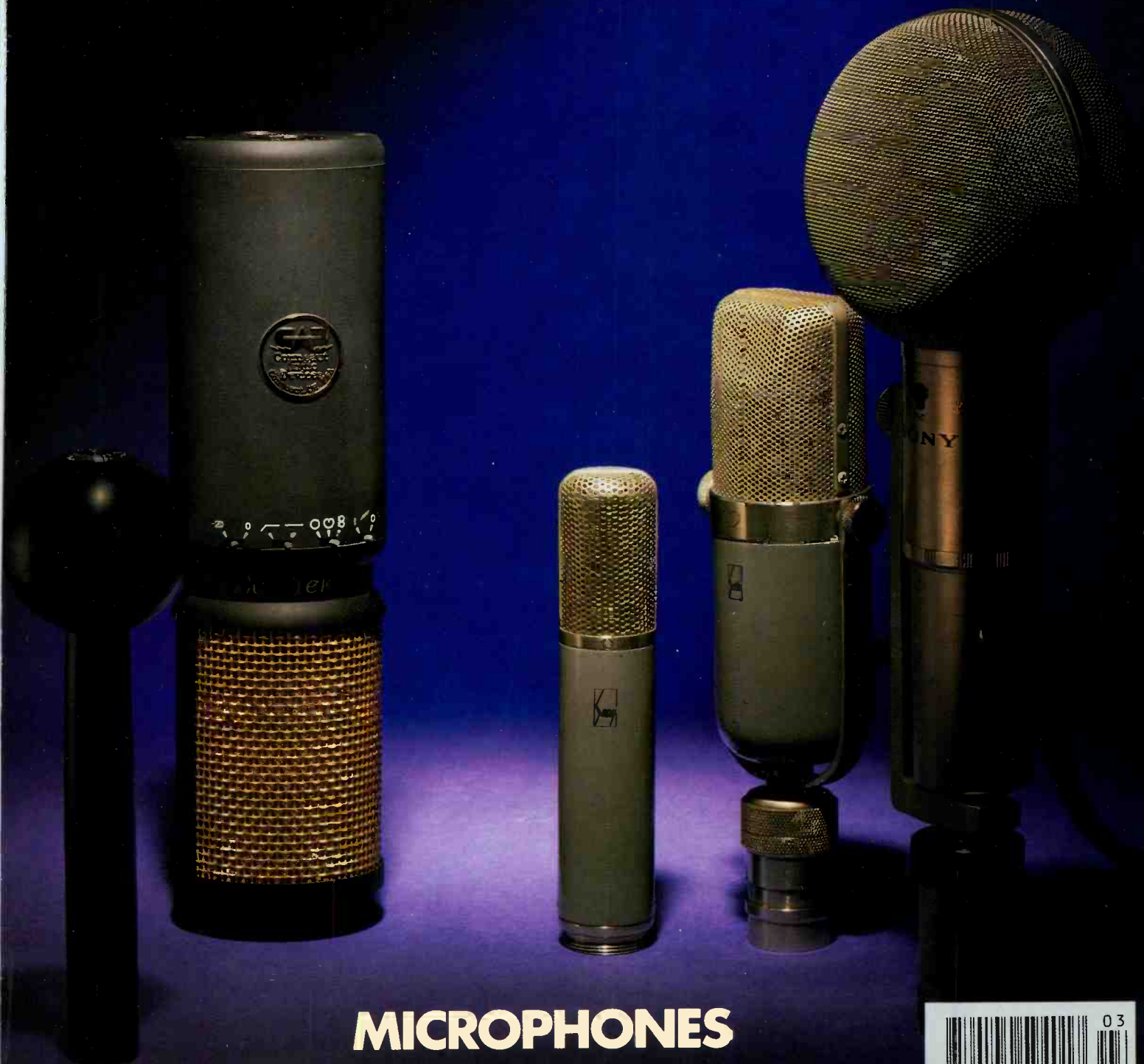


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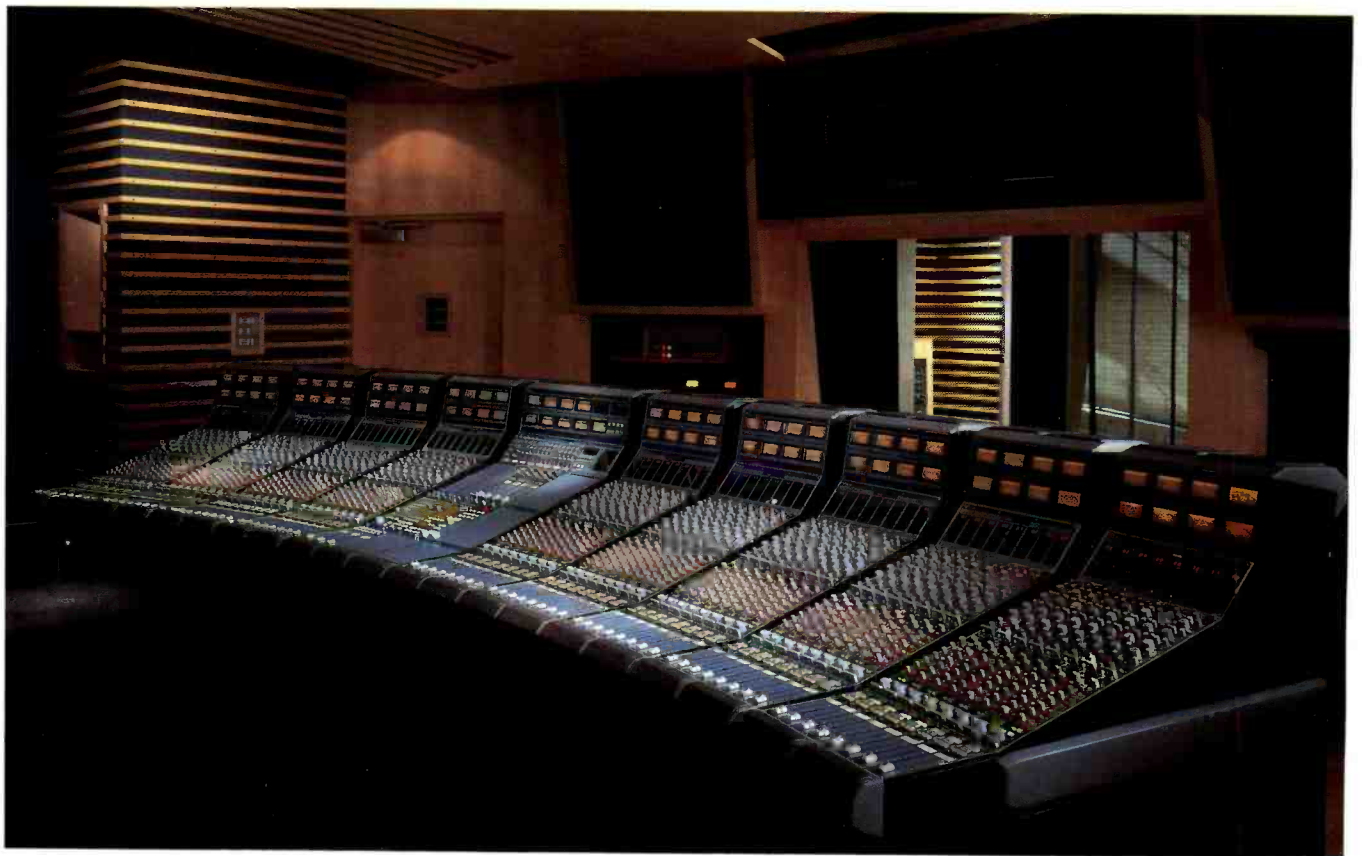
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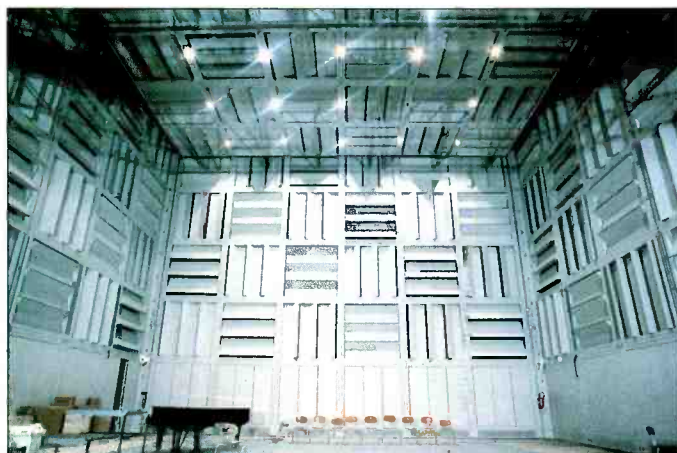


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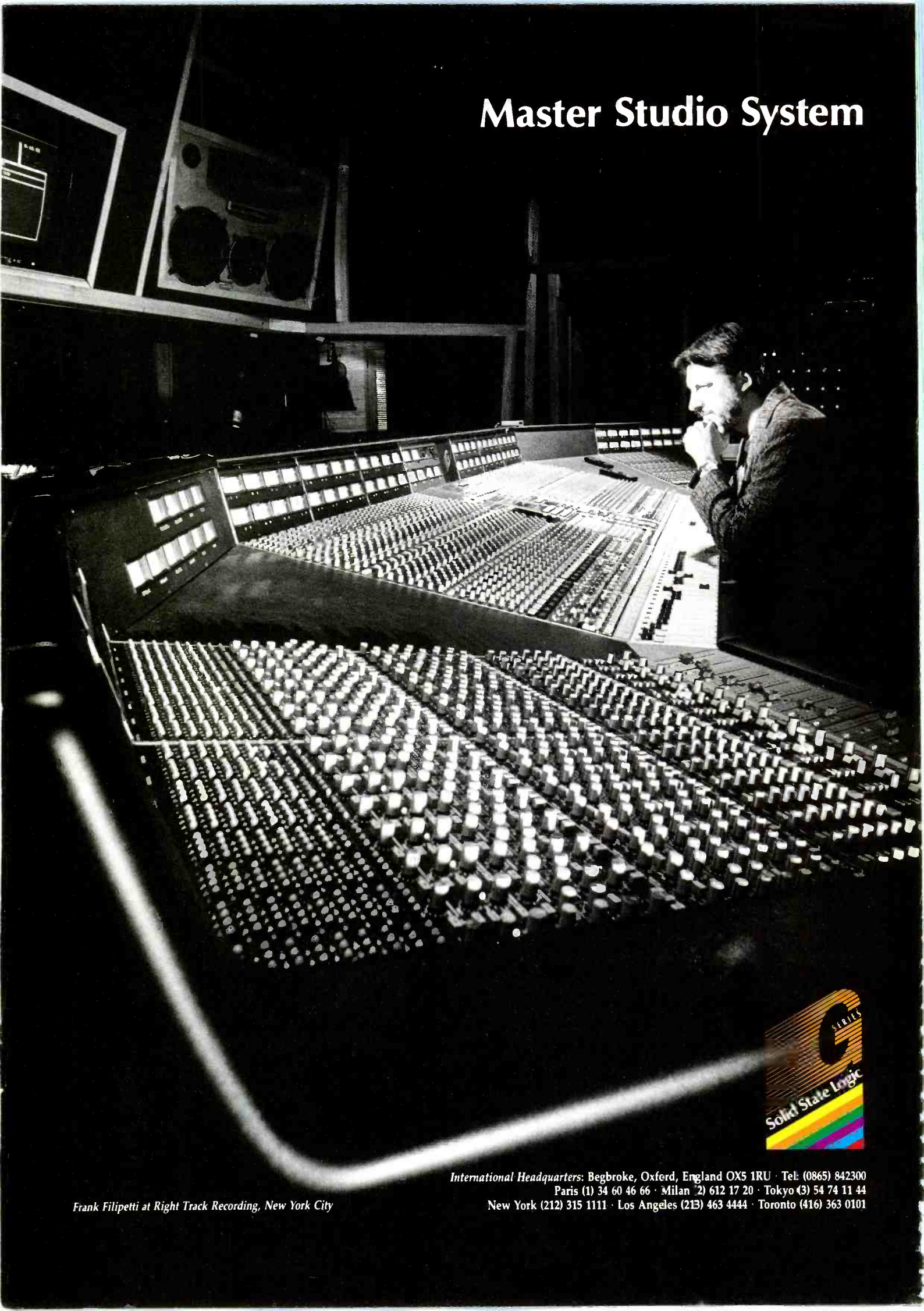
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Espace de Projection at IRCAM

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AND BROADCAST ENGINEERING

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Prove me wrong . . . or then again

I know something about audio. I expect you do as well. I know some people who know a great deal about video and they know others who know even more. I don't, on the other hand, know a great deal about video and there is a very good chance that you don't either. My video friends know even less about audio and I expect their very knowledgeable friends understand even less. There is a gulf between us and it doesn't matter as long as we respect and make allowances for each other's craft.

The two disciplines require quite different ways of thinking. They probably use different parts of the brain for all I know but there is no doubt they are widely different. I have known of projects that started off as a combined abstract video and audio album with both aspects being made by the same people at the same time. They have had to be stopped as no progress was being made. In the end the music was completed first and the video work after. Of course, it works equally well the other way around as most audio post-production work does. But together?

This preamble is really just an expression of concern at the developing interest in 'multimedia'. This is finding a form largely as a single computer running both audio and video signals and allowing varying degrees of creative control of both. At the moment the link between the two is fairly basic but with greater computing power and storage this will change. I think that in many ways such concepts are exciting and on a personal level it would suit any megalomaniacal feelings I may have about TOTAL CONTROL over a project. I still can't help but feel that creative people in audio are not at home with visual images and vice versa. Working to be conversant in both makes us purely average. And the cult of the average is not worthwhile following in creative terms. In real life we use the lack of expertise in dual media to our advantage. We make creative audio to accompany stimulating pictures, while our sounds are 'illustrated' by picture makers—we spark off each other. It works well when we only have our own field to play in.

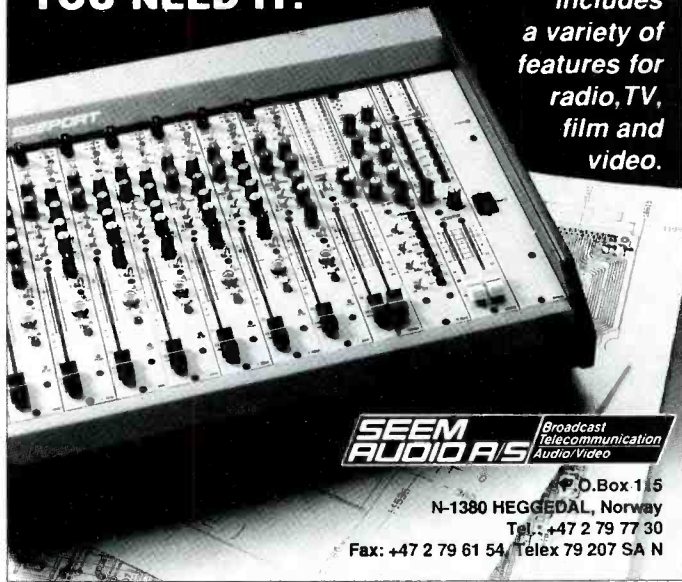
This may sound like the start of a campaign against multimedia—it isn't. But it is against giving total control of both areas to a single person because it doesn't work very well. No one is able to express themselves equally in both areas. If we then remove the need for the same person to undertake both media then what are the advantages of it being in a single box? Just because something is capable of being done is not really justification for doing it. Individually the video and audio industries have thrown up some highly creative and exciting artists and work. The true expertise of multimedia is learning to integrate the arts, not the technology.

Keith Spencer-Allen

Cover: (left to right) Bruel & Kjaer 4009 fitted with diffractive attachment;
CAD Equitek II; and 'antique' mics from Sony—C-19B, C-37A and C-500.
Photography by Tony Petch

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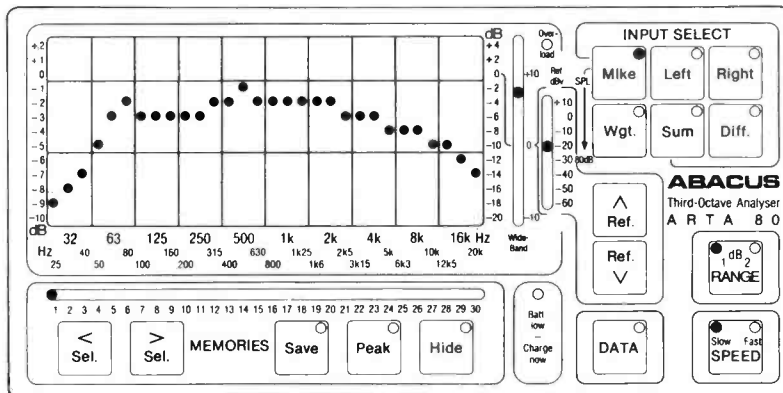
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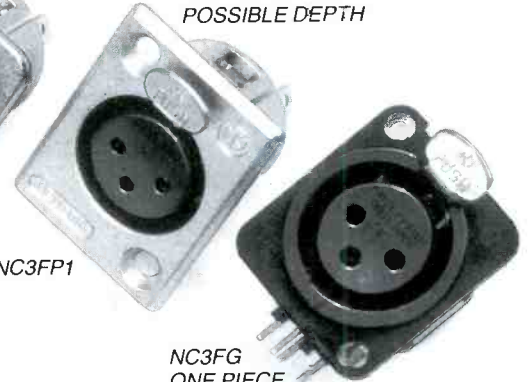
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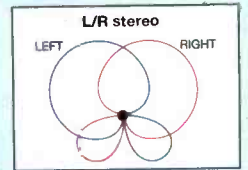
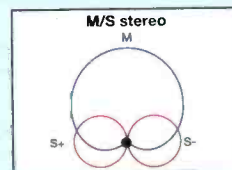
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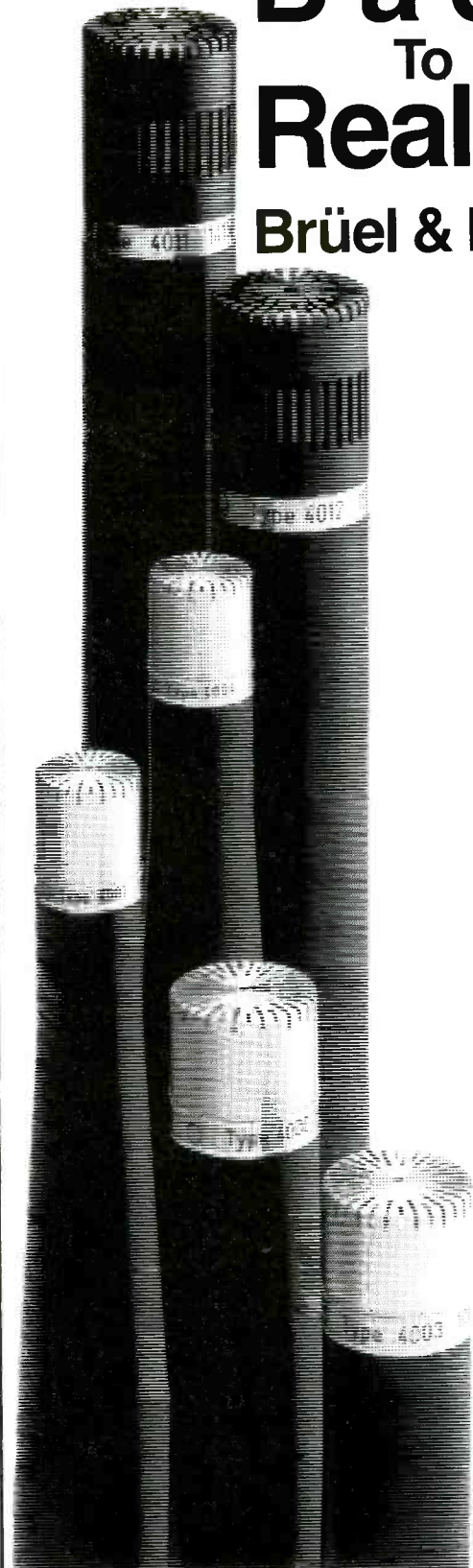
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- ALESIS Microverb II new (2 only) **£125**
- ALLEN & HEATH Saber 32:16 ex-demo **£5,750**
- ALLEN & HEATH SIGMA 44:24 (see box above) **£7,950**
- ALLEN & HEATH CMC 24 MkII brand new 2 only **each £1,150**
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- DIGIDESIGN Advert in Box for Apple Mac **£595**
- DIGITECH DSP-128 Demo model **£275**
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- LEXICON MRC remote control **£195**
- NOVAM SMC-1 SMPTE/midi box **£125**
- RODIME 100Mb SCSI drive for Sound Tools **£595**
- ROLAND U20 Synth - ex demo **£695**
- SONY PCM F.1 **£475**
- SONY PCM 701ES immaculate **£450**
- STUDIOMASTER 1DP-1 comp/lim. ex-demo **£345**
- STUDIOMASTER Series II 16:16 ex-demo **£2,975**
- STUDIOMASTER Mixdown 16:8:16, 18 months old **£1,250**
- TANNOY Little red monitors **£450**
- TASCAM 38 Bargain **£895**
- TASCAM Midi-izer - one only **£950**

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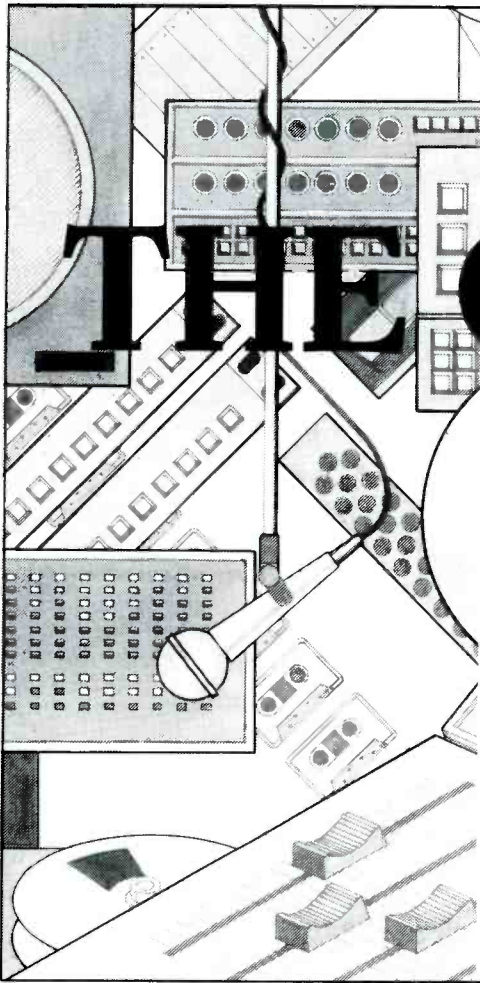
Please contact Tim Eastwood or John Moulds with any query you may have. Our price list will be sent at your request by First Class Post.

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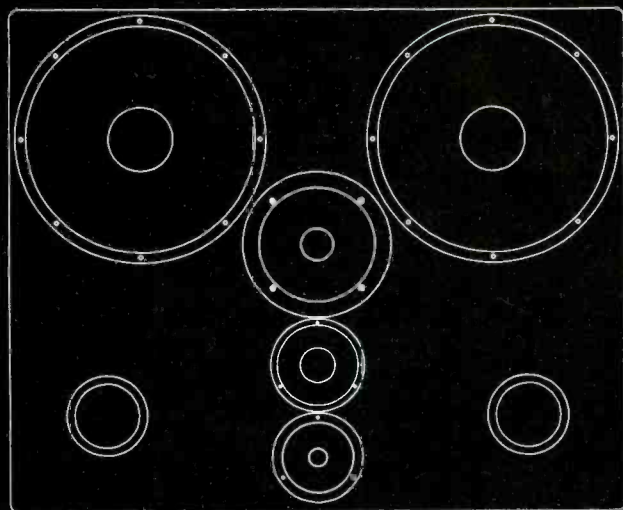
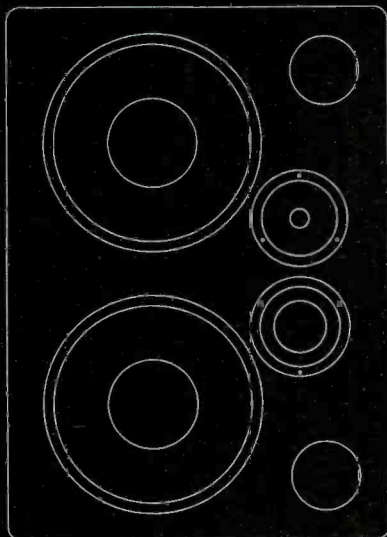
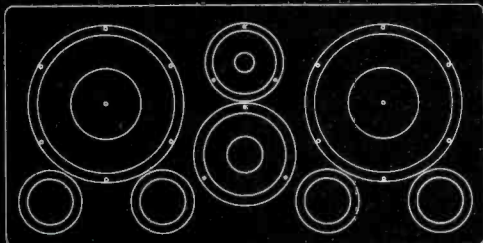
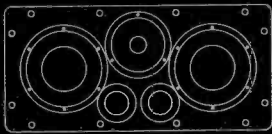
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"We recorded and mixed the Beautiful South's new album on these little M1 nearfield monitors. They really are outrageously accurate, ridiculously loud, and the record's No. 1!"

Mike Hedges
Record Producer

"One of the reasons that people come here is the monitoring. I recall that Polydor called me up to congratulate me once. They had just had 3 separate projects from here, with 3 different engineers, going to 3 different cutting rooms. Every one was cut flat. It was the first time ever, apparently! Do I like my M2s? I couldn't live without them!"

Rod Gammons
Berwick Street Studios

"I use M2s in my own studio and on location. Working with artists like George Michael, Hall and Oates and Living in a Box I need a reference point which is absolute."

Chris Porter
Engineer and Producer

"Our dubbing engineers feel that we have the best audio Post Production facilities in the Network. We use Dynaudio Acoustics M3 systems throughout, and they play a key role in this claim."

Graham Lee
TVS Southampton

"The DA-M4 is simply the best monitoring system that money can buy. It's the first setup I've had where the console doesn't get stacked up with different monitors. People like them so much, they ask me to swap apartments with them! Seriously, though, out of 10 album projects since May, only one has had to be remixed. That's impressive."

Freddy Hansson
Sweet Silence Studios, Copenhagen

dynaudioacoustics

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London SW3 4LW
England
Telephone 071-352 8100
Telefax 071-351 0396

1992 EC Interference directive—the implications

From January 1st next year an EC directive on electromagnetic interference comes into force. The Electromagnetic Compatibility Directive's aim is to unify standards of electromagnetic protection and methods of test. In effect, it will mean that almost all electrical or electronic products made or sold within the EC will need to be constructed so as not to cause excessive electromagnetic interference nor to be unduly affected by electromagnetic interference.

Manufacturers will need to certify that their equipment complies with the Directive and to ensure that new products also carry the 'CE' mark as further proof. The Directive will cover not only future products but

also those already in existence.

The implications will affect some companies more than others. For instance those European companies that already export heavily into the USA will have to have followed very stringent existing directives laid down by the FCC. The EC directives are unlikely to be more stringent.

The British Standards Institution and the AES are both holding seminars to discuss possible implications. BSI's seminar 'Looking Ahead' is on February 28th at the Sedgwick Centre, London E1 8DX. The AES British Section are holding their seminar 'Will you be legal?—Implications of 1992 to audio and video engineers', on March 19th. Full details from both organisations.

Design company splits market

Studio design company Studio Innovations, which was formed in the early 1980s has now spawned a subsidiary company called Audio Reform.

Audio Reform will concentrate on the high end studios where the company aim to question some traditionally held acoustic philosophies and attract some high-end recording facilities.

The original Studio Innovations will concentrate more on the smaller end of the market, primarily the home studio or musician's studio.

They aim to work to small and precise budgets, and to provide simple answers to basic problems.

Founder Carl Brown has been joined by Adrian Gibby as a co-director and both promise to raise some interesting new theories in both markets of studio design, and to introduce new products either produced by them or distributed from elsewhere.

Studio Innovations are located at The Top Office, c/o Rifles, Enfield Lock, Ordnance Road, Enfield, Middx, UK. Tel: 0992 700324.

Forthcoming events

April 8th to 10th Cable & Satellite Exhibition 1991, Olympia, London, UK.

April 15th to 18th NAB, Las Vegas, USA.

May 18th to 19th SPARS Technical conference on digital audio workstations, Orlando, FL, USA.

June 5th to 7th APRS, Olympia 2, London, UK.

June 13th to 18th International Television Symposium, Centre des Congres, Montreux, Switzerland.

June 25th to 27th Multimedia 91 conference & exhibition, Olympia 2, London, UK.

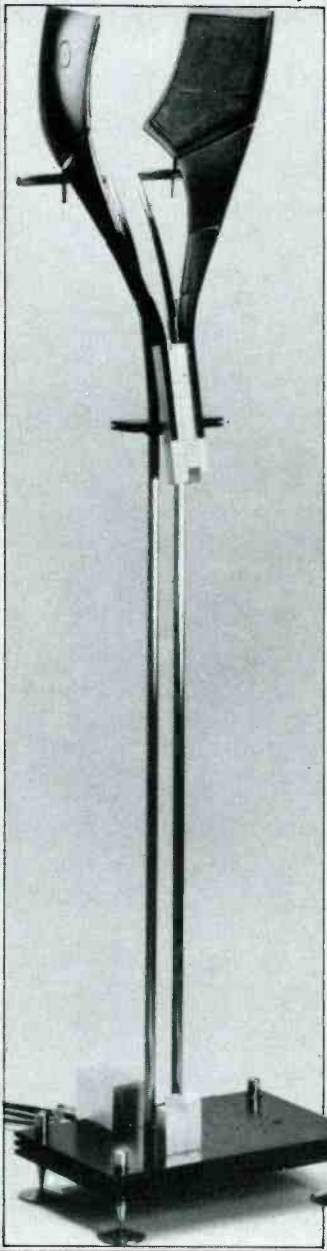
July 10th to 12th Pro Audio Asia 91, World Trader Centre, Singapore.

July 10th to 14th International Music Show, Olympia 2, London, UK.

September 8th to 11th Light & Sound Show 91, Olympia 2, London, UK.

September 15th to 18th Vision & Audio 91, Earls Court 2, London, UK.

The winning design in a non-traditional headphone design competition launched by Sennheiser last year. The competition was open to industrial design and art students at universities across Germany



In brief

● **London, UK: WordFit on foreign language dub:** London's Pelican Studio have completed a foreign language dub of a feature film using DAR's WordFit Automatic Dialogue Synchronisation and SoundStation II. The Danish to English dub of the 90 minute drama *Dance of the Polar Bears* was contracted to Pelican by Hit Communications.

● **London, UK: Livingstone fourth room:** recording complex Livingstone Studios, who already have four recording and mixing facilities, are to add a fifth studio in 1991. The new facility will feature a large customised control room and recording area for drums and acoustic instruments.

● **Royston, Herts, UK: TC MIDI from Thatched:** Thatched Cottage have announced the creation of a new division, TC MIDI. The division will specialise in all equipment with a MIDI capability including keyboards, samplers and drum machines. Sequencing and hard disk recording systems will be Mac and Atari based and all relevant hard- and software will be handled.

● **London, UK: British Telecom improve TV signals:** British Telecom are to invest more than £1 million in new automatic switching equipment to be installed at their London Television Network Switching Centre (NSC) in the BT Tower. The NSC provides facilities to carry TV signals between the studios, transmitters and headquarters of broadcasting authorities.

● **Cambridge, UK: Name change:** Labgear Cablevision Limited have changed their name to Teleste Cablevision Limited, to bring the company in line with their sister companies in Norway, Sweden and Finland.

● **Winter Park, FL, USA: Full Sail now training facility for TEF:** Full Sail Center for the Recording Arts is now an official training facility for the new TEF System-20 Sound Lab from Techtron.

Address changes

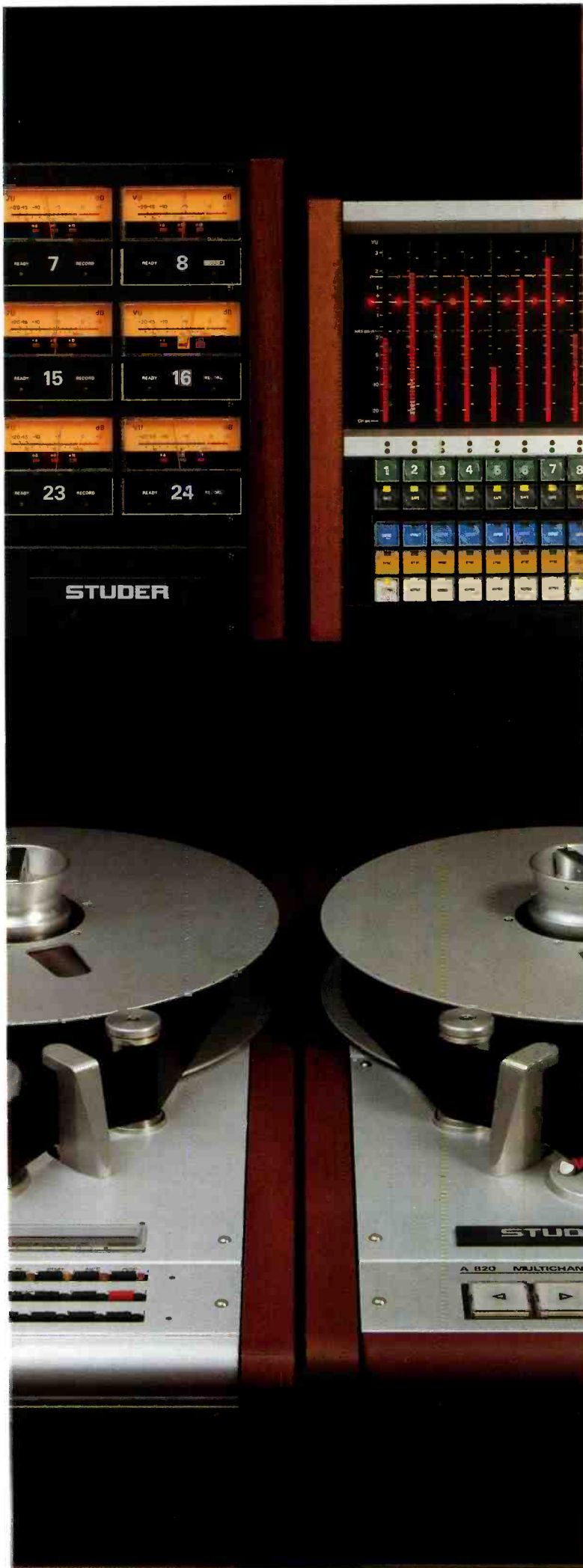
● **Sound and vision consultants, BJ Auditorium Design** are moving to new offices at 4-5 Wilson House, John Wilson Business Park, Thanet Way, Whitstable, Kent CT5 3QU, UK. Tel: 0227 770821. Fax: 0227 770832.

● **Music Lab**, the sales and hire

company, now have one telephone number for all enquiries—071-388 5392.

● **Entec Sound & Light's** new address is 517 Yeading Lane, Northolt, Middx UB5 6LN, UK. Tel: 081-842 4004. Fax: 081-842 3310.

SPOILT FOR CHOICE



Choosing between Studer's A820 and A827 multitrack machines is not easy.

True, the A820 is the flagship model and the A827 has been produced as a cost-effective solution, but fundamentally they are very similar. Both have the ultra fast proven tape transport with 14" reel capacity giving the highest spooling speeds (up to 15m/s or 590ips) for 24, 16 and 8 track tapes. Both feature the same microprocessor controlled DC capstan motor for standard 7 1/2/15/30ips, with reverse play and varispeed functions, and both incorporate the same comprehensive interfaces for the tape deck and audio peripherals.

The Features

A820 - The Flagship Model

- Integration of Dolby A/SR noise reduction system
- Full automatic alignment of audio parameters including noise reduction
- Bar graph metering PPM/VU with a resolution in alignment mode of 1db per segment

A827 - The Cost-Effective Model

- Optional integration of TLS4000 Synchroniser with local control panel
- Permanent sync output per channel for triggering noise gates etc.
- Microprocessor controlled audio alignment (MDAC)

Whatever decision is made, it will not have been easy. Such is the luxury of being 'Spoilt for Choice'.

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Contracts

- **John Storyk** has announced the completion of the \$¼ million renovation of the Manhattan School of Music's recording facility, lobbies and various student/teacher dining and lounge areas. Storyk worked in conjunction with New York City interior designer Beth Walters.
- **DDA** have supplied their third *DCM232* in Brazil to MOSH studios. The console is a fully fitted 56-channel model with bargraph metering fitted on all input modules and auxiliary outputs. Singer Jon Bon Jovi has just installed a *DCM232* mixing console in his new private studio, complete with DDA VCA fader automation.
- **Electrosonic** of Dartford, Kent, are completing a \$6 million contract for videowalls and the computer control of animated displays for a theme park in Japan, a contract for the A/V systems in McDonald's Training Centre in Munich and the lighting control system for the SAS

Hotel in Amsterdam.

- The Mastering Lab, Hollywood, CA, have installed **Gotham Audio's** *CDR 90* compact disc reference system. The system cuts a reference CD immediately in the studio, directly from the Sony *PCM 1630* master tape that a CD replication plant will use.

- **Kajem** Victory studio, Gladwyne, PA, have recently uprated their *SSL 4048E* to include the updated *G* series computer, which adds memory to the SSL mixing system. In addition **Kajem** has acquired several channels of **Neve 1081** EQ modules.
- **Klark-Teknik** have supplied two **DDA Q-MUTE** consoles to Disney for Disneyworld. One console is being used to process background music in the Polynesian Village restaurant, while the other is located in Pleasure Island.

- The Canadian Broadcasting Corporation have ordered a dozen **Studer 963** series audio consoles for the national radio network's Toronto Broadcast Centre. The centre is still under construction and is the

culmination of many years effort to consolidate all network and local radio and TV facilities into one location.

- **Focusrite Audio Engineering** and their Japan distributor **Timelord Inc** have announced the first contract for supply of the Focusrite *Studio Console* to Japan. **Studio Jive**, in Tokyo, already operate one studio with an **Amek APC1000** with **GML** automation, and a **Sony PCM-3348**. They have bought a 72-input Focusrite console equipped with **GML** automation.

