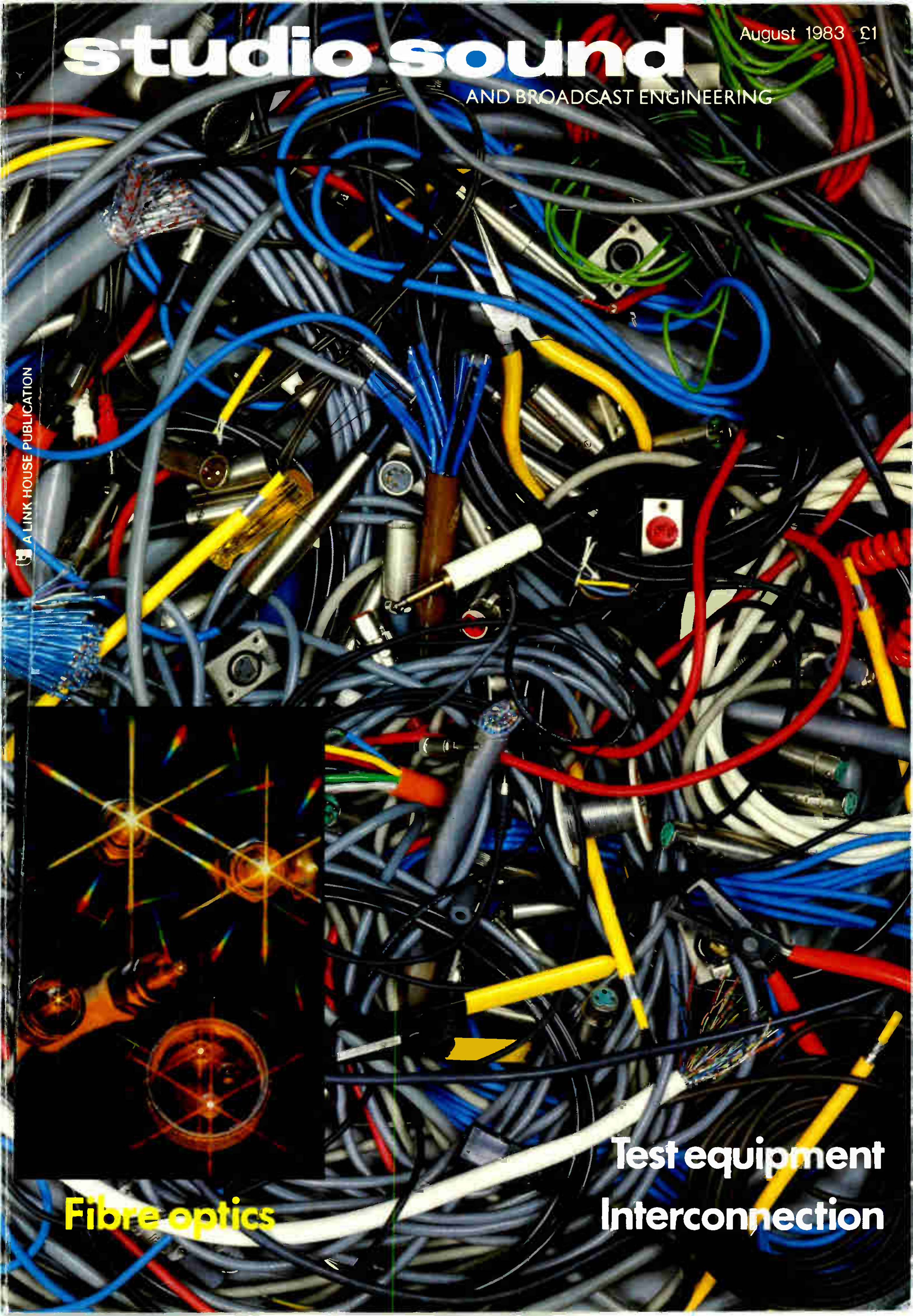
studio sound

AND BROADCAST ENGINEERING

August 1983 £1

A LINK HOUSE PUBLICATION



Fibre optics

Test equipment

Interconnection

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Photography Roger Phillips

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AND BROADCAST ENGINEERING

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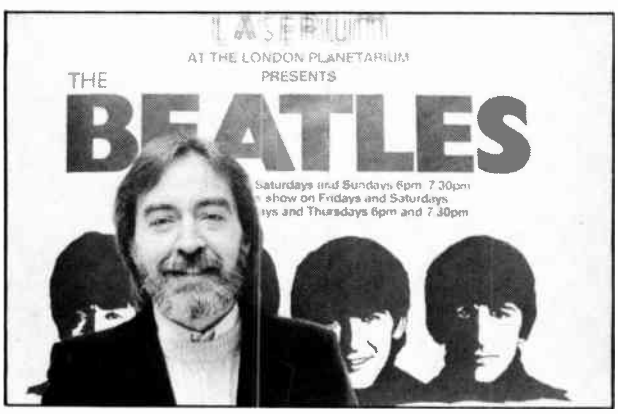

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EDITORIAL

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STUDIO SOUND is published on the second Friday of the preceding month. The magazine is available on a rigidly controlled requested basis only to qualified personnel (see back page for terms) or for an annual cost of **£12.00** UK, **$40** US surface mail, **$75** US airmail, **£17.50** overseas surface mail or **£32.50** overseas airmail to non-qualifying readers or where more than two copies are required in a studio or small organisation. *All* subscription enquiries, including changes of address (which should be *in writing* and preferably including an old address label or at least the 7-digit label code) should be made to the **Subscription Department, Link House, Dingwall Avenue, Croydon CR9 2TA, Great Britain.**

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Moving towards digital

We get a number of enquiries from people who are interested in evaluating digital audio systems. Some of them are studios who are quite small, but are worried about being outclassed. Some are larger facilities which are wondering exactly what to get. What gear should one look at? In the first instance, should you rent or buy? How far should you go today with digital audio?

These are all somewhat complex questions and not all are easily answered. Some answers are bound to be personal opinions, and should be correlated with your own working experience.

It seems to me that the 'digital audio revolution' in the professional sector (as opposed to domestic developments like CD), is most usefully divided into three sections, which will come in over a period of years. Initially, we are seeing the availability of digital stereo systems which can be used for 'mastering' (ie mixing, or recording straight to stereo). Then, as we are also seeing today, digital multitrack systems are appearing. Finally (for now, excluding 'digital mics' and 'digital speakers') digital consoles complete the chain.

All these systems are currently available, although some are more highly-developed today than others. Least widespread are digital consoles: only Neve are really 'in production' at the moment, with their *DSP*. It is not cheap, and neither would one expect it to be. Obviously the price will come down with time, but it will be some time. As a result, we can confidently expect analogue consoles to remain in production, and to be installed even in top-flight studios, for several years yet (don't ask me how long 'several' is!). Even in the long-term, quite respectable studios will still have analogue boards.

This fact helps us when we come to digital multitrack, a development which will probably catch on sooner. There are already several systems, from different manufacturers, and while it is still early days and the gear is still very expensive, there is an interesting selection to choose from. The advent of machines like the dbx delta-mod multitrack will bring the cost down to affordable levels, and interfacing with an analogue console means that, although there must be A/D and D/A conversions on each end, there does not have to be any fixed standard for the digital multitrack. dbx and Dolby systems can quite happily co-exist with PCM as long as there is an analogue console between them. Although I would expect the larger studios, who are expecting to equip themselves with *DSP*-type consoles within the life of the multitrack machine, to buy in PCM systems that will interface easily, other operators will not need to spend that kind of money when the DM-based equipment is available.

On the stereo front, matters are a little different and more clear-cut. PCM 16-bit is tending to become *the* standard, although I notice that many studios with Compact Disc in mind are tending to use 44.1 rather than 48 kHz sampling rates. Sony obviously have an edge here with the *1610*, but the *PCM-F1* offers a cost-effective way of 'testing the water', especially when the product is to be cut conventionally. Many cutting rooms will now cut from *PCM-F1* tapes. The problem with the *F1* is editing, but it is still possible to assemble an album with the *F1* as long as you do not need to actually cut the music itself. The *1610* system can also be rented from a number of sources, and many of these also have digital editing suites or equipment available based around the *DAE-1100*. There are at least 10 systems based around the *1610* available in the London area alone.

In the first instance it may be better to rent, if you have not experimented with the system before. Most of the rental companies offer a full service including training as part of the package (HHB for instance). When it comes to editing, it may well be best to book time in a local digital editing suite—rates are around the £35/hr mark including operator—rather than hire the gear and try to find room for the controller, processor and two clicking U-Matic machines in your studio. Bear in mind that the *1610s* drift a bit: they should be lined up before every session—this takes about 5 minutes—and if you hire them they should be twiddled when they arrive rather than before they leave.

Mastering on systems other than the *1610* is possible, of course, but most cutting rooms will accept *1610* tapes (and maybe *F1* tapes) only—and of course for Compact Disc there isn't even *that* choice: it must be *1610*. If you wish to use the dbx *700*, for example, you will need either to copy via analogue on to a *1610* (you may need to do this for editing anyway) or take a dbx processor along to the cut and set it up.

In the near future we will be seeing more reel-to-reel digital machines, but here we will have to watch out. I am sceptical of the idea that PCM recordings can be edited with a razor blade and will need to hear and see it done to believe the claim. It should be easier on the DM systems, but it is early days yet in that respect.

My overall view, then, is certainly invest in stereo digital if you feel you want or need to. The *F1*-type machines will allow you to experiment on the cheap. Renting the professional systems will get you acquainted with the most widespread format. On digital multitrack, if you have the money, look carefully at reliability before buying. Find a system with a good track record and satisfied customers—it's a lot of money. As for digital consoles, there is only one choice right now: if you can afford one and think you'll get your money back, good luck. I'm sure the investment will pay for itself ultimately, but it's a lot of capital to find.

Richard Elen

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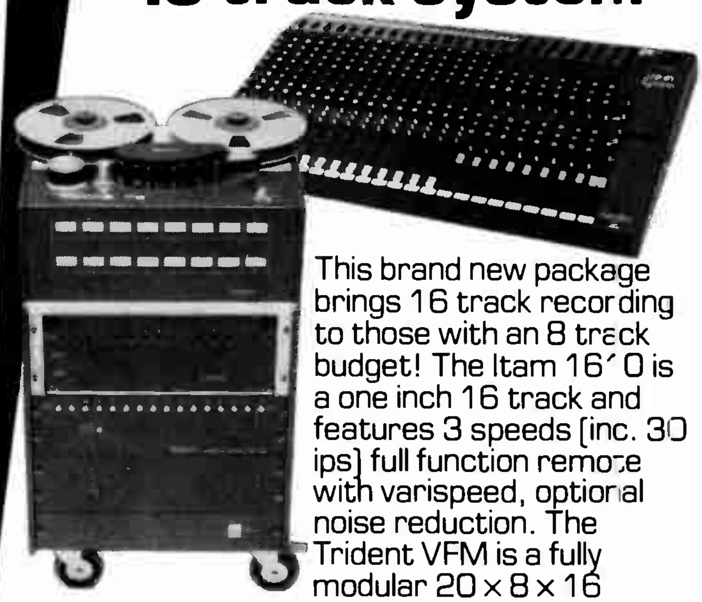

This brand new package brings 16 track recording to those with an 8 track budget! The Itam 16´0 is a one inch 16 track and features 3 speeds [inc. 30 ips] full function remote with varispeed, optional noise reduction. The Trident VFM is a fully modular 20 x 8 x 16 console with 20 inputs and full 16 track monitoring. Special Offer [subject to stocks]:

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STUDIO SYSTEMS

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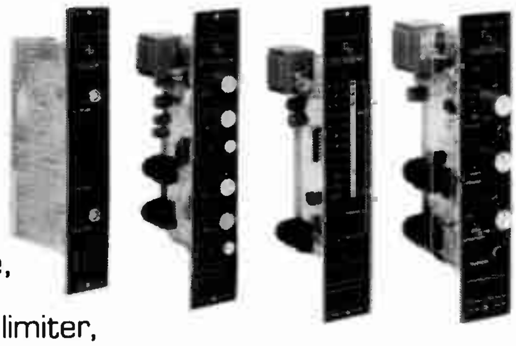

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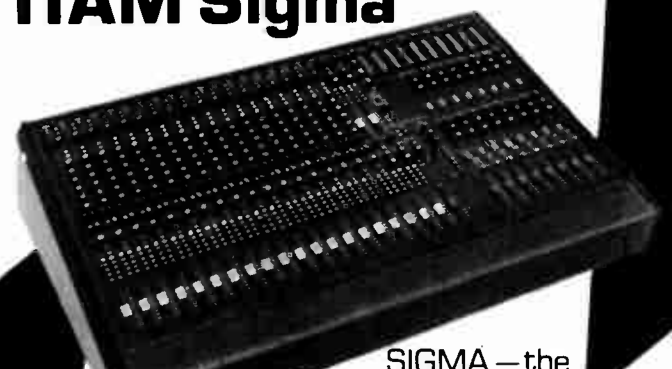

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Tascam 38 8-track ½"	90	50	30
Otari Mk.III-8 8-track ½"	110	60	40
Itam 8-track 1"	150	80	50
Itam 16-track 1"	200	120	75
Otari MTR90 24-track 2"	600	400	150
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Tascam Model 30 8 x 4	40	25	10
Fostex 350 8 x 4	35	20	10
Itam Stereo 8 8 x 2	45	25	15
Seck 10 x 4	25	15	10
Seck 16 x 8	75	40	25
Location 8 x 2 portable	60	40	20
Itam 14 x 4 8-track monitor	100	60	35
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406 1 inch NAB	25.45	24.25	5
406 2 inch 10½	52.90	49.50	2
407 7 inch (LP)	5.25	4.75	10
407 ¼ 10⅓ NAB	11.95	11.45	10
456 7 inch	5.65	5.25	10
456 ¼ 10⅓ HUB Bulk pack	—	7.20	10
456 ¼ 10½ NAB spool	10.46	9.90	10
456 ½ 10½ NAB	18.95	18.00	7
456 1 inch NAB	29.90	27.90	5
456 2 inch 10½ NAB	62.50	59.50	2
456 2 inch 14 NAB	144.00	140.00	2
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I.T.A. is pleased to add to its list of latest Otari users:-

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"Humanized" is the theme taken by the Oregon based firm, Project Synthesis International for its 'moving point' audio level display line. The modular system centers around the basic ALD-12 display unit.

