheaper perhaps but usually less reliable than the classical system.

The two Germans suggest using two motors. This is not in itself unique since at least one 'fifties recorder used one motor for the capstan and one other for the spool turntables. Herren von Hornstein have done away with the capstan motor, retaining a motor under each spool turntable (**fig. 1**). A toothed wheel right of the heads controls the tape speed through a frequency-comparison circuit. Equally important, the motor energies may be balanced to maintain constant tape tension throughout a reel.

Even simpler but no less interesting is an idea from the RCA Corporation of America (BP 1,230,361) concerning tape reels. Over and over again I have wished it were possible to stack tape (and for that matter film) reels and yet avoid going one step further than the Tower of Pisa.

Each proposed RCA reel has a pair of parallel circular flanges separated by a hub in the usual way, and each flange carries a circular bead on its outer surface at a position

(*continued on page 540*)

near the hub (**fig. 2**). The beads are of such a size that the inside diameter of one fits the outside diameter of the other. From there on it's quite simple. One reel sits on top of another with the beads of adjacent reels a snug fit (unless some fool puts a reel on upside down, in which case he deserves what he will get).

I had to read **BP** 1,232,129 several times before the simple idea the Audio Magnetics Corporation wanted to put over finally clicked. It concerns cassettes, the audio kind, and tries to kill two small birds with one stone. Look closely at a normal C60 cassette and you will find a small transparent plastic window which lets you see the amount of tape remaining without letting in dust. Inserting these panes costs money and Audio Magnetics do without them (first bird) by inserting larger sheets of transparent flexible plastic beneath the window socket. The sheets are positioned to press against the tape reels; the larger the reel the greater the contact area and thus the greater the frictional drag. Which in its simple way performs the same task as rim-brake tension servos: second bird.

With cassettes gaining more and more of a foothold in the audio market, the Patent Office Library will soon be ankle deep in patents for descriptions of every imaginable modification both to cassettes and the machines for handling them.

FIG. 1

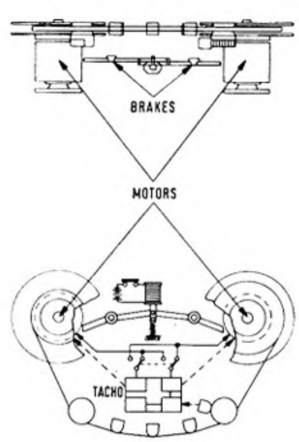


FIG. 2

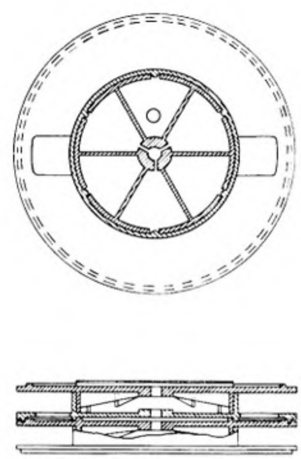
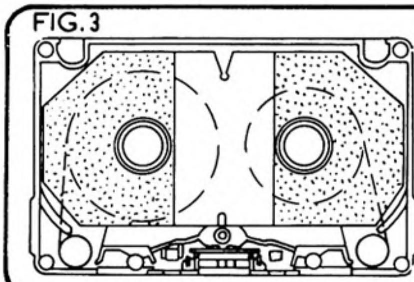


FIG. 3



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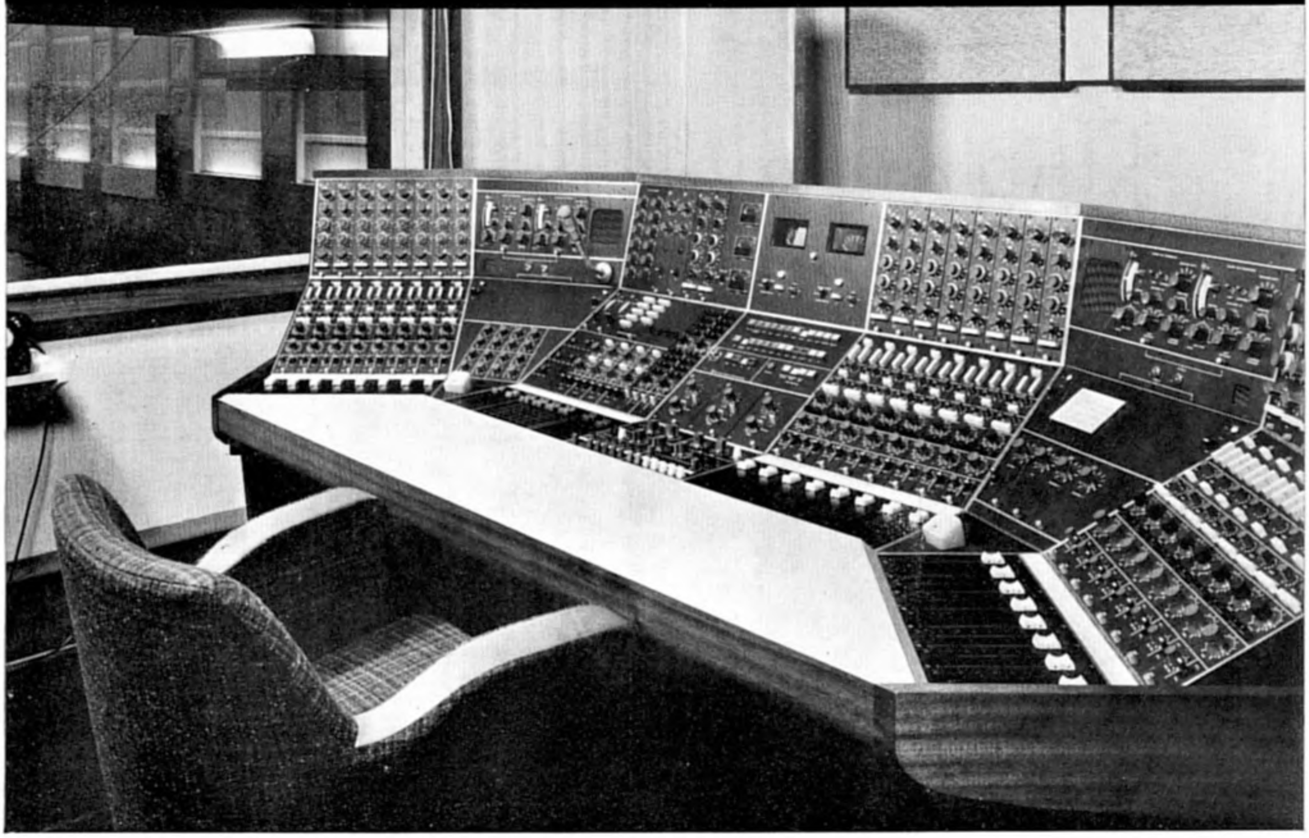

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