- **Digital Audio Research** have announced the sale of two *SoundStation II* digital audio production systems to **Video Headquarters (VHQ)**, one of the Far East's largest TV commercial video post-production companies.

- **Carlton Television** in London is introducing a large outside broadcast truck in 1991 to compete in the sports event market. The £1 million truck will run up to 10 cameras and include 10 betacam SP machines wired in composite to accommodate

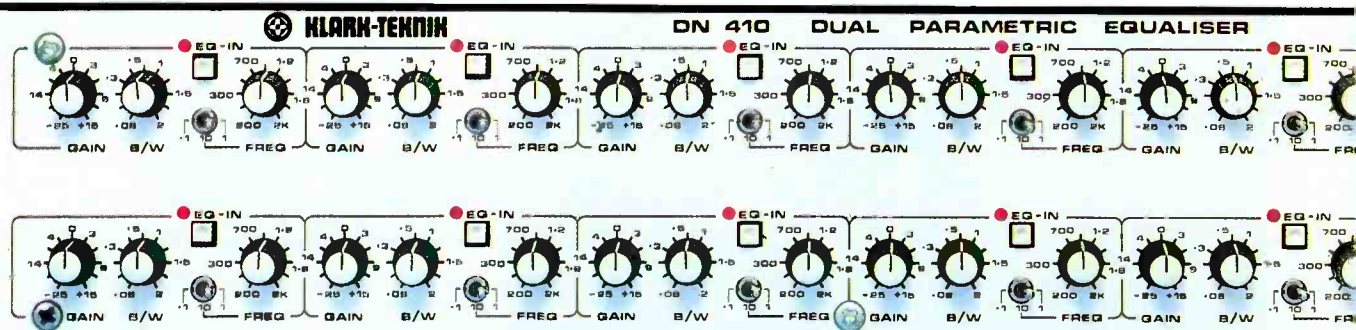
Panasonic digital composite VTRs.

- **Audio Facilities**, a broadcast facility and services company, have recently completed a consultancy contract for Network 1 at the Greenwood Theatre, London. The first production to use the facility is the three times a week live **Jonathan Ross** show, which is transmitted in **Nicam** digital stereo.

- The BBC have placed orders with **Stirling Audio Systems** for the **Sanken COS.11** miniature lavalier microphone. Quantities of the pig-tail version have been supplied to the BBC Television Centre in London and to the BBC's **Pebble Mill Studios** in Birmingham. **Sanken's** UK distributors have recently supplied the **CMS-7** microphone to **Sensible Music** who rented the mic to a **BSkyB** film crew working on location in Africa making a programme about rhinos.

- The Swiss Army Service (**AFD**) have bought a **DAR SoundStation II** digital audio production system for their recently expanded post-production facility in Bern.

Parametric Equalisation



Klark-Teknik Research Limited Klark Industrial Park, Walter Nash Road, Kidderminster, Worcestershire DY11 7HJ, England. Tel: (0562) 741515 Telex: 339821 KLARTKG Fax No: (0562) 745371

People

- **Tannoy-Audix** have appointed Tim Roberts as their new managing director. He replaces founder John Billet who becomes executive chairman of the company. Roberts has previous experience with British Telecom, TVS and electronics manufacturer Grand Met.
- Wilson Carson has joined **DDA** from Sony Broadcast as their new customer support manager. Among his responsibilities will be the technical support of customers and distributors including training seminars and console commissions worldwide.
- **Broadcast Electronics** have

announced the recent appointment of John J Nevin to the position of chief executive officer. Nevin has more than 30 years experience in the electronics and telecommunications industries.

- Continued expansion at **Stirling Audio** has resulted in a number of personnel changes within the Stirling sales and technical support operations. They have recruited Adam Rayner from Audio FX to represent BBE and Lexicon products. Rejoining Stirling after a short break is Nigel Scott who will be representing the *AudioFrame* and *CyberFrame* digital audio workstations. Keith Sherry assumes overall responsibility for Stirling/Syco in-house technical support.

Agencies

- **DDA** have appointed Earpro of Barcelona as their distributors in Spain. They plan to sell the *S*, *Q* and *D* series of consoles through a network of dealers, going direct for *DMR12*, *AMR24* and *DCM232* consoles.
- **Bruel & Kjaer Pro Audio** have appointed Hilton Sound Sarl to represent their range in France. Gabriel Nahas, Hilton Sound Sarl, 2 Villa Ghis 92400, Courbevoie, Paris. Tel: (1) 46 67 02 10.
- **RG Jones Sound Engineering** of London have been appointed sole British distributors for **Renkus-Heinz**. RG Jones (Morden) Ltd, Beulah Road, Wimbledon, London SW19 3SB, UK. Tel: 081-540 9881. Fax: 081-542 4368.
- **Evertz Microsystems** have appointed Plasmec Systems as exclusive UK distributors for their complete product range, which includes timecode generators/readers and chase synchronisers, as well as

clocks and displays for broadcast and recording studio applications.

Plasmec Systems, Weydon Lane, Farnham, Surrey GU9 8QL, UK. Tel: 0252 721236. Fax: 0252 712718.

● **Digital Audio Research** have appointed SAV in Paris as distributors for *SoundStation* digital audio production systems in France. SAV, 22 rue Rene Boulanger, 75010 Paris. Tel: (1) 42 40 55 22. Fax: (1) 42 40 47 80.

● New **BBE Sound** distributors include Mack srl who will look after distribution, marketing and sales in Italy. Mack srl, via Tiburtina 364, Rome 00153, Italy. Tel: 6 438 6644. Fax: 6 439 5911.

● **Samson Technologies** have appointed All Access to represent them in Asia. All Access, No 21 Sandanchi Hongo, Jinokuji Ama, Aichi, 49011 Japan. Tel: 52 444 2644. Fax: 52 443 7738.

● **FWO Bauch** have recently announced their appointment as exclusive UK distributor for *NVision*. FWO Bauch. Tel: 081-207 5970.

Contracts

- Famous Studios in Cardiff, Wales, have installed a **DDA DMR12** console, fitted with the **Audio Kinetics Reflex** automation system.

In Los Angeles, Music Animals have just taken delivery of their fifth *DCM224V* console. The *DCM224V* is basically a derivative of the *DCM232* but designed in conjunction with Music Animals engineers especially for video post-production work.

...DN410 - The Universal Equaliser

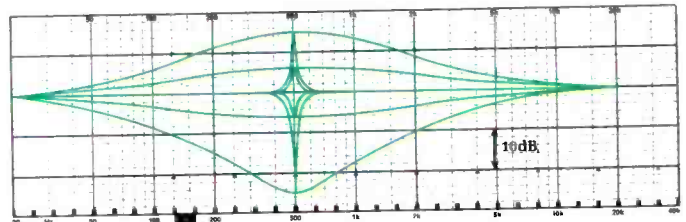
Unprecedented control - with ten *universal* parametric filters, each capable of performing the full range of notch filter and broadband, functions *anywhere* 20Hz to 20kHz.


Outstanding audio quality - carefully designed for minimal distortion and lowest noise, the DN410 re-affirms Klark-Teknik's reputation for sonic excellence.

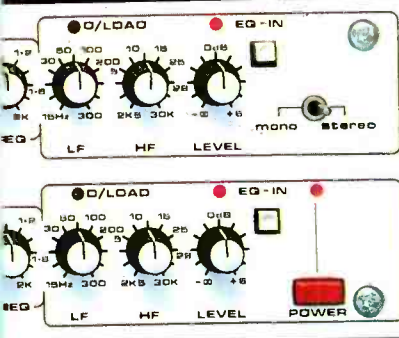
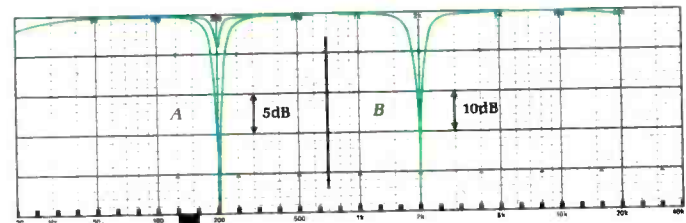
Professional features - with low and high cut filters, dual/mono mode select, fail-safe bypass and a choice of termination standards, the DN410 is thoroughly engineered - to suit your application.

Klark-Teknik reliability - designed-in from initial concept, the Series 400 parametrics feature quality assurance in the best traditions of Klark-Teknik.








 Parametric

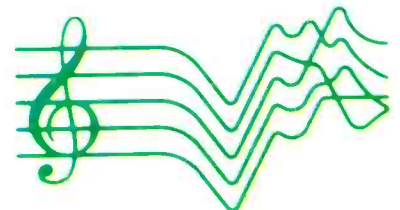


 Notching
A. Single filter
B. Two filters



The DN410...Specifications

	Frequency response (20Hz-20kHz)	± 0.5dB
	Distortion @ +4dBm	< 0.01% @ 1kHz
	Equivalent input noise (20Hz-20kHz unweighted)	< -90dBm
	Channel separation	> 75dB @ 1kHz
	Filter bandwidth	Variable from 1/2 to 2 octaves
	Maximum boost/cut	+ 15 to - 25dB
	Maximum output level	+ 22dBm



E Q U A L I S A T I O N

Klark-Teknik Electronics Inc. 200 Sea Lane, Farmingdale NY11735. Tel: 516 249 3660 Fax: 516 420 1863

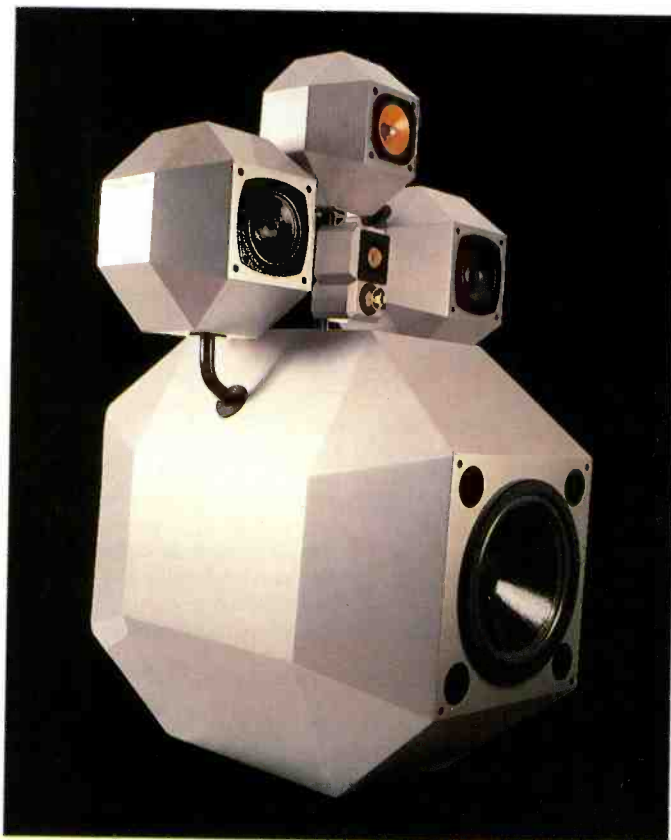
Klark-Teknik (Singapore) Pte Ltd. 7500A Beach Road, 05-305 The Plaza, Singapore 0719. Tel: 293 9736 Fax: 293 9738

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*Antoine de Rivarol 1753-1801
(What is not clear is not French)*



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Contracts

- Recent contracts for the *SCM* range of ATC studio monitors include The University of California; The Mill Studios, Berkshire, UK; Bob Ludwig; London-based post-production house Magmasters and Hilton Sound.
- Recent orders for the Mk III version of the Otari *MTR90* multitrack audio tape recorder include the New Order band for use in their private studio; and Music Lab Hire in London.
- David Hewitt's new Remote Recording facility has been equipped with two Studer *A820* 24-track analogue recorders with Dolby *SR*, two *A810s* with centre-track timecode, and *961/962* consoles.
- Recent sales of the Meyer *HD-1* studio control monitor include Mike Rutherford, Kate Bush, Paul Carrack, and Rod Argent with Tanita Tikaram.
- Video London have recently bought an Audio Kinetics *ES-Lock* system for their Studio Four. The system comprises a *Penta* 5-machine controller and four *1.11* units, together with an *SSU*, which has been incorporated to provide 16 event relays.

Management buy-out at Audionics

Broadcasting equipment manufacturers Audionics are in the final stages of negotiating a management buy-out from the

News from the AES

Our next lecture will be held on Tuesday March 12th and will be given by Egon Meier-Engelen on the subject of **Digital Audio Broadcasting—The Eureka System**.

"Remarkable advances in audio quality of the recording media and growing congestion of the FM broadcasting band have rendered sound broadcasting an inferior source of listening pleasure, especially for mobile reception. Digital audio broadcasting is proving to be the best solution to cure this situation.

"The Eureka 147—DAB system approach has convincingly demonstrated that superior sound quality, spectrum efficiency and immunity to multipath propagation effects are economically achievable with today's state-of-the-art of signal processing and IC technology. In a 4 year co-operative research project the Eureka partners have developed a system meeting all needs of sound and even data broadcasting."

Mr Meier-Engelen, who manages the Eureka Project will describe the initial concepts and the various approaches investigated. He will also discuss the convergence towards a standardisation proposal.

Newcastle-based Metro Radio Group plc, who've agreed to the sale because the company's activity falls outside their core business.

Audionics have grown in 4 years from a two-man operation working out of a small engineering department at Radio Hallam (the Sheffield-based independent radio

The presentation will include recorded demonstrations.

The lecture will be held at the ITC (formerly IBA), 70 Brompton Road, London SW3. The ITC is opposite Harrods and Knightsbridge underground stations, between the Nationwide Anglia Building Society and Boots. The evening starts with coffee at 6.30pm followed by the lecture at 7.00pm.

The next event to note is that the AES British Section will be organising a Conference with the title **Will You Be Legal?—Implications of EC Directives for Audio and Video Engineers** on Tuesday March 19th. This will cover the effects of legislation to be implemented on January 1st, 1992, and the chairman will be Allen Morningson-West.

This legislation affects manufacturers, designers and installers of professional audio and video equipment and systems. The Conference is intended to reveal the extent and scope of the legislation and will be discussing the strategies for coping with both the legal and engineering consequences of the European performance standards involved. Ignorance of the law is, we are advised, no defence. The planned conference

station), to a company with 20 employees in a larger industrial unit in Sheffield, UK.

The key management and technical team remain with the company as part of the buy-out. They are Michael Adams, engineering director; Phil Davies, electronic design & development director; Phil Myers,

programme is as follows:

- | | |
|--|--|
| Introduction | 9.15-9.30 |
| A1 EEC Harmonisation and Directive Background | Tony Bond, DTI |
| A2 BSI Standards Setting Activity | Gordon Blagdon, standards consultant |
| A3 The EMC Standards, Background and Documentation | David Hayes, RTL Kenley |
| B1 Your Route to the CE Mark | Ted Pease, BSI Testing |
| B2 The Role of Quality Systems Management, BS5750 | Harold Russell, BSI QA |
| C1 Complaints, Appeals and Regulating Activities | Lawrence Green, DTI RIS |
| C2 Indemnity Insurance | IEE/Frizells |
| C3 Marketing—Strategic Considerations | Chris Hollebone, Sony Broadcast & Communications |
| D1 Systems Installations EMC Considerations | Dr A Finney, GPT |
| D2 Case Studies in EMC Equipment Appraisal | Stephen Kirk, RFI Ltd |
| D3 General EMC Prevention Strategies | Tim Williams, Elmac Services |
| E1 Forum Discussion | Chair: John Woodgate, standards consultant |

Please contact: Heather Lane, AES British Section, Lent Rise Road, Burnham, Slough, Berks. SL1 7NY, UK. Tel: 0628 663725. Fax: 0628 667002.

production director; and Graham Slee who'll manage the sub-contracting and printed circuit board side of the business. They will be joined by Bill MacDonald, former managing director of Yorkshire Radio Network, who will be executive chairman, and Graham Blineow, former YRN company secretary.

The sheer cost of purchasing new equipment is always a bitter pill to swallow. Add a fast-moving marketplace – and choosing the right technology becomes a major headache. Fortunately, a perfect antidote is now available: Hilton Sound's hire service.

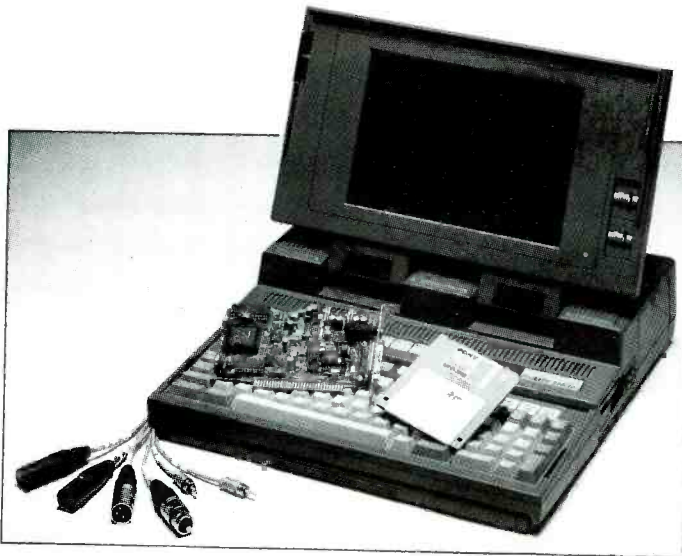
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PIONEERS IN AUDIO ACCESSIBILITY





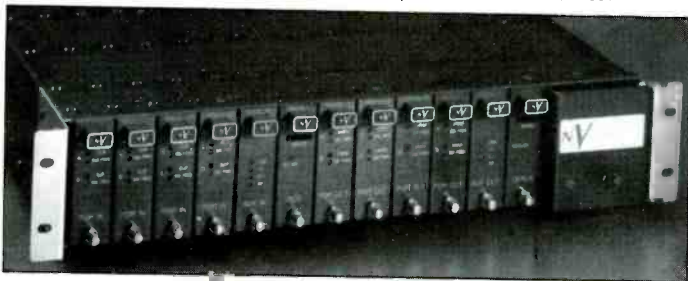
Prism Sound AES/EBU status editor

Prism Sound have announced an AES/EBU and SPDIF channel status analyser/editor designed to assist in identifying reasons for digital incompatibility without resorting to trial and error. Once the problem has been found the unit will allow received status to be modified so work can continue. The analyser/editor also contains a 16 bit D/A converter, which enables fault monitoring with headphones, etc. Other features include timecode injection/extraction, audio peak level metering and analogue line outputs.

A full package includes a mains or battery operated portable PC compatible computer fitted with a

digital audio interface adapter designed by Prism. The analyser is available ready installed on a small PC, or without for installation on an existing system. Screen displays of AES/EBU and SPDIF channel status are available with the ability to override individual fields. Where needed the field contents are decoded and displayed in text form and the 'fixes' developed can be stored as disk files for later recall. The analyser can also be fitted with custom implementations to order for end user applications of 'user bits'.

Prism Systems, Intercell Building, 1 Coldhams Lane, Cambridge CB1 3EP, UK. Tel: 0223 464739.



NVision NV2000 multiplexer

NVision have announced a high performance digital audio multiplexer designed to simplify audio interconnections for HDTV, D-1/D-2 and C-type VTRs. The NV2000 is designed to provide 20 bit encoding and distribution capability for multiple channels of programme audio with 110 dB S/N.

All the audio and ancillary signals are multiplexed together into a single datastream enabling one deck of a video routing switcher to carry

programme audio, timecode and cue information. The basic system is configured to carry two or four channels of audio with analogue interfaces but can be enlarged to eight channels with analogue and digital interfaces.

NVision, PO Box 1658, Nevada City, CA 95959, USA. Tel: (916) 265-1000.

UK: FWO Bauch Ltd, Borehamwood, Herts. Tel: 081-953 0091.

Neumann microphones

Neumann have announced three new microphones. The *KMS 140* and *KMS 150* are condensers with cardioid and hypercardioid polar patterns respectively. They are designed principally as vocal mics but with vocal and instrumental application. They may be hand held. Neumann claim the acoustic filter design and transformerless amplifier design mean that overloads do not occur in normal use. They also say the polar response has been maintained into the low frequencies improving the resistance to feedback in stage use.

The third new mic is the *TLM 50*. This is in the Neumann tradition of large stand mounting mics designed to meet a sustained interest in the obsolete *M50* model. The *TLM 50* is transformerless and the capsule is

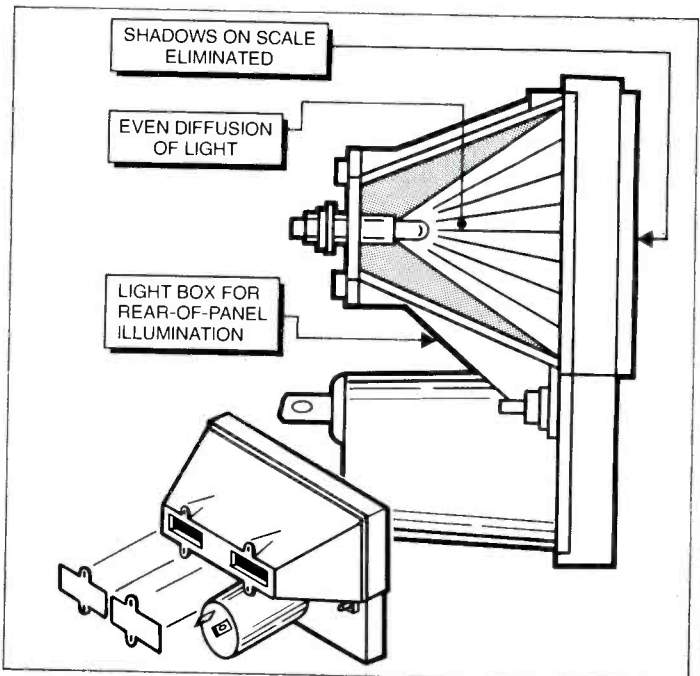
only 12 mm in diameter mounted within a 40 mm diameter sphere.

To quote Neumann: 'The *TLM 50* exploits the special acoustical pressure build-up and diffraction characteristics of a sphere.' The result is that the mic response is comparable to a pressure gradient design in the upper frequency range while operating as a pressure transducer in the lower frequencies with a linear response. The acoustic front of the mic is at the side.

Georg Neumann GmbH, Postfach 61 04 69, Charlottenstrasse 3, D-1000 Berlin 61, Germany. Tel: 0 30 2 59 93-0.

UK: FWO Bauch Ltd, Borehamwood, Herts. Tel: 081-953 0091.

USA: Gotham Audio Corp, New York, NY. Tel: (212) 765-3410.



Sifam illuminates

Meter specialists Sifam are now offering three forms of rear-of-panel illumination on their *Presentor* range of audio meters. Traditionally meters are illuminated by festoon lamps at the top of the meter but this can cause uneven illumination and shadows on the scale. Sifam have been producing meters with the lamps behind the panel, which cured much of this problem, but they have just added 'midget flange rear-of-panel illumination', which they claim

gives a more even diffusion of light and greater visibility. The third variation is the use of LEDs to increase robustness of the illumination. These options are available on the *Presentor 29WF* and *39WF* meters.

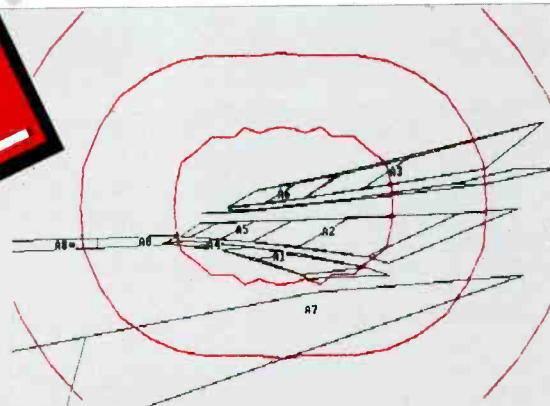
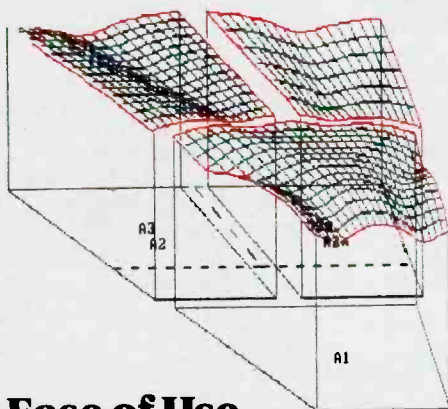
Sifam Ltd, Woodland Road, Torquay, Devon TQ2 7AY, UK. Tel: 0803 613822.

USA: Selco, 7580 Stage Road, Buena Park, CA 90621. Tel: (213) 921-0681.

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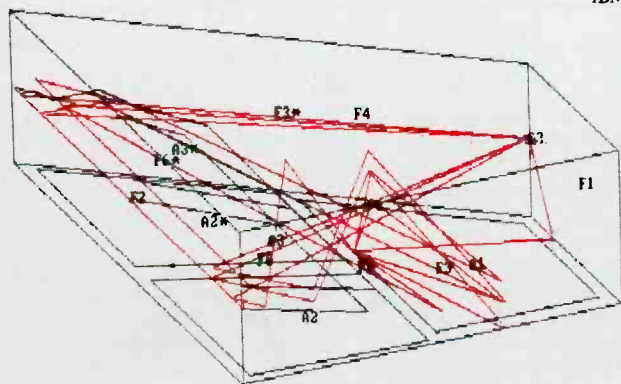
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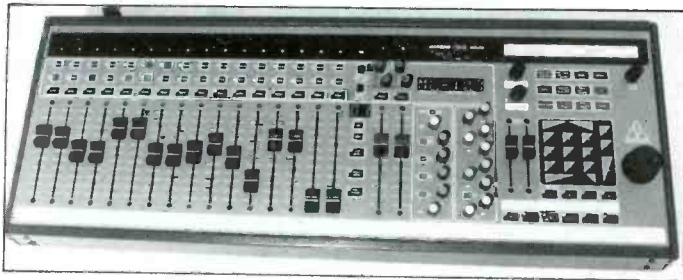
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Irvine, California 92714
Tel 714/250-0166
Fax 714/250-1035

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Kent ME13 8SD, UK
Tel 44 795 53 65 74
Fax 44 795 53 65 73

Solligrenda 48
N-0491 Oslo 4, Norway
Tel 47 2 71 18 80
Fax 47 2 71 18 85

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Audiomatica mixer controller

Italian company Audiomatica have developed a hardware mixer controller for use with the screen based mixers found within WaveFrame's *AudioFrame* and *CyberFrame* digital workstations. The Contact MIDI panel is described as easy to use and fully programmable using rotary digital pots, faders and switches. The unit has 16 channel faders, two assignable faders and two stereo mix faders, which can be assigned in banks to each DSP module. There is a single 4-band parametric EQ section that together

with four aux sends moves to the 'active' fader, allows adjustment of that channel's parameters. MIDI compatibility also allows simultaneous control through *AudioFrame* or *CyberFrame* of external MIDI processors and devices. Audiomatica, Via Faentina 250, 50133 Florence, Italy. Tel: 55 575 221.

UK: Stirling Audio Systems Ltd, London. Tel: 071-624 6000. Fax: 071-372 6370.

USA: WaveFrame Corp, Boulder, CO. Tel: (303) 447-1572.

Rapid Mac-based FFT

Rapid Systems have announced a low cost 2-channel FFT spectrum analyser in the form of the *R381* whose hardware simply connects to the serial port of a Mac *512e*, *XL*, *Plus*, *SE* or *II*. The system features two independent 14 bit A/D channels. Trigger level and conditions can be set using on-screen tools, or via remote control using the external trigger. A signal tracer and two dynamic cursors make spot measurements of voltage, time difference and frequency possible. Using the software the user can

cut and paste screen pictures into reports or drawings. There is provision for a software zoom control to analyse small areas.

Other features include: Autosave for unattended use where trigger and events to be recorded are set, captured and stored to disk; Compare allowing a signal from disk to be read into either channel and compared; and Save allows storage of signal with set-up information.

Rapid Systems Inc, 433 N 34th Street, Seattle, WA 98103, USA. Tel: (206) 547-8311.

Digital Dynamics DSP

Disk recorder/editor manufacturer Digital Dynamics have added a Digital Signal Processing option for the *ProDisk* range. This is a retrofit plug-in option that will extend the audio processing functions. Initial deliveries will provide internal level control of input and output signals, EQ, reverb, delay, as well as mixing functions. There is provision to connect to an external fader panel enabling realtime level control and stereo

submixing. Use with third party MIDI software running on a *Macintosh* computer or a sequencer will allow mixdown fader automation.

Future software releases will allow for time and frequency domain processing in realtime or batch processing mode depending on the complexity of the material.

Digital Dynamics Inc, 270-02 East Pulaski Road, Greenlawn, NY 11740, USA. Tel: (516) 271-5600.

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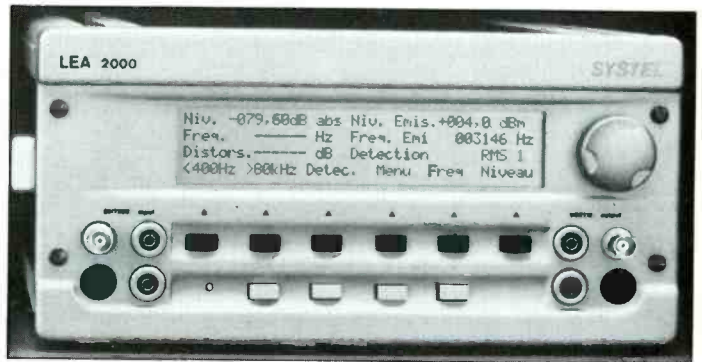
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LEA audio analysers

French company Systel SA have announced a new range of audio analysers—the *LEA 2000* series—that are described as modular, giving much scope for possible function and system evolution.

The Generator section has two ranges: 10 Hz to 150 kHz and 20 Hz to 20 kHz and is equipped with an output transformer. Output levels of up to 22 dBm are available balanced or unbalanced, with or without impedances, and a choice of output impedances.

The Receiver section contains a fully automatic distortion meter

function with a frequency range of 10 Hz to 330 kHz with a residual distortion level of -85 dB from 20 Hz to 20 kHz.

The Psophometer function can accommodate four filters from a list of six available filter characteristics.

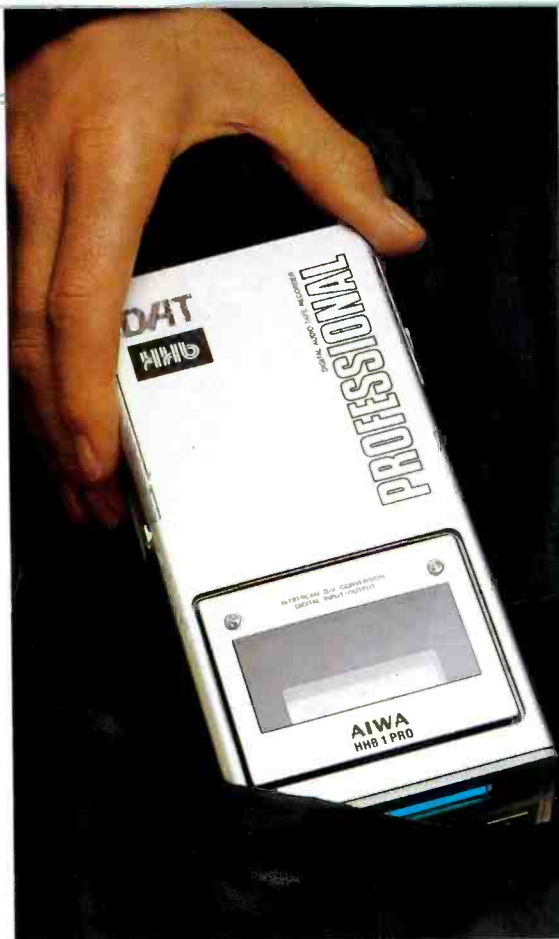
All models have IEEE, RS232 and Centronics ports. The unit is compact and robust and described as suitable for the bench or as a portable.

Systel SA, Groupe Balloffet, ZI de Pissaloup, Parc Heliopolis, Rue Edouard-Branly, 78190 Trappes, France. Tel: (1) 30 69 0110.

Every audio professional knows that the DAT format is ideal for portable recording. But at HHB we believe it need not cost the earth.

That's precisely why we've joined forces with Aiwa to design our own professional DAT portable – the HHB1 Pro.

In spite of its compact dimensions, the rugged HHB1 Pro offers a wealth of features for the professional user. A single

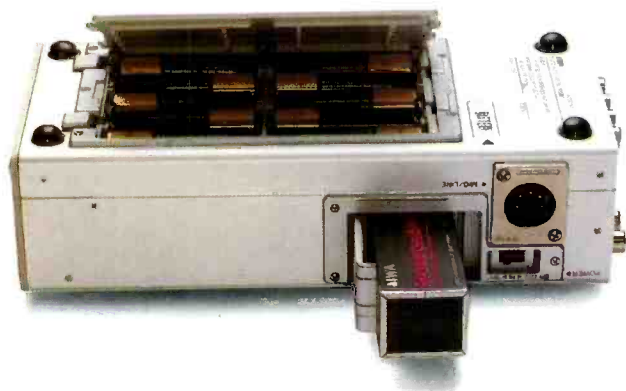


The HHB1 Pro stripes tape with 'absolute time' information as it records. So whenever you insert a recorded cassette, you can see precisely where you are on the tape. With Sony's PCM-7000 range of studio DAT recorders capable of editing to absolute time as well as time-code, you can be confident that your HHB1 Pro will function as their ideal low-cost acquisition partner.

The HHB1 Pro records for

A professional DAT recorder that goes easy on your pocket. And in it.

5-pin XLR switchable mic/line input allows stereo recordings in the field, while audio quality is assured thanks to the latest single-bit oversampling conversion technology. Of course, AES/EBU as well as SPDIF digital interfaces are provided as standard. And because the Pro's informative LCD display can be illuminated, monitoring in low-light conditions could not be more convenient.



up to three hours on conventional dry cell batteries. Meanwhile, a multi-voltage transformer and a NiCad battery pack – together with a selection of useful professional accessories including a wired remote controller – are supplied as standard. Since it weighs in at under £1,000 and less than a kilogram, picking up an HHB1 Pro from the world's number one DAT centre just couldn't be easier.

The MXP-2900 series.

Measuring up to any system requirement.

If you need eight channels for a video edit suite or 36 channels for on-air production, the MXP-2900 series of audio mixing consoles has the versatility to provide the perfect solution. With four frame sizes, fifteen different module types and user definable signal routing, a console can be configured

for any broadcast application.

All models feature comprehensive video editor interfacing, 'pop-up' fade depth control and options for metering and dynamic processing. For further information on the versatile MXP-2900 console range, contact your local Sony office.

MXP-2908



8-channel

MXP-2916



16-channel

MXP-2926



26-channel

MXP-2936



36-channel

VIDEO EDITING

- Video editor interface
- Preview switching
- Depth of fade control
- Four group outputs
- Cross fade control

PRODUCTION

- Assignable dynamics module
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- Choice of metering
- 3-band equalisers
- Four auxiliary sends

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- Fader start logic
- Robust mechanical and electrical design

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*MXP-2908 8-channel console
interfaced to BVE-9000 edit control system*

Sony Broadcast & Communications European Headquarters
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MOZART

& POST

"For the music mix, we locked two 24-track machines with Dolby SR, a video machine, a four track, and a MAC computer to one of our two MOZARTs. MOZART is a very SMPTE-orientated mixing console" Andy Waterman, The Bakery, LA, quoted in Post magazine, November 1990.

Nowadays, time is of the essence. Real time costs money, and the ability to work in the artificial world of SMPTE time earns money. AMEK's MOZART was designed with both sorts of time in mind. Computer-assisted mixing is now commonplace but systems of real sophistication were, until the arrival of MOZART, restricted to consoles in the highest price range.

Due to rapid developments in technology, computing power is now inexpensive and AMEK, in conjunction with STEINBERG, has developed advanced software for console automation which is unequalled.

SUPERTRUE allows the fader and 15 switches per input to be automated with real-time or off-line control of the functions. Move the faders, press automated switches such as Aux On/Off and Eq In/Out- all moves will be recorded as you make them, to quarter-frame accuracy. Fader and switch moves can be edited - or created - off-line.

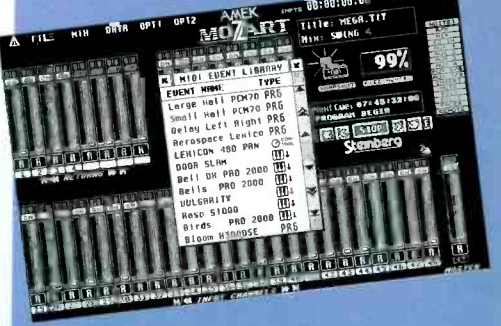
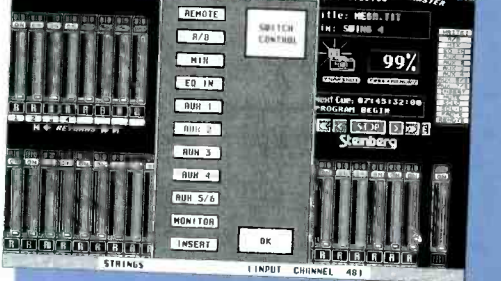
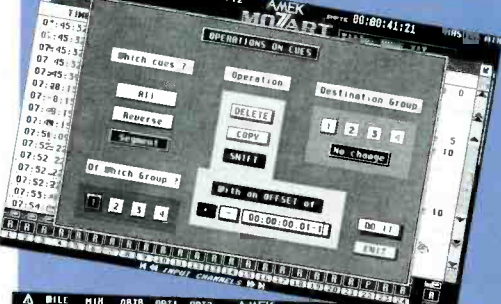
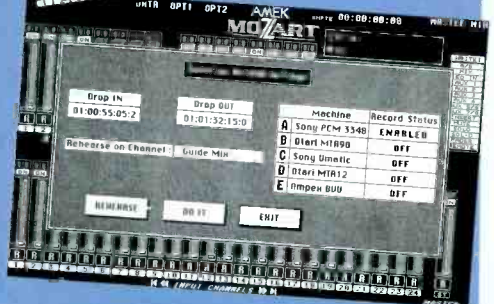
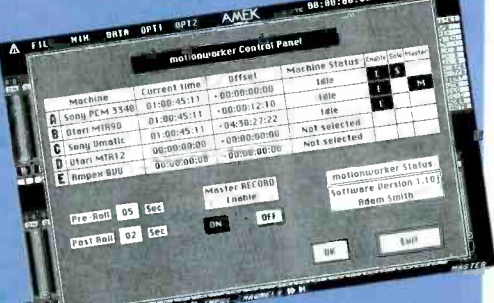
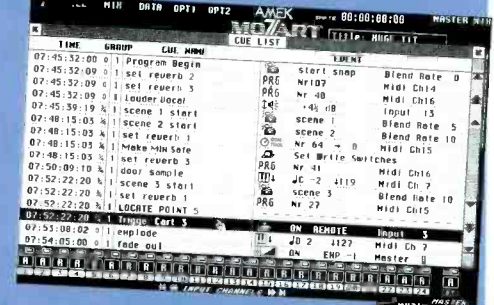
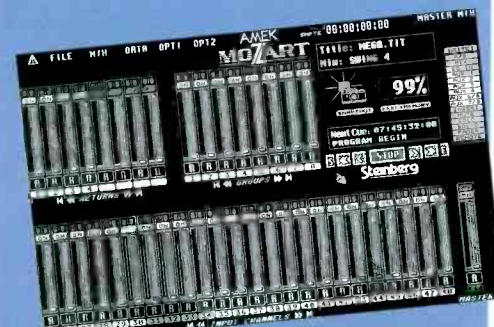
The heart of SMPTE control in MOZART is the automated mixing system. Extended real-time control is provided via the Cue Sheet. Cue Events include MIDI functions, FADER level changes, SNAPSHOT load and blend, SWITCH and MUTE changes, READ / WRITE / UPDATE mode selection and MACHINE CONTROL locator points. SUPERTRUE also allows you to draw your own fader curves on the Fader Jobs screen. Curves can then be inserted into the Cue Sheet and triggered on/off between two SMPTE points, allowing fades of any shape and duration to be created.