Developer Ron Purcell states, "Two major problems seem to plague most column level displays on the market right now. They are inflexibility of application and poor attention to human factors, i.e., the ability of the engineer to accurately assess levels through peripheral vision while reading a multichannel bank of indicators. The ALD-12 seems to solve both those problems. Engineers in recording, film and broadcast studios, as well as theatre and road sound crews, will find a range of features not found in displays costing up to eight times more." These include user-selectable VU or PPM modes, a three-color format designed for maximum peripheral-vision capture, and a separate bright amber CLIP indicator that flashes when any transient exceeds a user-selected level.

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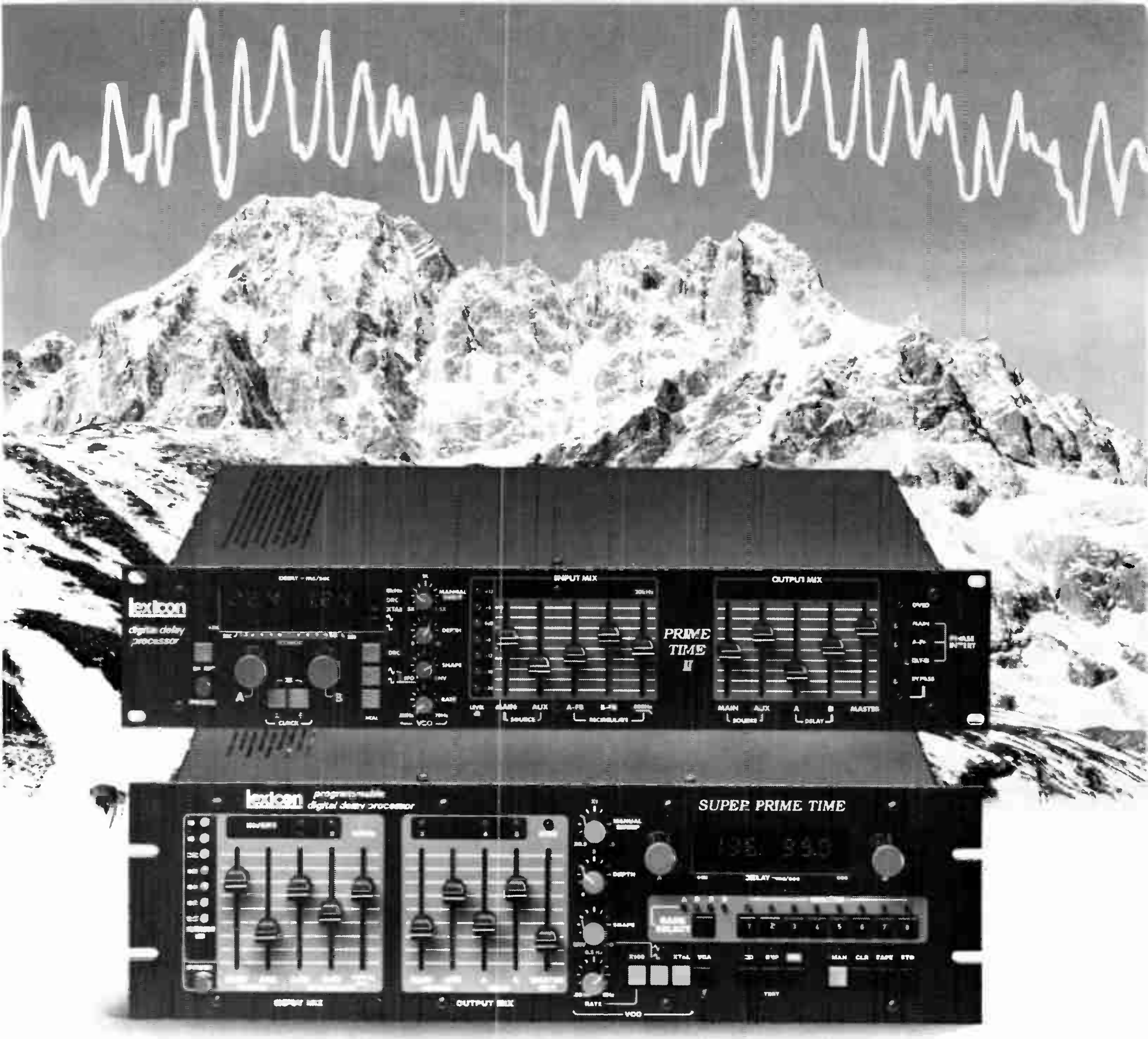
Developer Purcell adds, "Since all our design and manufacturing is right here, we can tailor the ALD-12 to a wide range of custom OEM versions, yet the standard ALD-12 seems to be one of the lowest cost displays on the market at less than $120."

Interested engineers can write: Ron Purcell, Project Synthesis International, 500 Hidden Valley Road, Grants Pass, Oregon 97526, U.S.A. Immediate literature will be dispatched by phoning (503) 474-2192.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Book corner

Microphones—technique and technology by the memorably named Norbert Pawera is a soft cover book with about 95 pages of text. It has a practical place-it-here approach that is suited to the reader with less practical experience. The basic introduction to theory and mic types is clear, simple but brief. It then goes on to discuss room acoustics and the basics of the science of musical instruments. These sections covered, there then follows nearly 50 pages of very specific information on virtually every instrument you may encounter with its frequency and musical range and acoustic projection details. Mic positions are clearly shown with excellent line drawings, in many cases giving several alternative recommended positions.

Unfortunately the book has one major disadvantage and this is not clear until you read the text or the last line of the introduction. All the mics recommended are AKG models. Now this is not a disadvantage in itself as AKG are a manufacturer of an excellent wide range of mics; however, they do not have a monopoly on good models. If you have access to the full range of AKG mics then this is a very good applications manual; however, in a more general context the book is less useful unless you are aware of other manufacturers equivalent parallel models. As the book appears to have been sponsored in some way by AKG this is not an unintentional state of affairs but I think some more obvious indication of the fact is called for.

Album Cover Album—a collection of album sleeve artwork compiled by Roger Dean and David Howells follows the format of the first successful volume published in 1977. Covers from classical and jazz albums through to rock and 'new wave' are featured. It is fascinating to study the packaging that sells that side of the recorded output of studios and how the art of cover design has developed even in the short time that this book spans. When covers are seen in a wider context such as this it often goes some way to explain the success and failure of some albums—to question why that remix was necessary when the final product was blessed with such a dreadful album cover?

This book/collection can be viewed as a collection of art with a purpose or as the packaging for the end result of our labours and as such is well worthwhile investigating. It has been argued that album cover art has reached its peak already and this book will become an epitaph to an art style without a future. The covers that this book displays are generally designed to be a little over 12 in square. If the future of recorded music for home consumption lies with the digital *Compact Disc* and hence an art work surface of around a sixth of the current size, will there still be the scope for creative packaging within this smaller dimension, and will the cover be so influential? And if not, will this shift the emphasis to and demand more of the recorded content? **KS-A**

Publication details: *Microphones*—Arsis Baedeker & Lang Verlags GmbH, West Germany, ISBN 3-88714-007-9. *Album Cover Album*—Paper Tiger, UK, ISBN 0 905895 72 X (hard) ISBN 0 905895 71 1 (limp).

Agencies

- Elite Sounds Inc of Plainview, New York have been appointed as Tannoy service agent. They have many years experience with Tannoy products and will carry sufficient stock of spare parts to offer a repair service throughout the USA. Elite Sounds Inc, 122 Dupont Street, Plainview, NY 11803. Tel: (516) 349-9180. Telex: 143154.

Abbey Road welcomes Beatles fans

Abbey Road, probably Britain's best-known recording studio, is opening its doors to the public from July 18 to September 11 with a celebration of Beatles memorabilia which includes archive tapes of outtakes, old promo films, original studio equipment, and even ashtrays used by the Fab Four.

Still a major shrine on the Beatle pilgrim route, the North West London studio will be screening hour-long audio-visual presentations at 10.30 am, 3.30 pm and 7.30 pm every day in Studio 2 — where the Beatles were recorded — while the split-level studio's control room is refitted with a new SSL desk.

Apart from using the dead time arising out of the control room refit, the exhibition comes 21 years after the first Beatles session at the studio (*Love Me Do* recorded on 4 September 1962).

Overdubbing on the PCM-F1

THE Sony *PCM-F1* digital recording system is approved all round for its sonic performance (see review in *Studio Sound* December 1982 and Tony Faulkner's article, March 1983). As the system consists of an A/D to D/A processor and separate video recorder, it emerges that there is a hidden versatility. Overdubbing, by copying in analogue form, can simply be done by just the addition of another VTR, the single *F1* processor coping with the separate D/A and A/D required.

The basic arrangement is shown in **Fig 1**. The digital playback VTR feeds the 'video in' socket on the *F1*, and the analogue conversion of this is fed to a suitable line input on a mixer, for monitoring and mixing to the additional signals required. The mixer recording output is then fed to the *F1* line inputs and the overdubbed recording is A/D processed to the second VTR.

Apart from overdubbing, the process is handy for making signal level changes, possible equalisation, fades at the start or end of items etc. Obviously, there has been a D/A and an A/D cycle, as opposed to the security of direct digital transfer. Tests, cycling a signal many times around the system, show none of the problems evident if the same thing is tried with an analogue system, no matter how carefully lined up. With analogue one can face a 3 dB worsening in signal-to-noise ratio each time, additional modulation noise, wow and flutter impairment, stereo imagery fuzzing and cumulative frequency range bumps and dips.

In practice, careful level-setting is required. The *F1* LED display only shows the playback from the first VTR machine. The mixer must have a trustworthy peak metering system to show the combined new signal. Setting up is done by recording 1 kHz at a sensible *F1* working level—say −20 on its LED display. (Incidently this is likely to be −16 in practice, if experience with three or four processors is anything to go by.) The test tone is then played back and copied on the second VTR such that an identical level results when this is played back. Also then the mixer's metering should be calibrated to a suitable working level. It is then feasible to allow signal peaks to reach 8 dB above this level.

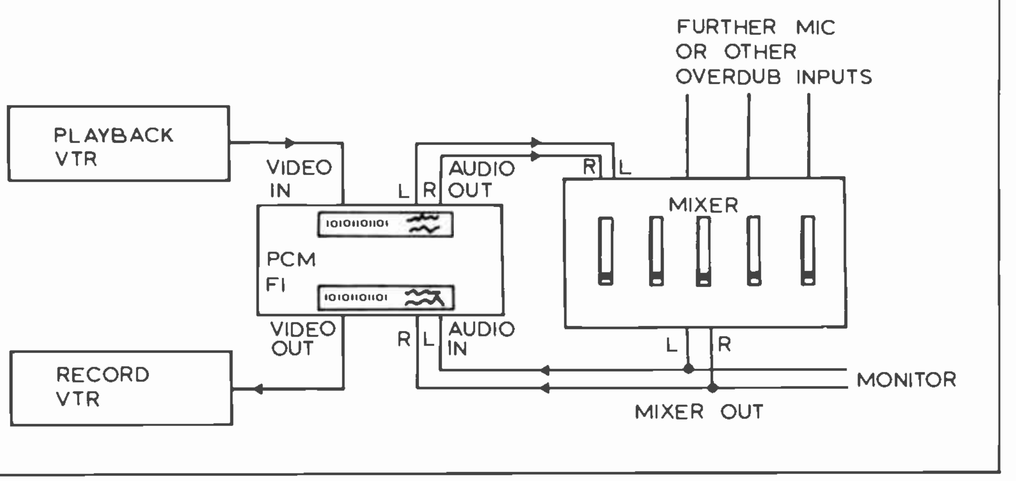
The overall mix level is then controlled with the following safeguards in mind. Depending on the musical requirements, there will be an increase in the signal level at each traverse and this must not reach the digital crunch point, although with the *F1* system, this, with transients at least, is inaudible as mere level limiting occurs. The second consideration concerns the fact that the *F1*'s metering necessarily shows the record pre-emphasis used prior to the A/D processor. This of course brings the digital crunch point much nearer as far as HF signals are concerned. Around 7 dB boost at 10 kHz is involved with respect to the 1 kHz indication. The mixer's metering could be given a similar HF lift to aid judgement, prior to playing back and finding out where one stands.

It would be quite in order, though, to reduce the transfer level at any time, to regain control, as the noise floor is way down and not rapidly coming up to join the music!

Perhaps this quality and 'endless' overdubbing will appeal to those who get into trouble all too rapidly with minor 4- and 8-track multitrack systems if they can put up with the need to completely traverse each time without having a drop-in facility. **Mike Skeet**

FIG.1

SINGLE SONY PCM-FI OVERDUBBING INTERCONNECTIONS



new products

Tascam Enhancement Series

Teac have developed a new range of products as part of the Tascam range. These are standard 19 in rack mount units offering facilities that may prove useful in a number of circumstances, not just with Tascam products.

The *MX-80* is an 8-input microphone mixer, rack mounting with a height of 2U. Each channel has mic attenuation switching, phase reverse, overload LED, mic trim, gain and pan controls. All mic inputs are 600 Ω balanced with *XLR* sockets and there is provision for phantom powering if a suitable external power supply is used. Each input also has a channel insert point with the facility to use the return point as an unbalanced line-input. Aside from the channel functions there are separate unbalanced and balanced output level controls and switching to allow outputs at −10 dB or 0 dBu line levels.

MH-40 is a headphone distribution system providing four stereo outputs with separate left and right level controls on each. There is provision for selection of input feeds, input level controls and mono/stereo operation. On the rear panel there are slave outputs allowing the cascading of units to provide more outputs.

The *PE-40* is a 4-channel parametric equaliser with four bands on each channel. The ranges cover HF 800 Hz to 16 kHz, upper mid 500 Hz to 10 kHz, lower mid 200 Hz to 4 kHz and LF 40 Hz to 800 Hz, with ±15 dB gain and variable Q of 1.1 to 5. Each channel also has a 15 kHz lowpass filter and highpass filters at 60 and 160 Hz.

Lastly, the *MU-40* is four VU meters with peak LED indicators in a 2U 19 in case. The meters are switchable as a block across two sets of inputs and also the operating level may be switched between −10 dBV and 0 dBu.

Teac Corporation, 3-7-3, Naka-cho, Masashino, Tokyo, Japan. Tel: (0422) 53-1111.
UK: Harman (Audio) UK Ltd, Mill Street, Slough SL2 5DD. Tel: 0753 76911.
USA: Teac Corporation of America, 7733 Telegraph Road, Montebello, CA 90640. Tel: (213) 726-0303.

Loft Products

Following on from our PA processing product guide in the May issue, we received a 30 page glossy brochure from Phoenix Audio Laboratory on the Loft product range. Contained in the literature were several items that we were actually unaware of and were definite omissions from that product guide.

The major omission was the range of crossover units of which there are four: *402* 2-channel 2-way or mono 3-way; *402-M* mono 2-way; *403* 2-channel 3-way; and *403-M* mono 3-way. All four models are 19 in rack mounting with 1U height. Critical front panel controls are recessed with all the models having continuously variable crossover points and levels controls for each band. Slopes are 18 dB/oct with Butterworth filters.

Aside from the crossovers there is the *Model 401* 4-band parametric equaliser with controls in each band for ±18 dB gain, continuous frequency sweep and variable Q of 1/6 to three octaves; and the *Model 100* professional phono preamplifier, rack mounting unit with RIAA and IEC EQ and polarity reverse.

The remaining items in the Loft range are the *Model 450* delay line/flanger and the *Loftech TS-1* audio test set, both of which have been recently covered in *Studio Sound.*

Loft Audio Products, Phoenix Audio Laboratory Inc, 91 Elm Street, Manchester, CT 06040, USA. Tel: (203) 649-1199.

Quad 405-2

Quad have introduced a mark II version of the well-known *405* power amplifier. The changes have largely been made in the protection circuitry enabling higher currents to be delivered on music programme without lowering the safety requirements for the output transistors.

The 'dynamic' protection circuit is contained in a custom thick film IC and senses voltage, current, phase, temperature and time. The amplifier will deliver 8.5 A peak into any load but if the combination of the five sensed variables becomes unsuitable for the transistors, the permitted current is reduced, returning to normal when the excessive demand ceases. It is claimed that the benefits over the original *405* will be audible when operating at high power levels and with speakers presenting a difficult load.

The Acoustical Manufacturing Co Ltd, Huntingdon, Cambs, PE18 7DB, UK, Tel: (0480) 52561.

Aphex Type B Aural Exciter

Aphex have introduced a simplified version of the *Aural Exciter* known as the *Type B.* This is a two channel unit in a standard 19 in rack format and with a height of only 1¾ in. It is intended for a very wide range of applications where the full Aphex *II-S* model facilities are not required such as live use, smaller studios, club installations and even domestic use. To this end the *Type-B* has switchable operating levels of −10 and 0 dBm and unbalanced jack socket inputs and outputs. Each channel has drive, tune and mix controls and a tri-colour level LED. The drive sets the correct input level so that the circuit is not overloaded or under-driven. The mix control adjusts the blend between the processed signal and the dry signal while the drive control allows you to adjust the frequency range of the enhancement effect. The effect may be switched in and out for A/B comparisons, etc, with a front panel switch and the status is indicated on another tri-colour LED.

Aphex Systems Ltd, 7801 Melrose Avenue, Los Angeles, CA 90046, USA. Tel: (213) 655-1411.
UK: AKG Acoustics Ltd, 191 The Vale, London W3 7QS. Tel: 01-749 2042.

New MCI Features

MCI has announced two new options for their product range. The first is that the *Plasma Display* offered as an option with most of their other consoles is now available for use with the *JH-636M* mobile console. This will offer the standard facilities of VU, peak reading or DC control voltages of channel faders.

The second development is a version of the *JH-110B* standard tape transport for use as part of an audio system for video 'layback'. Designated *JH-110B-3-LB/VP,* the unit has three channels of electronics and is fitted with standard C-format audio heads. Console mounting is either of the high or low profile cabinets or rack mounting. Once the video editing has been completed and the timecode resolved between the audio and video, there is often little need for the video to be monitored and so this audio only machine can free a C-format VTR for other work as well as providing an improved performance, it is claimed, in most of the major audio parameters over that obtainable with the standard VTR.

MCI, A Division of Sony Corporation of America, 1400 West Commercial Boulevard, Fort Lauderdale, Florida 33309, USA. Tel: (305) 491-0825. Telex: 514362.
UK: Sony Broadcast Ltd, City Wall House, Basingstoke, Hants RG21 2LA. Tel: 0256 55011.

Neumann TLM 170i

The *TLM 170i* is the first microphone from Neumann in their *fet 80* series to be designed as transformerless. The direct, balanced output has been achieved through the use of a completely new kind of circuit (see AES preprint 1986 unfortunately in German only). This has enabled the self-noise of the mic to be reduced to 14 dBA while giving a max SPL handling of 140 dB. It is possible to select five directional characteristics from the mic: omni, wide cardioid, cardioid, hypercardioid and fig-8. A future option will allow remote control of these characteristics. There is also a 10 dB pad and a 100 Hz LF roll-off.

Powering is with standard 48 V phantom powering although the mic will still perform identically with phantom power sources down to 24 V with no need for switch over. The mic is held by a tiltable, elastically suspended mounting bracket which is an integral part of the unit.

Specification: frequency response 40 Hz-18 kHz; sensitivity 8 mV/Pa; source impedance 150 Ω; minimum load impedance 1 kΩ; S/N ratio ref 1 Pa IEC 179 80 dB; max SPL for 0.5% THD at 1 kHz with pad 150 dB; weight 625 g; dimensions 60 mm diameter and 152 mm long.

Georg Neumann GmbH, Charlottenstrasse 3, D-1000 Berlin 61. Tel: (030) 2514091.
UK: FWO Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts WD6 4RZ. Tel: 01-953 0091.
USA: Gotham Audio Corp, 741 Washington Street, New York, NY 10014. Tel: (212) 741-7411. ■

A personal view of psycho

Ted Fletcher continues his personal view of psychoacoustics with part two of this occasional series, in which he considers the human ear and how it responds to sound.

SOUND is a cyclic compression and rarefaction in the medium in which it moves—air to us. The ear, as a complete instrument, allows us to convert such wave motion into information. Before expounding on psychoacoustics, or what we think we hear, it is as well to know a little about how the ear works.

Outer ear

The fleshy lobed bit on the outside of our heads is called the Pinna. It is shaped in such a way that sound arriving at the head is reflected towards the canal which leads to the eardrum.

Even a cursory examination shows that it is not symmetrical and this serves two purposes: (a) there is no predominant frequency at which it is better at reflection, and; (b) sounds from different directions follow different paths, ie, sound from the front is better reflected (at high frequencies) than sound from the rear. Similarly, sounds from above and below are not reflected identically.

The Pinna also has that curious fold at the rear and the top. I am not sure if this is significant in the physics of perceived sound placement, or if it is to stop fraying at the edges.

The Pinna helps sound to travel down the canal leading to the eardrum. This system is also a masterpiece of non-symmetry. The canal is neither straight nor circular in section and the eardrum itself is slightly dished and at an angle of about 15ft from perpendicular to the canal. Sounds travelling down the canal cause varying pressure on the eardrum which is a thin membrane and is capable of movement.

Middle ear

Inside the middle ear are the three familiar small bones: the Hammer; the Anvil; and the Stirrup. (The Hammer and the Anvil were named by Andreas Vesalius in about 1543, the Stirrup was discovered and named by Gian Ingrassia a little later—it must be assumed that they were both blacksmiths.) This is our biological transformer, converting the low impedance of movements of air to the high impedance of pressure in a liquid in the inner ear. The three bones connect together to give a lever action something like a car jack.

Oscar—Bell Labs dummy head

In order to work properly, the middle ear must be air-filled, and at the same pressure as the other side of the eardrum. This is achieved by that bane of cold sufferers and air travellers, the Eustachian tube; a tube that goes from the middle ear to the windpipe to keep the pressure equal but the acoustics isolated—could this also be a sidetone supressor?

Inner ear

The stirrup in the middle ear connects to another membrane called the Oval Window. This window is about 1/20 the size of the eardrum and forms the acoustic coupling to the inner ear. At this point hearing becomes a study in hydraulics because the inner ear is filled with fluid. Pressure from the stirrup on the oval window is transmitted directly to the fluid which, being nearly incompressible, transmits that pressure throughout the length of the Cochlea via the Vestibular Canal, and back the other way along the Tympanic Canal (see **Fig 1**). This pressure is transmitted to the nerve endings via a longitudinal membrane called the Basilar Membrane. This separates the tympanic canal from the 'Seat of Hearing', the Organ of Corti.

In response to acoustic pressure, small movements take place along the basilar membrane, these movements varying along the length of the cochlea with different frequency due to a complex system of tuning caused by the varying shape and cross-section of the cochlea and the membrane. High frequencies are sensed at the stirrup end, low at the other end.

Due to the extremely small movements encountered in the basilar membrane, this works within itself very like a contact microphone and reacts to sound present within the bone structure of the head.

Biological digits

The Organ of Corti itself is where the conversion takes place between mechanical movement and electrical energy.

The basilar membrane moves from a flat shape to an alternating convex/concave shape in response to sound pressure. This is converted to a sliding motion on hair cells which are fixed at one end. The shearing action excites the cells which 'fire' bursts of impulses along the Auditory Nerve to the brain, there

acoustics~The human ear

Ted Fletcher

being about 30,000 fibres in the auditory nerve.

The use of the word 'fire' is by no means accidental; the hair cells are unable to produce electrical signals that are proportional to the shear forces on them; they merely switch on and off when the force reaches a critical point. The similarity to digital systems as we all know (and love?) is unmistakable and is yet another illustration of the 'nature thought of it first' syndrome. However, here the similarity ends. Our digital systems work by referring instantaneous signal level to a number defined by the number of digital bits in a byte, the resolution, or 'quality' of the conversion being defined by this byte length and the byte rate (sample time). In the ear, the digital information is non-synchronous (as far as we know!) and the brain receives the pulses as and when the cells are excited. This gives us the extraordinary concept of a 30,000-bit-wide parallel digital data stream—no wonder the ear is so good!

This extraordinary data stream is transmitted along individual nerve fibres to the brain where it fans out to a number of processing centres via a series of 'buffers' which are themselves filtering and switching centres controlled in part by data streams from other areas of the brain. In a very simplistic way this can be likened to the buffer store in a computer where data is loaded and then distributed to the specific levels of memory or workspace as directed by the central processor and the machine code routines acting on it, but this comparison is a poor one.

This part of 'hearing' becomes increasingly mixed with less and less specific words like 'intelligence', 'language', 'visual and sound memory', 'motor areas', etc, all of which have been isolated to various areas of the brain, and all inter-react with the hearing buffers.

Psychoacoustics—what we think we hear

The description so far has been a simplified explanation of how the brain gets audio information. Of great interested to the audio engineer are a number of mechanisms that modify the sound on the way.

The pinna or outer ear is the first area to examine; it reflects and concentrates sound pressure towards the canal—but not uniformly. Sounds from the front, rear, up and down are reflected via different paths, off different surfaces of the pinna and, by definition because there is no other mechanism, this must produce the waveforms that give us this directional information.

Taking this argument further, it follows that the simplest way to reproduce sound with total surround realism is to record the sound with 'dummy head' microphones whose apertures are shaped like human ears, then to replay the signals at realistic levels direct into the ear canals.

Dummy head and stereophonics

At the Philips Centre in Eindhoven, sitting in a glass case, is a rather dirty and unpretentious looking lump of plaster and rubber with two microphones fixed to it. This was one of the first 'dummy heads' used to investigate stereo effects. It was made in 1926. Many countries claim 'firsts' for dummy heads, a well documented one being 'Oscar' who was manufactured in the Bell Telephone Laboratories in New York in 1932.

Research there was carried out by Dr Harvey Fletcher (no relation) who gave demonstrations to visiting scientists and engineers using standard headphones in an adjoining room (stereo recording being still in the future).