MOZART was designed as an open-ended system. The new autolocator hard- and software expansion allows total control of multi-machine audio and video systems. The Locator panel fitted into the centre of the console provides Master Transport Controls with a full range of find, start and cycle functions. The machine control window in SUPERTRUE allows offsets, location times and pre- and post-roll parameters to be set up for multi-machine operation. Another window allows automatic, quarter-frame accurate punch in/out recording with a full rehearse function.

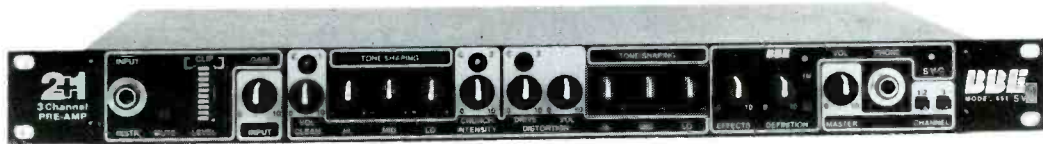
Finally, powerful routines provided in SUPERTRUE's Mix Processing and Cue operations screens allow extensive copying, moving and time-shifting of fader, switch and mix information.

MOZART gives you total synchronization flexibility whatever the various sources you are working with - multitrack, samplers, hard-disk recorders, video tape, computers - any realistic combination.

With its AMEK and Rupert Neve-designed audio systems, and an advancing digital control technology, MOZART is the best choice for all time.



Head Office, Factory and Sales: AMEK Systems and Controls Ltd., New Islington Mill, Regent Trading Estate, Oldfield Road, Salford M5 4SX, England. Telephone: 061-834 6747. Telex: 668127. Fax: 061-834 0593.
 AMEK/TAC US Operations: 10815 Burbank Blvd, North Hollywood, CA 91601. Telephone: 818/508 9788. Fax: 818/508 8619.



BBE processed guitar pre-amp

BBE have joined the host of manufacturers offering rackmount preamps for guitarists. Launched at NAMM, the BBE 651 has the added advantage of using the *Sonic Maximiser* circuitry already found in the company's range of studio orientated products.

Three front panel or footswitch channels are offered; Clean, Crunch (American style overdrive) and Distortion for the classic British sound. Front panel controls are available for input gain with the Clean channel offering volume, high,

mid and low tone controls; the Crunch channel featuring an intensity control; and the Distortion channel offering tone controls plus drive and volume. The separate *Sonic Maximiser* section has pots for effects and definition and the entire signal path is governed by a master volume.

In line with other manufacturers who are including 'power soak' circuitry on guitar processors these days, the 651 has Speaker Voicing Cabinet characteristics across XLR outputs for direct connection to a mixing console. Other back panel

sockets are available for a stereo effects loop, a tuner output and stereo output. The footswitch allows the *Maximiser* circuitry to be switched in and additionally offers a mute switch with 60 dB attenuation.

BBE are selling strongly on the 651's touch responsive performance, which, together with the BBE process stated to control and correct phase and amplitude distortion, makes the unit one of the most original guitar preamps available.

BBE Sound Inc, Huntington Beach, CA, USA. Tel: (714) 897-6766.

UK: Stirling Audio, London. Tel: 071-624 6000. Fax: 071-372 6370.

Soho drummer store

Opened to satisfy the strong demand for a one-stop percussion store to serve London's busy Soho district, Argent's DrumStop places special emphasis on latin and ethnic percussion as well as drawing on the company's wide MIDI experience to support any MIDI drum requirements. A full selection of spares is kept and educational aids include aural and visual tutors. **DrumStop, London, UK. Tel: 071-379 6690.**

Lync controller

The Lync LN1000 MIDI controller is equipped with a 49-note velocity sensitive keyboard with programmable aftertouch. Eight different types of velocity responses are available to accommodate different playing styles. Features also include reversible pitchbend wheel, programmable modulation wheel and realtime volume knob. The LN1000 offers 128 patch locations each containing MIDI channel, programme number, velocity response, transposition, volume, modulation wheel assignment and aftertouch assignment information with the wheel and aftertouch assignable to any MIDI controller number. **UK: Argents, London. Tel: 071-379 6690. Fax: 071-240 7696.**

Peavey MIDI master data processor

The MIDI master from Peavey features eight MIDI inputs and eight MIDI outputs with two independent MIDI processors. MIDI data from up to eight keyboards may be assigned to any or all outputs or either of the processors.

In addition to the routing and

processing, there is a MIDI merge function that can merge the output of the two internal processors. The processor functions include filtering (eight filters); compander (compression/expansion); velocity switching; and MIDI channel switching.



Kurzweil relaunch

Kurzweil have re-introduced the 1200 series of synthesisers following the acquisition of the company by Young Chang last year.

Comprising the Pro 88 and Pro 76 88- and 76-note weighted velocity and pressure sensitive keyboards respectively, and the Pro 1 rackmount version, all feature 163 sound samples including some from the popular K250 plus some brand new synth timbres. The series is characterised by 24-note polyphony, 16-channel multitimbrality and 6 Mbyte of sound ROM. Ninety-six MIDI control sources can be patched

to control program parameters and 64 user programs are offered.

On the performance side, layers and splits can be combined and overlapped to a total of four and the 1200 series has internal effects for chorus, tremolo and phasing and a MIDI Master Mode permits the keyboard to be used as a master MIDI controller with all the advantages that its splits and layers impart. Off-line storage and editing is facilitated by Kurzweil's *ObjectMover* software for the Mac, Atari or IBM. Kurzweil is back with a vengeance.

Software

• In line with the drop in price of Mac computers, **Evenlode Soundworks** are offering a free fully working demo of Steinberg's *Mac Cubase* MIDI recording system.

Evenlode, Stonesfield, Oxford, UK. Tel: 0993 898484.

• **Version 2 of Digidesign's SoundTools** offers new DSP functions that include time compression/ expansion, pitch change, digital compression and limiting and digital dither for improved low level linearity.

• **Digidesign's Sample Cell** for the Mac II is a 16 bit, 16-voice sampler card with eight polyphonic outputs and up to 8 Mbytes of on-board RAM. A 600 Mbyte CD-ROM of samples is included with the package along with *Sound Designer II* sample editing and transferral software. *SoundTools* hardware is used at the input allowing connection to a variety of analogue and digital sources. When used in conjunction with the *Studio Vision* hard disk recorder/MIDI sequencer, *Sample Cell* can operate as an integrated sample player running from the same computer.

Digidesign, Menlo Park, CA, USA. Tel: (415) 688-0600.

UK: Sound Technology plc, Letchworth, Herts. Tel: 0462 480000.

In brief

• **Roland UK** have moved from Brentford into a new purpose built 17,000 ft² office in Fleet, Hants. **Roland UK, Rye Close, Ancells Business Park, Fleet, Hants GU13 8UY. Tel: 0252 816181.**

• **Chris Martirano** has been appointed director of professional product development for **Kurzweil** music systems. Martirano was a Kurzweil district sales manager. **Chet Graham** has been named director of the **Young Chang R&D Institute**, located in Waltham, Mass, USA, which currently houses engineering staff devoted exclusively to the development of Kurzweil and Young Chang technology.

Studio Sound's Music News is compiled by Zenon Schoepe

At the end of the touring season and between AES shows, it's no surprise that there's little drama in the sound reinforcement world. But 1990 certainly saw a hardening of business attitudes, a few serious shake-outs and a few takeovers. The evolving face of the industry will be reflected in our Live Sound coverage this year.

New moves

- **Tannoy-Audix** marked the opening of their new Manchester sales office (tel: 0204 793 086) with a contract from Stafford Crown Court for a Tannoy-Audix PA and a Vector 'intelligent fire evacuation and alarm system'.
- **Wigwam Acoustics** have relocated their rentals division to a new 12,000 ft² premises in Heywood, Greater Manchester. Managing director Mike Spratt says it's the first phase of a two-year plan that will eventually see the company's

sales and admin departments moving onto the new site. Meanwhile lapsed Mancunian Phil Barrett (after 11 years as Fairlight's Scandinavian sales manager) joins Simon Campbell's sales team.

- **Samson Technologies**, wireless microphone manufacturers of Long Island, NY, have doubled the size of their facilities with a move to new interior-designed premises in Hicksville, NY. Their phone number is unchanged.

Studio Sound's Live Sound news page is compiled by Mike Lethby

Installations contracts

With the touring market suffering the effects of economic recession, manufacturers and SR service companies are looking to installations for new business opportunities. A tougher approach to marketing has led some firms who had previously been content to leave this sector to established specialists to develop new products for use in auditoria, conference halls, churches and clubs. Clair Brothers made their position on this issue clear in a previous Live Sound News page—and this month there are more.

- **Electro-Voice** have issued a statement outlining their commitment to installations, claiming they are determined to provide "more bang for the buck" for venue managers. A variety of E-V component systems and MT-4 SR systems have been installed in US stadia and theatres, including the Auburn Hills multi-purpose arena near Detroit and the Seattle Kingdome (described by E-V as "the loudest closed stadium in the US"). And a major contract has been completed at Singapore's new Broadcasting Corporation Auditorium, with consoles from Hill Audio in England.
- **BBE Sound** have won an order from London's prestigious Limelight Club for its 422A phase and amplitude distortion corrector for dynamic loudspeakers. Used in the

venue's main dance area system, BBE claims it reveals hitherto inaudible nuances and subtleties.

- **Altec Lansing** have stated their confidence in the installations market in a recent press release. With systems in major convention centres worldwide—from the Beijing and Korea World Trade Centers to the Nippon Convention Center in Tokyo and Canada's Victoria Conference Center—the company state they are in the business "for the long haul". They have also focused on the hotel industry, building a large presence in luxury hotel chains in the Far East. Altec Lansing—owned by Mark IV, who recently added Klark-Teknik to their pro-audio portfolio—last year notched up an overall 10% sales increase. Bob Rodgers, Mark IV's senior electronics projects engineer, used the Los Angeles AES as a forum to present his concept for "a standard communications interface for professional programmable sound products and computers"—the PA-422 serial communications interface and device control language.

- **Nexo** rounded up 1990 with numerous installations and sales to hire companies of their S12000 system, including the Harrogate Conference Centre through Wigwam Acoustics and two Belgian PA firms via leading Benelux promoter Herman Schueremans' production company EML.



Soundtracs SPA3200 on tour The Winans

New products

- **tc electronic's tc6032 EQ control system**—developed jointly with Clair Brothers and introduced last summer—has completed a number of major tours including Madonna, Fleetwood Mac and Janet Jackson. A remote panel controls 32 1/3-octave tc1128 equalisers, with frequency bands indicated by 28 motorised faders, at up to 100 metres from the EQ hardware. Each tc1128 offers features such as frequency band interaction correction, 100 presets, feedback suppression and a number of options including SMPTE and PC control, automatic acoustic alignment and security lock facility.
- **Soundtracs' SPA console**, launched last year, has won the endorsement of two FOH engineers. Bob Geldof's engineer Robbie

McGrath, whose credits include Boomtown Rats, Tears for Fears and Simply Red, used one on Geldof's 1990 European tour and found favour with the desk's EQ and layout. And Richard Bailey, engineer on top-selling US gospel act The Winans' dates at Birmingham and Wembley, regards it as "the purest and most flexible in its class".

- **Trouper Industries' cable crossover** protects cables in OB and live sound use. The protector is in the form of a ramp with a flat centre section and cover for the cables and features three 2 inch cable troughs. The finish is non-skid for the upper and lower surfaces and has black and orange safety colours.

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Trouper Industries Ltd, Gardena, CA, USA. Tel: (213) 327-5857.

Tour news

- **Britannia Row** have confirmed they will purchase the new Turbosound UHQ Flashlight system, which they have been evaluating on large shows since last summer. The news should confirm the esoteric UHQ's commercial viability, since it will compete for business alongside Brit Row's large TMS-3 and MSI stocks. The firm wound up a busy 1990 with tours by George Benson, Dionne Warwick, Sinéad O'Connor, Michael McDonald, The La's, Depeche Mode, Iron Maiden and Cliff Richard's nights at Wembley Arena. They also had little difficulty in finding two engineers to take their control gear to India for a string of shows (using local SR) by Samantha Fox. January dates included Robert

Cray, Deacon Blue and the remainder of Cliff's UK tour.

- **Audi lease** are fielding new technology for Paul Young's UK tour, which wound up at the Hammersmith Odeon in January. Pre-production versions of their new design SR cabinets are being beta tested as stage sidefills, and their newly acquired Midas XL-3 console is demonstrating its much-vaunted abilities in the FOH mix position. Other business includes Jonathan Butler's UK/Europe dates, Motorhead and monitors for EMF.

- **Canegreen** had a busy Christmas season with Van Morrison, Suzanne Vega, Aztec Camera in the US and UK shows at London's Dominion Theatre for streetwise classical virtuoso Nigel Kennedy, recorded for posterity by George Martin in a mobile truck.

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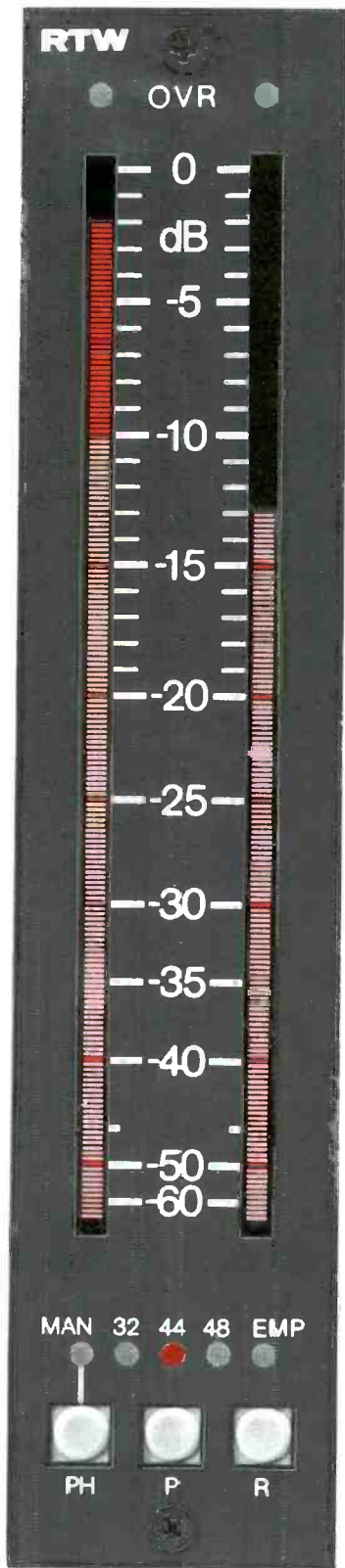
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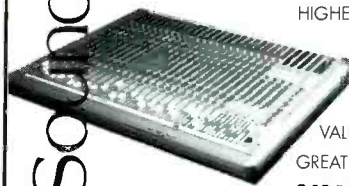
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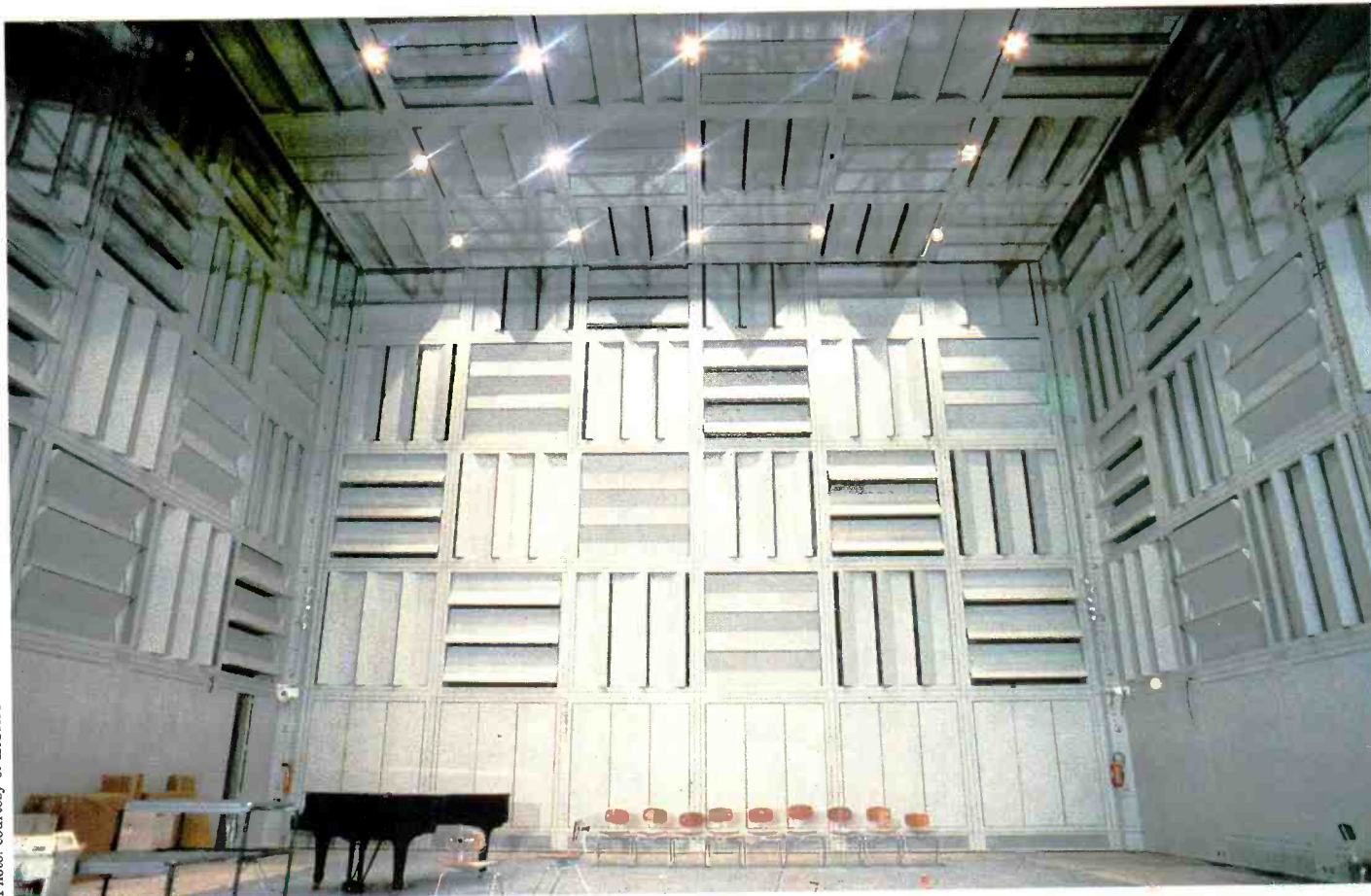
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IRCAM-RESEARCH AND DEVELOPMENT

IRCAM, or Institut de Recherche et Coordination Acoustique/

Musique, to give it its full title, is situated under the Tinguely fountain and the pedestrian plaza to one side of the Centre Georges Pompidou in the Beaubourg district of Paris. Founded by director Pierre Boulez in the early '70s and funded by the Ministère de la Culture, the underground complex was officially inaugurated in 1978 with a concert in the Espace de Projection, designed by Piano, Rogers and Francini (above).

This large 375 m² experimental room, whose floor is some 16 metres below ground level, has computerised variable acoustics with a reverberation time between 0.5 and 4.5 seconds. The walls and ceiling house prismatic modules called 'periactes' that can be rotated to present absorptive, reflective or diffusive surfaces and the tripartite ceiling can also be raised and lowered independently.

In addition to this impressive hall, the complex also contains an anechoic chamber, seven studios, three laboratories, a large computer room, an engineering workshop, technical department, conference room and several offices. In some of these offices people can be seen in pre-production mode, working with *Macintosh* computers and off-the-shelf electronic keyboards.

In 1978 IRCAM was founded in Paris by Pierre Boulez to investigate new musical forms and structures. It would seem that many of their original aims have been eclipsed by developments in commercial music products. Peter Ridsdale reports on the reality

In the last few years IRCAM has mushroomed above ground in the form of a 25 metre tower building, which serves as space for administrative and public relations functions. Two adjoining buildings are to be taken over in the near future for IRCAM's educational department launched 3 years ago for composers studying at the Conservatoire National Supérieur de Musique de Paris. These new buildings will free space below ground allowing further facilities for composers and researchers.

Shortly after Boulez had announced IRCAM's aims and objectives in 1974, Peter Heyworth wrote in the *Observer Review* that if IRCAM lived up to these expectations: "... it will be a milestone in the history of Western music as crucial as the advent of the airplane has been in the field of transport. IRCAM will probably succeed in pushing out the frontiers of sound as drastically as the great explorers of the Renaissance succeeded in expanding man's knowledge of the Earth¹".

research. If we think of the immensity of the problems involved (in understanding timbre for instance) you could say that we know nothing... In January we will be publishing a 700 page book just to say that it is a big, big problem. That you have no final answers, only more questions."

This ingenuous reply is perhaps a little tongue-in-cheek when one considers what has been achieved at IRCAM but it does show a commendable modesty. There is not even the slightest attempt to blind with science or to make over-extravagant claims.

"We have some partial explanations of the phenomena of timbre, some objective comprehension of timbre if you like but there is another problem—that of subjectivity—the life of the timbre depends to some extent on external elements, which we do not have the capacity to traduce in terms of scientific data."

To put it another and perhaps more prosaic way, what happens to a sound in the air is one

After over a decade of continuous research into the nature of sound, music and acoustics by teams of gifted musicians and scientists, artistic director Laurent Bayle has less sensational claims to make on behalf of the Institute: "We are not sure exactly that the results that we have now are as exciting as the



IRCAM's anechoic chamber

thing but what happens to it after it has reached the ear is another.

Psychoacoustics is but one of the areas that is covered by IRCAM's extensive research programme. The other fields include the analysis and synthesis of musical sounds, the acoustics of concert halls, the propagation and spatialisation of sounds and also the physics of musical instruments. As part of a more outward looking policy, information resulting from this research is being shared with acoustic designers and instrument makers in order to suggest ways in which halls and instruments can be improved.

All this research is quite apart from the intensive work that is going into the development of software for quite a number of musical applications; the development of ever more powerful 'musical workstations' and ways to make these high powered systems accessible to the composers and musicians who are to work with them. It would seem that this is the bottom line at IRCAM—research is not conducted for its own sake but is primarily geared towards the practical exigencies of understanding and making music.

Composers are either commissioned by IRCAM to work on specific projects or they may be invited to work there on the strength of scores submitted to the selection committee. Jonathan Harvey, for instance, who had already received commissions from IRCAM for two previous works, was recently invited to work on *Ritual Melodies*. The Institute paid for Harvey's studio time and his board and lodging while in Paris but the piece was commissioned by South East Arts.

Each year 10 to 15 composers work beneath the Place St Merri and since the inception of the Institute over 150 works have been produced by

100 composers; among them are some of the heavyweights of contemporary 'serious' music such as Boulez, Stockhausen and Berio, and a number of notable composers of the 'next generation': Birtwhistle, Harvey, Lindburg, Murail, Stroppa and Saariaho to name a small selection.

Composers usually take a 6 week preliminary course before beginning their own projects and they will then work with resident 'tutors' who advise them on the best way to realise their ideas and give them instruction in the use of the systems that are best suited to their needs.

"That is the nice thing about IRCAM," says Harvey, "when you go there you don't have to spend a lot of time learning how to do everything yourself. It's terribly complex otherwise to get to know a big system like that—all the UNIX facilities and how to relate to the big computer—let alone how to run the program itself."

Trevor Wishart, who worked at IRCAM in 1986 says that the Pedagogy course was, "Very exciting. I learnt more in 6 weeks there than I would have learnt in 6 months anywhere else. Particularly in the field of psychoacoustics."

IRCAM hardware

One of the major changes in direction in recent times has been the concentration on the development of software and 'firmware' for readily available hardware. The legendary 4X synthesiser/sound processor—a powerful and unique piece of equipment that is capable of analysing, synthesising and transforming acoustic sounds in realtime—represented the fourth

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generation of hardware developed at IRCAM by a team led by Giuseppe Di Giugno. Used in conjunction with the *MATRIX 32* (basically an audio routing device) it would be capable of taking a note played into it by, say a clarinet, almost instantaneously turning it into a cascade of notes that were each being turned inside out (sounding like clarinets turning into trumpets and oboes for instance) while simultaneously being sent whizzing round the concert hall. A fifth incarnation of this machine, known as the *5A*, briefly saw the light of day before technological developments in the outside world led to a radical rethinking by IRCAM staff. It was realised that non-dedicated commercial hardware was more powerful than that which had been developed at IRCAM and that there was absolutely no point in re-inventing the wheel.

A new project was begun that entailed making an 'accelerateur', which would interface with several NeXT computers working in parallel. The accelerator is in effect a multiprocessor consisting of several boards which each have two Intel i860 processors. These boards plug into the 'host' computers and use their graphic environments and filing systems. The result is a machine that surpasses the *4X* in terms of flexibility. This awesome sounding technological beast is known as the *IMW* (IRCAM Musical Workstation) and it is expected to be ready for the concert hall in the autumn of 1991. There are also plans to make the boards and the programming languages that they use commercially available by the end of 1991.

In addition to the six NeXT computers, IRCAM was recently given five 3100 DEC machines and a 6130 VAX by the Digital Equipment Corporation. These are now the most powerful computers that IRCAM possess and they join their existing collection: a VAX 780, a 3/260 SUN and 30 Apple Macintoshes. The 6310 VAX was a temporary addition and has been replaced by a 5820 DEC. This machine is capable of 36 MIPS (Million Instructions Per Second) and is therefore over 30x faster than the VAX 780. To think that it was

seriously suggested at one time that the entire world would need only four computers! A team of four people is fully occupied in ensuring that all these machines are networked, debugged, compatible and able to support the entire IRCAM software library.

IRCAM software

At its inception, IRCAM had a *PDP10* and used software that had been developed at computer music centres in the US, notably Stanford University and the Massachusetts Institute of Technology. Programs such as *Music V*, which was written by Max Matthews, and a Phase Vocoder developed by James Moorer were among the programs used before IRCAM began to develop their own software.

The Chant program developed by Rodet, Potard and Barriere was for a long time dominant at IRCAM but there are signs now that it is about to be superseded. It is essentially an analysis and synthesis package, which takes the human voice as its primary model, the idea being that if you can accurately model the voice then everything else will be easy. There are no helpful graphics in this program—it is all numbers and text (*en Francais*) and without a tutor to guide the way it is reasonably impenetrable.

"It was originally done as a voice simulation program and the idea is that impulses are pushed through a model of the vocal system; the larynx and the vocal cavities..." Jonathan Harvey demonstrates by tapping his cheek while making vowel shapes with his mouth. "The cavities are changed when I move my jaw to produce the required resonance. So what you're doing really is constructing cavities with a system of formants, or filters if you like, which can be placed anywhere; they can be moved very flexibly. That is the real power of the program. You get constant movement of the jaw or the instrument's resonant space (if it were a wind instrument) and

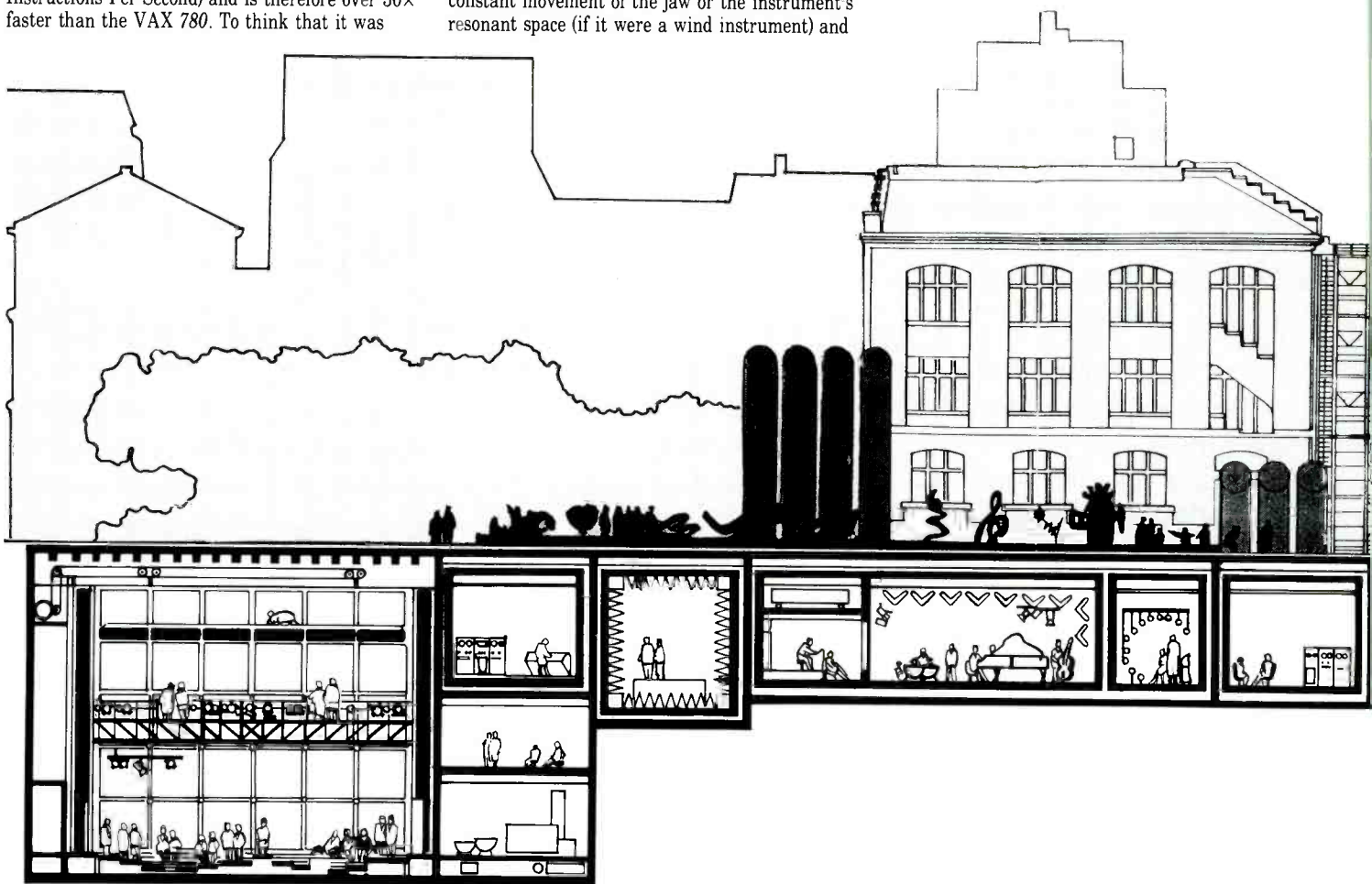
these formants can be louder or softer or broader, in what they allow to be emphasised, or much narrower. It can be so narrow that you completely shut the formant—it becomes one frequency and then you're dealing with additive synthesis—adding sine tones to each other.

"It was quite quickly found that it could make pretty convincing imitations of many instruments, not just the voice, once the facility for consonants, in other words noise, was developed (the 'sshh' and the 't' and what-have-you). You can control all of this in minute detail including its evolution in time. The evolution of the fundamental is very important—how it jumps around in the microsphere; if it's a steady note it sounds mechanical, if it's an irregular, jittering note it sounds like a real instrument or like the voice. That's quite separate from the vibrato which is on a much slower scale."²

One of the Chant modules has already been adapted to run on an Atari/Soundstreamer set up by the Composers Desktop Project, as has the Phase Vocoder, and both are available to members of that organisation.

Formes is a high level musical language program, which can be used to structure compositions and to control complicated processes. It can be used with any kind of synthesis program and is used in conjunction with Chant, for instance, in Harvey's *Ritual Melodies* where the sounds of synthesised kotos, shakuhachis, Tibetan monks, shenais and temple bells are made to transform into one another. This is quite a different effect from a crossfade as the spectra of the sounds themselves are actually mutating. It is possible to change from one voice to another three times a second or to effect a gradual evolution over a period of 30 seconds.³

The *Max* software is a good example of current trends at IRCAM. This package was developed by Miller Puckette and used to be known as *Patcher*.



It was used to control the *MATRIX 32* but was rather specialised and unwieldy. It has now been streamlined, adapted and 'MIDfied' so that it can even be run on a *Macintosh* as a general purpose graphic controller for synthesisers and MIDI processors. This package will soon be commercially available.

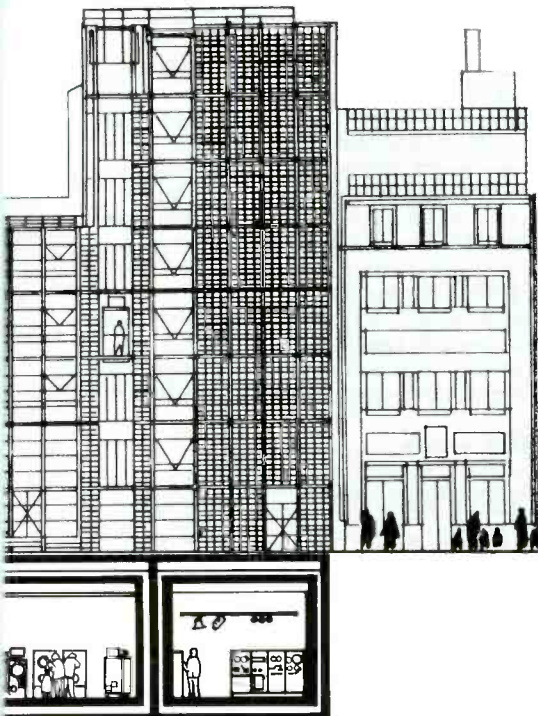
The *Signal Editor*, which runs on the IMW/NeXT, enables the user to zoom in to a Fast Fourier Transform spectrograph to examine the inner life of a timbre in microscopic detail.

New packages such as *ANIMAL* (ANIMATED Language) are in the development stage. *ANIMAL* is to be the basis of a graphical interface for the NeXT based workstation allowing the user to easily visualise sound making processes. It will work something like a drawing program with the user being able to select objects that represent elements of sound and then to cut and paste, redimension, copy and reverse, etc. As a bit of a non-sequitur I offer the following sentence from the IRCAM yearbook, purely for amateurs of computerspeak: "An *ANIMAL* application is composed of a tree of windows."

A team led by A Gerzso is working on software for Computer Aided Composition. This is where IRCAM enters the realms of artificial intelligence—composers who think in terms of statistical density, stochastic processes and fractal equations, as they hum the first few notes of a naissant opus may be interested in using the computer to take the donkey work out of laborious mathematical procedures but any discussion of this line of research leads directly into the murky waters of musical philosophy and personal taste so is outside our scope here.

Otherware

A brief glance through the list of works-in-progress in the yearbook gives the impression



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that everyone who comes to IRCAM is writing for the flute this year. This is no coincidence, however, it is merely a reflection of the fact that the 4X MIDI flute developed by Vercoe and Beauregard has been successfully completed. The Institute now has two of these flutes. Works using the new flute include Boulez'... *explosante-fixe*... in a new incarnation complete with high technology.

One of the major concerns of composers working in the electro-acoustic field is the problem of blending real and synthesised sounds. No matter how sophisticated synthesis techniques become there is still one major perceptual hurdle to overcome and that is the fact that all synthesis systems ultimately use loudspeakers that do not share the diffusion characteristics of real instruments. Research into the radiation of sounds has led to the construction of a dodecahedric speaker cabinet with a variable directivity index for each speaker of between 0 to 11 dB for frequencies below 1 kHz and between 5 to 24 dB for frequencies above. Careful measurement in the anechoic chamber combined

with listening tests have revealed further complications relating to directivity during the recording of sounds that are to be played back through the 12 speaker system for test purposes. Once this has been sorted out further tests will be carried out in acoustic environments and this research will go some way towards determining whether or not traditional loudspeaker designs will be adequate for the transmission of sounds in the future.

Funding

IRCAM is funded largely by the French Ministère de la Culture and receives roughly £3.6 million a year—the same amount of funding as a French symphony orchestra—it also generates some itself. It is instructive to learn that the French government allocates about 1% of the country's annual budget to the Arts as opposed to about 0.4% in the UK. Given this situation, attempts by The Sonic Arts Network and also by Sir Fred Warner to establish a 'National Studio' on the

South Bank in London have predictably fallen by the wayside. It is not likely that there will be an IRCAM by the Thames in the foreseeable future.