More recently, interest was revived by the BBC and EMI who produced a series of drama and music recordings for transmission, and highly impressive music for in-flight entertainment on Concorde. In the two years the ideal has again been revived with the 'new' name, 'Holographic Sound' [See *Studio Sound, July 1983—Ed.*] This

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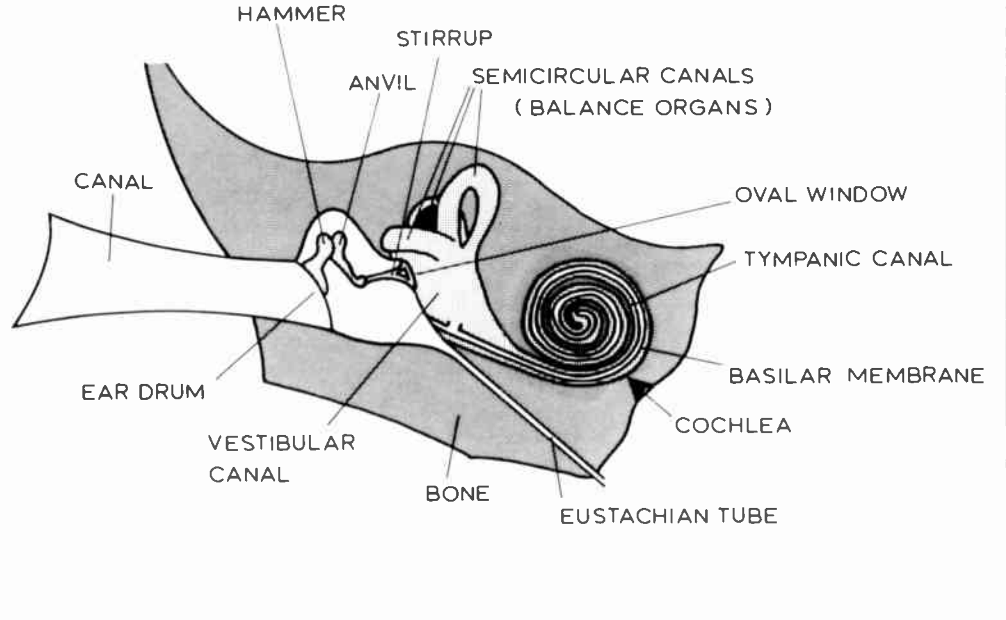


FIG1. MAIN COMPONENTS OF THE EAR, SHOWING OUTER, MIDDLE AND INNER PARTS.

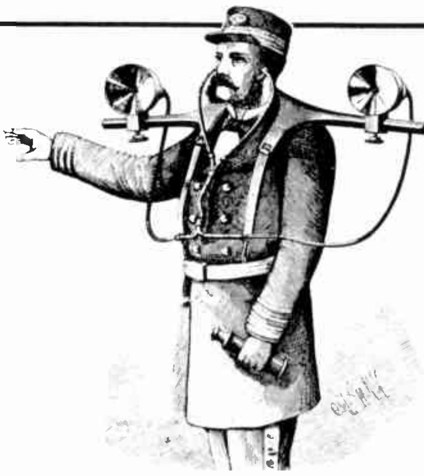
The human ear

implies a solidity to the stereo sound picture which, on some programme material, it seems to possess. Any further inference from the name of true spatial reality could only be realised using natural ear shaped microphones as outlined here.

All the more recent systems have the advantage of good fidelity due to excellent microphones and recording technology, but all are less than perfect because they produce a sound which is equivalent to a listener with his ears cut off; ie, no modifying effect of the pinna. Stereophony exists and is impressive, but this is a different mechanism caused by minute phase differences and reflections around the head. These do manage to fool the brain into creating a sound picture, but it still lacks up/down and front/back definition.

Phase shifts

Experiment has proved (Hornbostel and Wertheimer, 1920) that image placement is related to time delay between the ears. A time delay on a pulse of 0.03 ms places the pulse slightly to one side of centre to the listener. This represents a phase shift from one ear to the other of approx 10.8 ft at 1 kHz. Individuals vary in their perception of this phase difference but even more importantly, the brain needs more than a single pulse or tone to build a sound picture. 'Dry' or non-reverberant sound sources can form the basis of a good, well defined stereo image, but we have all noticed how this is enhanced by the random amplitude and phase components of reverberation. The brain has grown up and learnt with natural reverberation, and a 'dry' sound is incomplete to it.



Personal stereo?

The picture-making mechanism seems to be quite insensitive to the form of reverb—whether it is a random fixed decay, or a more complex multi-echo/multi-decay system. If this were not so, studios would be in real trouble!

Biological level controls

As stated in 'Overload' (*Studio Sound*, May 1983) the ear has a remarkable aptitude for level control. This is accomplished mainly in two areas of the ear.

The 'Rock Concert Effect' is the simpler of the two: when very loud noises are received by the ear, the data stream intensity along the auditory nerves cause a reaction in the brain which creates a motor impulse back to the middle ear and adjusts the muscular tension on the stirrup, softening its coupling on to the anvil. At the same time, muscles around the eardrum tighten, and restrict its movement. This accounts for some of the pain which can be suffered when listening to very loud sounds—the muscular tension is similar to cramp. Once these muscles have reacted, they tend to tire quickly and take time to recover, hence the 'dead ear' sensation afterwards.

The second level control is more subtle. Sustained sound causes continual firing of large sections of hair cells. This firing has to be supplied with power from somewhere and it is generated chemically within the cell. Overloads deplete the chemical stores so that the less-efficient cells cease to work for a while, reducing the output from the ear and effectively turning down the level.

This effect works at all levels of sound—some cells being depleted at all times during normal daily life. A walk in very quiet countryside at night, or a visit to an anechoic chamber will vividly demonstrate the effect: the ears 'turn on' and allow the recognition of sounds that are extremely low in energy.

Both of these level control systems have an effect on the 'quality' of hearing. It is well known that the ear is most sensitive at mid frequencies and this is shown on the modified Fletcher-Munsen curves (again no relation) shown in **Fig 2**.

The change in the frequency response at different levels of sound is certainly partly due to damping changes in the middle ear and basilar membrane, but the great variation at mid frequencies is modified significantly by the 'cell starvation' effect, the ear being more aware of subtle sounds at lower levels.

This appears to contradict the 'monitor loud' brigade, but it doesn't really. Monitoring at moderately high levels allows a flatter frequency response to the ear and, due to the selective way that the basilar membrane works, allows the picking out of subtlety, particularly in the upper harmonics. (It also reduces the mechanically-induced harmonic distortions of the loudspeakers.)

The psychoacoustic conclusion that can be gained from the hearing curves is fairly obvious: a modification of the overall frequency response will change the brain's perception of loudness. A tipping-up of gain at bottom and top gives this effect. No credit is due to me for this pronouncement; it was discovered long ago and it is no accident that the standard 'Baxandall'-type tone controls on hi-fi amplifiers simulate the curve for home use.

Linearity

Again in 'Overload', reference was made to odd- and even-order harmonic distortions.

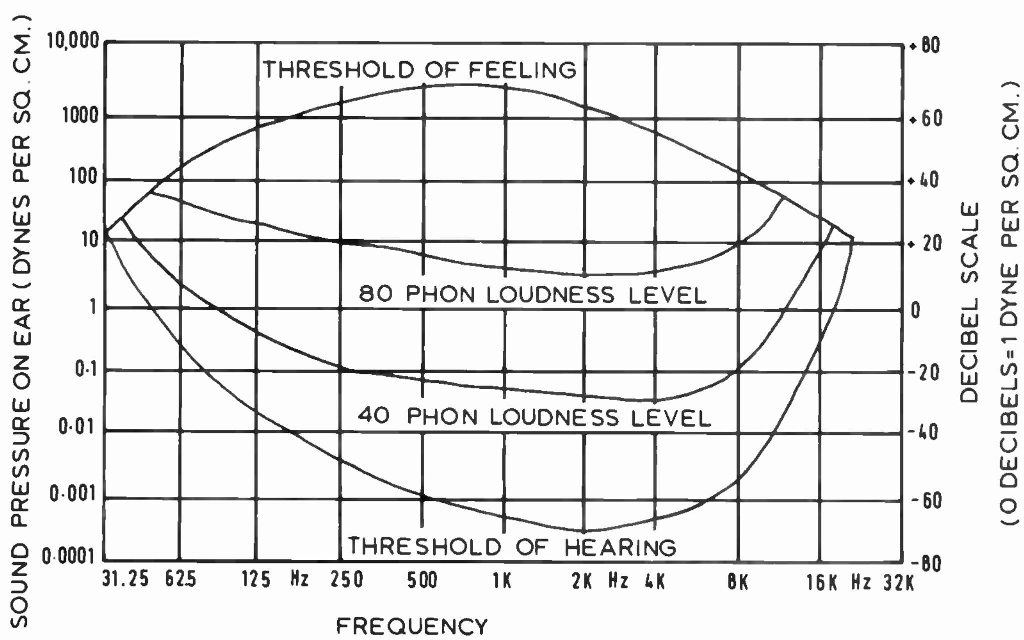
Valve amplifiers produce distortions that are basically 2nd-order—a non-linearity that is greater at one extreme of the wave excursion than the other.

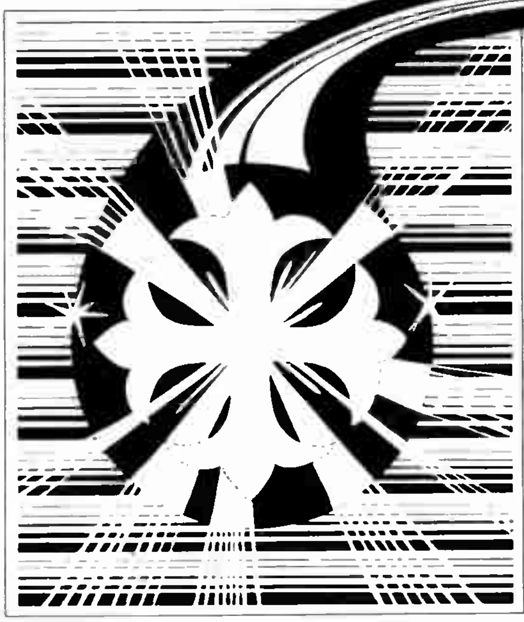
Solid state devices produce odd-order harmonics where distortions are evenly distributed whether positive or negative.

The ear is horribly non-linear. The hair cells activated by the basilar membrane lie at an angle and are fired by a shear action that is very much more efficient in one direction than the other.

This makes the ear very much less sensitive to even-order distortion; it is swamped by self-generated 2nd-order in the data stream. Odd-order products, however, are sensed at other places on the membrane causing unrelated signals to be generated. This accounts for the harshness in perceived sound of quite small amounts of odd-order distortion, and the more pleasant and 'natural' sound of even-order distortion. This is the basis of the musical scale used by the human race; a scale based upon even-order harmonic relationships. ■

FIG 2





THE OTARI MTR-10 SERIES

"...I thoroughly recommend this machine..."

Hugh Ford, Studio Sound, December 1981

"The Otari MTR-10 has an exceptionally high standard of construction in the electronics department with sensible controls which allow accurate and quick alignment.

"Great care has clearly been taken in the overall functional layout of the machine which has many unusual features for a machine at this price. Overall I thoroughly recommend this machine for its performance which could justify a considerably higher price."

The MTR-10 Series are fully microprocessor-controlled mastering/production recorders with 12.5 inch reel capacity available in four formats: ¼" full-track; ¼" two channel (DIN heads optional); ½" two channel and ½" four channel.

Working closely with industry leaders in broadcasting, film and recording, we have designed superbly reliable recorders which consistently deliver performance to the highest standards.

To receive the complete text of Hugh Ford's review, a comprehensive brochure and price details, or to arrange your own "hands-on" review,

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Fibre optics~

SUDDENLY everyone is talking about optical fibre as an alternative to copper co-axial cable. It is being heralded as cheaper and better. On the face of things it is. An optic fibre carries electrical signals as light pulses, which are free from interference and virtually bug-proof. Optic cables are smaller than co-ax. The frequency of light is so high that modulation bandwidth is, in theory, very wide. Fibres are cheap because they are made of glass which is in turn made of sand. They are waterproof, so underground links don't stop working when it rains. Well, think about what happens to British telephones after a day of rain!

But these are the simplistic plus points. The new technology brings its own problems, not least the high cost of ancillary equipment needed to convert electric signals into light pulses and back again at each end of the fibre. Volume production is the key to low cost, but there can't be volume production until there is volume demand. This is why some firms are flying a kite, promising optic fibre systems at low cost on the assumption that their promises will create the demand that is needed to make low cost possible.

At the same time firms with a vested interest in conventional co-axial technology are pulling out the stops to keep their existing markets alive. They lose no opportunity to point out the disadvantages of fibre and the remarkable things which co-axial can now do at much lower cost. With perfect honesty it's possible to prove conclusively that optic fibres are a non-starter and with equally perfect honesty it's just as easy to prove that anyone investing now in co-axial technology is living in the past.

Few people are offering a balanced appraisal of the facts, either because it's not in their interests to do so, or because they can't find enough facts to balance. Opto-electronics is a relatively new and very fast-moving technology. There aren't any down-to-earth reference books that are up to date, because in the time it takes to publish a book the situation has changed. Most of the technical papers published on the subject have been written in that special kind of jargon which experts use to build a moat of incomprehension around their subject, and thereby ensure that they remain experts. In this article we'll do our best to hack through the jargon jungle.

Opto-electronics is a relatively new and very fast-moving technology

Inevitably, emphasis has to be on the use of fibres and cables to transmit television pictures and telephone speech signals, because the thrust of development has all been in this area. But it doesn't take much imagination or expertise to extrapolate for audio usage, both in the analogue and digital domains.

The key to the whole debate is bandwidth. Telephone companies around the world, like British Telecom in Britain, need wide bandwidth on their trunk lines to carry a large number of telephone calls, simultaneously, through a relatively thin cable. The cable has to be thin because the lines are laid in underground ducts, where space is limited, and the thicker the cable the harder it is to pull through a long duct. Telephone companies also need wide bandwidth to handle digital data signals, for telex and computer links. Land lines are still used for some radio and television links, which take up far more bandwidth space than a telephone speech circuit.

Cable TV companies also desperately need bandwidth, because to be profitable they must carry a wide selection of television and radio programmes over long distances, for distribution to subscriber homes. The current plan is to start extensive cabling of Britain in the mid-80s, with a broad choice of programme channels. When direct satellite broadcasting (DBS) begins at around the same time, it will depend for its success on the cable network. Contrary to popular misconception, the great British public are not all going to erect their own dishes for direct reception, even though the signals coming down from the DBS satellite will be strong enough for a pick-up by a roof or garden dish 0.9 m in diameter.

The satellite for Britain will be orbiting in the sky over Brazil. International agreement has put it there, because that's the spot where it will suffer least from eclipses of the sun which temporarily shut down its solar-powered transmitters and black out programming. But the Brazil location means that the UK satellite will be located low on the horizon. It will always appear in the sky in Britain where the sun appears at 3 pm on an October afternoon. This is far lower than many people realise and it will be obscured by trees or buildings in many home locations. Then there's the problem of planning permission. Some local authorities may ban roof dishes. Landlords may refuse under the terms of the property lease.

Those who do have permission to erect a dish aerial in a spot which isn't in the shadow at 3 pm on an October afternoon will need to mount it very firmly for security against wind movement. Apart from the obvious danger of a dish lifting off in a high wind, like a roof tile, and saucering down to earth with a potentially lethal bang, the dish must 'see' the satellite with an accuracy of half a degree and no obstructions. Even roof tiles will block the signal, so forget about attic installations. As many as a quarter of British homes may be unable to site on a satellite with sufficient accuracy for good reception. Many others won't bother. This is

an overview

Barry Fox

why cable and satellite technology must advance together. The cable stations will pick up satellite TV and radio signals, and route them into people's homes along with other cable programmes. So once again, bandwidth is the key. The cable links laid in Britain will have to handle around 30 channels of TV. Each channel is around 6 MHz wide and with guard bands to eliminate crosstalk between adjacent channels, each colour TV channel carried on the cable soaks up 8 MHz of a bandwidth. So the main cables need at least 240 MHz capacity, and much more if they are to handle return signals for interactive services.

No-one disputes that co-axial cable *can* do the job: it can handle a bandwidth of 450 MHz. To double the capacity you just lay another cable alongside the first. But the signals need boosting, ideally after 250 m of travel and certainly every 2 km. This is expensive. To complicate the issue the channels which are stacked at the higher frequency end of the multiplex spectrum need boosting more than the lower frequency channels. Also it's impractical to boost all channels simultaneously, through a wideband amplifier. So separate amplifiers, of different gain, are needed for different channel bands. In other words long runs of co-axial cable need sophisticated equalisation if all the signals are to emerge with similar strength. As a guide, a TV signal carried at a frequency of around 10 MHz will be halved in strength after it has been carried over just 1 km by co-axial cable. The losses increase dramatically as the frequency rises higher; they are twice as great at UHF frequencies as they are at VHF.

Of course co-ax is far more efficient as a signal carrier than a twisted pair of wires, like mains flex inside a screening sheath, as used for some of the old cable systems in Britain. Over a kilometre of twisted pair cable, a TV signal reduces in strength by a factor of over 10,000. These old systems were laid before the war to relay radio signals into British homes which had no mains power. To keep losses down to a minimum, the radio signals were distributed by 2 kW amplifiers over long distances at 500 V and then for safety reduced to 55 V as they entered the home. It's been a triumph over adversity to use these wires for carrying TV signals. They can only carry a few channels at a time and will be replaced by co-axial or optic fibre as soon as the cable operators have the incentive to make the necessary investment. This incentive has recently been given by the Government, which is to authorise a dozen or so multichannel cable stations in Britain, on an interim basis until the necessary legislation has been enacted to give long term franchises.

The idea of sending signals by light is very old—Alexander Graham Bell patented his 'photophone' in 1880

Although twisted wire technology is dead, co-axial technology is very much alive, even though copper is a natural resource, which is running out. At the current rate of use, the earth's natural copper reserves will have been exhausted by the end of the century; or at least industry will need to mine from ores which contain an amount of copper which has until now been thought too low to be economic. But copper is very easily reclaimed from old cable. You simply make a bonfire and burn off the insulation. There remains a pile of refined copper which can be used to make new cables.

Copper co-ax clearly has a bright future for studio use. Very few studios are so large that they need a cable run of more than 1 km and few studios are so busy that they need a single cable to carry 450 MHz of audio signal bandwidth, even if the signals are in digits rather than waves. In any case it's no real problem in a studio to lay a second cable alongside the first, to double the bandwidth capacity. The most important advantage is perhaps the immunity of optic fibre to electrical interference.

The idea of sending signals by light is in fact very old. It was in 1880 that Alexander Graham Bell, the Scotsman who went to America and invented the telephone, patented his 'photophone'. This took light from the sun, a lamp or even a candle and focused it with a lens into a beam. The beam went through a rotating beam or oscillating blind to modulate it. The photophonic receiver was a lens which focused the modulated beam on to a very thin but hard rubber diaphragm mounted in a telephone. According to Bell's patent the chopped light beam made the rubber move to produce audible sounds. But it was obviously an im-

Copper is very easily reclaimed from old cable—you simply burn off the insulation

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practical approach. So Bell soon went on to modify his photophone by replacing the diaphragm with a sheet of light-sensitive selenium, connected in series with a battery and telephone ear-piece. An incoming modulated beam created a modulated current through the ear piece, which in turn produced sound. Bell built a prototype which is still in the Smithsonian Institution in Washington DC.

Bell's photophone suffered from the disadvantage that it relied on free-space communication. Rain, smog, snow and smoke blocked the beam and crashed the system. Nearly 100 years later, engineers around the world tried updating Bell's photophone by using a laser beam instead of an ordinary light beam. Although a finely focused laser beam is much better able to cut through atmospheric pollution, it is still scattered by water molecules and dust. And if any unfortunate person looks straight into the beam, they will end up blind!

Bell Labs, in the US, tried to send a laser beam through closed channels, like an optical wave guide. But the guide has to be straight, because light cannot pass around corners. The ideal answer is to send light down an optical pipe which guides it round corners. This is what an optic fibre does. There's nothing new in the idea of guiding light down a transparent tube. Thanks to the natural phenomenon of total internal reflection, light injected into transparent strip, rod, fibre or column of water will travel along its length, inside the material, and emerge at the other end. It's the principle on which perspex signs, water fountain displays and inspection lights work. It's the same reason why, when you are swimming under water, you can't look up out of the pool outside a certain angle. But there's a world of difference between sending light a short distance in this way and transmitting pulses for miles down a fibre link. Unless the link is optically very pure, the light is seriously attenuated in just a few metres, just as an electric signal is attentuated by a high resistance cable.

In 1966 two engineers working for Standard Telecommunication Lab at Harlow, C Kao, origially from China and G A Hockham, published a technical paper (*Proc IEE* July 1966) which identified the impurities which absorb light in ordinary glass, and predicted that it would be possible to remove them. Soon engineers all round the world were beavering away, looking for a way of producing super-pure glass. A number of different techniques were developed, all involving very high temperature gas treatment of silica to remove the water and metal ions which are natural constituents and absorb light. Progress has been startling. Ten years ago flexible fibres were drawn in which light was reduced to one hundreth its original strength after travelling 1 km. Today light loss over one kilometre is 7%. Over 10 miles the loss is only 3 dB. In future, fibres will be even more pure, and loss even less.

There's nothing new in the idea of guiding light down a transparent tube

Another snag with optical fibre is unwanted reflection due to refraction inside the material. As the light waves pass down the fibre they mix with their delayed reflections. This distorts an analogue waveform and introduces errors into a digital pulse train. There are several ways of solving this problem. If the central core of the fibre is made very small there is no room for reflection and refraction. This is so-called 'mono-mode' fibre, with a usable core only 5 microns wide. But it's obviously difficult to inject light into such a small core, and it's equally difficult to join two fibres together. But injection has been licked by the use of solid state lasers, and even out in the field mono-mode fibres can now be joined accurately by automatic welding in a precision jig.

Another design approach is to use multi-mode fibre which has a much wider optical core, of around 50 microns or the width of a human hair. So it's much easier to join and couple with a light source. But for obvious reasons, it suffers much more from spurious internal reflections. This limits the length of fibre run that can be used between booster stages. At each booster stage the light has to be reconstituted into an electrical signal, amplified and converted back into light for re-injection into the next stage of the link. This puts up the system cost over long distances, Currently there is much research activity on a technique to amplify light without reconverting it into electricity. But until all-optic circuitry is available, and mass-produced as chips, multi-mode fibre will remain the best bet for short runs, and mono-mode fibre the best bet for long runs.

Even discounting the need to amplify, any optic fibre link needs terminations at each end which convert electricity into light, and light back into electricity. This is what puts up the cost of the fibre link. At the present time British Telecom and the cable companies must pay up to £1,000 each for a solid state laser suitable for terminating a mono-mode link. If multi-mode fibre is used it's possible to get away with a Light Emitting Diode instead of a laser. The frequency of light emitted by an LED spreads more than the light emitted by a laser, which is why it is harder to focus into a small-core fibre. But an LED is cheaper, around £350. At the reception end, a light-sensitive diode converts the light back into electric signals, at a cost of around £150. All these prices will of course come down dramatically as mass production gets under way. It is for instance a fact that every *Compact Disc* digital audio player on the market today, selling for around £500, contains a solid state laser and receptor, albeit of different design and wavelength to those used for fibre links.

The wavelength used for optical fibre transmission is an important consideration. Even the purest optical fibre available today will absorb or scatter light at some frequencies, but pass it freely at others. As a guide, at high frequencies and short wavelengths, below around 0.7 microns, spurious reflections kill the signal. At 1.4 microns residual water molecules cause a drastic attentuation peak. At longer wavelengths, around 1.8 microns, there is another water absorption peak. But at 1.6 microns there is an absorption dip and a peak in transmission. Unfortunately it's difficult to make light sources and light sensors work at this relatively long wavelength. The current best bet for cable links is a wavelength of around 0.8 microns, where there is relatively little water absorption and scattering. With mass production in millions, the price of lasers and receptors operating at this frequency could fall to around £5 each. But this is only a future possibility. As the copper lobby will tell you, co-axial cable links require no opto-electronic conversions whatsoever.

There are two ways of transmitting a signal by light. The light source can be varied in intensity as an analogue of the signal or switched on and off in digital code. This is all easier said than done. For analogue tranmission the light output must vary in linear fashion with the electrical input. An LED or laser which behaves in linear fashion is much more difficult to make, and much more expensive, than one in which the light output only roughly corresponds to the power input. For digital operation, where the light is simply being switched on and off, linearity is not essential. But as audio engineers well know, a digital system is more expensive to build because of the coding and decoding circuitry needed at each end.

Here again we should look at the audio market, where PCM adaptors for domestic video recorders, and domestic digital disc players, are down in price to a few hundred pounds each, even though they incorporate 16-bit circuits.

There's been much talk of optical fibre bandwidth, because the wavelength of light is so small, and thus the frequency so high, that in theory it's possible to carry an almost infinite band of frequencies. But in practice there are finite limits. The longer the run, the more the waves spread or the more the pulses scatter. So fibre bandwidth is meaningless unless qualified by run distance. For instance a fibre link with a bandwidth of 5 GHz per km has a bandwidth of 1 GHz for a 5 km run and so on. Bandwidth is also finitely limited by the performance of the laser or LED and photo receptor at the ends of the fibre. There is a limit on how fast the devices can operate. Also they may shift in frequency if driven hard, which in turn creates inefficient injection and scatter which reduces usable run and bandwidth. LEDs suffer from the same problems as lasers, but more so.

Clearly the future for sound studios is in digital transmission down fibres

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To give you some clue to the future, British Telecom can now carry four TV channels, of 8 MHz bandwidth each, down a single fibre using a frequency-division-multiplex technique with a 0.8 micron laser. The laser light is amplitude modulated at the frequency of the signal and the four channels are multiplex-stacked one on top of the other in frequency. BT reckons that with better lasers it may go up to six or eight channels for a single fibre. The next step is to use several separate lasers of different optical frequency, all injecting light into a single fibre. Bell Labs in the US have now developed a laser which can be tuned to several different frequencies. But for the foreseeable future the cheaper approach is simply to use more individual fibres, each with their own laser.

Clearly the future for sound studios is in digital transmission down fibres. As a pointer, when BT lays the world's first transatlantic optical fibre cable, due to start service in 1988, it will have just two pairs of fibre, each operating digitally at 280 Mb per second, making a total capacity of around 8,000 simultaneous phone calls. (A phone call has a bandwidth of around 3 kHz.) In the future the cable capacity will be increased up to five times by boosting the digital data rate. Incidentally, although the industry hopes one day for a fibre so pure that it will carry light under the

The BBC has experimented with routing digital TV signals through an 800 m optic fibre

Atlantic without any boosters, BT is having to plan for opto-electronic amplifiers at distances of between 30 and 50 km under the sea. But as a yardstick this compares to 5 km spacing for repeaters in existing co-axial underwater links. In Britain at the moment, BT routinely uses 140 Mb/s links and will in the future, after the under sea cable experiment, move onto 560 Mb/s.