No-one who is seriously interested in the future of music can argue that there is no need for serious research institutes independent of commercial equipment manufacturing concerns but there has been criticism levelled at IRCAM along the lines that it is something of an ivory tower when it comes to music policy. This policy seems to cater almost exclusively to a musical clientele of the atonal and arhythmic persuasion, which comes directly from an aesthetic that dates back to the serialism of the '50s and before that to Schoenberg and Webern—its defenders, however, would point out that without the prestige of Boulez the whole thing would never have got under the ground in the first place.

Bayle is very much aware that we are living in a time of musical pluralism and observes that in terms of an historical perspective there is now: "... a period of transition which is characterised by a kind of cultural fatigue—there is a perplexity of the *avant garde* because you have many people who don't know what is 'the *avant garde*' anymore—there is a tendency for progressiveness to go with the past, as is the case with certain composers like Ligeti and Kagel...

"In between the '50s and the '70s the past was discarded as stupid and in the '60s and '70s there was an attempt at a new construction. These times were dynamic, there was a great deal of imagination, more interesting artistic points of view, etc, but what do we have now? It's normal that the new generation is now saying that the *avant garde* is establishment and that it's finished and I think that this is healthy. So I say, OK, but what are you doing? The reply so often seems to be 'Well, the past was good'."

"The new developments at IRCAM are some of the most exciting in the world," says Harvey while discussing the new *Musical Workstation*. Is he then of the opinion that IRCAM is at the cutting edge of music technology?

"I think so, yes. They have such an excellent balance between music and technology. They seem to be able to attract the best in both fields. There's always a certain tension, which is perhaps both good and difficult, but it's a place full of life and the fact that Boulez is at the head of it, I think, always ensures that it remains important musically and that standards are rigorous. The level of criticism is very high. It's a funny thing that IRCAM music is slightly sneered at by critics in the UK but I don't share that. I find a lot of the works that people dismiss to be very interesting—they may not be great masterpieces but they have something about them that is unusual, that is new, exciting and pointing to the future. I have a great deal of time for IRCAM." □

References

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- 3 Ibid Rodet X, Cointe P, *FORMES: Composition and Scheduling of Processes*, pp 405-421

Further reading

- Boulez P & Gerzso A, 'Computers in Music', *Scientific American*, Vol. 258, No 4, 1988
- Harvey J, 'The Mirror of Ambiguity'. See Emmerson S *The Language of Electroacoustic Music*, Macmillan, London, UK. Composers Desktop Project, 11 Kilburn Road, York YO1 4DF
- IRCAM, 31 Rue Saint-Merri, F-75004 Paris, France. Tel: 33 (1) 42 77 12 33, extension 69 98, for enquiries about publications and recordings

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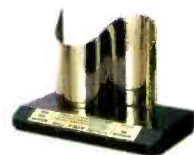
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Key

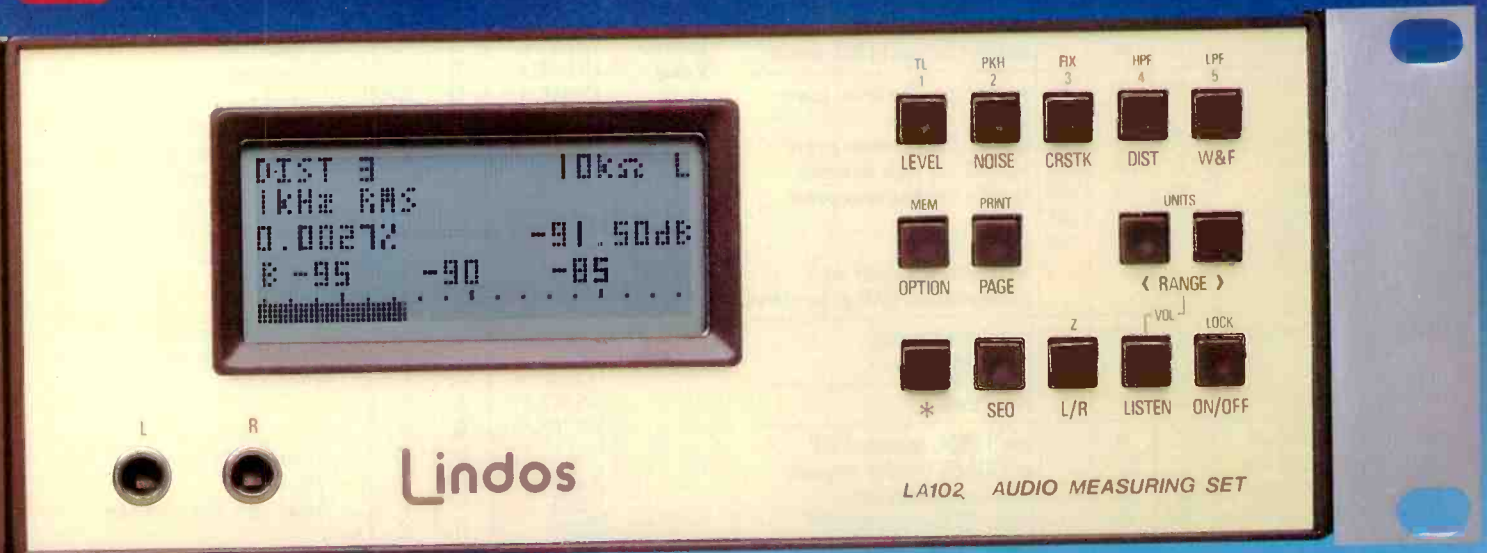
Type	C = Condenser	E = Electret
	D = Dynamic	R = Ribbon
Polar pattern		
O	= Omni	
C	= Cardioid	
SC	= Supercardioid	
HC	= Hypercardioid	
8	= Fig-of-8	
U	= Unidirectional (used to signify directional pattern that does not qualify under any of the above categories)	
H	= Hemispherical, ie boundary response	
MS	= MS stereo	
NC	= Noise cancelling	
BN	= Binaural (as in dummy head)	
O/C/8=	denotes pattern choice	
V	= Variable pattern, continuous	
M	= Multiple pattern, switched	

M/fr	Model	Type	Polar	Max SPL	Details
ACO Pacific	ACM48UP	C	C		compact multipurpose
AKG	D12	D	U		bass applications
	D58	D	NC		noise cancelling
	D70	D	C		
	D80	D	C		
	D90	D	C		
	D95S	D	HC		
	D109	D	O		lavalier type
	D112	D			bass applications
	D125	D	C		
	D130	D	O		
	D190	D	C		
	D310	D	C		general purpose live
	D321	D	HC		general purpose live
	D330	D	HC		general purpose live
	D510	D	O		gooseneck
	D541	D	C		gooseneck
	D558B	D	NC		gooseneck, noise cancelling
	D590	D	C		gooseneck
	D202	D	C		voice and general purpose
	D222	D	C		variable LF
	D224	D	C		variable LF
	D900E	D	U		shotgun
	C34	C	M		stereo
	C414-ULS	C	M		large diaphragms, low noise
	C428	C	M		stereo, large diaphragm
	C522ENG	E	2xC		hand held stereo
	C562BL	E	H		circular boundary mic
	C567E1	E	O		lavalier type, music or speech
	C568EB	E	HC		medium distance dialogue mic
	C747	E	HC		high gain live use, tight pattern
	C525S	E	HC		
	C401	E	HC		
	C1000S	E	C/HC		switchable response
	The Tube	C	M		vacuum tube mic
	C460-ULS	C			modular system; C, O, HC capsules
	C426B	C	V		stereo, suitable MS/XY
	C451EB	C	C		with CK1 capsule; wide range other types
	C408	E	HC		miniature percussion/drum mic
	C409	E	HC		mini instr mic on gooseneck
	C410	E	HC		miniature headset mic
Amfon	BL-9	C	C		10 dB pad, two HPF filters
	BL-3	D	C		
AMS	ST250	C	S		switchable X/Y, M/S, remotely controlled
	Soundfield	C	V		4-channel and 2-channel O/Ps; continuously variable pattern
Audio-Technica	AT801	E	O		
	AT802	D	O		

M/fr	Model	Type	Polar	Max SPL	Details
Audio-Technica cont'd	AT803B	E	O		mini lavalier
	AT805B	E	O		mini lavalier
	AT810		U		headset mic
	AT811	E	U		
	AT812	D	U		
	AT813	E	U		
	AT814A	D	U		
	AT81S	E	SC		shotgun
	AT831A	E	U		mini lavalier
	AT835		SC		short shotgun
	AT836		U		vocals
	AT838G	D	U		console mounting
	AT841A	E	H		boundary type
	AT851A	E	U		boundary type
	AT871A	E	U		boundary type
	AT877	E	SC		
	AT4031	C	U		
	AT4049	C	O		
	AT4051	C	U		
	AT4053	C	HC		
	AT4071	C	SC		long shotgun
	AT4073	C	SC		short shotgun
Beyer	MC740	C	V	134	stand mount
	MC742	C	S	134	stereo, adjustable capsule angles
	MC734	C	C	138	vocal use
	MC736	C	SC	123	lightweight shotgun, hand use
	MC737	C	SC	122	lightweight long shotgun
	MCE5	E	O	116	tie clip mic
	MCE6	E	O	146	tie clip mic, high level
	MCE10	E	HC	116	cardioid version MCE5
	MCE80	E			LF filter
	MCE81	C	SC		for stage use
	MCE86	E	SC		low cost shotgun
	MPC40	C	H		boundary type, circular base
	MPC50	C	H	130	boundary mic in wood plinth
	MPC60	C	C		boundary mic, capsule raised
	M69	D	HC		high sensitivity, music/voice
	M88	D	HC		instrumental mic
	M160	R	HC		double ribbon, string instruments
	M200	D	C		low cost
	M260	R	HC		instrument mic
	M300	D	C		vocal/general use
	M400	D	SC		vocal/general use, presence boost
	M500	R	HC		vocal
	M600	D	HC		vocal, variable LF
	M700	D	HC		vocal use
	M420	D	HC		high quality, live speech use
	M422	D	SC		low cost speech mic
	HM560	D	8		headset mic
	M580	D	O		extra long reporter's mic
	M380	D	8	140	bass instruments, large overload margin

Lindos

LA100 Audio Analyser

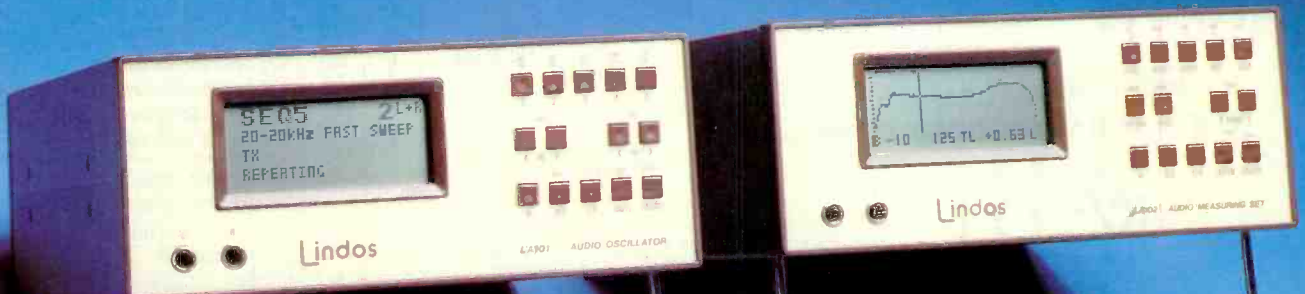
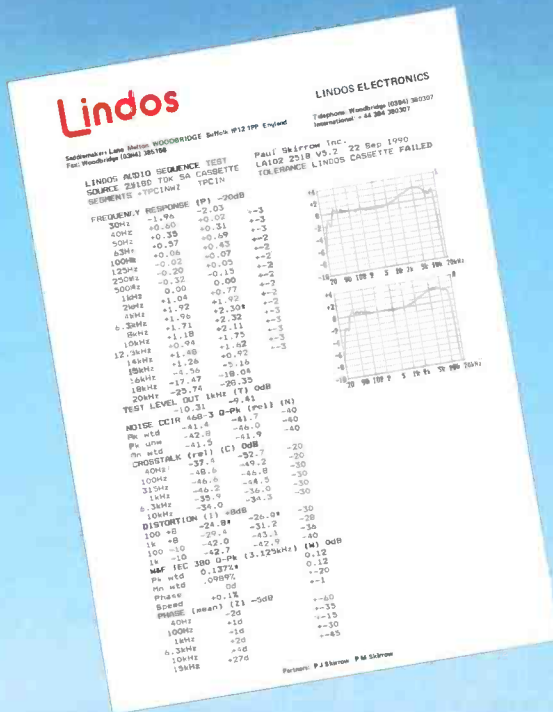


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M/fr	Model	Type	Polar	Max SPL	Details
Beyer cont'd	M101 M130	D	O 8		slight HF emphasis suitable for use in MS stereo
Bruel & Kjaer	4003	E	O	154	pencil type, line level, power supply
	4006	E	O	143	as 4003 but phantom power
	4004	E	O	168	as 4003 but high intensity
	4007	E	O	155	as 4004 but phantom power
	4011	E	C	158	
	4012	E	SC	168	
	5930				head/torso simulator with phase matched 4006 pr for stereo
CAD	Equitek II	E	O/C/8	148	large stand mount, transformerless
Coles	4038	R	8		stand mount
Crown/ Amcron	PZM-6R	E	H		small PZM, enhanced HF
	PZM-6F	E	H		as PZM-6R but flat response
	PZM-20	E	H		permanent installation
	PZM-30R	E	H		larger PZM, enhanced HF
	PZM-30F	E	H		larger PZM, flat response
	PCC-160	E	C		phase coherent boundary
	PCC-200	E	C		as PCC-160, variable gate
	CM-100	C	O		
	CM-200	C	C		general purpose/vocal
	CM-310	C	DF		high gain before feedback
	SASS-P	E			stereo system using PZM technology
	SASS-B				boundary mount system for B&K 4006 mics
	GLM100			O	subminiature type
	GLM200			HC	subminiature type
CM-30	C	SC		miniature mic for hanging applications	
LM300	C	SC		miniature gooseneck mount	

M/fr	Model	Type	Polar	Max SPL	Details
Electro-Voice	ND257A	D	C		vocal mic
	ND357A	D	SC		vocal mic
	ND457A	D	HC		vocal mic
	ND757A	D	SC		vocal mic, roll-off switch
	ND857	D	SC		vocal mic, roll-off switch
	ND308A	D	C		instrument mic
	ND408A	D	SC		instrument mic
	BK1	C	C		hand held vocal mic, gen instr
	PL68	D	C		
	PL80BL	D	C		
	PL88	D	C		
	PL10	D	C		
	PL20	D	C		
	PL50N/D	D	C		no proximity effect
	PL60N/D	D	SC		no proximity effect
	PL70N/D	D	HC		
	635A	D	O		hand held voice
	CO90	C	C		tie clip mic
	DS35	D	C		high gain live vocal use
	RE10	D	C		
RE11	D	C			
RE16	D	C			
RE18	D	C			
RE20	D	C		stand mount, general purpose	
RE45/ND	D	SC		hand held short shotgun	
RE50	D	O		hand held voice	
Fostex	M11RP	R	U		
	M22RP	R	S		MS stereo
	M33RP	R			outdoor applications
	M44RP	R			
	M77RP	R	U		LF applications
	M88RP	R	8		speech use
Milab	D-37	D	C		vocals, guitars, drums
	VIP50	C	V	112	transformerless, variable filters
	DC96B	C	C	118	multipurpose, large capsule
	VM44	C	C	128	slim style, transformerless
	LSR2000	C	C	133	stage vocal mic
	LC25	C	C	128	transformerless, line level option
	MP30	C	H	110	boundary type
	Neumann	KMS140	C	C	138
KMS150		C	HC	142	hand held vocal mic
TLM50		C	O	136	transformerless, sound related to M50
GFM132		C	H	137	triangular boundary mic
KM100					modular microphone system, range of capsules
KM130		C	O	140	
KM131		C	O	140	flat direct field response
KM140		C	C	138	
KM145		C	C	138	bass roll-off
KM150		C	HC	142	
TLM170		C	V	140	transformerless, stand mount
U87		C	O/C/8	117	stand mount, multipurpose
U89		C	V	134	similar but smaller than U87
SM69fet		C	O/C/8	123	stereo, fully variable angles
USM69i	C	V	132	stereo, fixed selectable patterns	
KU81i	C	BN	130	stereo dummy head system	
RSM191	C	MS	134	MS stereo shotgun	
KMR81i	C	SC	128	short shotgun	
KMR82i	C	SC	128	long shotgun	
KMS84	C	C	138	hand held vocal mic	
Pearl	CC30		C		double capsule, transformerless
	TL-4				double membrane system with two amplifiers
	MS2/MS8	C			stereo MS
	TL6		C		
	MD87	D	C		
PA54	C	C		transformerless	
Peavey	ERO10	E	O		small capsule, recording
	ERC12	E	C		large capsule, recording
	PVM38	D	C		vocal, live use

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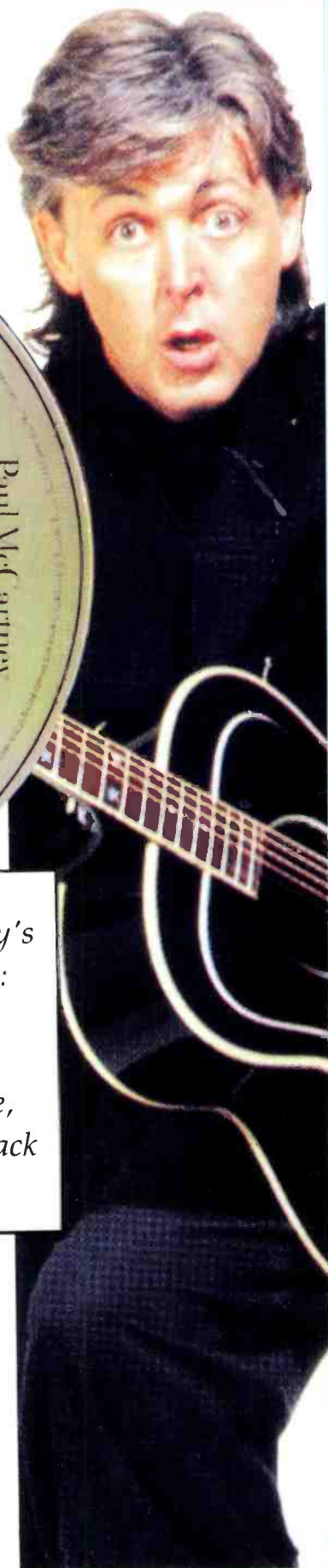


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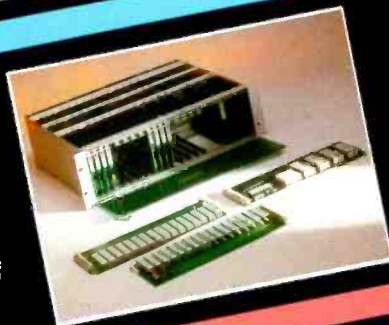
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M/fr	Model	Type	Polar	Max SPL	Details
Peavey cont'd	PVM380N	D	C		vocal, live use, tight pattern
	PVM520TN	D	C		stand mount, instrument use
	PVM580TN	D	C		hand held, vocal use
	PVM45	D	HC		general instrument use
	PVM48	E	C		general instrument use
	PVR-1	E	O		small capsule, flat response
	PEL20	E	O		lavalier
	PEL25	E	U		lavalier
	PVN535N	D	C		hand held vocal mic
Ramsa	WM-S1	E	U	148	sub miniature, wide band
	WM-S2	E	U	138	sub miniature, for brass
	WM-S5	E	U	158	sub miniature, for percussion
	WM-S10	E	U	138	sub miniature, headset type
	WM-D70	D	SC		vocal use
	WM-D65	D	SC		vocal use
	WM-D55	D	U		general use
	WM-P50	D	U		instrumental use
WM-P40	D	U		instrument/vocal use	
Sanken	CU41	C	C	140	twin capsule, general purpose
	CU44X	C	C		twin capsule, general purpose, transformerless
	COS-11	E	O	123	ultra miniature lavalier
	CMS-7	C	S		X/Y and MS stereo, hand held use
CMS-9	C	MS		stereo mic for ENG	
Schoeps	Collette series				modular mic range with choice of amplifiers and capsules
	MK2	C	O	130	
	MK3	C	O	132	tailored for use in reverberant soundfield
	MK4	C	C	131	
	MK4S	C	C	130	tailored for speech
	MK41	C	HC	130	
MK5	C	O/C	131		

M/fr	Model	Type	Polar	Max SPL	Details
Schoeps cont'd	MK6	C	O/C/8	132	
	MK8	C	8	132	
	MK21	C	C	130	'subcardioid' off axis signals lower in level but same tonal balance
	BLM03C	C	H	130	small boundary mic for Colettes
	BLM3	C	H	130	boundary mic
	CM03	C	O	130	compact flat clip-on type
	CMH541C	C	HC	132	hand held vocal mic
	CMH54C	C	C	131	hand held vocal mic, range of powerings
	CMH52C	C	O	132	hand held vocal mic, range of powerings
	CMTS501	C	O/C/8	125	stereo mic, also as CMTS301 for 12 V operation
	KFM6U	C	S	120	sphere stereo recording system
	Sennheiser	MKH20	C	O	134
MKH30		C	8	134	
MKH40		C	C	134	
MKH50		C	SC	134	
MKH60		C	SC	125	short shotgun
MKH70		C	SC		shotgun
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	SM81	C	SC	146	acoustic instruments, drum O/H
	SM80	C	O	147	as SM81
	SM98	C	C	153	mini mic for drums, horns, gtrs
	SM99	C	SC		miniature gooseneck mounted
	SM83	C	O		miniature lavalier
	SM84	C	SC		miniature lavalier
	SM90	C	H	141	boundary type
	SM91	C	H	144	boundary type, half cardioid response
	SM7	D	C		vocals
	55SH Mk2	D	C		redesign of original 55 series
	520D		O		'Green Bullet' harmonica mic
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	VP64	D	O		ENG, A/V production
VP88	C	MS	129	stereo	

M/fr	Model	Type	Polar	Max SPL	Details
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	ECM-55	E	O	126	lavalier, multi use
	ECM-66	E	C	130	lavalier, musical applications
	ECM-77	E	O	120	lavalier, miniature
	C-38B	C	O/C	140	stand mount, multi use
	C-48	C	O/C/8	128	stand mount, high performance
	C-74	C	SC	126	shotgun (17 ins approx)
	C-76	C	SC	126	shotgun (27 ins approx)
	C-535	C	C	138	pencil type, multi mic use
	C-536	C	SC	138	pencil type, multi mic use
	ECM-672	E	U	114	short shotgun type, camera mount
	ECM-MS5	E	MS	130	suitable hand held use
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DIGITAL AUDIO RESEARCH





It is difficult to overestimate the importance of the work of Bill Price in the field of recorded popular music. Although now in his 40s, it is hard to imagine that he has been a professional sound recordist for some 28 years. Such longevity at the sharp end of pro audio is quite an accomplishment in itself. He also maintains an enthusiastic approach to his work and an appreciation of many types of music. He's equally at home working as sound engineer on a performance orientated Elton John session as he is co-producing an album with Big Audio Dynamite which is largely constructed from samples. Also few people can equal his vast knowledge and experience of recording from the early days of analogue multitrack to current digital work.

Price started as a tape op at Decca Recording Studios, London, in 1962 and within a few months he graduated to sound engineer. At Decca he engineered sessions for Tom Jones, Kathy Kirby, The Fortunes, John Mayall, Eric Clapton, The Moody Blues, The Applejacks and a colossal number of other '60s singers and bands. He remained at Decca until 1970 when he had an interview with George Martin and subsequently joined the newly formed AIR team, helping with the planning of the company's innovative independent Oxford Street recording studio complex. He was chief engineer there until 1975, his engineering credits from the period including Harry Nilsson, Kenny Rogers, Marc Bolan, Stevie Wonder, Pink Floyd, Stan Getz, Paul McCartney and Gary Moore.

While at AIR Price was to form a long lasting working relationship with producer Chris Thomas

BILL PRICE

Producer Bill Price served his 'apprenticeship' in the UK during the early '60s. Here he tells Ralph Denyer the story

and subsequently engineered many of his projects. The two were later to work on the Sex Pistols' *Never Mind The Bollocks Here's The Sex Pistols* album, which bore the intriguing credit, 'Produced by Chris Thomas or Bill Price'. He also engineered album sessions for Thomas with Elton John, Pete Townshend and The Pretenders.

In the mid '70s AIR became part of the Chrysalis group of companies. Chrysalis also acquired Wessex Studios in north London and Price left AIR to take on the job of planning a complete rebuild of the studios where he subsequently became studio manager and chief engineer until 1980.

In 1981 he became managing director of Wessex

and since then has continued to engineer for Chris Thomas. He has also co-produced a number of album projects with bands including The Clash, Dave Vanian and the Phantom Chords and Big Audio Dynamite (aka BAD). He has, particularly over the past 2 or 3 years, been very active as a mix and remix engineer, working on tracks for Paul McCartney, The Mission, Thrashing Doves, Rod Stewart, World Party, Nik Kershaw and The Heart-throbs.

From his very early days Bill had an interest in electronics, as he explains: "My father was an electronics design engineer and so electronics were readily available in our house, so to speak. I remember from being a small boy, we had a television my father had built, which was ensconced in a plywood case with a hole sawn for the screen. I think I just took electronics as a normal thing for anyone to dabble in. I very rapidly gravitated towards audio in all its different aspects.

"I used to have a huge box of bits from which I could just tie up my own circuits and tinker with them. Valve electronics was very easy. The main problem was digging the holes out of the metal chassis. Once you had a piece of metal with enough holes in you could build anything: equalisers, record amps, power amps and things of that nature. The main reason I wanted to build amplifiers was to be able to listen to records at ever-increasing volume in my bedroom. It was music which generally motivated it all."

Price went straight from school to work for Plessey Telecommunications as an apprentice, concurrently taking an HNC electronics course. But at Plessey he was to discover that electronics

can take a young man in unexpected directions: "The Plessey side of it disillusioned me a bit because I was working in labs that were heavily involved in military electronics. I was

working on something, one module of which would come into play should Britain decide to drop its nuclear weapon. This was something installed in V-bombers and if a coded decimal number was sent to the bomber and set up in a row of decade switches, the chap opens the safe—you know, sort of 'Doctor Strangelove'."

The realisation that he was working on 'the ultimate box of destruction', did not sit well with this teenage apprentice. This was at the very beginning of the '60s and he also had a healthy interest in rock'n'roll. He was involved with local bands and dabbled in management and promotion. He was a fan of Duane Eddy—he of the detuned guitar recorded with the aid of a grain silo for reverberation—and had been to see him live at The Regal, Edmonton, London. Price was impressed.

"One of my favourite albums at the time was of Duane Eddy and I was in my bedroom playing that with some friends, at ever-increasing volume, and we noticed that a certain Eddie Bracket was credited as sound engineer on the album cover. We all started jeering at what we considered, with our adolescent humour, to be this chap's unfortunate name. We're talking about 17-year-old boys lusting after sex and the word 'bracket' was immediately sexual to us. So we had a good laugh at Mr Bracket's surname and then it slowly dawned on me that this was a real chap and he

They had this chair, like a giant kid's high chair, on which they used to sit the acoustic guitarist

Photo: Ralph Denyer



must be doing something reasonably interesting that would tend to appeal to me. I thought: 'Sod it, I'll have a go at this.' So I wrote to the address that appeared on the sleeve of every album that I had."

Many of the addresses were merely transient labels but several were record companies, which owned their own recording studios.

"Of the various people who replied and interviewed me, I opted for Decca where I saw the redoubtable Arthur Haddy who used to be the

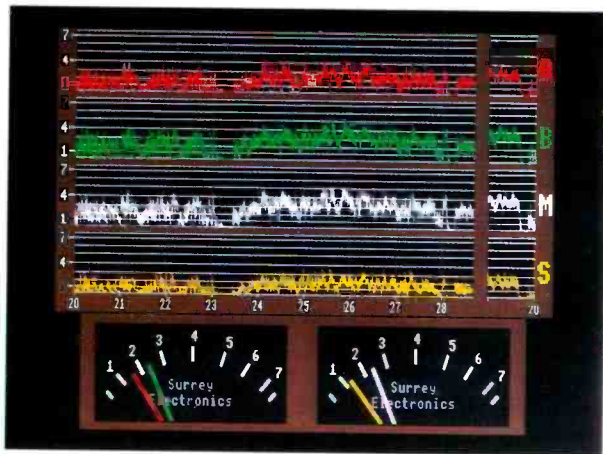
studio manager in those days. I was lucky enough to work with some fantastic engineers. The chaps who were close to retirement in the recording engineering field at Decca were the

people who'd started with the very beginnings of the technology. They'd started recording on wax with one microphone and knew the techniques for recording a dance band straight on to wax with a single STC 'ball and biscuit' moving coil microphone. And they still had lots of the equipment they had used in those days.

"They had this chair, like a giant kid's high chair, on which they used to sit the acoustic guitarist so that he could be offered up to the microphone closer than the rest of the band. Then the trumpets and the drummer would be right at the back of the room as far away as the engineer could get them. The singer would be standing between the band and the microphone and the balance would be achieved by moving the singer backwards or forwards. So the two main chaps I worked under in those days were Arthur Lillie and Arthur Bannister. They were an absolute fountain of information and good practice.

"Arthur Lillie recounted to me the extreme battles he'd had with the people who were responsible for building the recording equipment at Decca, because there wasn't a hell of a lot of industry as far as equipment manufacturers were concerned when he started. Arthur recounted tremendous battles he'd had to get them to build something whereby he could use *two* microphones for instance, because he used to specialise in popular music. I think one of the credits you can

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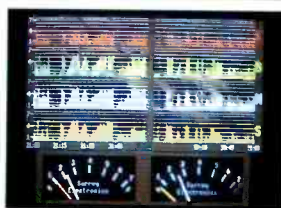
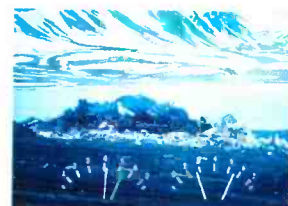
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put down to dear old Arthur was *The White Cliffs Of Dover* by Vera Lynn. And he thought it would be a good idea for popular music to have two microphones, one for the orchestra and one for the singer, because this would save putting off a singer who might be nervous about having to record by constantly shuffling backwards and forwards and hence worrying about the technical process. That is an excellent principle which easily translates into modern day recording.

"If you worry somebody with the technology when they're trying to give a good performance that is the opposite of what a recording engineer is supposed to be doing. So good old Arthur was working along those lines many years ago and he finally persuaded Decca to build him

something with two mic inputs. This was of such enormous benefit that they then made something you could plug six microphones into, which was rapidly extended with another four channels. And when I started at Decca a 10-channel valve console was still in use. As I remember, the last valve console they built at Decca was a 20-channel device, which was of absolutely superb quality as long as it didn't crackle. Of course, when a valve went you had to rummage around the back to find out which of the many thousands it was and replace it."

When Price started at Decca a new console was being built using newfangled devices called *OC71* transistors. He recalls that the two successful tape media at the time were mono-to-mono 15 in/s full track on ¼ inch tape, which was superseded by the Studer *J37* 4-track on 1 inch. To this day he feels that for analogue machines, including those used for mastering, close to a ¼ inch of tape per track remains the best format. I mentioned that recently Mike Hedges and Chris Tsangarides had said they had both gone back to using Studer 16-track on 2 inch tape machines in tandem with digital multitrack machines.

"I can understand why. When the Ampex *ATR 100* 2-track on ½ inch format came out in more recent times, immediately it sounded absolutely wonderful, again using nearly ¼ inch of tape per track."

After around 6 months or so working as a tape op and soaking up as much information as he could from the senior Decca engineers, Price somewhat suddenly found himself in charge and engineering his first session. At the time there were three 'sessions' a day at Decca, which ran from 10am to 1pm, 2 to 5.30pm and

7 to 10pm. Upwards of four songs would be recorded per session. If Price's memory is a little hazy on his early credits he can be forgiven as he was recording 60 to 80 songs during a busy week and was therefore responsible for a major part of Decca's output. But one particular session he remembers well. The 'superb pop engineer' he was tape-op'ing for had achieved a good sound during the afternoon session and one potential A-side was successfully recorded. Then they all took a break before the evening session.

"For one reason or another, this superb pop engineer was paralytic after half an hour up at

the pub and was incapable of making it back into the control room. I got a slurred phone call to the effect: 'Please put my briefcase out in the corridor and I'll sneak out and you can finish the session.' Finishing the session didn't involve much more than continuing tape-operating because he'd already got a sound on the band. Just by sheer chance the song that I did was preferred by the A&R department and released as the A-side. I did also record the mixes. I seemed to get on well

The valve console was of absolutely superb quality as long as it didn't crackle. Of course, when a valve went you had to rummage around at the back to find out which of the many thousands it was and replace it

with the producer or something, I can't remember now."

The single was *Tell Me When* by the Applejacks and was a Top 10 hit for the group in March 1964. Bill was immediately promoted to full recording engineer status.

"To be honest, at that time in the Decca A&R department they used to always rely exclusively on a process named 'Magic'. This was because nobody really knew why one record was a hit and another wasn't. They used to look for 'magical' elements. So-and-so played the tambourine on a hit so the tambourine *might* have made the record successful. The engineer was considered in a similar vein: 'We don't know exactly what the engineer did but he must be doing something right and we'll use him again next week.' And I suppose that is still current among record companies to a certain extent. I get lots of phone calls mainly angled from the point of view that a new band a record company wants me to work with is a bit like Clash or BAD so they think I'm the man to do it. If you actually look at the kinds of bands I've worked with in the past, they include just about every kind of music you could imagine. I don't consider myself to be a specialist from any one particular point of view except that recently I've specialised in recording bands in the general sense."

During the early to mid '60s Price found himself working on pop, orchestral, classical orchestral,

I don't consider myself to be a specialist from any one particular point of view except that recently I've specialised in recording bands in the general sense

spoken word and special effects sessions. But the major influences on popular music were originating from the USA. Thus for potential chart singles, Decca engineers were actively encouraged to get the same sounds that were on American records.

"This happened in several ways. Don't forget that in the '60s a lot of British pop hits were straight copies of American records, the originals of which at that stage, nobody was releasing in this country. So one of the jobs the engineer was given was to strictly copy the sound. Decca would employ a musical director who would listen to a

Stax, Coral or RCA Series single and 'transcribe it for orchestra' so to speak and give it to a bunch of London session musicians to play. The engineer would listen to the record and attempt to copy the latest Tamla Motown sound or what have you, which was incredibly difficult but at times we could achieve a modicum of success. Again it was based on the principle, 'We don't know what's good about it but it's sold millions in America so we just want to copy it as closely as possible.

Little did the record companies realise that the session musicians they were employing, such as Jimmy Page and John Paul Jones, would eventually write their own pages in the history of popular music but as Price says, "That's another story."

At one point Decca sent a producer over to the States to find out how the Americans were achieving all these new sounds. The producer was unfortunately not technically orientated but at least he returned with a list of the model numbers of equipment he'd seen in use in the studios.

"This was brilliant for us because we were able to say we've got to have them, and overnight we had a huge bank of Fairchild compressors and Pultec equalisers, the stock-in-trade of the American studios. In those days America did have the beginnings of an equipment manufacturer set-up. Fairchild and Pultec must have been among the first. So we were immediately blessed with a Fairchild 660 compressor and the wonderful Pultec peaking equaliser, the *EQP1A3* or something. It's still wildly fashionable today, I remember using that in the mid '60s. The same goes for the valve Fairchild. So that was the benefit of that producer's trip. He also came back with the number 'U47', which he'd seen stamped on Elvis Presley's microphone. We told him we'd got some of them and were using them already. He said, 'Oh, Jolly good!' But it is amazing how many of those things are still common currency today."

Towards the end of the time he spent at Decca, Price had formed a close working relationship with Peter Sullivan. Sullivan was very successful as a Decca staff producer, recording many hits with Tom Jones, Engelbert Humperdinck, Kathy Kirby and others.

Sullivan decided to join forces with John Burgess, Ron Richards and George Martin—all of whom had previously been very successful staff producers for EMI—to form Associated Independent Recording,

aka AIR London, the first major independent record production company in the UK. The income from record production was substantial, as was the money spent hiring studios, as were the amounts paid in income tax. The famous and ambitious, and quite logical decision was taken to build Air Studios.

During 1967 it was the Price engineered and Sullivan produced single *Release Me* by Engelbert Humperdinck that brought a temporary halt to Beatles singles automatically going to No 1 in the charts. The *Penny Lane/Strawberry Fields Forever* double A-side only made it to No 2, after

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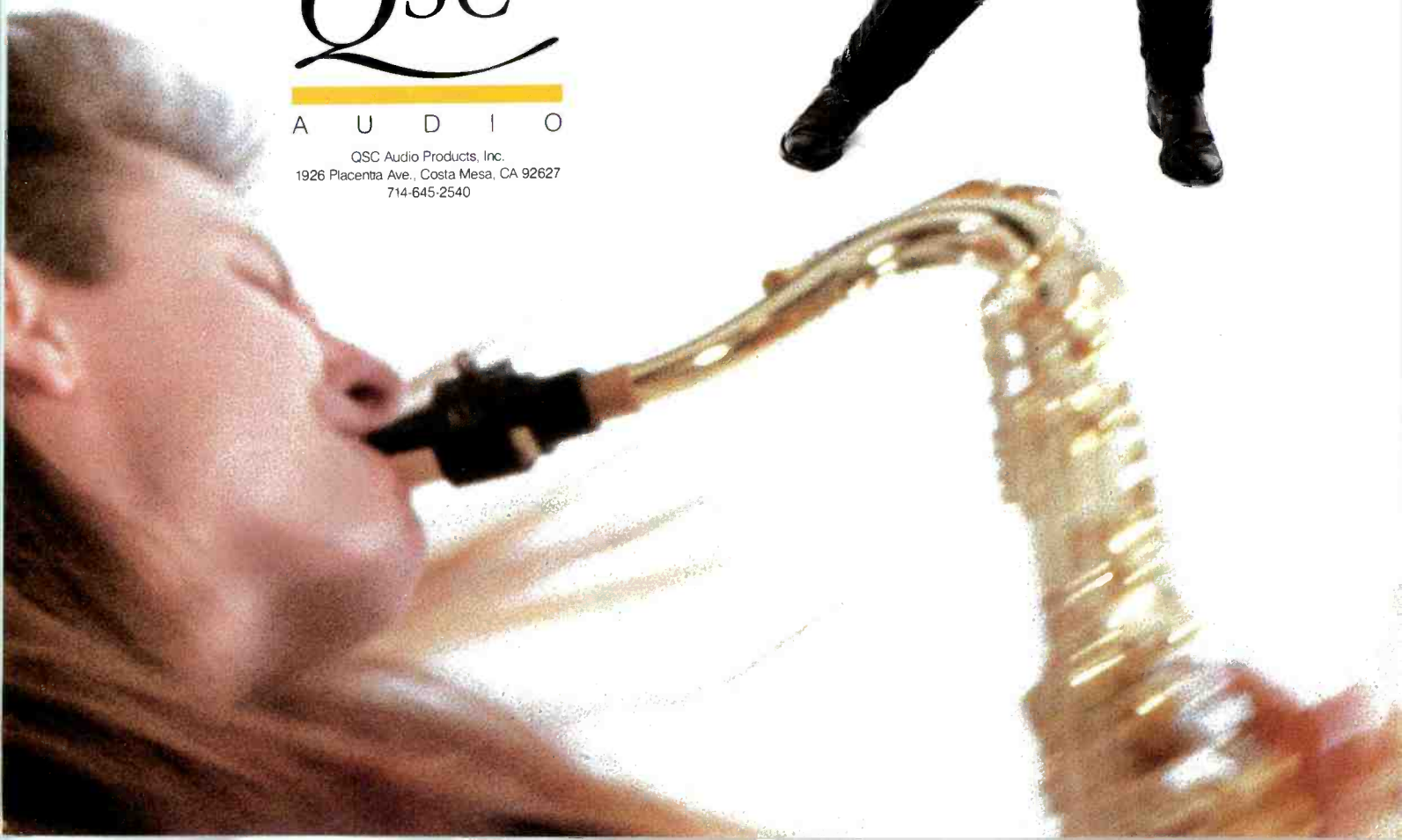
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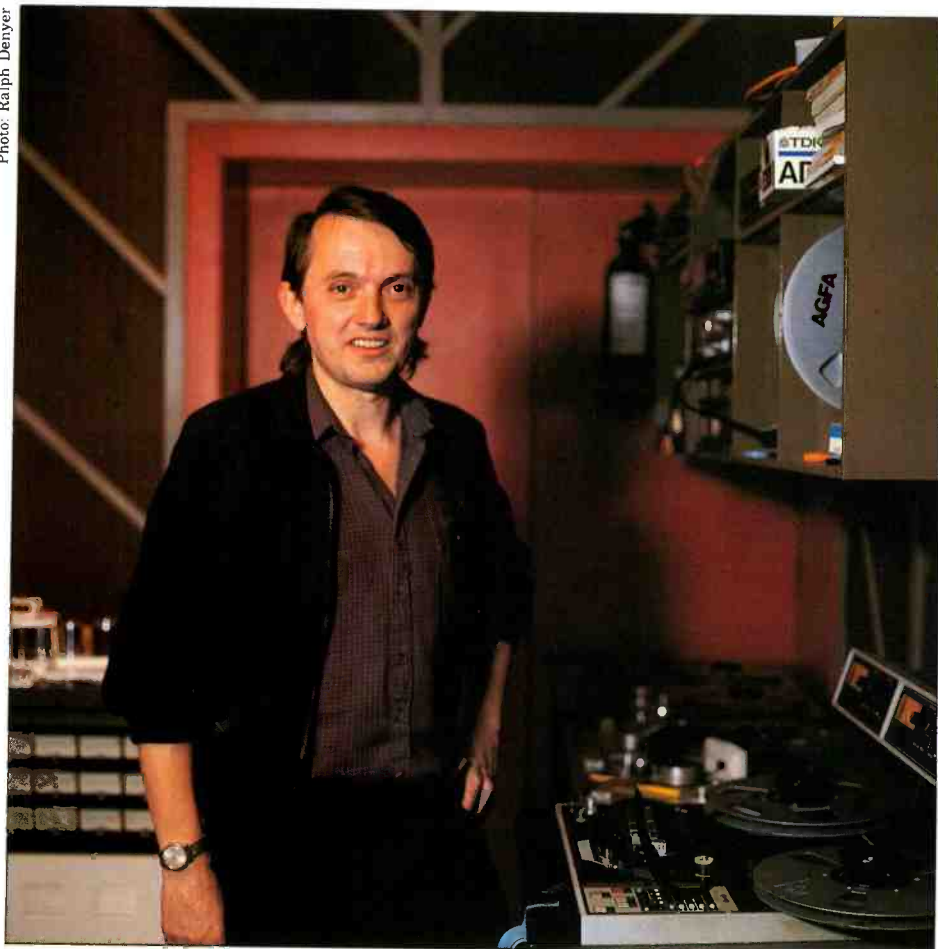


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Young engineers can get so wrapped up in the choice of microphone, position of pop shield, and can fiddle about with a singer for so long that the poor person forgets what they came to the studio to do in the first place

somewhere in the region of 12 Beatles singles—depending on which chart you go by—had gone straight to No 1 during the week of issue.

“Peter suggested that I go for an interview with George Martin and so off I went and joined Dave Harries and Keith Slaughter in the planning of Air Studios which eventually opened in 1970. I started some months before we actually got going with test sessions. George had hoped to bring Geoff Emerick who was the engineer he had worked with at Abbey Road, Geoff being famous for recording The Beatles. But unfortunately at the time Geoff was tied up with The Beatles’ own Apple Studio in Savile Row so he couldn’t join us. I think it was 5 or 6 years before Geoff got himself out of the Apple situation but that’s another story.”

Bill brought Decca engineer John Punter to Air and Jack Clegg who had been at Decca before moving to CTS where he had gained valuable experience in recording sound for motion pictures.

“George was quite keen that we should use the expertise from both Decca and EMI Studios. In those days there weren’t that many independent studios in the country and with four rooms Air was destined to be the largest of them all. George thought of Decca and EMI as the competition and

he also stole what was a huge chunk of the maintenance staff from Abbey Road. Dave Harries was one of those people and he is, of course, still involved with Chrysalis.

“There was a bit of the Abbey Road way of doing things and I brought with me the Decca way of doing things and some of Arthur Lillie’s good lessons. He always considered it very important to put yourself in the place of the person you were recording and not to intimidate them unnecessarily with technicalities. Young engineers can get so wrapped up in the choice of microphone, position of pop shield, and can fiddle about with a singer for so long that the poor person forgets what they came to the studio to do in the first place.”

Air had wanted to equip all the studios with Studer A80 VU 16-track tape machines but there was a problem with availability and only one machine eventually arrived. 3M M56 16-tracks were to be the main multitracks during the studio’s early years, and then there was Air’s famous collaboration with Neve regarding consoles.

“We worked very closely with Neve. Quite a lot of the facilities we demanded then became Neve standard issue in later consoles. Basically there

were three phases of desks over a period of time. The big console now in Studio One is the culmination of that process. Malcolm Atkin was very much involved in forcing Neve to improve on the specifications of their electronics. The basic building blocks which their style of consoles use were very much improved by Malcolm demanding tighter specifications, a few less transformers than was typical and things like that. The console in Studio One as it stands has subsequently been extended. The original bits haven’t been changed but it was extended by Rupert Neve and the original Focusrite company with modules which are a hybrid, physically and to a certain extent electronically, matching the existing modules and being Focusrite modules, have a slightly different coloured front panel. So it is a bit complicated to explain but that is a jolly good sounding desk. One of my favourite Neves, that one.”

When Price went for his initial interview with George Martin he was introduced to someone who was about his own age who was in the basement of Martin’s office working with a very strange piece of esoteric looking equipment, the likes of which he had never seen before, which came in a large number of flight cases with a huge number of cables.

“This chap was Chris Thomas who George had taken on as a trainee assistant producer to himself. Chris had previously worked at EMI. And this strange piece of equipment he was working on was a Moog synthesiser George had imported. I think it was if not the first, the second Moog in Britain. It required about 3 or 4 hours setting up in order to get a sinewave out of it. Chris was getting very excited because he could work it and he went on to provide synthesiser for a lot of pop records of that vintage.”

And didn’t he play harpsichord on The Beatles’ *Piggies*? “Well I think that most people know about Chris’s involvement with The Beatles by now and that’s a matter of separate stories. But in those days he used to do shifts with George. George would work from 10am to 7pm at the studios and The Beatles would arrive at some time during that stage. George would go home at a respectable hour and leave Chris to stay up all night and supervise whatever crazy idea The Beatles were up to. So Chris had a lot of experience.”

The first test sessions at Air, although an album was released from the sessions, were with Thomas producing Climax Chicago Blues Band and Price engineering. They also recorded the Apple signing Badfinger at the studios. Other albums the two worked together on include Pete Townshend’s *Empty Glass*, *All The Best Cowboys Have Chinese Eyes*, Bryan Ferry’s *Let’s Stick Together*, The Pretenders’ *Pretenders I and II*, and Elton John’s *The Fox, Jump Up, Too Low For Zero and Reg Strikes Back*.

“I worked with Chris for many years at Air and subsequently as a freelance engineer. And basically, in terms of working with rock bands, I suppose in a way I learnt 90% of what I know from Chris. He must be one of the best producers I’ve worked with. He’s superb. He doesn’t impose his ideas on people. He takes everything in that a band has to offer and very subtly capitalises on it, at the same time putting his own stamp on a track. He’s not somebody who rushes into the studio and says, ‘Well, I think the song will be much better if you play it at this speed,’ or ‘I want to add keyboards; make it how I want it’. He’s not that sort of producer at all. He just shapes what a band has to offer incredibly well.” □

Part Two follows

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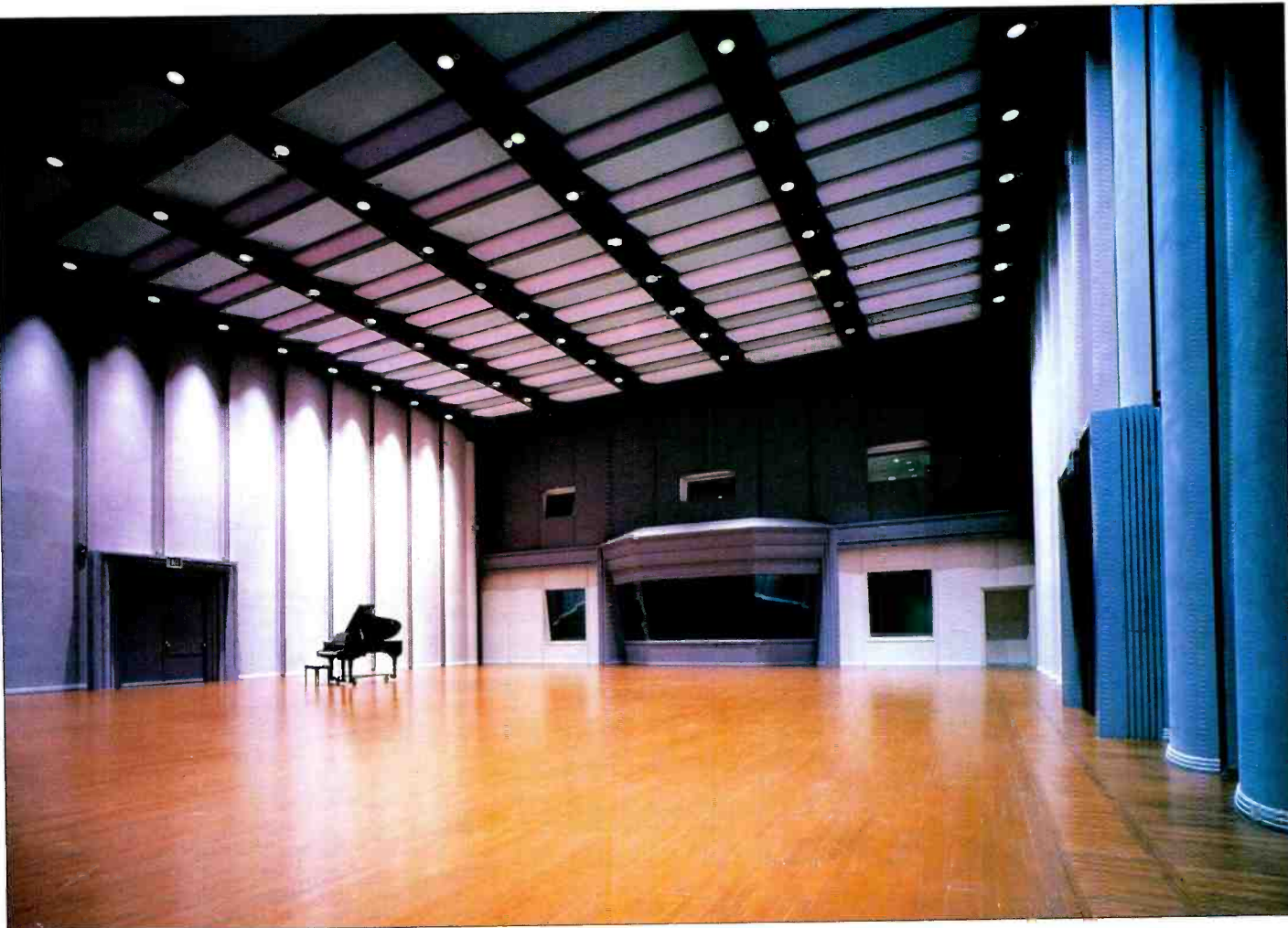
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The name of Skywalker Ranch is closely associated in most people's minds with George Lucas and Lucasfilm. While a lot of production work for Lucasfilm does go on at Skywalker Ranch, it is perhaps less well known that the technical facilities can be hired in the same way as any other studio, under the name of Sprocket Systems.

The facility is situated just north of San Francisco and San Rafael and is accessed via the appropriately-named Lucas Valley Road, which turns off Route 101. The entrance to the private road is inconspicuous and there is no indication at all that it might be a studio as it looks exactly what it is meant to be—a ranch. It is in a real country setting but with very fast access to the entertainment centres, as well as many interesting places to visit. Wine connoisseurs will time their sessions to fit in with the grape harvest festivals in nearby Napa and Sonoma counties.

George Lucas is, above all, a storyteller and the Ranch was built from the ground up to a script. The theme is that the ranch had been built by a successful farmer, who then added wings on to the main house for the children and then their families and so on. The different outbuildings were added during the various stages of development until it reached the state it is today. Of course, all this was part of the overall design but it definitely works.

The Main House is used for George Lucas's personal office, various small screening rooms (one for film and one for video), a very comprehensive library for filmmakers, the staff restaurant and solarium plus various large rooms, which are used for social gatherings.

Behind the house is the Gate House, which gives access to a courtyard flanked by the Carriage House and the Stable building. The former houses the THX Design Group with the latter containing a demonstration room over the stables for Home THX.

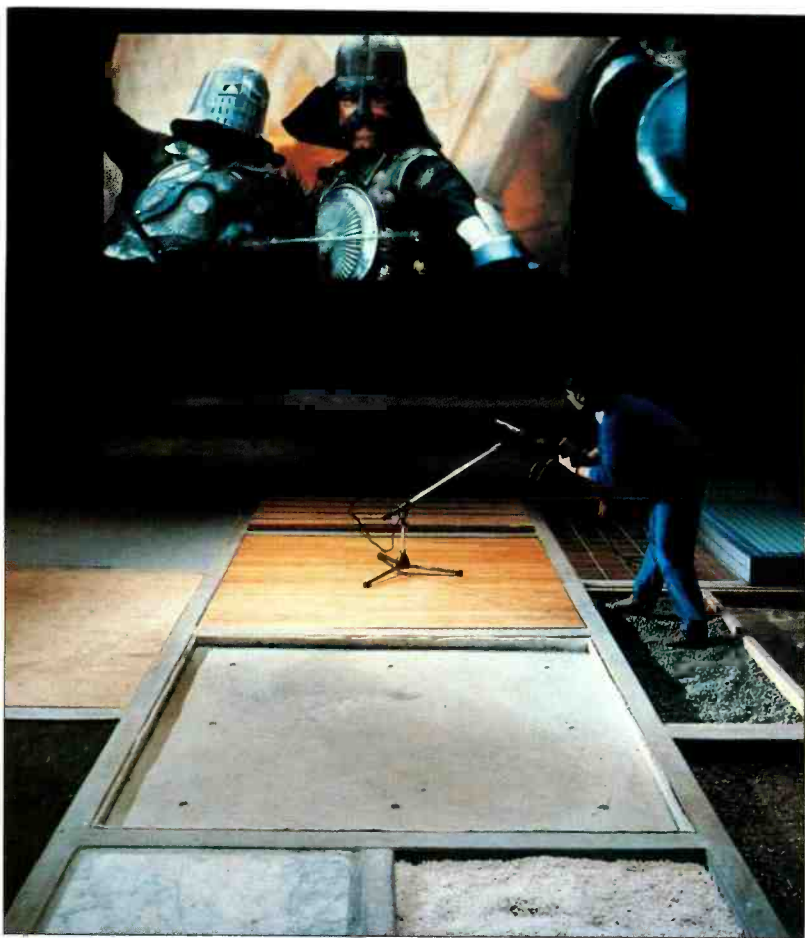
The studio areas are housed in the Technical Building, which is situated further round on the circular service road, and the building is an authentic Californian winery (together with vineyards outside).

SKYWALKER RANCH

Within the Californian base of the Lucasfilm company, Sprocket Systems are the technical studio operations. Terry Nelson visits



Above: Scoring stage. Below: Technical House



Foley stage

Though Sprocket Systems are heavily slanted towards post-production for film and video, music recording by no means takes second place. Tom Scott is general manager for Skywalker Systems, and his credentials include a Record Plant studio and remote operations in Sausalito and Los Angeles during the '70s. As far as he is concerned: "My roots are definitely in audio."

The studio is accessed via a large staircase leading from the reception area, with separate entrances for the rear of the control room and scoring stage. The control room is spacious and is built on an 'expanding box' principle, ie the dimensions widen as they move away from the window. The acoustic treatment is mainly absorptive though the floor is high quality hardwood.

The main monitors are housed in a soffit over the control room window with a reflexion-free path to the engineer position and there are also concrete pedestals for mounting close monitors in front of the console.

The control window is a three-sided panoramic installation that juts and leans out into the studio area and offers very good visual contact with the studio floor, as well as the large screen at the far end of the studio.

Recording centres around a Neve V series console and whatever multitrack happens to be around for the session in the adjoining machine room, though Lucasfilm do seem to have quite a few Otari machines.

The layout of the control room is such that the console is on floor—or lowest—level, with rising platforms behind it providing work space for producers and other personnel. This means that everyone has a clear view into the studio and can work without interference.

At the time of this visit, Tony Faulkner was in session for a series of CDs for Harmonia Mundi and he commented: "The sound is beautiful here, just like a small concert hall but more controlled. For a start, it is very quiet so I don't have to worry about traffic or aeroplanes."

No multitrack was in sight during Faulkner's sessions as he was working straight down to digital stereo.

"The support here at Skywalker is very good—I could almost call it quietly efficient. I can get on with what I have to do yet

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if I need anything sorted out, it just gets done very quickly with no fuss."

The least one can say about the studio is that it is impressive, as it can easily hold a 125-piece symphony orchestra. The room features no basic parallel surfaces and thus there are no standing wave or flutter echo problems. The acoustic design is deceptively simple but very effective.

The two side walls and ceiling can best be described as poly-ellipticals (rather than poly-cylindricals) made out of concrete, there being a gentle curve terminating in a sharp one. In order to change the characteristics of the room, sliding, absorbent panels are installed behind the concrete structures and these can be pulled out as required.

Says Tom Scott: "With the room in fully reflective state and empty, the reverberation time is in excess of 4 seconds. Whereas this might seem a lot, the moment you have a full orchestra in here, the time is reduced to around 2 seconds so you do have to have that leeway built in.

"With the panels, you can adjust the time to suit solo artists, small groups, etc. However, we do find that when most people come here for the first time, they say that the room is too lively so we damp it down and then it's 'can we have just a little more reverb' until we are back where we started. When you have a big room that sounds good, most people end up by wanting to take advantage of it and get more natural ambience into the recording."

A small vocal booth is situated to the front left of the control room which also looks into the studio. The booth is large enough for instrument dubs where a dry acoustic is required.

The Technical Building has 35 editing rooms for film and video, four transfer bays that cater for all formats to all formats (including Nagra SN, PCM-FI, DAT and 1/4 inch DASH) complete with all variations of synchronisation, timecode and noise reduction, ADR studio, Foley studio, film dubbing theatres and a screening theatre.

For editors, a useful facility is the Lucasfilm sound effects library and this is in the process of being fully transferred to CD and DAT, complete with a computerised retrieval system.



Transfer room

THX—The audience is listening

In a world full of multiple standards, the film industry has a creditable amount of them and among those covering sound there exists the dreaded 'Academy Curve'. THX is a set of architectural, acoustic and equipment performance specifications that provide compatibility between the sound heard in the dubbing studio and that reproduced in the cinema.

Jerry Zernicke, THX project manager, comments: "The audience in the cinema should hear the same sound quality that the mixing engineer heard at mixdown. The sound is all part of the film

experience and is every bit as important as projection quality."

If recording studios were to devise fixed criteria for monitoring maybe there would be less problems at the mastering stage or when working between studios.

With developments such as CDS (Cinema Digital Sound), LC Concept from France or other digital systems, being part of the evolution towards digital production for the cinema, monitoring standards such as THX will be paramount if the full benefits are to be passed on to the audience.

The line and mic inputs, as well as recording outputs, are transformerless designs which use proprietary, laser-trimmed, thick-film resistive networks. This provides highly accurate tracking of the output stages, which clip only at levels that exceed +27dBu.

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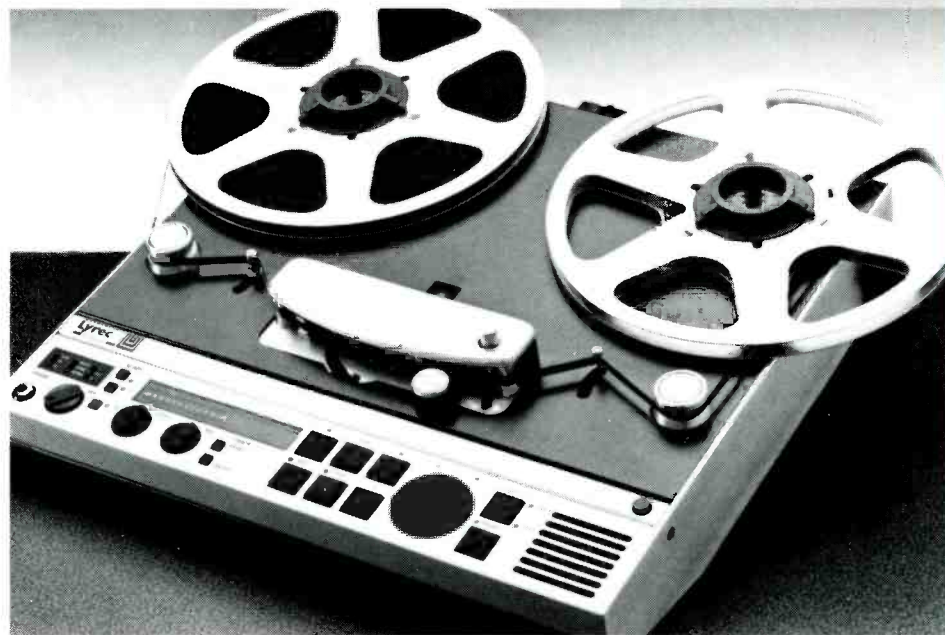


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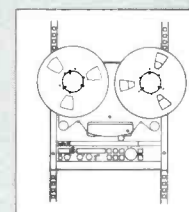
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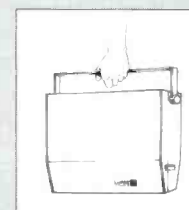
Console



Rack-mounted



Portable



A sound effects compilation area has several isolated workstations (complete with video screen for the picture) where an editor can page through the different categories of sound effects, call up the ones of interest and play them through in order to decide on the final selection. Tom Scott demonstrated the system and it is certainly easy to use, as well as quick and efficient.

The ADR and Foley studios have been conceived as an interlocking unit that features a central machine room together with film and video projection facilities. Both studios are spacious with the Foley stage being one of the largest—and quietest—in the US.

Rather than a console, the ADR control room features API microphone preamplifiers, a selection of very high quality microphones and a Rane headphone amplifier for multiple feeds to the actor(s), producer, editor, script supervisor, etc. The ADR controller is a Magnatech *EL-2* computerised unit linked to a 6-track film recorder and a second stripe recorder for selected takes. A ¼ inch recorder with Dolby is used as a logging machine to record all performances and slates for a session sequentially.

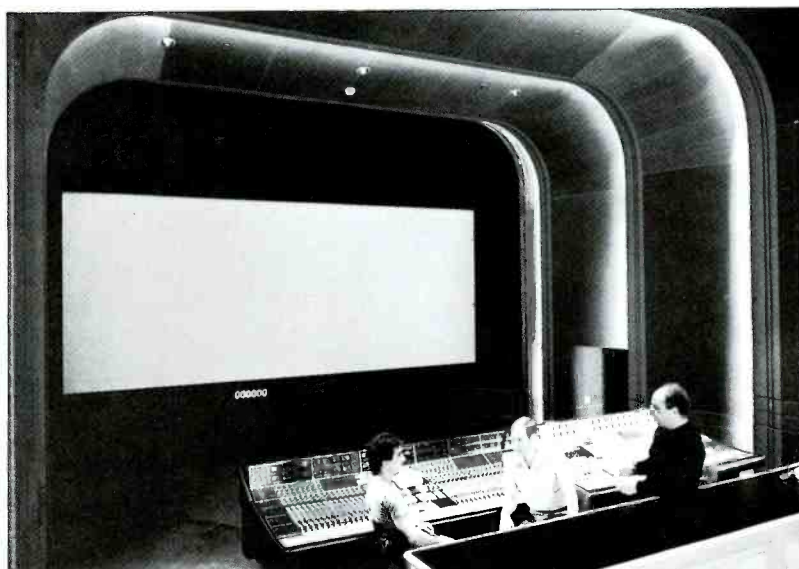
The Foley control room features a small SSL *5000* film console with four microphone channels (complete with dynamics) and 24-track monitoring, most of the recording being done on multitrack rather than on 35mm mag recorders.

There are four film mixing studios at Sprocket Systems: two small rooms with SSL *5428* and *5654* consoles and two large rooms with SSL *56110* consoles (110 inputs), all with automation. The studios are served by a central machine room housing a plethora of Magnatech recorders and dubbers, which can be assigned to the different rooms as required. Dolby *SR* and *A*-type noise reduction are also available.

The layout of the mixing studios and consoles has been carefully designed to allow one to four-man operation, depending on the project and preferred method of working.

Planning is one of the omnipresent—but hidden—factors at Skywalker, as a tour of the distribution and machine rooms demonstrated.

Tom Scott explained, "The wiring and patching is modular so that it can be upgraded or changed at any time without causing stoppages. We also give ourselves a lot of margins so that if, for



Mixing stage

example, we find we need 24 lines then we'll run 48, thus building in expansion. It is a lot of work at the beginning but it saves a lot more further on down the line."

The screening room (in reality, a luxury cinema) seats 300 spectators and offers full 35 and 70 mm projection facilities together with a *THX* specified sound system.

Sprocket Systems at Lucasfilm offer all the facilities needed for successful post-production and music recording. In terms of working atmosphere, it is doubtful whether many studios can offer the degree of workmanship and finish of the surroundings found at Skywalker and though this is decorative, it does make work that much more pleasant.

Accommodation can be arranged in hotels within easy reach but clients wishing to 'live in' can also choose to stay in the hotel and apartment rooms on the ranch itself. □

Sprocket Systems, Lucasfilm Ltd, PO Box 3000, San Rafael, CA 94912, USA. Tel: (415) 662-1000. Fax: (415) 662-2429.

Thirteen years after George Lucas wrote and directed *Star Wars*, Lucasfilm have emerged as one of the most successful independent production companies in the world. Their special effects R&D and sound quality have earned them and their founder a place in history as pioneers of visual and sound technology. Lucasfilm's feature films have won 16 Oscars and have received 40 Academy Award nominations. To date, the company have produced six of the Top 10 box office hits of all time. The latest release, *Indiana Jones And The Last Crusade*, was the No 1 hit worldwide for 1989.

George Lucas is dedicated to quality film production and his commitment to research and development led to expansion which prompted the creation of Lucas Arts Entertainment Company. This subsidiary is comprised of eight divisions.

THX was established to develop and promote advancements in motion picture presentation. The division includes the theatrical *THX* Sound System Program, which ensures all members of the audience in the *THX*-certified theatre experience sound as it was intended by the filmmaker; the Home *THX* Audio Licensing Program, which has developed technologies and quality standards to allow consumer electronics manufacturers to bring the same quality to the home; and the Theatre Alignment Program (TAP)—a service that specialises in the manufacture and exhibition

of release prints.

Skywalker Sound offers a full range of recording, editing and mixing services for film, video, radio, music and theme park attractions for both Lucasfilm and outside production companies and has won Academy Awards for *Star Wars*, *Raiders Of The Lost Ark*, *ET* and *Indiana Jones And The Last Crusade*. In addition, the music facilities have become rehearsal and/or recording venues for Mick Jagger, Linda Ronstadt, John Williams, Bobbie McFerrin, Huey Lewis and The Grateful Dead.

Industrial Light & Magic (ILM) was formed in 1975 to create the visual effects for *Star Wars*. ILM has contributed to more than 40 films and has won 10 Academy Awards for such films as *Star Wars*, *The Empire Strikes Back*, *Raiders Of The Lost Ark*, *ET*, *Return Of The Jedi*, *Indiana Jones And The Temple Of Doom*, *Cocoon*, *Innerspace*, *Who Framed Roger Rabbit?* and *The Abyss*.

Lucasfilm Games develops entertainment software for personal computers and video game machines and recently published the international hits *Maniac Mansion*, *Indiana Jones And The Last Crusade*, *The Graphic Adventure*, *Their Finest Hour*, *The Battle Of Britain* and *Loom*.

Lucasfilm Learning develops innovative media-based education products for schools,

community education, business training and public space projects. The division recently completed design and production of an interactive videodisc product entitled *GTV: A Geographic Perspective on American History* targeted toward middle school students. This project was developed in collaboration with the National Geographic Society and the California State Department of Education. Other multimedia projects have included design examples addressing environmental issues and scientific discovery.

LucasArts Licensing controls licensing and distribution of products related to Lucasfilm's most popular motion pictures, this division emphasises long-term growth and creative marketing, managing a diverse portfolio of properties. Licensing also provides services to other clients including major celebrities and internationally recognised trademarks.

Lucasfilm Commercial Production's produces high quality live-action and special effects commercials for the advertising industry. Recently, the division has gained national recognition for its work with such clients as USAir, Merrill Lynch, Burger King and Diet Coke.

LucasArts Attractions designs and produces themed attractions for speciality venues. This division was formed following ILM's successful involvement in such theme park attractions as *Star Tours* and *Body Wars*.



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MONITOR SYSTEMS CONTROL ROOMS

PART 11

Philip Newell looks at the diversity of control room designs and philosophies

Recording studio control rooms are becoming almost as disparate as the domestic listening environments in which the end product will be enjoyed. Complaints are coming from the hi-fi fraternity that the variability in spectral balance of modern recordings is beginning to become unacceptable. There is probably a wider range of monitor systems now in commercial use than at any time in the past, and the acoustical philosophies behind control room designs are beginning to become polarised into what are effectively areas of mutual exclusivity. Almost inevitably there is a grey area in between and design concepts exist aiming to straddle the divide. However, gone are the days when the established concepts led to one general trend in design formats.

The evolution of control rooms has been from something tantamount to a booth, to the present day where, in many circumstances, 'control rooms' and 'studios' are one and the same area. Much static equipment such as tape recorders has been moved to a machine room; particularly to help reduce the disturbance created by their mechanical noise but also to make space. The new demands on space are made by ever larger recording consoles, ever increasing numbers of effects units and by the very great quantity of space needed for effectively moving the entire musical ensemble into the control room. Often purpose built studio areas are no more than a convenient store for flight cases and superfluous equipment.

While the objectives of control rooms for studios generally involved in recording classical/acoustic music have changed little, those of control rooms for electronic recording are somewhat confused. The term 'control room' may now be something of a misnomer. If the rooms are to be the performance space during the recording process they need to be large enough to accommodate all required personnel and machines. During mixdown, the rooms frequently still house enormous amounts of equipment as many instruments are MIDI controlled and timecode triggered directly into the mix. During recording, the monitoring needs to be capable of creating the required excitement but when mixing, a more 'definitive' monitoring environment is required. One major problem with all this is that the mountains of equipment imported for each session can be sufficient in size and variability as to render control of the acoustics at best, arbitrary.

A distinct gap now seems to exist between the two sets of requirements of the classical/acoustic and rock/electronic camps. The criteria for which side of the divide a recording process will lean are whether the music ever existed as one

performance in real space, or whether the music was synthetically generated. In the former, real acoustic reflexions exist, the perception of which rely largely on inter-aural time and phase differences as well as amplitude differences, while in the latter, positional information is almost entirely in the amplitude domain. (Part 10, *Studio Sound*, February 1991, discussed the different and often conflicting priorities for the realistic perception of each of these domains.)

Although time domain panpots will soon throw another spanner into the works, a degree of mutual exclusivity will still apply to optimisation criteria for the best perception environments for the two aural mechanisms for detection of source direction.

Toole and Olive¹ state, 'in the making of recordings, the monitoring environment should have some important acoustical similarities to the intended listening environment. There is the further implication that the necessary similarities, in this respect at least, might be satisfactorily achieved electronically, in the form of synthesised reverberation' and 'an amount of equalisation appropriate for one listening condition may not be equally appreciated in another. It is one more source of variability in the trouble-prone record/reproduce cycle'. They were identifying problems in the chain from the musician to the record buying public yet, in one way, the requirements to fulfil these objectives are almost contradictory.

The first statement refers to the detection of timbral subtleties. Depending on whether the signal is transient or steady in nature, reverberation will either assist or detract from the ability to detect those timbral characteristics. The second statement implies that any equalisation added in the mixing process will be dependent on the combination of transient/steady state nature of the musical signal and the degree of reflexion/reverberation in the mixing room. In other words, changing the acoustics of a control room by piling in variable and arbitrary amounts of keyboards and effects racks will change the day-to-day assessment of the appropriate amount of equalisation to be applied to a sound but the effect cannot be quantified because it in turn depends on the transient or steady nature of the musical signal. The variables are so circumstantial that no general rule can apply and this is the cause of one control room compatibility problem.

When all music was of acoustic origin, control rooms developed to give the 'clearest' picture of what was happening. Hi-fi enthusiasts aspired to a control room quality listening environment. The rapid expansion of generally available hi-fi in the

'70s led to the growing use of 'domestic' references in studios and from that, 'nearfield' monitoring was born when it was realised that close range monitoring was less affected by room interaction.

By around 1980, the practical requirements of the working studio had retarded the progress of control room fidelity to such a degree that for general use, domestic hi-fi was frequently 'higher-fi' than control room monitoring systems. In order to hear all the relevant detail while still being held back by the constraints of control room practical requirements, new approaches to control room design were developed. Unfortunately, certain compromises had to be made to allow their suitability for general musical use. At this time totally new music began to grow around new technology, and the varying characteristics of music of different origination, spawned new design concepts tailored to each. Self-perpetuating cycles had begun.

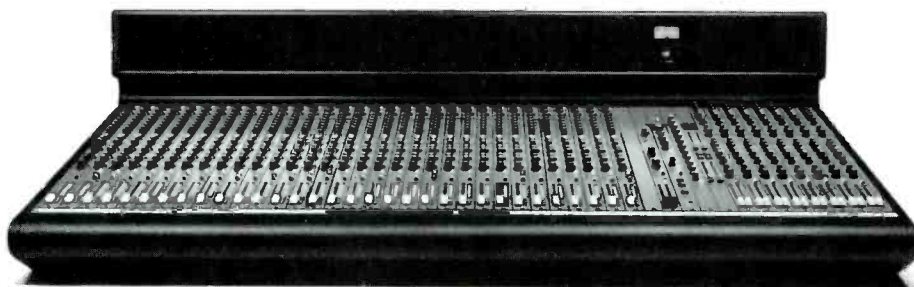
By the beginning of the '90s, three distinct approaches to control room design had become apparent: scattering/reflective, diffusive and absorbent. The extension of the main line development from the classical approach was the scattering type of room where distinct reflexions retained a certain amount of life. The energy in the most objectionable room modes was scattered or broken up into less obtrusive smaller modes, largely by the use of geometry. Selective absorption helped to keep the frequency/reverb time parameters within generally accepted 'desirable' limits.

By the mid '80s, Tom Hidley, in particular, had begun building rooms that were almost anechoic from the point of view of the monitoring. These rooms were capable of supporting very powerful phantom images from highly unstable, amplitude panned stereophonic sources. During this time diffusive rooms were beginning to emerge, frequently using patent diffusers in an attempt to straddle the fence that was beginning to divide the other approaches. An earlier approach was the 'Live End, Dead End' concept, which brought a more diffused reverb from the rear of the room, leaving clean the 'first pass' of the wavefront from the monitors.

Reflective/scattering

Until recently, the classic requirements for a control room were neutral, full-range monitoring; sufficient space to house the mixing console, the tape machines, outboard equipment, recording personnel; and the provision of a pleasant environment, conducive to the mood of the work in progress. The operational variables were few, possibly the number of people in the control room would vary but around a fairly consistent average. The control room was a constant—a fixed, known reference and that was its very function. It was the point from which to make all

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decisions and was the reference on which all decisions on sound quality were based. Within the constraints of any given building, dimensions could be optimised for recording and monitoring. Internal shapes and geometrical designs could be chosen to give appropriate internal acoustics. The shift from the concept of an idealised monitoring environment to a multifunctional recording and mixing room, has obviously not changed the laws of physics. The change has, however, very markedly shifted the compromise points and now many more variables enter the equations for 'good' control room design.