Although cable engineers have so far been most concerned with the tranmission of speech, data or television, their work on bit-rate reduction is a clue to what could happen with high quality audio. For direct encoding of the colour TV picture, the lowest bit-rate possible for good pictures on a conventional TV set is 140 Mb/s, which is roughly equivalent to an analogue signal of 140 MHz. With a very expensive receiver, including a frame store, the bit-rate can be reduced to 34 MHz. With differential pulse code modulation, where only changes in the picture are encoded, the rate can be 70 Mb/s. If studio quality pictures in red, green and blue basic component signals are to be transmitted, the rate rises to 260 Mb/s which can then be reduced to 140 Mb by electronic tricks. So the practical choice for digital TV transmission down optical fibre is 70 or 140 Mb/s. With current fibres, lasers and receptors, it's only possible to send a single digitally-encoded TV channel down an optical link. This has generated some confusing comparisons between the capacity of optical fibre and co-ax. Those who are committed to copper can say with perfect honesty that optical fibre is only able to carry one channel of TV whereas a co-axial cable can carry up to 30.

As a guide to the likely capacity of fibre links for audio, you need only look at the specifications for the digital audio *Compact Disc* and look at the data rates used by the BBC to transmit sound signals for the radio and TV tranmissions. *Compact Disc*, with 16-bit coding and 44.1 kHz sampling, has a bit-rate in stereo of 1.4112 Mb/s which, with error correction and housekeeping steps up to 4.3218 Mb/s off the discs.

For the last 10 years, the BBC has been routing its radio signals around the country between transmitters, using a much more 'economical' PCM technique. Many of the people who are now so vociferously criticising 'the sound of digital audio', have in fact been listening to the sound of quite primitive digital audio coding for the last 10 years, without ever complaining. Doubtless this is because they haven't realised what they have been listening to. For PCM links, the BBC samples at 32 kHz, to give a bandwidth of around 15 kHz, and encodes in linear 13-bit words. This means a basic bit-rate of 416 kb/s, per audio channel, plus extra bits for framing and error correction. The BBC system was designed to match the British Telecom tranmission links, and for this reason handles 13 channels at a time, with a total bit-rate of 6.336 Mb/s. This is equivalent to 487 kb/s per mono channel.

For TV sound, the BBC uses an even more economic digital approach so that it can pack mono sound into the video waveform. Gaps, each 4.7 µs in length, are naturally created in the video waveform by the picture line synchronisation pulses. To pack sound into these gaps, the BBC uses a com-

Any cable system can accommodate several channels of digital audio in the space of just one colour TV channel

panding technique in the analogue domain and then samples at 31.25 kHz, which is twice TV line frequency. Encoding is into 10-bit words with a pilot tone used to control expansion of the analogue dynamic range after decoding. Two 10-bit words and one marker pulse are transmitted in each 4.7 µs gap, which makes an intermittent bit-rate of 4.468 Mb/s.

The BBC is soon to convert its PCM links to Nicam technology. Using Nicam (Near Instantaneously Companded Multiplex) the BBC can transmit six audio channels, or three stereo pairs, over a 2048 kb telephone link, or four channels over an analogue video circuit. For Nicam encoding each audio channel is sampled at 32 kHz and coded into 14-bit words. But there is compansion in the digital domain. Only 10 of the 14 bits are transmitted. A ranging system works out which 10 out of the 14 bits are used. Five ranges are available and extra bits of information tell the decoder which one to select. For bit economy each range code is good for 32 consecutive digital samples. Digital compansion is more expensive than analogue compansion, but potentially more accurate. Thanks to the bit economy gained by ranging, the BBC can send 18 channels of Nicam audio over one 8448 kb link.

Another approach to bit economy is Delta modulation. Both dbx and Dolby have recently proposed their own Delta systems because they are a logical extension of analogue companding. The audio signal is sampled at very high frequency, and then coded with just two quantising levels which represent any change in the signal. So bit-rate is reduced. Dolby Labs manage with 250 kb/s per channel. The system is proposed for low cost digital tape recorders, and programme distribution to the home via cable or satellite. But the system could be used to route audio around studios in digital domain.

The relatively low data rates necessary for digital audio, in comparison with those used for colour TV, clearly mean that any cable system—whether fibre or coax—can accommodate several channels of digital audio in the space of just one colour TV channel. Technology developed for cable TV will thus be easily adapted for high quality digital audio links in and between studios. Already the BBC has experimented with routing digital TV signals between Lime Grove and Wood Lane through an 800 m optic fibre. A single fibre, terminated by an 8.2 micron laser was used, with a transmitted bit-rate of 270 Mb/s, handling separate red, green and blue picture component signals. Just think how many digital audio signals you could send instead of that one TV signal!

The big question for the future is whether it will be worthwhile for studios to invest in optic fibre links, instead of co-axial cable, to route digital audio signals around and between buildings. The answer will depend entirely on the cost of the systems initially developed for mass market cable TV. That cost in turn will depend on the demand which is created for futuristic cabling, that is to say multichannel systems with 2-way interactive links to give the subscriber a chance to return signals to the cable station, for instance to vote on programme preferences.

But frankly no-one, least of all the cable operators, knows how well cable and satellite will sell in Britain. They don't know whether it will be worth investing in a high technology system when members of the public are interested only in a wider choice of programme pap. Nevertheless, the recording industry will soon be offered all kinds of exciting new fibre technology, often as a kite-flying exercise.

As should by now be clear, there are really only two questions to answer: 'what will the new technology do for me that co-axial cable can't?' and 'how much will it cost?' Easy questions for a studio to ask, but difficult for a kite-flying salesman to answer.

AKG
acoustics

A little goes a long way

The AKG 567 is a professional omnidirectional miniature condenser microphone of exceptionally rugged construction and excellent acoustic qualities. Because it is small, it is perfectly suited for use by singers, speakers and interviewers and also as an instrument-mounted pick-up for the violin, piano, flute, saxophone and acoustic guitar.

The C567 is supplied complete with tie-pin and clip, for attachment to clothes and instruments, allowing completely free movement by the user, whilst maintaining a constant working distance.

All in all, the C567 is a little masterpiece.

Technical Data:

Directional characteristic: omni-directional

Frequency range 20-20,000 Hz

Sensitivity. 6 mV/Pa ≙ 0,6 mV/μbar (–64 5 dBV, no-load operation at 1,000 Hz)

Electrical impedance 200 ohms ± 20% balanced

Max. sound pressure level (for 1,000 Hz and 500 ohms load impedance, harmonic distortion k = 1%): 80 Pa ≙ 132 dBSPL

Connector type 3-pin standard XLR-type connector
pin 1: ground
pin 2 audio (inphase)
pin 3. audio (return)

Dimensions:
11 ∅ 24 mm (microphone)
7/16" ∅ x 1"
21 ∅ x 80 mm (output-module)
13/16" ∅ x 3-3/16"

Cable length. 1,3 m (≈ 4 ft)

Weight: 9 g (microphone only) – 0.35 oz approx. 100 g net (microphone + output module) – 3 5 oz

Included accessories:
Wire-mesh windscreen W37
Tie pin H 20
Universal clip H 21
Belt clip H 16

AKG

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studiofile

3M Digital at Decca

A 3M 32-track digital mastering system (DMS) has been bought by Decca to play an important role in a busy schedule of operatic and choral recordings.

It may come as a surprise that in a world where multi-tracking and overdubs are the norm, Decca still finds 2-track stereo recording the best method of working. Decca's technique for classical music is to mix-down live at their recording sessions and to record straight on to their own 2-track digital recording system.

A second surprising fact about Decca is that, unlike most other major recording companies, it has no studios of its own, preferring to work 'on location' in the concert halls and auditoria that have contributed so much in building the reputation of Decca's recorded sound. There are, however, occasions when 2-track stereo recording and a live mix just can't be relied on; when recording a live concert, large-scale choral or operatic works, for example.

Decca prefers the freshness of the live mix approach but also recognises the need to have a good sound balance. So for those occasions when an off-stage band or sound effect has to be balanced correctly, and when this may not be achievable during the recording sessions, Decca must use multi-track recorders. Decca uses multi-track equipment to store stereo pairs, rarely using more than eight tracks (four pairs). This enables the balancing options to be widened and the time-scale in which the balance must be 'got right' to be stretched.

Decca took a unique decision for a major recording company back in 1978 when it decided that, from that date, *all* recordings would be made using digital technology. But there existed the problem that 10 per cent of recordings demand the use of multi-track machines in a back-up role. Decca was not prepared to consider mixing-down from an analogue multi-track master to balance-in difficult ensemble passages or offstage bands to a digital 2-track master. For a while, Decca used a 4-track version of its own recorder to get around the problem. But greater storage was needed.

And then came a prestige recording event—the Joan Sutherland/Marilyn Horne/Luciano Pavarotti gala concert 'Live from the Lincoln Center' in New York. For this recording Decca hired a 32-track 3M DMS in America. Tony Griffiths, Decca International's technical manager (R&D) tells how Decca began to get experience with the 3M recorder and were equally pleased with the technical support given by 3M. With the Lincoln Center tapes back home, Decca hired a DMS for the stereo reduction, producing finished discs praised by one critic for the 'bright, vivid digital recording'.

"Experience with the 3M DMS and the knowledge that technical support would be forthcoming from 3M in Britain was behind our decision to buy the recorder here," says Tony Griffiths.

He's adamant that Decca's reputation for quality sound is grounded in an ability 'to keep on top of the recording technology'. Having developed its own digital system, Decca doesn't intend to bring equipment in-house that its technicians cannot maintain and modify. Decca's 3M DMS will be shorn of its digital-to-analogue convertors to enable it to interface directly with Decca's own prototype digital editing system.

At present the DMS is being used for a world premier recording of Ambroise Thomas' opera *Hamlet* being made in London's Kingsway Hall with Joan Sutherland and Sherril Milnes conducted by Richard Bonynge.

Coming up later in the year will.be a recording of Mozart's *Idomeneo* and a recording to be made in Berlin with Italian conductor Riccardo Chailly of Carl Orff's very popular *Carmina Burana*. There is a strong possibility that the recorder will be used at the Bayreuth Festival in conjunction with Decca's recording plans for the Sir Georg Solti/Peter Hall Wagner 'Ring' cycle.

With Decca's location work, a reliable, robust recorder is essential. Decca have confidence both in 3M's DMS and in the technical help they will receive in 'customising' the 32-track recorder for its unique role with them. **David Prakel**

Atmosphere, London

If you were to take a stroll, heading north-west up Soho's Great Windmill Street you would eventually find yourself entering the rather less extravagant domain of Lexington Street, home of Future Film Developments, Atmosphere Studios and an inordinate number of traffic wardens. Street parking here is lethal, and unless you arrive early in the morning, you will usually have to queue up to get into the NCP multi-storey which is situated close by.

Whilst parking is tricky, access for equipment is pretty good—a set of double doors lead off of Lexington Street, straight into a large goods lift. The lift takes you down one storey into the basement where a short walk will take you into the control room of the main 24-track studio.

The cosmetic design of the control room was down to the former owner, Israeli composer Nachum Heiman and, like the rest of the complex, is based on various shades of brown hessian, bark, and open pine boarding. A wall mounted air conditioning unit keeps the atmosphere generally fresh and relaxing, although on those occasions when an ad agency sees fit to send along their entire staff plus the tea lady's nephew to witness the recording of a jingle, it does get rather fuggy.

A certain Mr Buckle was responsible for the acoustics, and although he was not available for comment, chief technical engineer Paul Graves, who was involved back in 1977 with the construction, gave me a rough outline of the treatment. The control room is a room within a room construction with a 6 in cast reinforced concrete floor resting on TECO pads. The inner shell is built up from this in 4½ in brickwork, on top of which is a metal mesh false ceiling, backed with *Rockwool,* and faced with strips of pine to form a chequerboard of hessian and bark. *Rockwool* is applied to the walls, with a covering of hessian plus pine supports and trim. The subjective result is one of a fairly dead acoustic, with a high average absorbency coefficient and of course a low room gain. This isn't much of a practical problem unless you like to get your drum sounds, especially bass drum, at high volumes, in which case the JBL *4333*s, suspended from the ceiling, tend to struggle a bit. A review of the monitoring situation is, however, rumoured. Meanwhile, the JBLs are powered by a Turner, corrected by a pair of White ⅓-octave graphics and supplemented by a pair of Auratone cubes. The desk is a Soundcraft *2400* and mastering on a Studer *B67,* with a Revox *A77* for tape echo, and both 16 and 24-track headblocks are available for the 3M *M79* multitrack machine.

Auxiliary equipment includes an EMT *240* plate, an Eventide *H910 Harmonizer,* a Klark Teknik *DN34* analogue time processor, a DeltaLab *DL1* DDL, a *Scamp* rack containing compressors and gates, together with parametric and sweep EQ modules, and finally a Klark Teknik *DN22* graphic. Any extras can of course be hired in at extra cost. The rates are low for a fairly spacious 24-track in the West End; the engineers and technical back-up are of the highest standard, and you shouldn't let the lack of expensive processing equipment fool you into thinking that the service offered is anything less than highly professional.

Closely associated to the studio, and in fact housed in the same building, is a publishing and production company going under the name of Logorhythm (pronounced logarithm) who have been very much involved with jingles and music for film and television for some years. Although Atmosphere Studios and Logorhythm function as two separate concerns, they do work very closely together, and much of the studio's business is more or less in-house. For this reason they are fully equipped for VAPP, and were one of the first studios in the country to try out the Audio Kinetics *Q-Lock* system. The teething troubles experienced with the original *2-10* and its software have made Paul somewhat of an expert on the subject, and now that it has been replaced by a new *3-10,* problems are very rare on music-to-picture sessions.