For a long time, I adhered to the general concept of the control room being an attempt to mimic a typical domestic environment but without any of the unduly predominant room modes found in most domestic rooms. The usual way of scattering each of the room modes over a wider frequency range is to angle as many surfaces as possible in order to avoid the parallel surfaces that reinforce conventional room modes. Where the distance between two parallel surfaces gives rise to a mode whose wavelength is a function of that distance, the parallel surfaces will allow a mode to reinforce itself on each subsequent 'bounce' between those two surfaces. By angling all the surfaces each subsequent bounce encounters a different distance between the surfaces, hence the Q of the modes are reduced, broadening the individual modes towards a point of overlap into a more uniform overall room response. In general, it is the strongly reinforced modes between the parallel surfaces that become most noticeable as room colouration.

Parallel or angled, the total energy in the modes will be the same but in the parallel walled rooms, the energy is concentrated at certain

frequencies so is usually more objectionable. This concept involves maintaining the reverb times of the 'average domestic listening room', while attempting to remove any 'untypical' predominating modes. 'Untypical' because although domestic rooms do have predominating modes, they tend to be at different frequencies from room to room, hence a predominant mode in the control room would be typical of only a very small proportion of domestic rooms. It therefore seems prudent to reduce any such modes to the general level of the others.

At low frequencies, angled walls are usually insufficiently large or angled to have any effect, so absorbent trapping is used to deal, as far as reasonably possible, with the LF modes. Usually, such modes cannot easily be dealt with domestically, although three-piece suites do go some way towards the break up of the lower end. Where the reverb times of a control room are undesirably long, mid and high frequencies are dealt with by means of surface materials. Control room reverb times usually tend towards the low side of the usual domestic range, the interesting point here being that they have been steadily reducing, particularly in rock and electronic music studios.

What we are generally trying to achieve here is a control room in which one could reasonably represent the general acoustic of a domestic room. Such a concept is still valid for classical type recordings of acoustic ensembles, especially when the number of personnel and equipment within the room is kept to a predictable minimum. The compromises in such designs have been rooted in the need for more floor space—as ever-increasing amounts of personnel and equipment have invaded the control rooms—and a generally lower

than previous optimum reverb time.

The reason for the lower reverb times is partially to compensate for the highly reflective nature of much of the equipment but also such equipment is normally associated with electronically generated music, panned in the mix solely via left/right, amplitude differentiating panpots.

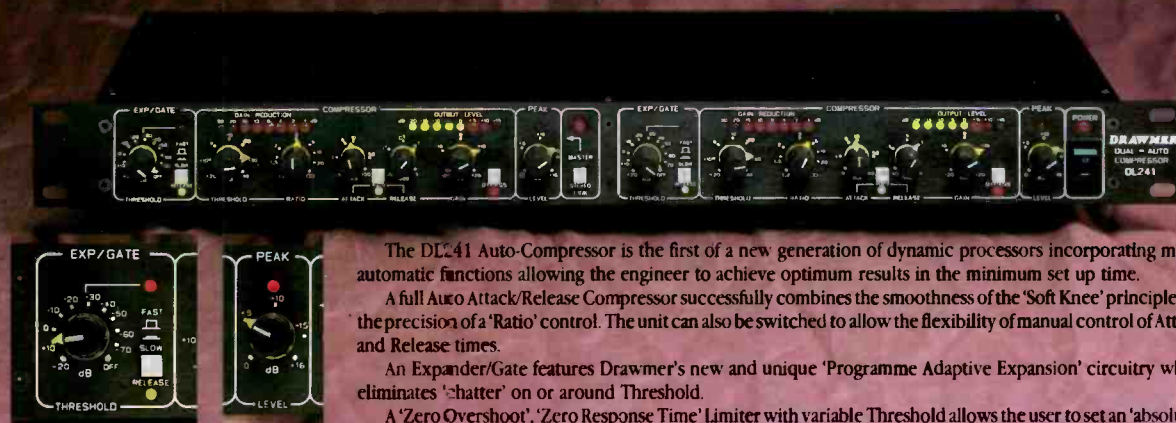
Such amplitude panned images are highly positionally unstable in reflective environments, so my approach was to keep lateral reflexions well separated in terms of time and amplitude from the axial wavefront leaving the loudspeakers. This meant mounting the loudspeakers roughly one third of the way along the length of the long wall of the room and using a front wall that was quite absorbent in the mid/high frequency band. Compared to the axial wave, lateral reflexions would thus be required to travel a considerable distance to and from the side walls in order to reach the ears of the listeners. They were thus lower in level and more separated in time. Any higher frequency reflexions from equipment within the room, which may return in the direction of the monitor wall, would be absorbed to avoid confusion and smearing of the axial wave, as would be the case if a hard monitor wall reflected them back into the room.

I still held to the principle that as spaciousness was a function of lateral reflexions, those reflexions must come from the sides. Reflexions from the forward direction served only to time smear and timbrally colour the 'true' sound. Vertical reflexions were relatively innocuous as we are so used to floor reflexions that evolution has led us to largely ignore them. (In evolutionary, survival advantage terms, it is

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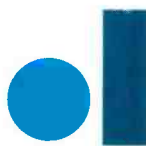
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better to be aware of the absence of a floor rather than the presence of one.) Reflexions and reverb from the rear are also generally beneficial in terms of spaciousness so long as no 'chatter' develops from the rear reflexions returning to and then reflecting from the front.

Within this design approach, a conundrum began to arise, based largely on expectations from the past clashing with the requirements of the present. Throughout the '80s, an increasing proportion of recorded music was from electronically generated sources. The control rooms when empty were acoustically quite different when loaded with equipment, and the unpredictability of the equipment load made room optimisation difficult. Unduly deadening the room broke the link with the past practices and people coming into such deader-than-usual rooms frequently felt uncomfortable. Low frequency reverb times were largely unaffected by the ingress of equipment, so a room that acoustically compensated for vanloads of equipment frequency showed a reverb time tilt towards low frequencies end of the spectrum when in a relatively mixdown mode. In order to take down the frequency reverb time, based on the questionable assumption that the subtleties of the mix acoustic were more important than the acoustics during the recording process, some rooms became more heavily 'trapped' at low frequencies leading to a general reduction in overall reverb times.

Subjectively, such rooms still looked as if they ought to be more reverberant, and over a period of a few years the term 'over trapped' applied to many rooms. Effectively, engineers and producers were not hearing as much LF reverb energy as they had come to expect, so they were considered bass light, with the result being a tendency towards bass-heavy mixes leaving rooms. To some degree, this problem was compensated for by the frequently disastrous approach of employing monitor graphics. If the time-averaged response was assessed on real-time spectrum analysers, which summed the direct and reflected signals leading to an imbalance in the direct/steady state responses of the room/monitor combination. By the mid '80s some designers began to use loudspeaker directivity control to attempt to split the subjective mid/high frequency reverb times with respect to the monitors or the general conversation within the room. Fig 1 shows a typical geometry of such a scattering room. The increasing percentage of recorded music from synthesised sources required a much deader acoustic as far as the monitoring was concerned, in order to better support the amplitude panned stereo imaging and deliver more subjective punch. These effects were becoming highly fashionable and were actually developing around the strengths and weaknesses of contemporary monitoring acoustics.

Other people were using different approaches to address the changing requirements of electronic music. For example, some designers used the 'Live End, Dead End' concept where the front half of the room was very dead, and all the life of the room towards the rear. Such a concept allowed a very clean first pass of the wavefront from the monitor system to the ears, the life being added from the rear of the room. Various approaches were largely aimed at better support for the stereo phantom images while allowing a reverb time in the control room that met conventional expectations. These approaches were not so much based on 'first principles' but were developments that sought to provide an improved acoustic for the new music while maintaining many of the

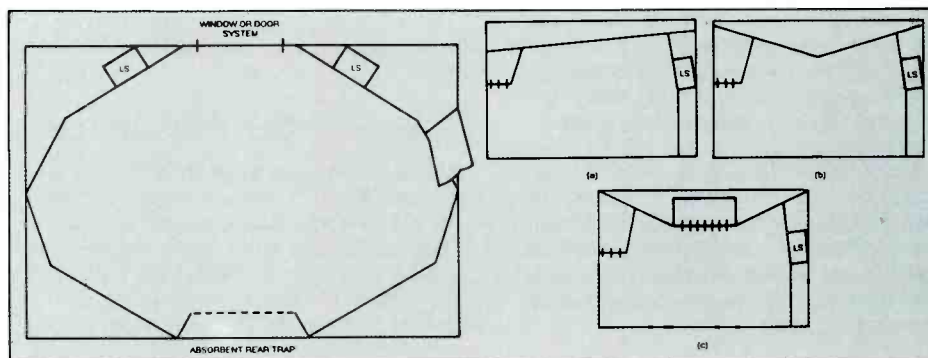


FIG 1

attributes of the older generation of rooms.

Recording studio owners had been loathe to specialise for fear of limiting their appeal. The search for the ultimate control room that was all things to all people was still on; the reality, however, was becoming quite a different matter.

CAPTION MISSING

selectively introduced by the addition of reflective surfaces into a relatively dead room. The reverb time can then be increased by the installation of diffusers, which add to the overall reverberation while reducing the risk of compromising the stereo images, as would be the case if too many specular reflexions existed within the reverberation. The level of the overall sound would be louder in the scattering and diffusive rooms as compared to the absorbent room: effectively, the rooms would be subjectively louder.

Most rooms using the diffusive technique are constructed using patented diffusers, based on prime number sequences, which phase scatter the incident wave and re-radiate the energy as a total reverberation rather than with echoes. The technique is relatively new.

There is, however, much potential for the acoustical variability of such diffusers in the studios themselves, if not in the control rooms. One of my main reservations is that people do not as yet have diffusers in their conventional home environments. Few people live in anechoic rooms either but the anechoic room is essentially monitoring what is on tape, without attempting to compensate for the average room. The nearfield systems in the more reflective environment of the mixing console will be used for that.

I have often wondered just what the effect would be of building a diffusive control room with a solid floor and a sturdy front wall to house the

monitors. The walls and ceiling would be of open frame construction covered in chicken wire and thin fabric. The frames would be built leaving a 6 ft gap to the solid walls and ceiling. The gaps would be filled entirely with logs and brushwood, randomly scattered and well mixed up, with the diameter of the branches varying from 6 inches to ¼ inch or less, and lengths from inches up to several feet. I am sure that the fire hazard could be overcome by careful and adequate supply of automatic inert gas discharge devices. It could be an interesting approach. Panels of appropriate size and texture could be added to the side walls for the introduction of any desired lateral specular reflexions. The problem with all compromises is that different people have different orders of priorities. Furthermore, many of the subtleties of technically addressing a problem can lead to remarkably similar measured solutions: all too often, however, despite the objective similarity, the subjective differences are far from subtle. As yet, we have no means of predicting many of the subjective subtleties of objective change.

Absorbent rooms

While the arguments continue, the conclusion as to what represents the average domestic listening room seems to be no nearer. Indeed, it is highly contentious as to whether that average would have any practical meaning even if it were realised. If even 10% of the population lived in 'average' circumstances, then that would still leave a large majority of the music buying public totally unrepresented by average reference rooms. There is a strong body of opinion that believes studio control rooms and monitor systems should accurately portray what is on the tape and not confuse the issue by attempting to mimic the ambiguities of domestic listening conditions.

Around 1984, Tom Hidley, founder of Westlake Audio and Eastlake Audio, returned to the studio building scene announcing his totally new approach to control room design. He had, among other things, taken his ideas on bass-trapping to an extreme point of all-trapping, and he exercised ruthless control over the room acoustics and monitoring. There was a limit to how far he would bend as the new approach was to be no compromise to anything that would disturb the stability of stereo localisation.

Hidley has promoted his 1980s control room concept as the non-environment environment. Certainly under these conditions fewer overall performance compromises need to be made, though the overall practical realisation of the technique is somewhat difficult to achieve. Monitoring outdoors is a close approximation of the goal with the obvious drawback of extraneous noises. Large anechoic chambers may seem ideal

but even here problems arise. To achieve reverb times of 0.1 sec or below at 30 Hz, a room of say 30 m³ with absorbent wedges of 3 metres length would be a good starting point. In theory that is; in practice it is obviously out of the question. There is, however, another problem. When we are outdoors, environmental noise and visual cues render the relatively anechoic environment to be natural. The low ambient noise level and visual constrictions of an anechoic chamber can be most disconcerting to many individuals to the extent that it would not be conducive to the mood for recording or mixing.

Differential RT

The monitor dead approach is one solution to the problem. This allows for reflexions from the floor and front wall of the room, the remaining surfaces being highly absorbent down to low frequencies. Very rarely, even outdoors, do we walk on anechoic surfaces, so a floor reflexion can be perceived to be very natural. Reflexions for the natural acoustic presented to any people speaking in these control rooms are further enhanced by the hard surfaces of the equipment in the rooms, together with glass or other hard surfaces on the front wall only. Looking from the monitor loudspeakers however, we can see no reflective paths to the listening position. The mixing console blocks any direct paths from the floor reflexion to the listener's ear. The rear of the mixing console itself, or any other pieces of hard equipment, will be treated with at least 6 inches of material such as *Sonex* absorbent, in order to prevent any reflective path back to the acoustically reflective front wall. In effect, the monitors face into an anechoic termination, while people in the room hear an acceptable amount of 'life' from their own speech and actions. The rooms thus sound quite natural to be in but are effectively anechoic to monitor in.

Rooms of this nature therefore have reverberation times that are entirely dependent upon the position of the source of the sound. The term 'reverberation time' is used somewhat loosely here, possibly 'echo time' would be more apt as true reverberation hardly ever exists in these rooms. No single reverberation time figure can in any way describe the performance of the room.

To the monitors the rooms are effectively dead, while to the personnel working within the room, they present a perfectly reasonable, naturally reverberant acoustic. Many people find these rooms very easy to work in, and also that the mixes they produce travel well to a wide range of domestic listening conditions. For those people, no average seems to be the best average: compromise to one and you immediately compromise to all.

This philosophy does seem to have a growing army of followers.

Size requirements

One drawback to the wider use of this type of design is that they do tend to require a rather large shell of a building in comparison to the final working area within the finished room. A typical construction is shown in Fig 2. Except for the front wall and the floor, all surfaces are covered to around 3 ft deep with angled panel absorbers, behind which are continuously joined hanging panels running the full length of each wall, almost from floor to ceiling. These flanking absorbers are quite effective down to frequencies whose half wavelengths are equivalent to the length of the panel. From this it is obvious that maintaining control to very low frequencies inevitably involves rather large rooms. There are also some audiological perception problems, which seem to dictate half wavelength paths equating to the length of the room, so for a subjectively, acceptably smooth response, one would be looking for a room with an absolute minimum front-to-back dimension of 14 ft at 40 Hz, 18 ft at 30 Hz, 28 ft at 20 Hz and so forth. Practical rooms tend to be around 16 ft, 24 ft and 32 ft for those respective frequencies. In the latter instance, this would require an empty shell, prior to the construction of the control room, of say 45x35x15 ft high. The laws of physics, however, cannot be bent, so that would seem to be an absolute prerequisite for such a design concept effective to 20 Hz.

Another prerequisite of this room philosophy, is that the floor must not be resonant in the audio bandwidth as there is no reverberant masking. This can require as a starting point a concrete base, floated on rubber, pneumatic, coil spring/hydraulic, or other form of suspension, with a total system resonance of 10 Hz or less. The final solution could be a concrete slab of 8 to 12 inches thick for conventional, audio frequency rooms, and up to 2½ ft in the case of the newly proposed infrasonic rooms.

The largest possible space around the room perimeter is also desirable. Despite the elaborate, absorbent 'trapping' systems, the low frequencies still penetrate, bounce off the structural walls, penetrate the trapping once again, and return to the room environment, albeit severely attenuated. An attenuation through the trap of 24 dB or more can be achieved down to the halfwave path of the trap design, with a minimum of about 22 dB being required to prevent any perceivable pressure change being audibly detectable in the response curve. Even shorter low frequency reverberation time can be achieved if the closest perimeter wall is itself diaphragmatic. A timber-

framed structure clad in foam rubber and lead would be a worthwhile addition with a further surrounding air space before the structural walls are encountered. Once again, however, cost and shell size are increased, not to mention weight.

Monitor considerations

From the point of view of monitoring system design, the 'non-environment' rooms are something of a mixed blessing. Choice of actual drivers can be made more readily on the basis of sonic characteristics without as much attention having to be paid to the directivity indices. All listening is carried out virtually on-axis, so what happens 40° off-axis is of little consequence as it will not be reflected back into the room. Axial impulse response assumes a much higher priority over total power response than would be the case in a more reverberant room. This should ultimately lead to more definitive, repeatable, and accurate monitoring of electronic/rock music. On the other hand, the monitor 'loudness' gets no help from the room, as virtually all off-axis radiation, which is a significant part of the loudspeaker's total output, is absorbed and lost to the listener. Therefore, for the same perceived sound pressure level at the mixing console, the monitor systems need to be capable of producing a higher output than would be the case in a more conventional room. What is more, these non-environment rooms tend to be larger than their reverberant counterparts, and due to their attempts to reproduce freefield conditions for the monitors, the sound levels tend to fall off following an inverse square law with respect to the distance to the listener: in other words falling 6 dB with each doubling of distance. It would be reasonable to anticipate the use of a monitor system with an output capability at least 10 dB higher than would be expected for a conventional control room of similar internal proportions.

In terms of perception, the non-environment rooms do have differences from conventional 'scatter the modes' rooms. Phase accuracy within a signal appears to be much more perceptible, as the characteristics are not masked by the random phase of the reflexions from the reverberant field. Back in the '50s, Manfred Schroeder produced a 'phase organ' upon which he could play tunes. This consisted of a pulse train having 31 harmonics from 100 Hz to 3 kHz, all with zero relative phase angle. By varying the phase, and phase alone, of certain harmonics, notes were produced that were clearly audible above the 100 Hz pulse train buzz. The amplitudes of the harmonics were in no way varied. The 'organ' was very effective on headphones or in anechoic

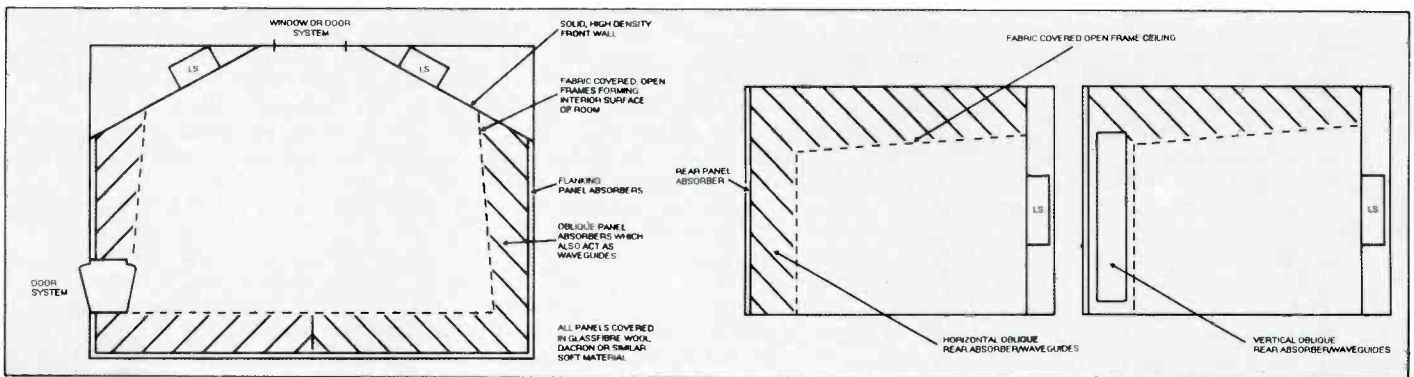


FIG 2

rooms; in reverberant conditions, however, no tones were audible, just a more reverberant buzz! Schroeder's *Models of Hearing*² makes very interesting reading. Digital audio recording preserves much more phase coherence than analogue recording, so relatively suddenly, phase/impulse accuracy needs to be addressed in a much deeper way than was previously the case; hence the sudden upsurge in interest in the more phase preserving non-environment rooms.

The concept of an average listening room is relatively meaningless and, certainly for electronic music, anechoic impulse accuracy in the control room is the most worthwhile goal. Obviously, the non-environment control rooms are more suitable for this but they need to be large to be effective. Below a certain shell size, geometrical 'scatter and trap' rooms will still probably be most practical acoustic answer. There are 'tricks' such as special ceiling trapping that act as waveguides, absorbers and diffusers, altering the effective waveshape requirements, but space savings of around 15% are about the limit achievable by these techniques. The only way I can foresee non-environment conditions being achievable in smaller rooms, is by fully active, digital control using inverse filtering and electrically driven absorbers.

One problem is that of subjective levels of artificial reverberation committed to tape in the different kinds of rooms. In the dead room, the ear seems to be more sensitive to the amount of added reverberation such that a less reverberant overall sound is accepted as the norm when mixing. In a more reverberant control room, reverberation is added to the mix as necessary to make it noticeable above the naturally reverberant room. It appears that it is the differential that we perceive, as we soon adjust to the environmental levels. No subjective difference seems to be evident in the quantity of artificial reverberation added to a mix in well designed rooms of any system philosophy. The reverberation that may be added artificially is in any case usually much longer than that of any respectable control room, so it is clearly distinguishable from the ambient reverberation of the room.

Jacks of all trades, or masters of one

In real life, of course, control rooms do not fall neatly into the black, white and mid-grey of these three approaches, there are rooms of all shades in between. The principles of scattering the modes, diffusing reflexions, or absorbing the reflexions are, however, the three constituent building blocks from which all other rooms are derived.

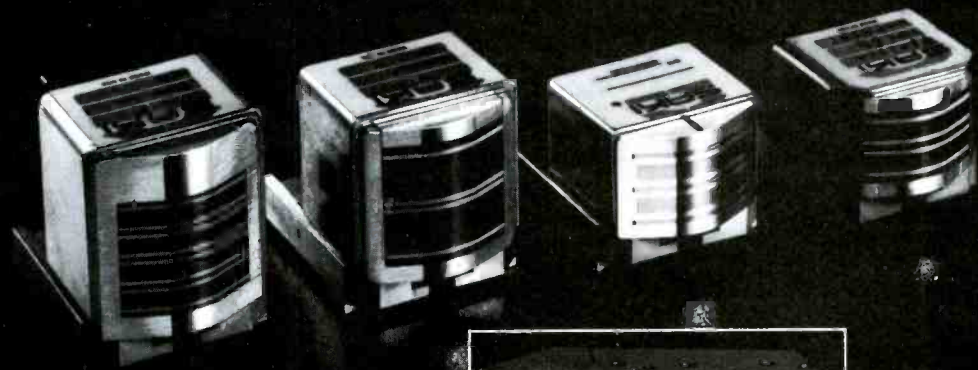
Classical and acoustic recordists rely heavily on the spaciousness of lateral reflexions to present a realistically natural reproduction of recorded music containing a considerable proportion of inter-aural time/phase cues. Pinpoint positional accuracy is not in the nature of the original performance, so the spaciousness for definitive positioning trade-off seems wholly justifiable. The order of the day would seem to be spacious control rooms with a generally live acoustic, especially from the sides, and relatively constant directivity, wide dispersion-angle monitors. As we are seeking to attempt to reproduce the actual performance of an event, there is no reason to use monitoring levels above those experienced at the real event. The SPL requirements from the monitors are further eased by the 'help' from the reverberant

loudness of the room. Plenty of high top end also seems to be desirable for classical work, possibly because much of the sense of space comes from the higher harmonics. While timbral neutrality is a fundamental goal of all monitor systems, it is particularly important in these circumstances as one always has a real life comparison, and it is also more easily achieved in systems of moderate SPL requirements.

Electronic music has no 'original' for comparison, it is heard first through the monitors of mixdown. Stereo imagery and pinpoint positional accuracy is a fundamental of the art form. Highly transient sounds, often of extremely 'unnatural' frequency range can make punishing demands on monitor systems, especially when played against a realistic backdrop of a drum kit at a natural level. Undoubtedly, such music is best supported by an absorbent approach to control room monitoring. The deadness of the

acoustic produces no confusing reflexions, but neither does it help the loudness. Given the lack of help from the room, together with the higher required SPL within the room for much electronic/rock music, the 1 metre axial output from the monitor systems may be required to produce 10 to 15 dB more than monitor systems for the reflective or diffusive rooms. This extra output usually requires larger physical size, which serves to exacerbate the problems of time/phase integrity for all but axial listening positions. Consequently, in reflective rooms, such monitor systems would be more likely to produce reflected-wave response aberrations, as such large, high level systems rarely have fully representative off-axis performance. Nonetheless, the fact that there is no actual reference to the 'sound' of a computer generated waveform, and given that certain sounds will be perceived differently on every different type of domestic

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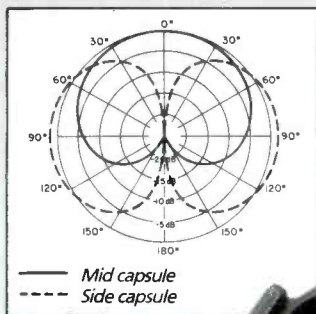
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system, the requirements for imaging, high SPL, and extended, high level, low frequency response can override some of the more subtle requirements of timbral accuracy.

When I say subtle, I mean subtle, as gross timbral inaccuracy in such situations is neither use nor ornament; but at low frequencies, the rate and frequency of roll-off can be very misleading from system to system. There are powerful and different philosophical arguments applying to monitor system bass response. One can either maintain it as flat as possible for as far as possible then let it drop abruptly, or let it roll off gently, beginning at a higher frequency than the previous case but possibly extending lower in frequency for the 10 dB down point. Subjectively, the difference is massive. If one looks at the Fletcher-Munson curves for equal loudness, although at 1 kHz, 10 dB is considered to subjectively double loudness, at frequencies below 100 Hz, a mere 4 dB can double loudness. The different low frequency philosophies for the monitors can obviously have drastic repercussions on the subjective bass balance when mixing.

The main point here is that with current technology, specialisation of control room monitoring and acoustics with regard to the type of music most likely to be recorded in that control room, would seem to be almost mandatory if the best results are to be hoped for. The subjective requirements for the different types of music, and indeed for the hearing mechanisms associated with those different types of music, more or less dictate that such should be so. If one were to subjectively rate monitor system/control room combinations on a scale of A to F, then an A/A for classical/electronic is all but impossible to achieve with current technology. The way things

are going, an A/C or C/A is probably a better compromise, dependent upon what constitutes the majority of any particular studio's clientele, as opposed to a B/B compromise. In broadcast or jingle studios, a B/B compromise may be a necessity; as is the case with mobile recording trucks, which perform a wide range of duties, and as they begin from a disadvantaged set of dimensions, a C/C may even be a laudable achievement.

The only way I can currently see any hope of an A/A would be to use an absorbent room, as for rock/electronic music, but with delayed and frequency contoured small monitors placed in the side walls, enabling the introduction of lateral reflexions for classical monitoring. The high frequency roll-off and precise delay would take some experienced assessment on initial set-up but would, once set, hopefully be left at a relatively constant setting. Remember, those lateral reflexions *must* come from the sides, they cannot be incorporated into the frontal signal if a natural perception is desired.

Further, there are other requirements for the classical/electronic specifications. Most classical recording engineers seem to require more high top on their monitors. The rock/electronic recordists tend to use systems which are around 1 dB down at 8 to 10 kHz and say 3 dB down at 15 kHz. While one would normally expect a reduced top end response on the monitors to produce a top-heavy tape, a system at high level with a flat top end response can produce listening fatigue such that a disproportionate amount of top is subjectively lost by the ears. The subsequent compensation produces a top-heavy tape from the monitors with most top. The '1 down at 10, 3 down at 15' curve seems to have been adopted by

much of the industry as an unwritten standard. This once again relates to the Fletcher-Munson curves.

Certainly, on grounds of timbral neutrality, different monitor systems tend to be preferred by the different camps. Here, however, it may be possible to mount two monitor systems side by side, blanking off the one not in use. If the rock/electronic monitors were positioned furthest apart, the classical/acoustic monitors would not unduly suffer by being slightly closer together, as the side-wall mounted, lateral reflexion monitors would add a sense of spaciousness, which may be compromised by the closer spacing of the main classical/acoustic monitors.

I know that people will vilify me for making these statements, as I am aware that they go against much of our traditional upbringing. Unfortunately, rock/electronic music has grown up around the practicalities of the equipment available to the recording industry, and has spent more time exploiting those practicalities than contemplating the altruisms. I certainly do not have one favourite monitor/room combination for all types of music.

One final point: as far as optimisation is concerned, probably only 2 or 3% of control rooms are built in a large enough shell to be optimum for anything, so inevitably 97% are compromises. A 40x40x15 ft shell should be a realistic starting point for any attempt at optimising a control room. □

1 Toole FE and Olive SE, 'The Modification of Timbre by Resonances: Perception and Measurement', *JAES*, vol 36, pp 122-142, March, 1988

2 Schroeder 'Models of Hearing', Proceedings of the IEEE 1974

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DIGITAL AUDIO SYNCHRONISATION

Francis Rumsey summarises AES draft recommendations on digital audio synchronisation and highlights some of the problems to be encountered

An understanding of synchronisation requirements in digital audio systems is vital to successful working where more than one digital device is used. It is a subject that will become more important as devices are interfaced without passing through the analogue domain, especially in environments involving video equipment or timecode. Here it is proposed to introduce the recent AES draft recommendations for digital audio synchronisation, currently available for comment, and to address the problem of ensuring that all devices in a system operate at the same sampling rate, describing the problems that will arise if they do not, offering some solutions. Secondary to this is the question of machine transport synchronisation using timecode but this follows naturally and without too many problems if the foregoing questions of system synchronisation have been tackled correctly.

Transport vs signal

It is important to distinguish between the synchronisation of two tape recorder transports, such as might be required for electronic editing or in audio-video dubbing, and the synchronisation of two digital audio signals. That said, one cannot be discussed without reference to the other, because there is a vital inter-relationship between the timing of audio data, video signals and timecode if successful operation is to be achieved.

To synchronise two audio machines using timecode either an external or internal timecode synchroniser is employed, which has control over the capstan speed of one or both machines, thus allowing the synchroniser to compare the timecodes from the two machines and adjust their speeds to ensure they remain within a certain tolerance of a given offset between the two timecodes (in other words to 'lock' them together). In a typical arrangement where an audio machine is to be locked to a video machine (say for dubbing sound to picture) the video machine (VTR) acts as 'master' and the audio machine as 'slave'. In such an arrangement, the video machine dictates the running speed of 'master timecode' and the audio machine is controlled to follow it. In a broadcast environment where it is vital that all video signals are synchronous, the video machine's speed is referenced to a source of video generated by a Sync Pulse Generator (SPG) but in environments where video is not required to be referenced the VTR may 'free-run', such as might be the case with a single VHS machine used in a dubbing suite.

In video-to-video locking (such as in an editing suite) all machines are slaves to the reference generator, with timecode simply being used as a positional reference to locate and lock the machines during pre-roll, after which the speed control of the machines is released to external video sync.

Analogue tape recorders are mostly free-

running, in that they do not need to be referenced to an external clock of any kind for normal operation. Since analogue audio is a continuous waveform it does not have any 'timing elements', whereas digital audio and video are time-discrete signals, which are split into easily-identifiable frames, samples or blocks. Two analogue audio signals to be mixed together may have any timing relationship but the same is not true for two digital audio signals or two video signals, which must have a fixed timing relationship. From now on we must consider digital audio as much closer conceptually to video than to analogue audio.

So, transport synchronisation is the locking of two or more machines so their timecodes run at the same speed but signal synchronisation is the locking of two or more signals (digital audio or video) so they run at the same frame or sampling rate. In a properly-operating system the two should go hand-in-hand: that is, when the two timecodes are locked so will be the two signal outputs from the machines. But it does not follow that signal synchronisation and transport synchronisation are the same thing, since there are many instances where signals will have to be synchronised without there being a tape transport in sight, such as in a studio centre where signals are mixed or routed digitally, or where digital effects devices are interfaced digitally to other digital audio equipment. It is these systems problems that will predominate over the next 10 years, as we move away from the isolated use of one or two digital recorders in a basically analogue world to a situation in which signals remain in the digital domain for the majority of their lives during production and post-production.

If timecode is to be recorded alongside analogue audio on a conventional audio tape recorder then it normally originates from a timecode generator that free-runs or is locked to video. The speed of the tape machine, though, is controlled by the tape recorder's internal crystal oscillator, whose stability will dictate the long term speed drift over the length of the tape. If the sound recorded on this tape machine accompanies a video recording being made at the same time then the timecode recorded on both allows them to be locked together at some later stage using a synchroniser. If the speed of the audio machine had drifted during the recording then the timecode would follow this drift on replay and since there is no clear timing element in the audio against which to compare the passing of a second one cannot say that the recording is either synchronous or asynchronous.

But consider the situation in which the audio tape had previously been recorded with a clicktrack, which marked the passage of time, say one click per second, and that the timing of the clicks was known to be accurate. This tape is now post-stripped with timecode on another track and the '1 second markers' on the audio track are compared with the 1 second boundaries in the timecode. Unless the audio machine were running at exactly the same speed on both occasions and

the speed drift over the length of the tape were identical at the same rate, there would be a discrepancy between the signals. One second in timecode terms may not equal 1 second as marked by the clicks, even if by only a small amount.

Sometimes the timecode may be ahead of the clicks, sometimes behind. It is possible to say in this case that the timecode is not synchronous with the audio, because we have something to compare it with. Furthermore, the reason for the asynchronicity was that the audio and the timecode had been recorded at different times and we could not guarantee that the audio machine had been running at exactly the same speed on both occasions. Had the clicks and the timecode been recorded at the same time and had we been able to guarantee that 1 second in terms of timecode equalled exactly 1 second in terms of clicks, then we would have had a synchronous recording. The only way to have ensured this would have been to reference the click generator and the timecode generator to the same clock.

Had we wanted to post-stripe a pre-recorded tape of clicks with timecode, and maintain synchronicity between clicks and timecode, we would have had to have a means of ensuring that the tape speed was exactly the same on both passes and thus the tape transport also would have had to be locked to the same clock as the clicks and the timecode. This is the nature of the problem that arises in digital audio systems, since the rate of clicks in the above example is analogous to the sample rate in digital system. Everything has to be locked to the same clock: timecode, audio, tape transports, sampling rates of mixers, disk recorders and any video equipment to be used in conjunction with the audio system. If this does not happen then problems arise.

Digital difference

The sampling rate of a digital system dictates the timing of audio data. If the sampling rate is 48 kHz, we know that 48,000 samples should be generated per second. This rate is dictated either by an internal crystal oscillator (rather as the analogue tape machine's speed was controlled in the above example), or by an external reference signal. This external reference may be provided in a number of forms, depending on the system concerned, and in some cases it may be a video signal. The external reference dictates how long a second lasts. (A remarkable liberty when you consider it!)

If two digital audio devices are referenced to the same external clock then it can be guaranteed that their sampling rates will be the same. It then becomes possible to interconnect these devices digitally and transfer information between them. It should go without saying that a device operating at 48 kHz cannot transfer information directly to one operating at 44.1 kHz but here we are talking about two devices, which nominally are supposed to be operating at the same rate. Even if one device is running at 44.1 kHz and the other is running at 44.001 kHz, one cannot claim they are synchronous, since samples from one will drift in relation to the other. The audible result of this when attempting to mix their outputs together or to transfer sound from one to the other (provided that the incoming signal is within the lock-in range of the receiver) is that small clicks will be heard at the difference frequency between the devices, an effect often referred to as 'sync slippage'.

The upshot of this is that we must find a means of distributing an audio sync reference to all the

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devices that need to talk to each other. There are a number of ways of going about this, depending on the operational situation.

Video recorders

The subject of the use of video recorders for recording digital audio brings up some extra points. We are at a stage in the development of digital recording where we haven't yet lost the first generation of products, many of which were based on video recorders. Most people will be familiar with the EIAJ format (Sony *PCM-F1* and *701* family) and also the CD-mastering format (Sony *PCM-1610* and *1630*), both of which used VTRs for recording. More recently, dedicated digital audio recorders have been developed (R-DAT, DASH and PD machines among them), which have no relationship to video.

Since the CD-mastering format required the use of 30 frames/s or NTSC VTRs it followed that the timecode used with these recordings was of the same rate. The use of 25-frame timecode with such recordings was not straightforward and the sampling rate followed the video frame rate such that at 30 frames/s the sampling rate was 44.1 kHz and at 29.97 frames/s the sampling rate was 44.056 kHz. The EIAJ format came in PAL and NTSC versions, and again the timecode followed the video frame rate (if it were used) unless complicated means of timecode re-referencing were employed.

In dedicated digital audio recorders, the sampling rate is often switchable and any type of timecode may be used with any sampling rate, provided they are both locked to the same reference. Furthermore, many dedicated digital recorders may be referenced to video of any standard. The clock dividers in such recorders are versatile enough to be able to relate one of a selection of video frame rates to one of a selection of audio sampling rates but it is important to make sure that the correct relationship has been established (usually set in software by DIP switches or on the front panel). This makes for much greater flexibility in operation in conjunction with any video standard and thus in any country.

Sync references

A number of reference signals may be used for locking the sampling rate clock of a digital audio device. AES draft recommendations state that all machines shall be able to lock to a reference clock

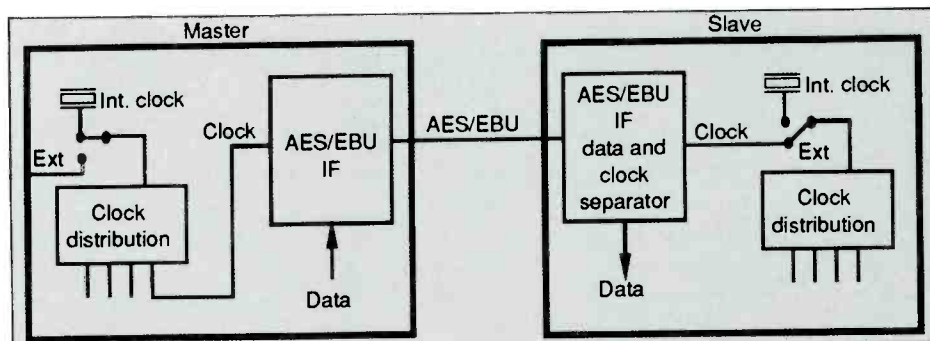


Fig 1

Sample rate (kHz)	24 fps (film)	25 fps (PAL/SECAM)	30 fps (mono)	29.97 fps (NTSC)
32	4000/3	1280	3200/3	16016/15
44.1	3675/2	1764	1470	147147/100
48	2000	1920	1600	8008/5

(provided as a standard AES/EBU interface signal whose sampling frequency is stable within the tolerance allowed) and that all machines should have a separate input for a synchronising signal (this takes the form of a single AES/EBU *XLR* socket).

Currently, digital audio recorders are provided with a wide range of sync inputs and most systems may be operated in the external or internal sync modes. In the internal sync mode a system is locked to its own crystal oscillator, which should be accurate within ± 10 parts per million (ppm) if it conforms to AES recommended practice (AES5-1984). If in the external sync mode the system should lock to one of its sync inputs, which may either be selectable using a switch, or may be selected automatically based on an order of priority depending on the mode of operation (for this the user should refer to the operations manual of the device concerned). Typical sync inputs are word clock (WCLK), which is a squarewave TTL-level signal (0 to 5 V) at the sampling rate usually available on a BNC-type connector; 'composite video', which is a video reference signal consisting of either normal picture information or just 'black and burst' (a video signal with a blacked-out picture); or AES/EBU, which is a reference signal conforming to the tolerances outlined below. In all cases one machine or source must be considered to be the 'master', supplying the sync reference to the whole system and the others as 'slaves'.

It is also possible to lock a device to its own AES/EBU digital audio input (if one exists) and

this technique is often known as 'genlock'. It can be used for small systems operating in a daisy-chain, or where an external reference is not available (Fig 1). Alternatively, a separate WCLK may be distributed between devices in cases where the AES/EBU interface is not available, such as when equipment is interfaced using SDIF-2. A 'sync' light is usually provided on the front panel of a device (or under a cover) to indicate good lock to an external or internal clock and this may flash or go out if the system cannot lock to the clock concerned, either because it has too much jitter, is at too low a level, conflicts with another clock, or is not at a sampling rate that can be accepted by the system.

Video sync (composite sync) is often used when a system is operated within a video environment and where a digital recorder is to be referenced to the same sync reference as the video machines in a system. It also allows for timecode to be recorded synchronously on the audio machine, since the timecode generator used to stripe the tape can be locked to video syncs also. The relationship between video frame rates and audio sampling frequencies is shown in Table 1. In mixed digital audio and video environments a number of ways of ensuring that audio, video and timecode are locked to the same clock are possible (Fig 2). Either everything can be locked to the video reference (if all digital audio devices have a video sync input), or the audio reference generator can be locked to the video SPG. The timecode generator would normally be locked to the video SPG but we may begin to see timecode generators with AES/EBU or WCLK sync inputs if the demand exists.

Distribution

As in a video environment, it is possible to use a central high quality audio reference signal

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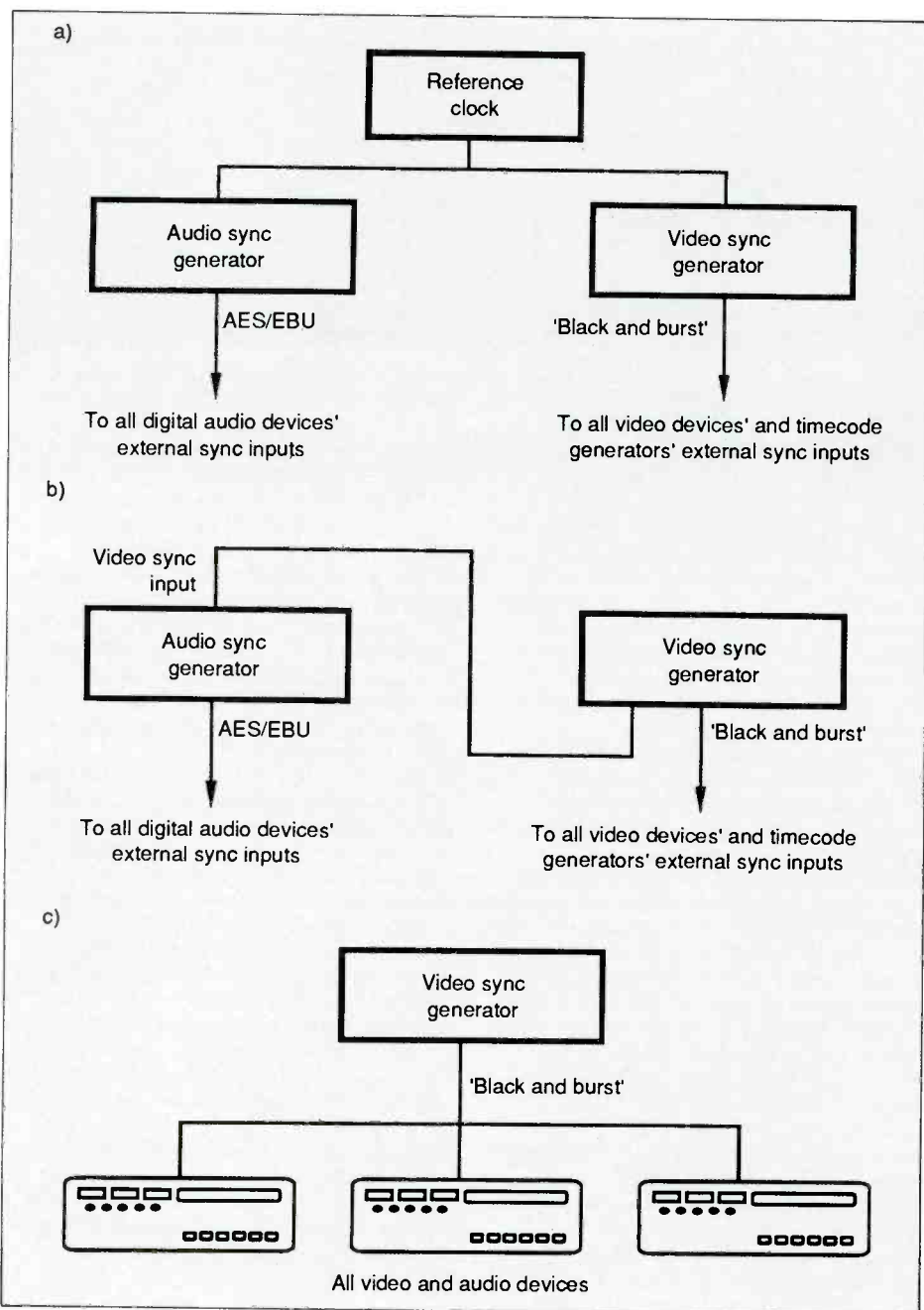


Fig 2

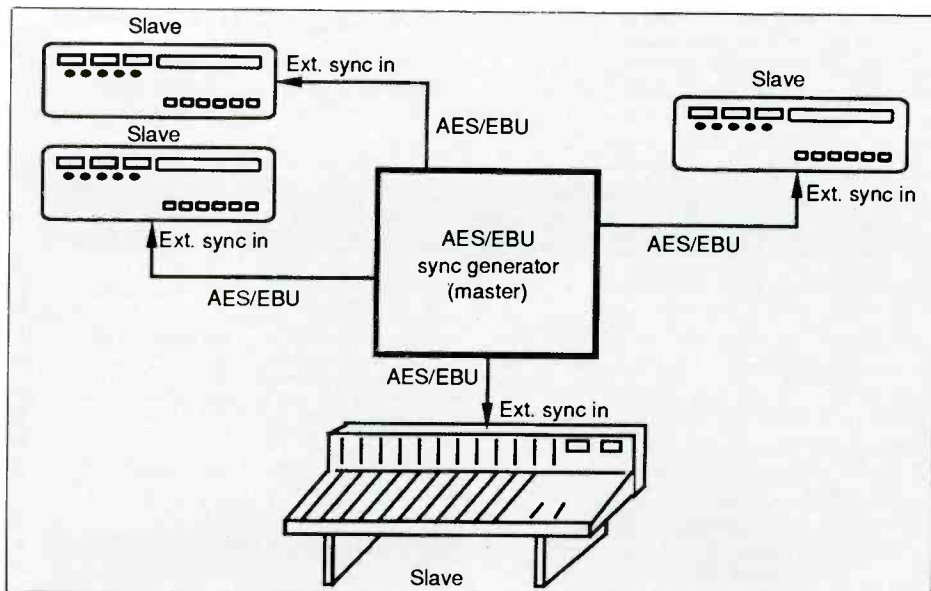


Fig 3

generator (the equivalent of a video SPG), the output of which is made available widely about the studio centre, using Digital Distribution Amplifiers (DDA's) to supply different outlets in a 'star' configuration. In video operations this is often called 'house sync' and such a term may become used in digital audio as well. Each digital device in the system may then be connected to this house sync signal, and each should be set to operate in the external sync mode. In the future, as described above, it is most likely that house sync will take the form of an AES/EBU-format signal and this should be adopted wherever possible for the sake of standardisation.

Using the technique of central sync-signal distribution (Fig 3) it becomes possible to treat all devices as slaves to the sync generator. In this case there is no 'master' machine, since the sync generator acts as the 'master'. It is a concept many analogue recording engineers may find unfamiliar and it requires that all machines in the system operate at the same sampling rate, unless a sample-rate converter and signal synchroniser are used.

Alternatively, in a small studio, it may be uneconomical and impractical to use a separate SPG and in such cases one device in the studio must be designated as the master. This device would then effectively act as the SPG, operating in the internal sync mode, with all other devices operating in the external sync mode and slaving to it (Fig 4). If a digital mixer were to be used then it would be sensible to use it as the SPG, but, alternatively, it would be possible to use a tape recorder, disk system or other device with a stable clock.

In a configuration such as this it would be necessary either to use AES/EBU interfaces for all interconnection (in which case it would be possible to operate in the 'genlock'-type mode described above, where all devices derive a clock from their digital audio inputs) or to distribute a separate wordclock or AES sync signal from the master.

In the genlock configuration, there is the danger of timing errors being compounded as errors introduced by one device are passed serially down the signal chain.

In situations where sources are widely spread apart, perhaps even being fed-in from remote sites (as might be the case in broadcast operations) the distribution of a single sync reference to all devices becomes very difficult or impossible. In such cases it may be necessary to synchronise external 'wild' feeds to the house sync before they can be connected to in-house equipment, and for this purpose a sample-rate synchroniser should be used.

Sync references, whether in the form of wordclock or AES/EBU are better distributed using DA's than by 'teeing-off' cables. The AES/EBU interface is designed to drive up to four receivers from one transmitter but don't rely on this in all situations. The WCLK signal accompanying SDIF signals may be badly loaded down if it is paralleled to a number of receivers. It is better to chain it between devices by using the WCLK IN and WCLK OUT connectors, as one would with a video referenced signal.

AES recommendations

The AES draft recommendations for digital audio signal synchronisations define the limits for signals that nominally may be said to be

synchronous. They state that the signals must be of the same sampling rate and that input signal frame boundaries must be within $\pm 25\%$ of a sample period when compared with the AES/EBU reference signal input. Output signals are to have a tighter tolerance to prevent the compounding of timing errors and should be within $\pm 5\%$ of the reference frame edge (defined as the start of the 'A' preamble of the AES/EBU sub-frame). Fig 5 shows this diagrammatically.

The reference signal itself should be in the form of an AES/EBU audio signal (either carrying programme, line-up signals or silence) having one of two standards of accuracy. A Grade One reference must have a sample frequency accurate to within ± 1 part per million (ppm), while a Grade Two reference should be accurate to within ± 10 ppm. Grade One signals are intended for the systematic timing of studio centres, while Grade Two signals are intended for less demanding environments where cable runs are likely to be shorter and perhaps less equipment involved.¹

Once these recommendations are accepted we should begin to see more digital audio equipment fitted with sync inputs and perhaps outputs to this standard.

Sample rate converters and signal synchronisers

Sample rate converters and signal synchronisers are problem-solving devices. A sample rate converter changes a digital audio signal from one sample rate to another, with minimal signal degradation and a synchroniser takes in an audio signal and locks it to a local reference. The synchroniser is intended for the situation in which a remote or free-running signal of nominally the same rate as the system sampling rate is required to be locked exactly to the house reference. This might be needed in the case of interfacing a domestic CD player or DAT machine into a professional system, where it was not possible to lock the domestic machine to the house sync. Alternatively it would be useful for synchronising signals from remote sources that could not be locked to the house sync.

Furthermore, a synchroniser might also fulfil the function of ensuring that data is stable within the jitter requirements of a converter.²

A sample rate converter is useful when interfacing devices that operate at different rates (eg from the 48 kHz of professional audio to the 32 kHz of a broadcast transmission system such as NICAM 728, or from a 44.1 kHz CD master to a 48 kHz DAT machine). There is debate over whether sample rate converters affect sound quality, and it is true that they will, but the extent of the effect is normally extremely small in modern designs.

Conclusion

The above has provided a short introduction to the problems of digital audio synchronisation, together with some possible solutions. The interested reader is encouraged to refer to some of the recent papers describing the system recently installed by Thames Television at their Euston centre, since this system exemplifies many of the points described above concerning the systematic referencing of audio, video and timecode in a large network. □

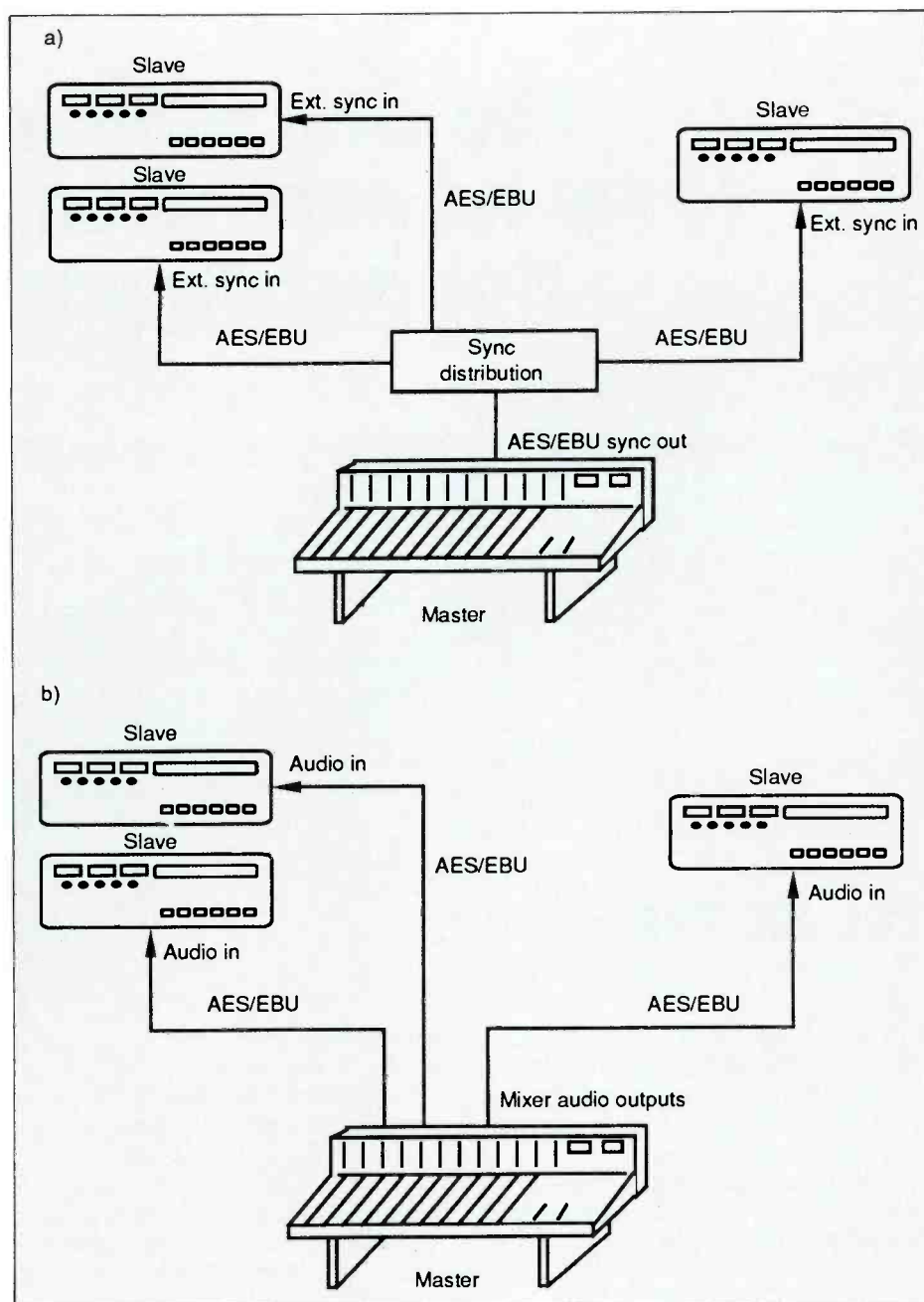


Fig 4

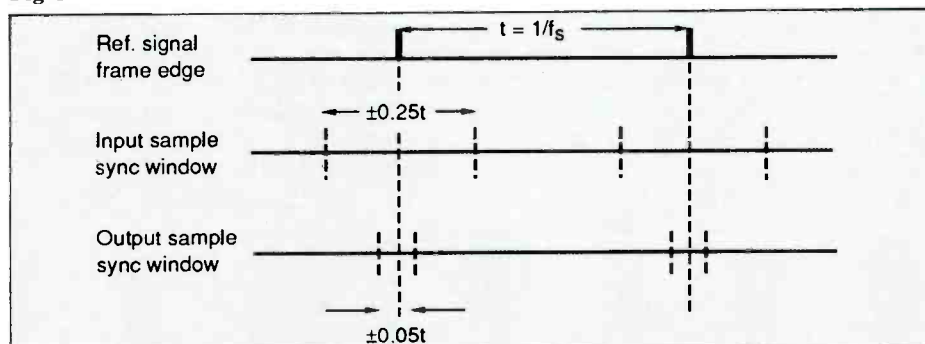


Fig 5

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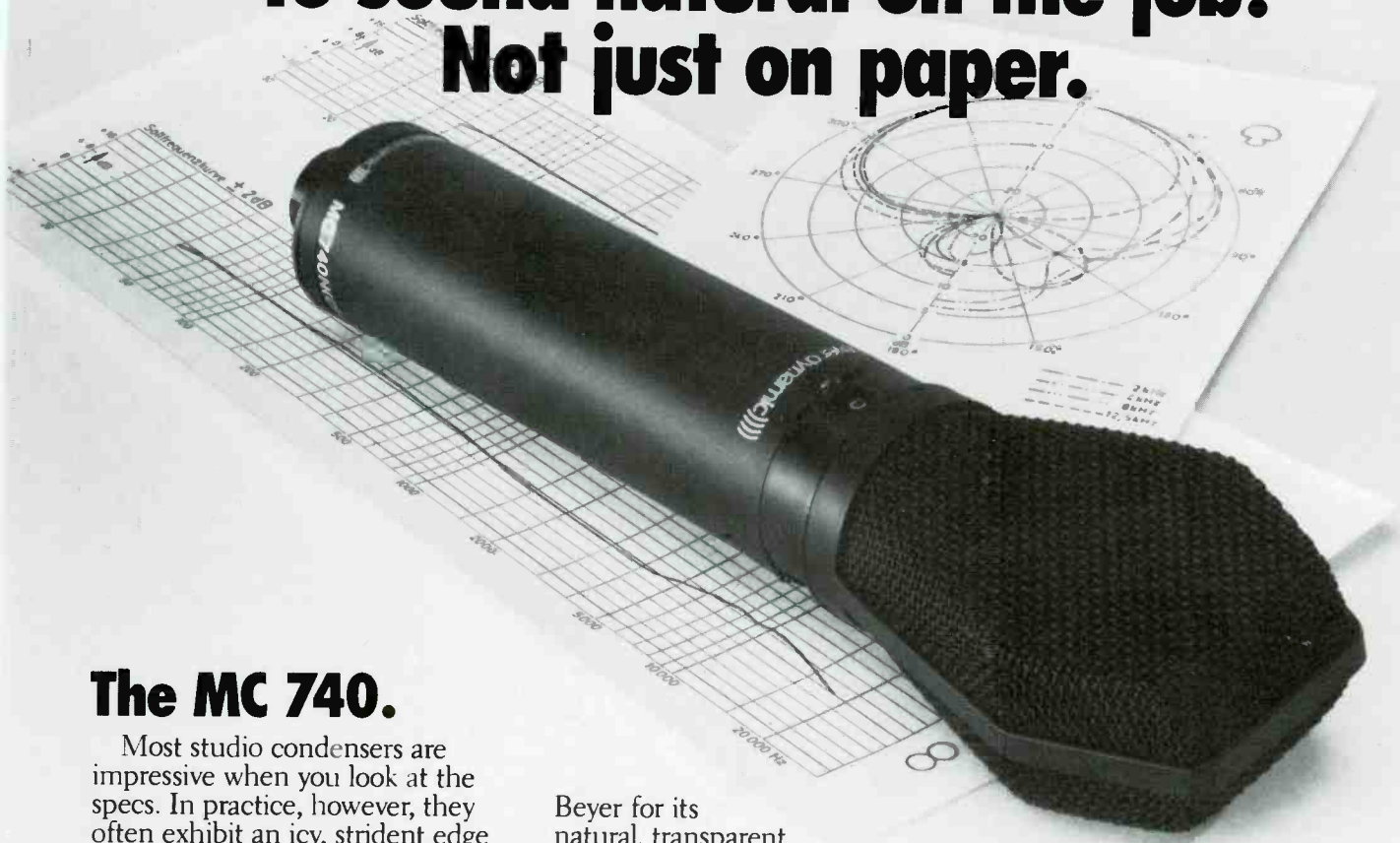
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“Actually,” explains Rod Halling seriously, “Simon suggested the three of us band together to buy a *Portastudio*, but it all got a bit out of hand.” The ‘three of them’ are musicians/producers Roy Shipston, Simon Holmes and Halling, and what got out of hand is the fact that they now own The Mill recording studios. A large two-studio residential complex housed in an 18th century flour mill, situated on a private tributary of the River Thames in Cookham, Berkshire.

A watermill has stood on the site from early 1600. During the 19th century it belonged to Sir Evelyn de Larue who entertained many prominent writers at his country residence, including Tennyson and Keats. It became a recording venue when Gus Dudgeon took over and constructed a studio within the original building. Jimmy Page acquired it in 1980 (called it The Sol) and recorded his solo work there before selling to the present owners last year.

Only 18 months, or so, ago the Halling/Shipston/Holmes team had no such grand aspirations. Having formed HSH in 1988 they were involved in a variety of projects ranging from film scores and corporate videos, to jingles, songs and television documentary soundtracks, singing, playing, writing, arranging and producing. There inevitably came a point where they felt they were spending too much money in other people’s recording facilities.

So they began looking around for a suitable house in which to install their own studio. As they all lived in London, it seemed the obvious place to start. Having found what they considered to be a large house, they invited a friend, engineer John Etchells, to cast an opinion. All he cast, however, were doubts and aspersions, informing them that they needed a much bigger room to serve their purposes. When they came across an advertisement for The Sol, as it was then, describing its location as being ‘on its own island’, they envisaged a wooden hut erected on a lump of mud in the middle of the Thames.

When Halling went to check it out he was bowled over, rushed the others round the following day and virtually committed to buy it on the spot. Finance took a little longer, however, and they eventually took over in August 1989. There followed 2½ months of refurbishment, after which the first session (new artist Steve Booker under the guidance of producer Jon Kelly) started work.

“They used lots of acoustic instruments,” says Halling. “The studio was built around the idea that it should provide a natural environment, taking the natural sound and bringing it out; natural ambience.”

Studio manager Karolina Bostrom points out: “People are playing live together again. MIDI rather took over for a period but we are getting back to bands playing together as bands. A&R companies are signing up ‘bands’ again, not sounds.”

Original construction was designed by Eddie Veale. Halling was very impressed by the isolation work: “I think they must have had shares in ARC; you wouldn’t believe the amount of concrete that has gone into these walls.” Not only were there the usual problems of isolating the rooms acoustically, there was also a stream rushing past the window to contend with. “It took 5 days to dig a trench through the concrete for the mixing console wiring,” Halling laughs.

THE MILL

Janet Angus visits The Mill in Berkshire, UK. Built on a tributary to the River Thames the studio is situated in a peaceful and creative setting

“The studio was designed in 1976 for Gus Dudgeon and reflected all the design features of that time. While it was entirely possible to record great albums (after all the last album done in it was Jeff Beck’s), it wasn’t what we wanted.”

Rather than taking the usual route of appointing a studio designer and working up to the equipment, the trio had already decided on a Neve VR console and set about assessing monitoring.

Halling: “We looked at UREIs, which are rather outdated now, good though we used to think they were; Questeds we felt sounded different in different studios; we listened to the Genelecs at Metropolis and they were pretty damned good but the difference between low to mid and loud volume was rather



too much for our taste and the price was—well—astonishing.

"Then we went to the BBC Transcription Unit where they have ATCs—excellent in every detail: stereo imaging, bass end, and they sounded the same whether quiet or absolutely flat out. We felt we could trust them."

And this is how they came to meet acoustician Nick Whitaker and the Recording Architecture design team. Recommended by ATC to install the *SCM200* softdome monitors, Whitaker arrived at the studio and started to laugh. Halling explains: "I think I know where your bass end problem is," he said, looking at a rather lovely fireplace in the monitor wall!"

Having filled that and a matching cupboard with bass traps, Whitaker measured the room and made recommendations for updating the acoustics.

"The hard ceiling was causing a treble splatter," recalls Halling.

When asked to describe the original control room design Halling says: "It was brown," which seemed to sum it up. "The tape machines were arranged along the back wall, probably disguising the horrible problem with the bass." Aware that modern recording requires the removal of machinery from the control room, a bit of lateral thinking resulted in the resiting of a staircase to create a separate machine room.

According to Halling and Shipston, the reworked control room is now flat down to 25 Hz with "... a lovely round bottom end. It shows up any anomaly in the mixes and EQs. It really is dear to all of us that what is done in the studio should come out on your CD as intended. If it sounds wonderful in the studio then it will be really great elsewhere; it is in no way flattering. We do believe that the truth is always the best way."

The 45 m² room has been treated at the front end (walls and ceilings) to combat midrange reflections. Under the console, the floor is maple while the rear of the room is carpeted. One side looks out across the mill stream to the studio's own small island, the other is furnished with a stained glass window depicting the mill wheel and stream. Far from being brown, the room has been decorated in contrasting greys and blacks giving it a contemporary feel, complemented by the light maple wood treatment and trims.

Two black leather settees arranged against the back wall provide accommodation for band members and their entourage, while between these and the mixing console is an equipment rack/producer's table, housing all the outboard equipment. DAT and cassette machines are recessed on shelves in the back wall. In consideration of the trend towards working in the control room, there is provision for inserting guitar amp leads through the wall into the studio.

The Neve VR series 72/60 console, equipped with recall and *Flying Fader* automation, was chosen principally for its sound. "We suspected that was where the bookings would lie in the future," explains Shipston. "We decided very early on (before they even launched the VR), that we wanted a Neve. We simply prefer the sound of the desk compared with other makes and when, during negotiations, Neve launched the recall for it, that was just an added bonus."

Outboard equipment complement is extensive with AMS *dmx 15-80S* digital delays, Bel *BDE2600* delay/sampler, Publison

DHM89B2, Lexicon *Delta T*, Eventide *Instant Flanger*, Summit Audio *TLA-100A* compressors and *SU-EQP-200* equalisers, dbx *160* and *162* comp/limiters, Universal Audio *1176LN* limiters, Drawmer *DS201* dual gates and APSI graphic equalisers.

There are also Lexicon *480L LARC* and *PCM70*, Yamaha *SPX1000* and *SPX90s* as well as Ibanez *SDR1000s*, ART *MultiVerb* and an AMS *rmx 16* digital reverb.

Housed above the studio are three EMT echo plates including a *240 Gold Foil*. ("A lot of American clients like that.")

Although the bulk of outboard equipment came as a job lot with the facility, the new owners added many of the valve compressors and equalisers. "There wasn't even a DAT machine here," exclaims Halling, as though the facility therefore dated back to the Ark. An '18 bit' Technics DAT machine is employed for mastering, with other options including *SR ¼* inch or *½* inch.

A 9 ft Bechstein grand piano in the studio has been furnished with a MIDI controller in the keyboard.

In the machine room, behind the control room, are two Studer *A827s* and a Mitsubishi *X880* digital multitrack. Studers were chosen on the basis of past experience. Shipston: "We felt they were a good investment as well as being reliable. The new *A827* was attractively priced and offered an uncomplicated and good tape transport. The idea of a machine which offers auto line-up was not all that appealing to us; we don't have a jingle producing environment where different tapes are coming into the studio every hour—people come here for weeks on end—so that feature (offered on other makes of machine) wouldn't necessarily be of much benefit."

Studio acquisition isn't the only matter to get out of hand it seems. Halling: "We didn't originally intend to buy a digital multitrack—rather go the Dolby *SR* route. The Mitsubishi machine was very persuasively sold to us and I must admit more than 50% of our business has been done on the strength of it."

The *X880* arrived in November 1989, and The Mill is now planning to offer a DASH 48-track within the next 18 months.

Meanwhile, the three multitrack machines may be synced up in any combination—Studer/Mitsubishi being a popular choice. There is timecode patching from the machine room.

The air conditioning plant is housed in an adjoining room. Prior to its installation and during the very hot English summer a local advertising agency arrived with an order for 35 tracks to be produced in less than a month. "We said yes, of course, and then realised what we had done. You see one of the rules here is that you never say no. Say yes, and then work out how to do it. At one point the temperature rose to 103°F. The equipment was fine; nothing broke down—just us!"

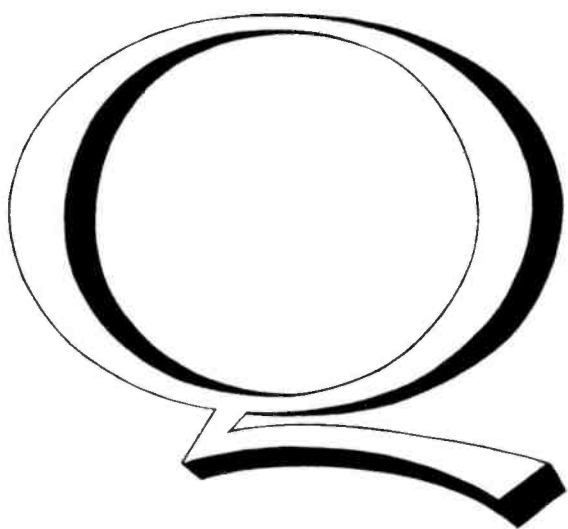
The studio itself also overlooks the mill stream—the daylight providing a comfortable working atmosphere. The room, 84 m² with a 13 ft high ceiling, has been designed to be principally live and incorporates two isolation booths. Design input came from a number of sources, including all three owners, their chief engineer John Etchells, and associate drummer Charlie Morgan.

"It's very important to talk to people who are used to making great sounds and pick their brains until both they and we are satisfied," says Halling. "If we didn't feel happy with the room we wouldn't have the confidence to sell it. We wanted the acoustic to immediately sound good in the room as well as being controllable. When we acquired the building the studio was completely soft—ceilings, walls the lot. We felt that more or less the whole room should be live, with a large degree of controllability. We didn't want to bodge it and therefore took the time to investigate different ways of doing it."

The result is a maple floor, which may be carpeted if required. The walls are also maple clad, the rear wall being reversible between maple and Rockwool by means of doors that fold back to offer the alternative acoustic. The two booths have maple walls on three sides with glass fronting onto the main studio area. An adjacent corridor doubles as a small isolation area for amplifiers, etc.

As is always the way, originally acquired to service the needs of the Halling/Shipston/Holmes composition, production and recording company, HSH Music, the trio found that they now had difficulty gaining access to their own studio. Not to be outdone, they installed themselves in the garage, duly refurbished and acoustically treated.

Thus two birds were killed with one stone as they had a



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substantial amount of recording equipment left over from the original studio update. All original tape machines and console from the main room were just sitting about not earning their keep. The grand old MCI 500 series 40-channel console has therefore been put to work along with two JH24 multitrack and JH110 ¼ inch tape machines.

"We designed the control room layout (I won't say 'acoustics') ourselves, taking all the computers and MIDI equipment into consideration," says Shipston. "As it is intended for our own use we felt we were most concerned with the ability to move around the room in the right sequence without getting in each other's way. John Etchells gave some acoustics input but it is not on anything like the scale of Studio One."

Halling: "The MCI 500 is basically a great desk with fantastic EQ. We have used the tape machines a lot and get really good sounds. They naturally need on-going care and attention, probably needing aligning more often than the Studers. You must treat them more like the old fashioned machines they are but if they are kept up to scratch they perform exceptionally well."

The original JBL monitors, however, have not fared so well. "We put those up basically because we had them and it didn't seem right to discard a perfectly good speaker. It was our intention just to equip this room with all our leftover gear but I really can't work on these JBLs. The main point for monitoring these days is to be accurate rather than loud."

In addition to all the recording equipment, Studio Two is crammed full with Halling's, Shipton's and Holmes's various instruments including a selection of keyboards and MIDI equipment. In the small adjoining studio area (which is again live), there is also Charlie Morgan's drum kit, which makes his contributions to the recordings a relatively quick and simple process. "When we need him he just comes along and plays without any setup problems."

The studio is littered with guitars, Boogie and HiWatt amps; there is even an old Hammond organ complete with Leslie cabinet. "All these things are being used more and more these days," adds Halling.

Although the recording area is small, Halling maintains that a good drum sound is achievable due to the high ceiling. "It is also good for vocals."

At the back there is a small area divided into three rooms offering kitchen, storage and toilet facilities, making the studio completely self-sufficient. Nothing, however, is sacred, and just when HSH thought they were home and dry with their own private recording facility, ELO booked in to record in Studio One but somehow managed to overspill into Two and install themselves in both simultaneously.

Next door to Studio Two is the maintenance workshop, engineer Phil Buckley's domain. "If the equipment breaks down you have to be able to fix it straight away; on-site maintenance is therefore essential."

As of February of this year The Mill signed an exclusive deal with Pete Townshend to manage bookings at Eel Pie. As a result of this there is a reciprocal maintenance arrangement whereby both studios are covered 24 hours a day by the two maintenance teams.

Having taken on mammoth proportions, the project's Berkshire location seemed an academic change of plan. Only 10 minutes drive from the M4 motorway, it is as little as 30 minutes' drive from London. All three components of HSH live in West London as do many major record companies these days and, quite apart from anything else the attractiveness of the location was deemed to totally outweigh any objections to moving out of town.

Having made the decision, the trio have become total converts. Halling: "It is a completely different environment to town. People think you flop in the country but in fact you tend to work harder. It can take only 6 weeks here to do what would take 8 in town. Daylight in the rooms helps; I get really claustrophobic in the classic basement studio now."

"The environment really does affect you. When ELO worked here recently they got up at a reasonable hour and played tennis or something before going into the studio for a 12 hour day. It's just grown up people doing it in a grown up way. So many people act like kids in studios. They work 18 hours and then sleep 15 hours; all that does is knock you out. Record companies are no longer prepared to pay for a band's social life

in the studio. There are lots of places to have fun around here—boating, sports activities, etc—but people don't. They may fish for our killer pike, which keeps eating the ducklings, but that's as far as it goes.

"When the Booker project was here for 10 weeks, they went out twice, and one of those occasions was when we dragged them to the pub for a drink!

"The location doesn't make you want to run away; it channels creativity, the first time we stayed here ourselves as a client (we thought we'd better find out what it was like), we found we were getting up earlier every day. Three tracks were sewn up in a week: recorded, mixed, the lot."

The residential aspect of The Mill was never in any doubt, even though it was not part of the original HSH plan to take on such a big commitment. Halling: "It would be a terrific waste of a beautiful location and building not to offer residential facilities. Part of the whole ethos of the place is to mellow out and get on with your work. Producers with children may go home but everyone else always stays. We feel that it is important to at least have the option to be residential."

The four existing double/twin bedrooms and associated bathrooms, were redecorated and furnished. A further two bedrooms with *en suite* bathrooms were constructed by rearranging the accommodation above the studio, while also providing office space, which offers all the usual office facilities to a client. All the rooms have a tranquil outlook—many of them overlooking water. The most spectacular have been



constructed within the space originally occupied by two 14 ft water wheels. The associated wildlife provides added interest, with many unusual birds visiting the banks of the stream.

Arranged in three distinct areas, the accommodation allows for the tensions that can build up during an album project, with space to get away from everyone when circumstances demand.

Up to 11 people can be provided for, though numbers don't usually approach that. A catering firm provides full time cover, offering 'good home cooking with a once-weekly fab spread'. Dietary preferences are investigated on the studio booking forms and, by having a company rather than a person responsible for the catering, should a cook be off work through illness a replacement is provided within minutes, rather than days. Meals are timed to suit the band and a kitchen garden is being developed to provide organically grown vegetables.

In addition to the bedrooms there is a living room with television, etc, which looks out across the island and waterways. There is also a separate pool/games room. Outdoor recreation may soon include some small boats. "We did have some canoes," says Shipston, "which arrived during the storms but we had to give them back to the Venture Scouts when they finally discovered where they had got to!"

If you are in any doubt about having to drive to a studio 'out of town', just try it. Having ambled along the riverside, watched a few boats negotiating the locks and generally absorbed the peaceful atmosphere you will be hard put not to feel inclined to creativity by the time you arrive. □

The Mill, Recording Studios, Mill Lane, Cookham, Berks SL6 9QT, UK. Tel: 06285 23522.

Nobody promised us a Rose Garden but 1990, more than any other year in recent memory has turned into a festival of thorns. The financial climate of the audio world has not turned sour for all concerned but it is clearly reflecting the greater economic pressures of the various national economies. The 'R' word, Recession, is heard more and more from both independent and government forecasters. Many studios, rental houses, equipment makers and resellers are thriving but almost everybody has grave concern about controlling expenditure and of receiving credit from banks, etc, for expansion or equipment purchases or just sustaining the bottom line. This in a year when commercial credit has become tighter than at any time in recent history.

Some simple techniques can be employed to prevent escalating costs from becoming major cash flow problems during these and other 'lean' times and also to keep control of expenses during 'fatter' periods. Credit needs can also be managed, at least to some small degree, without resorting to difficult-to-obtain commercial loans or equity-reducing venture financing. The following areas deserve individual attention as control points for the internal economic well-being of business enterprises involved in the commerce of audio.