The remainder of the VAPP equipment consists of a JVC *8500 U-Matic* VCR, a large Mitubishi projection television for the studio, plus a 20 in colour TV monitor suspended between the monitors in the control room.

A good size, double-glazed window in front of the desk looks out into the studio area, the main part of which is approximately 25 × 15 ft. The acoustic treatment is similar to that of the control room, giving a generally dead sound, although there are hard, wooden screens which can be hung on the walls to provide liver areas if desired. The separate 8 × 10 ft drum booth has the same fairly dry character; it's large enough to take most kits and is fitted with overhead, suspended mic booms to make the most of the available space.

There are no real recreational or catering facilities that extend beyond a cup of coffee, however, positioned as it is in the heart of Soho, you don't need to look far to find the means to satisfy most physical appetites.

Atmosphere Studios, 6-10 Lexington Street, London W1. Tel: 01-734 7443. **James Francis**

product Interconnection reference

	Jack plugs	Jack sockets	Jack panels	Jackfields	Phono plugs	XLR-type sockets	XLR-type connectors	Screw connectors	Patch cords	Patch panels
ADC (USA) **ADC Products 4900 W 78th Street. Minneapolis, MN 55435. Tel: (612) 835-6800. Telex: 290321.** UK: Communication Accessories & Equipment Ltd, 70/80 Akeman Street, Tring, Herts HP23 6AH. Tel: 0442 82 4011. Telex: 82362.	●	●	●	●	●	●	●		●	
AMPHENOL—Tuchel (West Germany) USA: Amphenol Connector Division, Buker Ramo Corp, 2801 S 25th Avenue, Broadview, IL 60153. Tel: (312) 345-9000. Telex: 910-226 1974. UK: Future Film Developments, 36/38 Lexington Street, London W1R 3HR. Tel: 01-437 1892. Telex: 21624.						●	●	●		
AUDIO ACCESSORIES (USA) **Audio Accessories Inc, Mill Street, Marlow, NH 03456. Tel: (603) 446-333.** UK: Technicord Ltd, Melbourn House, 2 Black Bank Road, Little Downham, Ely, Cambs CB3 2TZ. Tel: 035387 721.	●	●	●	●					●	●
CAE (UK) **Communication Accessories & Equipment Ltd, 70/82 Akeman Street, Tring, Herts HP23 6AJ. Tel: 044282 4011. Telex: 82362.**	●	●	●	●	●	●	●		●	●
CANFORD (UK) **Canford Audio, Stargate Works, Ryton, Tyne & Wear NE40 3EX. Tel: 089422 4515. Telex: 537792.** USA: Canford Audio (USA) Inc, 652 Glenbrook Road, Stamford, CN 06906. Tel: (203) 324-2889. Telex: 643678.						●				
CANNON (USA) **ITT Cannon Electric, 666 East Dyer Road, Santa Ana, CA 92702. Tel: (714) 557-4700.** UK: Future Film Developments, 36/38 Lexington Street, London W1R 3HR. Tel: 01-437 1892. Telex: 21624.						●	●			
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CONNECTRONICS (UK) **Connectronics Ltd, 20 Victoria Road, New Barnet, Herts EN4 9PF. Tel: 01-449 3663/4044. Telex: 8955127.** USA: Connectronics Inc, 652 Glenbrook Road, Stamford, CN 06906. Tel: (203) 324-2889. Telex: 643678.						●	●			
FUTURE FILM (UK) **Future Film Developments 36/38 Lexington Street, London W1R 3HR. Tel: 01-437 1892. Telex: 21624**	●	●	●	●	●				●	●
MOSSES & MITCHELL (UK) **Mosses & Mitchell Ltd, Wydon Lane, Farnham, Surrey GU9 8QL. Tel: 0252 721236. Telex: 858820.**		●		●					●	
NEUTRIK (Liechtenstein) **Neutrik AG, Obergass 16, FL-9494 Schaan. Tel: 075 2.63.83. Telex: CH-77771.** UK: Eardley Electronics Ltd, Eardley House, 182/4 Campden Hill Road, London W8 7AS. Tel: 01-221 0606. Telex: 299574. USA: Philips Audio Video Systems Corp, 91 McKee Drive, Mahwah, NJ 07430. Tel: (201) 529-3800.						●	●			
RENDAR (UK) **Wilmot Breeden Electronics Ltd, Durban Road, Bognor Regis, West Sussex PO22 9RL. Tel: 0243 825811. Telex: 86120.**	●	●								
SWITCHCRAFT (USA) **Switchcraft Inc, 5555 North Elston Avenue, Chicago, IL 60630. Tel: (312) 792-2700. Telex: 910-221 5199.** UK: FWO Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts WD6 4RZ. Tel: 01-953 0091. Telex: 27502.	●	●	●	●	●	●	●			
SYMETRIX (USA) **Symetrix Inc, 109 Bell Street, Seattle, WA 98121. Tel: (206) 624-5012.**										●
TECHNICORD (UK) **Technicord Ltd, Melbourn House, 2 Black Bank Road, Little Downham, Ely, Cambs CB3 2TZ. Tel: 035387 721.** USA: Audio Accessories Inc, Mill Street, Marlow, NH 03456. Tel: (603) 446-3335.	●	●		●					●	
TRIMM (USA) **Trimm Inc, 400 Westlake Street, Libertyville, IL 60048. Tel: (312) 362-3700.** UK: Future Film Developments, 36/38 Lexington Street, London W1R 3HR. Tel: 01-437 1892. Telex: 21624.	●	●	●	●						
TROMPETER (USA) **Trompeter Electronics Inc, 8936 Comanche Avenue, Chatsworth, CA 91311, Tel: (213) 882-1020.** UK: Lee Engineering Ltd, Napier House, Bridge Street, Walton-on-Thames, Surrey KT12 1AP. Tel: 09322 43124.	●								●	●
TURNKEY (UK) **Turnkey, Brent View Road, London NW9 7EL. Tel: 01-202 4366**									●	●

product reference

Metering

ALICE (UK)
Alice (Stancoil Ltd), 38 Alexandra Road, Windsor, Berks. Tel: 07535 51056. Telex: 849323.

PPM drive circuit for analogue meter movements.

ALPS KEIKI
UK: Servo and Electronic Sales Ltd, 24 High Street, Lydd, Kent TN29 9AJ. Tel: 0679 20252. Telex: 965265.

VU analogue meters.

A & R (UK)
Amplification & Recording (Cambridge) Ltd, Denny End Industrial Centre, Waterbeach, Cambridge CB5 9PB. Tel: 0223 861550.

LED column level indicator and accessories.

AUDIO & DESIGN (UK)
Audio & Design (Recording) Ltd, North Street, Reading, Berks RG1 4DA. Tel: 0734 53411. Telex: 848722.

LED display with four 12-section columns.

BACH-SIMPSON (UK/Canada)
Bach-Simpson (UK) Ltd, Trenant Estate, Wadebridge, Cornwall, UK. Tel: 020881 2031. Telex: 45451.
Bach-Simpson Ltd, PO Box 5484, 1255 Brydges Street, London, Ontario, Canada. Tel: (519) 452-3200. Telex: 064 5843.
USA: Simpson Electric Company, 853 Dundee Avenue, Elgin, IL 60120. Tel: (312) 697-2260. Telex: 722416.

Analogue VU meters with instrument construction; custom design service.

BOWMAR (USA)
Bowmar/ALI Inc, 531 Main Street, Acton, MA 01720. Tel: (617) 263-8365.

Series of solid state analogue panel meters.

BURROUGHS (USA)
Burroughs Corp, PO Box 1226, Plainfield, NJ 07061. Tel: (201) 757-5000.
UK: Walmore Electronics Ltd, 11-15 Betterton Street, Drury Lane, London WC2H 9BS. Tel: 01-836 1228. Telex: 28752/25177.

Gas plasma vertical bargraph display devices.

CAPITAL COMPONENTS (UK)
Capital Components, 28 East Street, Rochford, Essex SS1 1PY. Tel: 0702 547252.
UK: Cliff Electronics Ltd, 97 Coulsdon Road, Caterham, Surrey CR3 5NF. Tel: 0883 47713. Telex: 8813346.

12- or 20-segment LED column indicators and VU meters with LED semicircle.

COMPONEX (Japan)
Componex Ltd, 48-56 Bayham Place, London NW1 0EU, UK. Tel: 01-388 7171. Telex: 27364.

Analogue VU meters, some available as PPMs; mini VU meters and bargraph peak VU meters.

CROMPTON (USA)
See Ernest Turner/Crompton

DIXSON (USA)
Dixson Inc, PO Box 1449, Grand Junction, CO 81501. Tel: (303) 242-8863.

Range of analogue VU meters.

ESE (USA)
Ese, 142 Sierra Street, El Segundo, CA 90245. Tel: (213) 322-2136.

14-LED column level indicators.

INOVONICS (USA)
Inovonics Inc, 503-B Vandell Way, Campbell, CA 95008, Tel: (408) 374-8300.
UK: Feldon Audio Ltd, 126 Great Portland Street, London W1N 5PH. Tel: 01-580 4314. Telex: 28668.

Peak reading audio level indicator.

JEWELL (USA)
Jewell Electrical Instruments Inc, Grenier Field, Manchester, NH 03108. Tel: (603) 669-6400.

Range of analogue VU meters.

McCURDY (Cananda)
McCurdy Radio Industries Ltd, 108 Carnforth Road, Toronto, Ontario M4A 2L4. Tel: (416) 751-6262. Telex: 06963533.
USA: McCurdy Radio Industries Inc, 1711 Carmen Drive, Elk Grove Village, IL 60007. Tel: (312) 640-7077. Telex: 910-222 0436.
UK: Seltech Equipment Ltd, Rose Industrial Estate, Cores End Road, Bourne End, Bucks SL8 5AT. Tel: 06285 29131. Telex: 848960.

Peak programme meter movement with electronics.

MINIFLUX (UK)
Miniflux Electronics Ltd, 8 Hale Lane, London NW7 3NX. Tel: 01-959 5166.

Range of LED peak level column indicators and bargraph meters.

MODUTEC (USA)
Modutec Inc, 18 Marshall Street, Norwalk, CT 06854. Tel: (203) 853-3636.

Range of analogue VU meters.

NEVE/CHROMATEC (UK)
Chromatec Video Products Ltd, 10 Barley Mow Passage, London W4 4PH. Tel. 01-994 6477. Telex: 8811418.
UK: Neve Electronics International Ltd, Cambridge House, Melbourn, Royston SG8 6AU. Tel: 0763 60776. Telex: 81381.
USA: Rupert Neve Inc, Berkshire Industrial Park, Bethel, CT 06801. Tel: (203) 744-6230. Telex: 969638.

56-channel TV display, switchable to spectrum analysis.

NTP (Denmark)
NTP Elektronik A/S, 44 Theklavej, DK-2400 Copenhagen NV. Tel: 01 10.12.22. Telex: 16378.

Wide range of light spot PPMs, gas discharge PPMs, LED column meters, analogue meters, CRT displays, etc.

PSI (USA)
Project Synthesis International, 500 Hidden Valley Road, Grants Pass, OR 97526. Tel: (503) 474-2192.

LED column level indicator.

RACAL/BPL (UK)
Racal-British Physical Laboratories, Radlett, Herts WD7 7HJ. Tel: 09276 4844. Telex 25312.

Wide range of analogue meters.

REBIS (UK)
Rebis Audio, Kinver Street, Stourbridge, West Midlands DY8 5AB. Tel: 0384 71865.

20-LED column meter with switchable VU and PPM characteristics.

RTW (West Germany)
Radio-Technische Werkstätten GmbH, Elbeallee 19, Postfach 718250, D-5000 Köln 71, West Germany. Tel: (0221) 701055.
UK: Audio & Design Marketing, North Street, Reading RG1 7DA. Tel: 0734 53411.

Range of peak reading light column meters.

SEW (Japan)
UK: ITT Instrument Services, Edinburgh Way, Harlow, Essex CM20 2DF. Tel: 0279 26811. Telex: 81146.

Analogue meters.

SIFAM (UK)
Sifam Ltd, Woodland Road, Torquay, Devon TQ2 7AY. Tel: 0803 63822. Telex: 42864.
USA: Selco Product Co, 7580 Stage Road, Buenapark, CA 90621. Tel: (213) 921-0681. Telex: 655457.

Analogue VU and PPM meters in a wide range of designs.

SOUNDEX (UK)
Bulgin Electronics Soundex Ltd, Park Lane, Broxbourne, Herts EN10 7NQ. Tel: 09924 64455.

PPM meters with electronics.

STUDER (Switzerland)
Studer International AG, Althardstrasse 150, CH-8105 Regensdorf. Tel: 01 840.29.60. Telex: 58489.
UK: FWO Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts WD6 4RZ. Tel: 01-953 0091. Telex: 27502.
USA: Studer Revox America Inc, 1425 Elm Hill Pike, Nashville TN 37210. Tel: (615) 254-5651. Telex: 554453.

Dual plasma display meter with PPM or VU characteristics.

SURREY (UK)
Surrey Electronics, The Forge, Lucks Green, Cranleigh, Surrey GU6 7BG. Tel: 04866 5997.

PPM drive circuits for analogue meter movement and complete free-standing housings.

tts (West Germany)
tts-Electronic GmbH, Dammühlenweg 4, D-6270 Idstein. Tel: 06126 2014. Telex: 4128 297

2-channel free-standing switchable PPM/VU LED meter, LED phase meter.