Controlling space allocation

The objective evaluation of current space usage is a vital factor for any business enterprise. No one wants to cut back existing space usage because of hard times, only to find the facilities cramped when boom times return. On the other hand, many studio facilities control storage space and parking spaces external to the main studio complex. If the undesirable alternatives in a fiscally compromised situation is total shutdown or staff cutbacks, the loss of parking and/or storage space is a much more tolerable alternative. Several studios have taken to leasing space in 'storage condominiums' or 'U-Store' complexes, as an alternative to more expensive space they used to control. Street parking can be found by the staff of many studios, though safe night-time access for female staff members can be a very real complication. If actual studio space is not being used and you rent it, it is probably time to take a long hard look at your current space requirements. If the space is owned or long-term leased, perhaps it could be leased (or sub-leased) out to a 'third' party. One recording studio had a fourth 'room' that was virtually unused over a 6 month period. By leasing the space to a CD mastering facility, the full service reputation of the studio complex was enhanced while new income was created and expense cut.

Use of personal credit

No issue is quite as vexing for a studio owner or small audio manufacturer as the problem of bridging a period of slow payment by clients. That is the one problem that most often plagues the cash flow of any small business, let alone the audio industry. In today's economic climate, it is very, very difficult to get such a bridging loan from a commercial bank or thrift institution. Venture credit can be obtained in some cases but

Martin Polon

Our US columnist offers some essential cost saving advice

it carries the most onerous penalty of loss of financial control in many instances. The path that many studio and small business owners frequently ignore involves using personal credit. Many times a facility owner will have as much as £25,000 (\$50,000) of credit extended to him or her based on their good personal credit history. They may have a home that has appreciated over the last 10 years or so. It is frequently not difficult to obtain £25-50,000 (\$50,000-100,000) in such a fashion. However, such a personal credit extension can and should be used only once and to bridge a cash flow gap that is unresolvable in any other way. If such a gap is not temporary in the mind of the owner, however, it would be foolish to use such a personal credit extension. So the bottom line is to analyse debt and cash flow very carefully before committing personal credit resources.

Use of credit cards

Many studio operations, manufacturing companies and a broad range of other business enterprises in audio issue their staff members company credit cards. Such cards are viewed as a symbol of success, a valuable tool for illuminating business expenses with the per employee, per card breakdowns and as a simpler way than extending cash advances or doing expense reimbursements. Take it from a business school professor who says, "Employee credit cards frequently cost a company more than anyone realises. Firstly, if you have 10 employees with so-called 'Gold' cards, you are paying a fee of £30 to £40 (\$60 to \$75) per card. Ten times that means you could be creating overhead of close to £500 (\$1,000) just for the privilege of having the cards. If you have 100 employees, the total just for fees becomes staggering. With 1,000 employees. . . and so on."

A second issue is that there really aren't any savings in bookkeeping at your end with company cards. The bill for each card has to be scrutinised by management each month, the employee has to OK the items charged and each bill has to be paid off. A third item of interest in the use of company cards is the real cost of the card. Any credit card ends up costing you more than you think. If your employees buy fuel for business trips, they pay a 'credit card' price for petrol. The cash price is usually 5-10% lower. If you send 10 employees to Paris to attend an AES Convention and they all use their company 'Gold' card, you will have 10 times say £1,000 (\$2,000), for airfare, hotel and food for a week. The credit card companies these days charge interest from the moment a charge is entered into. That means the £10,000 (\$20,000) total for all 10 individuals will

be surcharged by the close to 20% annual rate that most credit card companies impose. On a monthly basis, that works out to about 1.60% per month and for that £10,000 (\$20,000), £160 (\$320) per month in interest alone. Lastly, study after study indicates company credit cards encourage overspending on entertainment and meals—especially with the nurturing of potential clients. Bottom line: use company credit cards very carefully, if at all.

Control of utilities

Reduce your expenses for the basic utilities. OK, in the US we can curb our water bill by putting in new water efficient toilets or sticking bricks in old ones, lower our electric bill by putting in lower wattage bulbs and save on heating costs by lowering the thermostat. Yes, those solutions will work but in addition we can install disconnects on water and electric connections that are exposed to the public in a back parking lot. One manufacturer was providing water to a competitor who pulled a water wagon to load up at an outside spigot twice a week at 3am in the morning. Use solar power, if at all feasible, to heat hot water. Use the hot water to heat the studio or facility. It's done all over the world. Even the cost of converting to solar energy is frequently encouraged with tax credits. Make sure your facility is energy efficient. See that the building or buildings are well sealed against heat loss. Use fans to help circulate air in summer (and heat in winter), thus reducing the cost of air conditioning. Use 'cooler' lighting in recording studios to reduce the amount of air conditioning needed. There is an acoustic payoff to this, too.

Control of telephone

Oh, boy, can we save some money here. First, no free telephone calls for clients. No exception. . . none of the time. The abuse of studio telephones was estimated recently by one studio owner as costing in excess of £1,000 (\$2,000) per month and that was in a good month. If clients need telephone service during sessions, you can install one or several permanent lines that are accessed by plug-in telephones in the studio being used. These phones are exclusively for the use of the clients and they will be billed the total cost plus a small override for your administrative expense and monthly charges from the phone company.

Two, control staff usage of phones by scrutinising the bills and making staff members cough up the change for extravagant non-business calls. Do not attempt to create a fascist atmosphere by restricting all staff calls but establish respect for phone control.

Third, do use telephone credit cards for key employees who need them. There is a large saving for calls made during travel.

Lastly, use 800 or 0800 services, available in most of North America and the UK, to handle your outgoing business calls beyond your region. With these and other similar techniques, rising telephone expenses can be kept in check.

Rate and charge analysis

Go through your rate card. Sit down with your

accountant and break down all your costs relative to a specific rate. Frequently, a studio will discover it is losing money on some rates, breaking even on others and making a fortune on yet other rates. That doesn't sound so bad but in fact the various categories usually do not balance out and more often than not, a studio or an equipment maker is losing money.

By adjusting the rates or prices to actual costs, you will find a big increase in profit. Frequently the increases are small and combined with a drop in rates or prices that are too high, the client base usually perceives these changes as positive. In addition, the knowledge behind the improved rate base allows the studio management to explain rates to clients with a good deal more veracity than before.

Control of ancillary benefits

No expense has irritated studio owners more than that of food. Many studios had been continuing to provide some level of food service to customers (and by default to staff) as a kind of prerequisite for using the facilities, even after this late-1970s practice fell from grace during the '80s. Most operations providing food had converted to some kind of charge basis but never really recouped the total expense. If such a service is to be retained by a studio as a differentiator from the competition, it must be at least a break-even operation covering all its expenses, not just the obvious ones.

In fact, one studio owner cut a window in the wall of his building facing the street, obtained the necessary licences to sell food to the public and converted his studio's popular Mexican kitchen into a neighbourhood take-out favourite.

Everybody pays the same price—bands, staff and outside customers. The food operation is now quite profitable, with the chef taking a small cut. Other operators have taken to using specific caterers billed directly to the project. Direct billing keeps the studio out of the line of fire if the food service becomes a bone of contention after the fact. Other studios have said 'Never Again' and segued out of the food arena on a hopefully permanent basis.

Other special services not directly related to recording, such as leasing motel or hotel space for recording groups and/or operating a more rurally located living and recording centre, have had to reshape their focus. Frequently such operations have opened their facilities to tourists, or to short courses in recording or other areas. As one studio owner opted, "It's time to get back to basics. I am not a hotelier or a restaurateur. I am an expert in the business of recording music and voices and that is my core responsibility. Anything else just distracts me from my ultimate goals."

Collecting due bills from clients

No matter what the financial environment, there is little or no excuse for allowing some clients to ignore bills due so that the account 'ages' excessively and/or 'drifts' unpaid for months or years or even forever. Nothing kills small and medium sized businesses off faster than cash flow problems brought on by clients who do not pay in a timely fashion for services rendered. One studio owner has a lovely story about his 'collectables'.

"I had about 20 clients who were paying very slowly or not paying at all. They accounted for about 25% of my total billing and I was afraid to push them, since I 'needed' them. After all, who am I but a lowly recording studio owner. I kept telling myself I couldn't go after advertising agencies and record companies. Like the books say, you only get stiffed by the best people.

"Finally, in desperation, I went to a collections firm that only charged me 15% of the debt. I thought that was reasonable since all I had at the time was 100% of nothing. They called up these bad debts and I don't know what they said but it must have been very motivational since all but two paid up right away and the two have filed payment schedules.

"What is hysterically funny, is that these debtors call me up nearly in tears and tell me their tales of woe. I sound shocked and alarmed and share *soto voce* the fact that I had no idea that this would happen. I simply say my attorney forced me to go to collections. I commiserate with them on the phone and they still love me. In fact, I am thrilled and only sorry that the collections people did not use pliers on the debtor's toenails. Then again, considering the speedy repayment...?"

Using buy out services

The last cuts any manager or owner wants to make involve staff. It is estimated that a new employee will need between 6 months and a year to perfectly mesh into the unique business and technical environment found in a recording studio. So there is no justification for releasing staff, since the later cost of training new hires will more than eat up any saving achieved during the short run of down economic cycles. However, correctly sizing up a facility's needs in terms of permanent staff is equally important. When the overhead of health benefits, insurance programmes, retirement programmes and administrative functions like tax withholding are added up, it is not unusual to be spending half as much again (50%) on an employee, over the base salary. The answer for many businesses is to retain outside service contractors and buy in many functions that were formerly provided in-house. Janitorial and security services come to mind most frequently in this category, as do food services and car rentals. But areas like studio equipment repair may also be more cost effective. Such a contractor is frequently on-call to several studios and is available by beeper. If the previous practice was one of having the studio's technicians earn overtime to accommodate repair needs, the use of buy out help does mean real savings in this category as well.

Insurance and security

Probably the last category of protection to be removed, even beyond personnel and equipment. The insurance policy covering the entire physical plant of a recording studio or audio manufacturer is one of the most valuable documents that a business owner can possess. An up-to-date policy is one of the signs that bank officers always look for in granting further loans to an ongoing business. The use of on-site security is another

category that indicates a strong desire to protect the physical plant investment. Whether the security takes the form of drive-by checks by car-borne officers or a physical presence on premises when the operation is devoid of staff, the expenditure on security also serves to lower the costs of obtaining insurance coverage. However, it is always wise to shop the price on insurance coverage and for security services obtained every year to make sure that the lowest cost is obtained for a reliable level of protection. One does not sacrifice quality, if the competitive forces in the insurance industry among reliable carriers are made use of. The same can be said for security. In fact, it is a crucial role of responsible management to monitor all charges to the entity and to negotiate the best possible arrangements, come each renewal.

Tax and accountancy planning

The careful analysis of the tax codes, perhaps with the aid of an accounting professional can sometimes suggest many techniques for cost control. One studio owner stumbled upon a solution to his equipment rental cost problems.

"My rental 'shop' operated two ways. There were outside rentals to anyone in town and there were inside rentals to our customers working within the studio's 'four walls'. We were losing money overall and my tax adviser suggested splitting off the rental operation into a separate space. We repriced all the charges both inside and out, used separate staff and printed up new flyers, rate sheets, order forms, etc—all the time staying under the same roof. The rental operation finished its first year as a unique entity with a small loss but not an unacceptable one considering the utility it provides for the studio customers as well as bringing in some cash for equipment that would otherwise collect dust. The bottom line was improved somewhat and the next rate sheet should make us profitable. We found it curious that as a separate unit, we could charge the going rate for add-on equipment, which our studio customers would never accept when they thought everything was coming from the same company."

It seems clear from the above list that the individual business owner or manager has a great deal more control of the financial destiny of his or her operation than a first look at the books might suggest. Careful management will cut some costs without cutting proficiency or the service level so important to today's studio customer. Some of the cuts suggested above will amount only to a couple of hundred dollars or pounds per month or even less. Yet, as the savings in each category begin to mount, the total savings for the studio, manufacturer or business will become important. £50 (\$100) saved each month in each of the nine or 10 categories suggested here, soon amounts to nearly £500 (\$1,000) per month. Yearly, that is about £6,000 or \$12,000. If you save more per month, the total savings could well move into the six-figure area, depending on the size of the business. Such careful economy that does not cut crucial jobs or reduce needed equipment can save the day financially, during tight times—and during not so tight times as well. □

Herb Belkin of Mobile Fidelity Sound Lab was in London recently *en route* back to California from the Soviet Union where he runs a joint venture record company with the Union of Composers, Domestic Concert Agency and Electronica state consumer electronics manufacturing company.

The joint venture now operates in Lithuania as well as Russia, in direct competition with state record company Melodiya. They record mainly serious classical and jazz music, with studios in Moscow and Vilnius. Belkin issues only on cassette, duplicating around 100,000 a year at a small facility in Moscow. Although Melodiya are starting to issue CDs, they are bought mainly by the government classes. Soviet LP pressing quality is very poor.

Belkin was in London on a life-saving mission. Although few people realise it, JVC in Japan closed its Rinkan LP production plant at the end of March. Belkin had been using the facility to press Mobile's discs for 13 years; in fact the last record pressed by JVC was a Mobile title.

When Belkin heard that the plant was closing, he asked JVC to sell him the presses. But the Japanese said they had 'made other arrangements'. JVC did, however, offer technical assistance, and even sold Belkin raw pellets of the 'supervinyl' material that made JVC discs so famous. Belkin supplied the pellets to two Western factories (he won't say which) but both failed to produce acceptable pressings.

"I didn't invent the phonograph record," says Belkin, "but I am trying to keep it alive. I remain in love with the feeling and sensitivity of the vinyl record. My mission in life is to try and make CDs sound like LPs."

Belkin gets his conventional CDs pressed at RCA's plant in Alabama, with gold releases produced by Ultech in Japan, a plant which otherwise specialises in CD-ROM pressings. He was in London talking with Linn, hoping to set up some kind of joint venture deal. It's an obvious marriage because although Linn, like Mobile, now release recordings on CD, the two companies still share faith in vinyl.

Linn get their CDs pressed by Mayking in France, and LPs pressed by Sonapress in Germany, via a tortuous distribution deal with Polygram via Virgin. Linn are, however, always looking for plant "on which we can have a stronger influence". Linn and Mobile have now "informally agreed to pool resources".

Belkin was especially chuffed to see, in an interview published in US magazine *Audio* (July 1990), engineers from the Start Lab in Japan explain that they used gold plating for their recordable CDs: "because we find it produces better results, and because we believe it will last longer than aluminium".

As soon as the word got round that JVC would cease LP production, there was a run on Mobile LPs; 80% of Mobile's vinyl catalogue is now sold out, with all the popular titles (like The Beatles' discs) long gone. Belkin, of course, still releases on CD and cassette format, the latest being a two-CD re-issue of Pink Floyd's *The Wall*.

"There are many titles we would like to release but can't," says Belkin. "Our rule is that we have

Barry Fox

Keeping the LP alive; problems with Q Sound

to have the original master and must be able to improve on the previous issue."

Belkin is cagey about what he describes as the "black magic" and "alchemy" involved in remastering for Mobile release. Often the tape is replayed at half speed (following the technique pioneered for supercut LPs by Stan Ricker) and sometimes backwards to improve transient response. The half speed signal is then encoded and doubled in speed for digital mastering. The aim is to make all signal paths as straight and short as possible, with no unnecessary processing.

Belkin bewails the difficulty of locating original master tapes. "We can't go back to the multitrack," he explains, "because the record company has no right to remix without the artist's permission. So we have to try and find the original stereo master. It took us 5 years to find an original master for *Tommy*. Pete Townshend finally found one in the basement of his house. It's not exactly the same as the record company's master but that's what makes it interesting.

"There are many other Who masters that can't be found. We had a Led Zeppelin master that was damaged. We had another tape that was sticky. We sent it for analysis and the chemist said it was a mix of bourbon and *Coke* from the original studio session.

"When I started in this business I was dealing with 25 record companies, now I am dealing with six. They have all amalgamated. Then everything moves lock, stock and barrel. With tens of thousands of tapes, often mislabelled, misboxed, they have no idea where their masters are. Remember that up until 1978 the industry was putting out 4,000 new recordings a year. Since then it's been 2,000.

"When they can't find the original master, they just make a copy of the production master used for making LPs, CDs or cassettes. We want the original from which the production masters were made. We've been sent so-called masters that are actually 12th, 13th, even 14th generation copies. Is it any wonder some re-issues sound so bad?"

Mobile will go on hunting for original masters, recently tracking down Elton John's *Honky Chateau* and some original tapes of Frank Sinatra from the Capitol years. But unless Belkin can find a record pressing plant to take over JVC's pressing role, future Mobile releases will be on CD and cassette only.

Ihear that the American journalist who, quite literally, bought shares in Canadian company Archer Communications, is still collaring manufacturers and journalists on press trips and preaching the gospel of Q Sound—an interesting approach to independent investigative journalism.

Curiously he has been refusing to say how the system works, even though Archer's patent application has long since told all to anyone who takes the trouble to read it. To pre-empt any comment about the patent not telling the real or full story, bear in mind that a patent can only legally protect what it accurately describes.

The first Q Sound recording reached the shops shortly before Christmas. It was a bunch of Madonna's hits, the *Immaculate Collection*, re-released by Warner Brothers after processing in Q Sound. Almost immediately alarm bells started ringing inside the engineering divisions of the BBC and IBA. They were soon warning radio and TV stations all round the UK to listen very carefully to any Q Sound recording before using it for any broadcasts.

Archer had puffed the system as "revolutionary new audio technology" which "provides three-dimensional imagery" and makes sounds that "actually seem to be coming from outside of your speakers". As I have previously reported, the system works by taking the recorded sound of each voice or instrument, splitting it into two channels and introducing artificial shifts of volume and phase at different frequencies. All the doctored pairs of channels are then re-combined into a single pair of channels, which is recorded on disc or tape just like an ordinary stereo signal.

Q Sound creates an odd effect in stereo (described by one engineer as "like Christmas cake icing") with images spread wide and more high and low end bite. Like Aphex, listeners may or may not like the effect. What worries the BBC and IBA is the question of mono compatibility.

How a stereo signal reproduces in mono is of vital importance to broadcasters because many portable radios and most TV sets reproduce only mono sound. If there is too much phase discrepancy between channels, sounds reduce or cancel out in mono.

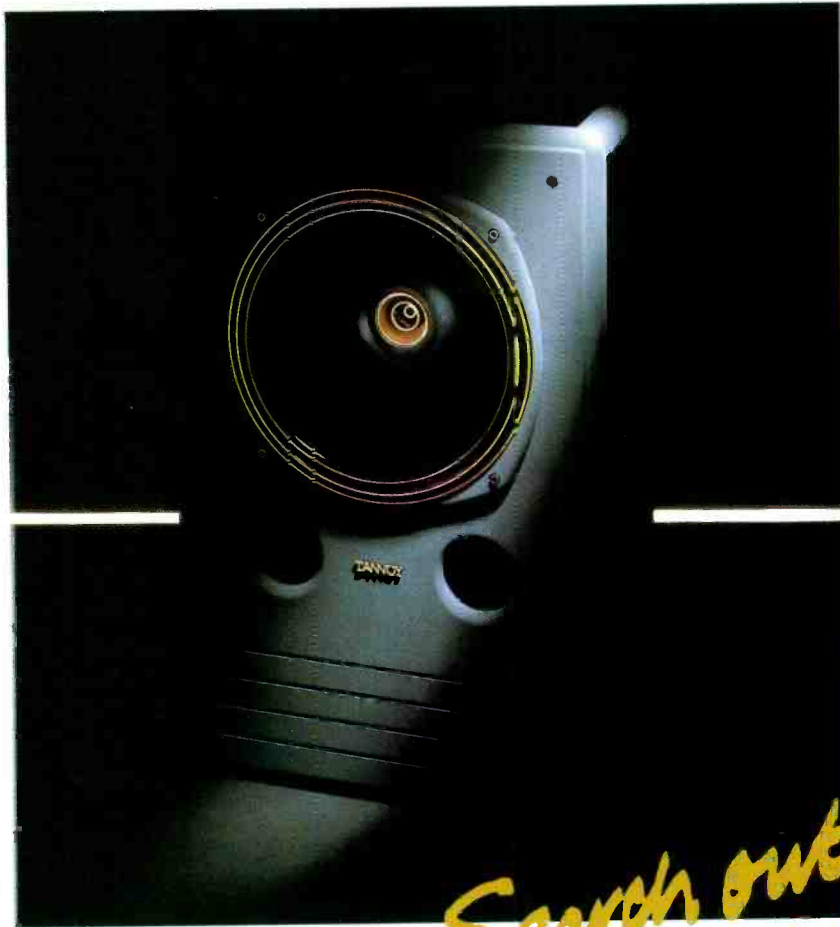
This is of course what killed some of the early quadraphonic surround-sound systems. And binaural systems, too. Recordings that sounded good in surround or stereo mode, or on headphones, sounded thin in mono, with lyrics or instruments pushed into the background. So broadcasters refused to play them. Without radio and TV play a record is dead. And so is the system used to make it.

Q Sound relies for its exaggerated stereo effect on phase shifts. The BBC found that the difference signal on the Madonna CD is sometimes higher than the sum.

Even before the official alert, BBC engineers at Broadcasting House in London were trying to avoid material from the *Immaculate Collection* CD and using the BBC Library copies of the original recordings, which were made without Q Sound processing. If new releases, eg from Sting, are made available only in Q Sound, radio and TV stations may be unable to broadcast them at all. If that happens it's goodbye Q Sound; and the promoting journalist will have lost his investment.

If you can get hold of the Madonna CD, start with the track 'Vogue'. Listen to the rap-style vocal passages while switching between stereo and mono. □

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AMS ST250

Dave Foister evaluates the ST250 stereo microphone providing a flexible pick-up area via a separate control box and surround possibilities

I should start by owning up to being a Calrec *Soundfield* man. My experiences with the Mk III version over the past year have turned me into a dedicated fan and made me particularly interested in the introduction of the *ST250* microphone from AMS, now the manufacturers of the *Soundfield*.

The *ST250* employs the same tetrahedral capsule array as the *Soundfield* and its updated electronics extract the same B-format signals from the array.

For readers who are unfamiliar with the *Soundfield*, the B-format signals are the four virtual microphone outputs, which can be combined in so many ways to provide astonishing versatility. They comprise an omnidirectional component called W, a front-facing fig-of-8 called X, a left-facing fig-of-8 called Y and an upwards-

facing fig-of-8 called Z. These signals are used to provide facilities such as 360° steering, tilting, zooming and full 4-speaker Ambisonics but the *ST250* takes a much simpler path. Although the B-format signals are available for external processing (such as a *Soundfield* control box) the *ST250* confines itself to providing a highly flexible stereo output.

At this point it is extremely important to realise that it does this using M-S techniques. Failure to understand this or to read the manual fully can easily lead to confusion and incorrect use of the microphone, which is not helped by the front panel legending, which could be misleading. AMS are aware that the possibility of confusion exists and have already updated—indeed almost rewritten—the manual. (*Now much clearer—Ed.*)

Control of the microphone is handled on a

separate box, which carries two main control knobs marked Pattern and Width. Since the width control is calibrated 0 to 180 it is easy to assume that it sets the angle between two synthesised microphones, as does a similar control on the *Soundfield*. Assuming this, however, leads to all sorts of anomalies, such as coincident omnis giving a stereo output as the width is increased, or 180° fig-of-8s failing to produce complete cancellation in mono. In fact the Width control is precisely what it says, controlling the width of the stereo output by adjusting the gain of the Side signal (remembering that this is an M-S microphone). Similarly the Pattern control sets the polar pattern of the 'M' microphone, which may well not be the same as the equivalent X-Y polar patterns.

The upshot of all this is that if you wish to synthesise a particular configuration of crossed pair, it is necessary to consult a graph in the manual, reading off the required Pattern and Width settings to produce the desired angle and polar pattern. Unfortunately, this chart was missing from my initial early manual and it would never have occurred to me that, for instance, 180° fig-of-8 would be a sensible configuration; in fact this produces a standard Blumlein pair—90° fig-of-8s.

The original manual states that the figures on the width control indicate an approximate angle between an equivalent crossed pair of microphone capsules, which is clearly incorrect; with this as a guide is it any wonder that so many users got hold of the wrong end of the stick? Perhaps the conversion chart could be printed on the top of the control box to aid those more used to X-Y techniques and that the choice of calibration for the Width control is a bad one; an arbitrary 0 to 10 would have removed the possible ambiguity.

Although the ears should be able to tell you all you need to know, I, for one, feel uncomfortable if I don't have a fairly precise idea of what my equipment thinks it's doing.

Performance

Once all this is mastered, the microphone is a delight to use in many ways. No conventional twin-capsule mic can provide the versatility of the *ST250* unless used in an M-S configuration and even then could not approach its near-perfect coincidence. The control of the stereo pickup is everything one would expect, and the resulting image is vividly clear and rock steady. The sound of the microphone is exceptionally real and transparent, including the extended low frequency response inherited from the *Soundfield*. In every situation I tried, from drum overheads to an entire symphony orchestra, the *ST250* performed superbly.

A major selling point for the *ST250* is its go-anywhere flexibility. The control box is small and light and can be powered in three ways: mains, internal batteries (surprisingly only two 1.5 V cells) or phantom, although the manual warns that many phantom supplies may not work properly due to the relatively high current the



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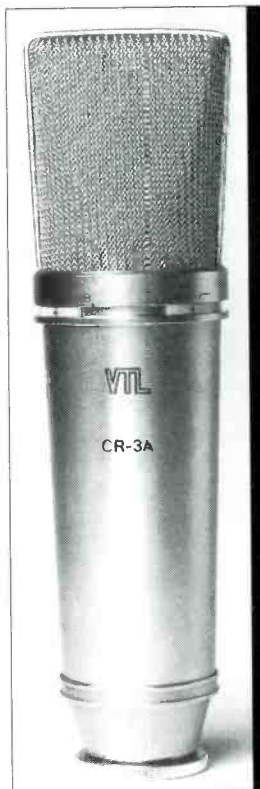
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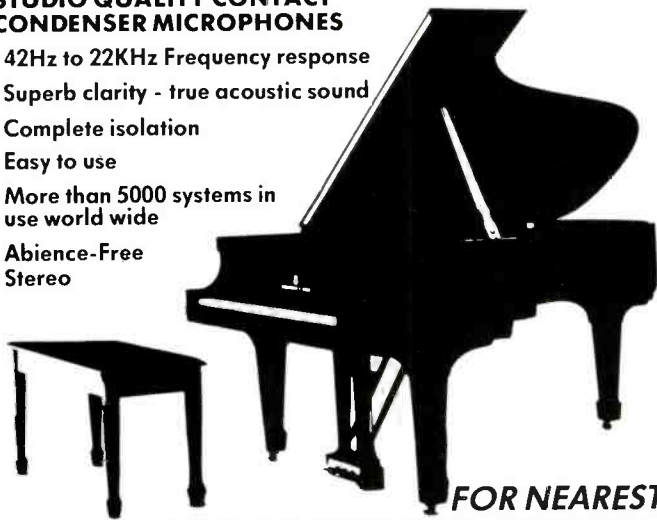
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microphone draws—standard 6.8 kHz phantom series resistors will drop the voltage at the microphone to less than the required 25 V, causing 'high noise and peculiar stereo imaging'. In practice, I was not aware of this causing any significant problems. The battery capability, however, makes it an ideal partner for a portable DAT machine to provide an extremely portable high quality system for location work, sound effects recording and so on. The drawback to the multiple-powering design is that the microphone produces a compromise output level, which is neither a convenient line level nor low enough for some mic inputs. With several pieces of equipment I have connected it to this has caused problems; some line input stages don't have

enough gain to produce sensible levels from it while some mic inputs lacked the headroom to cope. The manual sheds little light on this but a rough measurement of the levels produced by a loud jazz band showed peaks of around -10 dBm without the mic's pad in. I would have liked to see some kind of variable output control fitted.

Similarly, the B-format outputs are approximately 20 dB down on nominal line level. I checked the behaviour of the microphone with these signals suitably amplified and connected to the B-format inputs of the *Soundfield* box and it performed exactly like the *Soundfield* itself, providing all the steering facilities expected.

One thoughtful development concerns the calibration of the capsule array. This B-format

approach requires exact matching of the four capsule output levels and in the *Soundfield* this is done in the A-B matrix module of the control box, which means that any one microphone can only be used with its matching control box. In the *ST250* this calibration is done within the microphone itself—surface mount technology has allowed more electronics to be built into a smaller body. This, of course, means that all microphones and control units are interchangeable, a point worth noting for anyone thinking of acquiring more than one *ST250*.

The control box also has a row of pushbutton switches providing various obvious and not-so-obvious facilities. The obvious ones include bass cut and a 20 dB pad, while the less obvious include a switch to select end-fire or side-fire and another to allow for inversion of the microphone. These permit the *ST250* to be mounted in virtually any orientation while preserving the correct L-R front-back relationship at the output. A further switch provides raw M-S outputs in place of the stereo L-R, while another selects the B-format output. It is worth pointing out that the B-format signals are unbalanced and require the use of specially-made adaptor cables since the four signals share two XLRs. The front panel also features a power-on LED, which doubles as an overload indicator by going out during excessive peaks. The headphone socket, which has its own level control, is described as a guide monitor signal only and does not work when the microphone is phantom powered. (See below—Ed.)

Construction

The construction of the unit appears sturdy and professional. The *Soundfield*, although built like a tank, always looks a bit home-made and it is good to see, for instance, that the *Soundfield's* wobbly and occasionally unreliable bayonet multiway connectors have been replaced on the *ST250* by a much more reassuring screw-in type.

The standard kit comprises a rugged attache-style case containing the microphone and control unit together with a 3 metre multicore and a foam windshield. Optional extras include longer multicores (up to 100 metres), B-format output leads, a control box carrying case and a Rycote windshield.

Conclusion

Despite my reservations about the front panel legending and the odd output levels, I have little hesitation in recommending the *ST250* as an extremely versatile, very high quality stereo microphone. Its B-format capabilities are the icing on the cake for those with the facilities to exploit them but even without these it must be seen as a serious contender in the very top league of the microphone market. □

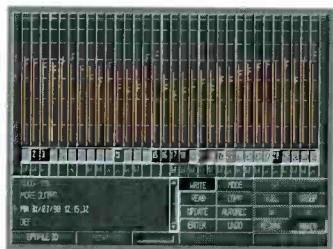
AMS comment: As suggested we are looking at applying conversion table to top of control box. The headphone socket is now operational when the socket is phantom powered.

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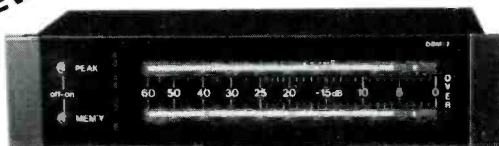


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Crown SASS-P

Dave Foister presents an operational view of this stereo boundary microphone



Having launched the *Pressure Zone Microphone* upon the world, Crown have since seemed reluctant to jump on the bandwagon they themselves created. Since then other manufacturers have introduced their own models using related principles and even gone stereo. Crown have until recently been satisfied to produce the mini 'lavalier' version and the cardioid *PCC* without venturing further. Now all that has changed, and it comes as no as no surprise that Crown's latest model, the *SASS-P*, is radical almost to the point of weirdness.

SASS stands for Stereo Ambient Sampling System, and even without the elaborate name it would not take a genius to discover that this microphone is a rather unconventional stereo array. It consists of two *PZM* elements on independent boundaries mounted in a sizable plastic housing which is designed to produce an optimised stereo image at all frequencies.

The instruction leaflet (it would be pretentious to call it a manual) goes into some detail about the principles involved in the design and, clearly,

a lot of thought has gone into the problems of creating natural stereo from *PZM* techniques. Its methods of localising sound at different frequencies are designed to closely match the mechanisms of human hearing so that at lower frequencies localisation is mainly due to arrival time differences (the elements are some 6 inches apart) while at higher frequencies intensity differences provide the cues, with a crossover region from 1.5 to 3 kHz. Part of this relies on the fact that the polar response of the two microphones varies with frequency, being cardioid at higher frequencies and virtually omni at low frequencies, and this also explains the fact that the microphone works with such small boundaries without the LF losses normally associated with *PZMs*. Phase problems at high frequencies are minimised by the foam-filled 'nose' that reduces crosstalk between the microphones.

The first obvious consequence of all this is that the *SASS-P* is nothing if not eye-catching. With its all-enveloping black cloth windscreen in place it looks more like a large format SLR camera than a microphone, and the further addition of

the spherical foam windshields beneath the cloth gives it a very strange appearance.

All this is easily forgiven, however, when the *SASS-P* is in use. However bizarre its design principles have made it look, they certainly work extremely effectively. I have had the opportunity to try it in a wide variety of situations and in each it has performed outstandingly.

Perhaps an obvious use is as a drum overhead where its stereo imaging is extremely stable and precise, giving a strikingly lifelike picture of the kit. On a grand piano it produced a clear natural image, while confronted with a classical vocal quartet it reproduced the group's physical spacing and internal balance with impressive accuracy.

An acid test was a concert in the Barbican Hall, London, with a large symphonic wind group, where the *SASS-P*, suspended over the stalls in approximately the same place as I would normally position a conventional coincident pair, gave at least as transparent an image as any other technique I have tried, together with a breadth and depth of sound that would stand up well in any company.

While noise did not appear to be a problem, Crown also offer the *SASS-B*, a similarly-shaped unit designed to accept B&K 4003/4006 microphones, which are recommended 'for applications requiring extremely low noise'.

The operation notes suggest that the optimum position for the *SASS-P* in any situation may well be different from what might be expected with other techniques and, indeed, a little experimentation proved rewarding. I felt that the spacing of the array gave a particularly interesting effect on headphones, with a significant amount of out-of-head localisation but not everyone who heard the microphone agreed with this. This in no way compromised the results with loudspeakers, however, which always showed a clear realistic spread with no centre hole.

Since the only part of the *SASS-P* made of metal appears to be the back plate, the microphone is much lighter than might be imagined. Crown suggest several location applications and even supply a stubby pistol-grip-type handle for this kind of use. Location use is further simplified by the battery powering facility, requiring two standard 9 V batteries in holders mounted in the back plate. A large rotary switch selects battery or phantom power and also selects an LF cut at 12 dB/octave below 100 Hz.

While the microphone itself looks less than robust thanks to its largely plastic construction, it comes supplied in a huge apparently bomb-proof case with holes in its foam for all the standard accessories and more. Provided with the *SASS-P* are the windshields and handle already mentioned plus a novel multithread stand adaptor; I understand other accessories are available including, apparently, a chromakey blue cover.

This is certainly a piece of kit that gets noticed although not all of the reactions are exactly complimentary. The results, however, more than compensate for the bizarre high-profile image. The *SASS-P* is without doubt a worthwhile addition to anyone's microphone arsenal. □

NB: Crown is known as Amcron outside the USA.

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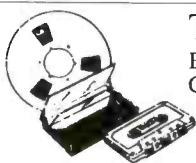
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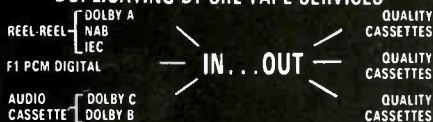
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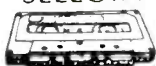
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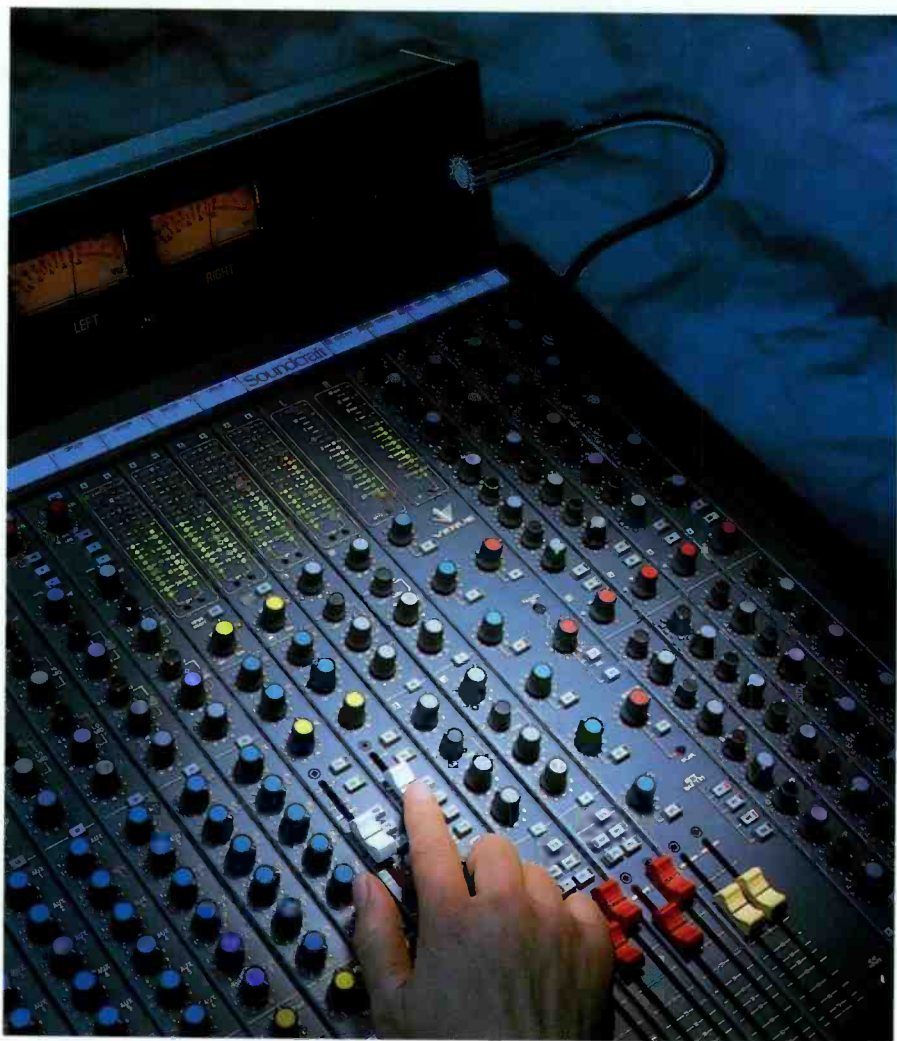
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