ERNEST TURNER/CROMPTON (UK/USA)
Ernest Turner Instruments, Totteridge Avenue, High Wycombe, Bucks. Tel: 0494 30931. Telex: 83444.
USA: Crompton Instruments Inc, 1562 Parkway Loop, Tustin CA 92680. Tel: (714) 731-2333.

Analogue VU or PPM meters, stereo VU and PPM versions, gas plasma bargraph meters.

UREI (USA)
United Recording Electronics Industries, 8460 San Fernando Road, Sun Valley, CA 91352. Tel: (213) 767-1000. Telex: 651389.
UK: FWO Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts WD6 4RZ. Tel: 01-953 0091. Telex: 27502.

16- or 32-bargraph display generator using TV monitor.

WESTON (USA)
Weston Instruments, 614 Frelinghuysen Avenue, Newark, NJ 67114. Tel: (201) 242-2600.
UK: The Radio Resistor Co Ltd, 4 Trust Industrial Estate, Wilbury Way, Hitchin, Herts SG4 0TN. Tel: 0462 4072. Telex: 826251.

Analogue VU meter movements.

WESTREX (USA)
Westrex, 2629 West Olive Avenue, Burbank, CA 91505. Tel: (213) 846-3394. Telex: 698254.
UK: Westrex Co Ltd, Bilton Fairway Estate, Long Drive, Greenford, Middx. Tel: 01-578 0957. Telex: 923003.

Light bar recording meter with 42in horizontal scale and large projection meters. ■

Test equipment

ABACUS (UK)
Abacus Electrics, 10 Barley Mow Passage, London W4 4PH. Tel: 01-994 6477. Telex: 8811418.
UK: Kirkham Electronics, Mill Hall, Mill Lane, Pulham Market, Norfolk IP21 4XL. Tel: 037976 594/639.

⅓-octave real time analyser and oscilloscope adaptor.

ACOUSTILOG (USA)
Acoustilog Inc, 19 Mercer Street, New York,

product reference

Test equipment

NY10013. Tel: (212) 925-1365.

Reverb timer and *The Impulser*.

AEC (West Germany)
Audio Engineering Components GmbH, Obertshausen, D-6053 Geleitstrasse 11. Tel: 610 44.23.24.
Export: Audio International Vertriebs GmbH, Box 560229, Gonzenenheimstrasse 2B, D-6000 Frankfurt 56, West Germany. Tel: 611 50.47.33. Telex: 413039.

27-band ⅓-octave realtime analyser and frequency response measurement equipment.

ALTAIR (USA)
Altair Electronics, 1694 Calle Zocalo, Thousand Oaks, CA 91360. Tel: (805) 529-2496.

Tape/transport diagnostic system.

AMBER (Canada)
Amber Electro Design Ltd, 4810 Jean Talon West, Montreal, Quebec H4P 2NS. Tel: (514) 735-4105.
UK: Scenic Sounds Equipment Ltd, 97-99 Dean Street, London W1V 5RA. Tel: 01-734 2812. Telex: 27939.

Multipurpose audio test set with accessories, weighting network kit and portable distortion measuring set.

ANNIS (USA)
R B Annis Co, 1101 N Delaware Street, Indianapolis, IN 46202. Tel: (317) 637-9282.
UK: Leevers Rich Ltd, 319 Trinity Road, London SW18 3SL. Tel: 01-837 9054. Telex: 923455.

Range of magnetometers.

AWA (Australia)
Amalgamated Wireless (Australia) Ltd, PO Box 2516, Sydney 2000. Tel: 20233. Telex: 21515.
UK: Marconi Instruments Ltd, Longacres, St. Albans, AL4 0JN. Tel: 0727 59292. Telex: 23350.

Low distortion oscillators, noise and distortion meters, psophometer, and wow and flutter meter.

BACH-SIMPSON (Canada/UK)
Bach-Simpson Ltd, PO Box 5484, 1255 Brydges Street, London, Ontario. Tel: (519) 452-3200. Telex: 0645843.
UK: Bach-Simpson (UK) Ltd, Trenant Estate, Wadebridge, Cornwall PL27 6HD. Tel: 020 881 2031/3. Telex: 45431.

Wide range of test equipment including digital and analogue multimeters, function generators and frequency counters.

B & O (Denmark)
Bang & Olufsen, DK-7600 Struer. Tel: 07 85.11.22
UK: David Bisset Ltd, 52 Luton Lane, Redbourn, Hertfordshire AL3 7PY. Tel: (058285) 2637.

Wide range of audio measuring equipment including filters, wow and flutter meters, noise meter, oscillators and stereo wattmeter.

B & K (Denmark)
Bruel & Kjaer A/S, DK-2850 Naerum. Phone 02 80.05.00. Telex: 37316.
UK: B & K Laboratories Ltd, Cross Lances Road, Hounslow, Middx TW3 2AB. Phone: 01-570 7774. Telex: 934150.
USA: Bruel & Kjaer Instruments Inc, 185 Forest Street, Marlborough, MA 01752. Phone: (617) 481-7000.

Vast range of audio test equipment and measuring microphones.

CONSILIUM (SWEDEN)
Consilium Industri AB, Parkvagen 12, S-17138 Solna. Tel: 08-83 22 36. Telex: 11083.
UK: Dawe Instruments Ltd, Concord Road, Western Avenue, London W3 0SD. Tel: 01-992 6751. Telex: 934848.

⅓-octave analysers, sweep generator, noise generator, and curve tracer monitor scope.

CROWN/AMCRON (USA)
Crown International, 1718 West Mishawaka Road, Elkhart, IN 46514. Tel: (219) 294-5571. Telex: 810-295 2160.
UK: HHB Hire & Sales, Unit F, New Crescent Works, Nicoll Road, London NW10. Tel: 01-961 3295. Telex: 923393.

Realtime 32-band ⅓-octave analyser and 'audio microcomputer' programmable audio measurement system.

DALELCO (DENMARK)
Export: Hammer Trading Co ApS, Dalen DK-3060, Espergaerde.
UK: Telonic Instruments Ltd, 2 Castle Hill Terrace, Maidenhead, Berks SL6 4JR. Tel: 0628 28057. Telex: 849131.

Wow and flutter meter with oscillator and 2-channel LF wattmeter.

DOLBY (USA/UK)
Dolby Laboratories Inc, 346 Clapham Road, London SW9. Tel: 01-720 1111. Telex: 919109.
USA: Dolby Laboratories Inc, 731 Sansome Street, San Francisco, CA 94111. Tel: (415) 392-0300. Telex: 34409.

CAT98A noise weighting filter.

EMT (West Germany)
EMT-Franz GmbH, Postfach 1520, D-7630 Lahr. Tel: 07825 512. Telex: 754319.
UK: FWO Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts WD6 4RZ. Tel: 01-953 0091. Telex: 27502.
USA: Gotham Audio Corp, 741 Washington Street, New York, NY 10014. Tel: (212) 741-7411. Telex: 129269.

Range of wow and flutter meters with accessories.

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product reference

Test equipment

EVENTIDE (USA)
Eventide Clockworks Inc, 265 W 54th Street, New York, NY 10019. Tel: (212) 581-9290.
UK: Feldon Audio Ltd, 126 Great Portland Street, London W1N 5PH. Tel: 01-580 4314. Telex: 28668.

Real time spectrum analyser for use with variety of personal computers.

FARNELL (UK)
Farnell Instruments Ltd, Sandbeck Way, Wetherby, Yorkshire LS22 4DH. Tel: 0937 63541.

Sine/square oscillator, X-Y chart recorders, dual trace 12 MHz oscilloscope, digitally synthesised signal generator, power meter.

FEEDBACK (UK)
Feedback Instruments Ltd, Park Road, Crowborough, Sussex TN6 2QR. Tel: 08926 3322. Telex: 95255.
USA: Feedback Inc, 438 Springfield Avenue, Berkeley Heights, NJ 07922. Tel: (210) 464-5181.

Function generators, variable phase oscillator, sine/square oscillator, electronic wattmeter.

FERROGRAPH (UK)
Audio Marketing Ltd, Unit 21, Royal Industrial Estate, Jarrow, Tyne & Wear NE32 9XX. Tel: 0632 893092. Telex: 537227.
USA: NEAL-Ferrograph (USA) Inc, 652 Glenbrook Road, Stamford, CT 06906. Tel: (203) 348-1045. Telex: 643678.

Tape recorder test set and *ATU1* accessory for use with *RTS2* which provides balanced inputs and outputs, monitor loudspeaker, meter loading, weighting network, oscillator amplifier and attenuator; frequency response analyser.

FIDELIPAC (USA)
Fidelipac Corp, 109 Gaither Drive, Mt Laurel, NJ 08057. Tel: (609) 235-3511. Telex: 710-897 0254.

Portable wow and flutter meter with internal oscillator.

FORMULA SOUND (UK
Formula Sound Ltd, 3 Waterloo Road, Stockport SK1 3DB. Tel: 061-480 3781.

2-channel, 20-band ½-octave graphic equaliser and analyser.

GENRAD (USA)
GenRad Inc, 300 Baker Avenue, Concord, MA 01742. Tel: (617) 369-8770. Telex: 923354.
UK: GenRad Ltd, Norreys Drive, Maidenhead, Berks SL6 4BP. Tel: 0628 39181. Telex: 848321.

Range of microphones, preamplifiers and accessories, sound level calibrators, integrated realtime ⅓-octave analyser using 5 in display screen, chart recorder, narrow band spectrum analyser, output power meter, random noise generators.

GOLD LINE (USA)
Gold Line, PO Box 115, West Redding, CT 06896. Tel: (203) 938-2588.
UK: Anglia CB Ltd, Yew Tree Farm, Brockford, Stowmarket, Suffolk IP14 5PE. Tel: 04494 345.

Range of audio spectrum analysis systems.

GOULD ADVANCE (UK)
Gould Advance Ltd, Roebuck Road, Hainault, Essex. Tel: 01-500 1000. Telex: 263785.

J3B test oscillator.

HEATH (USA)
Heath Co, Hilltop Road, Benton Harbour, MI 49022. Tel: (616) 982-3411.
UK: Heath Electronics (UK), Bristol Road, Glos GL2 6EE. Tel: 0452 29451. Telex: 42179.

Sine and squarewave generators, oscillators, distortion analysers, audio loads, strip chart recorder and X-Y chart plotter.

HEWLETT-PACKARD (USA)
Hewlett-Packard Corp, 1501 Page Mill Road, Palo Alto, CA 94304. Tel: (415) 493-1501. Telex: 348461.
UK: Hewlett-Packard Ltd, Kings Street Lane, Winnersh, Nr Wokingham RG11 5AR. Tel: 0734 784774. Telex: 847178.

Function generators, oscillators, distortion measurement set, wave analyser, spectrum analyser, strip chart recorders and X-Y recorder plotter.

INOVONICS (USA)
Inovonics Inc, 530B Vandell Way, Campbell, CA 95008, Tel: (408) 374-8300.
UK: Feldon Audio Ltd, 126 Great Portland Street, London W1N 5PH. Tel: 01-580 4314. Telex: 28668.

Realtime ⅓-octave analyser and reverb analysis system.

IVIE (USA)
Ivie Electronics Inc, 500 West 1200 South, Orem, UT 84057. Tel: (801) 224-1800. Telex: 910-971 5884.
UK: FWO Bauch Ltd, 49 Theobold Street, Boreham Wood, Herts WD6 4RZ. Tel: 01-953 0091. Telex: 27502.

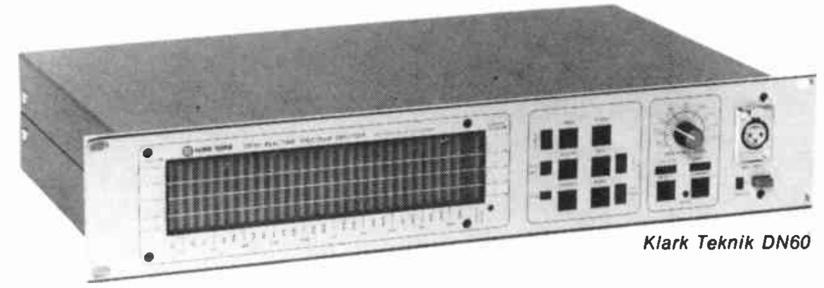
Handheld full-octave real time analyser, handheld pink and white noise generator, handheld 30-band, ⅓-octave analyser, microprocessor audio analyser and range of calibration microphone capsules, preamps and power supplies.

KENWOOD (Japan)
USA: Kenwood Electronics Inc, 1315 E Watsoncenter Road, Carson, CA 90745. Tel: (213) 518-1700. Kenwood Electronics Inc, 75 Seaview Drive, Secaucus, NJ 07094.
UK: Harman (Audio) UK Ltd, Mill Street, Slough SL2 5DD. Tel: 0753 76911. Telex: 849069.

Suitcase-mounted acoustic measuring system includes chart recorder, level meter.

KIKUSUI (Japan)
UK: Telonic Instruments Ltd, 2 Castle Hill Terrace, Maidenhead, Berks SL6 4JP. Tel: 0628 28057. Telex: 849131.

Low distortion oscillator, function generator, sweep generator, AC millivoltmeter, wow and flutter meters, automatic distortion meter, voltage and insulation resistance tester, and a wide range of oscilloscopes.



Klark Teknik DN60

KLARK—TEKNIK (UK)
Klark-Teknik Research Ltd, Walter Nash Road West, Coppice Trading Estate, Kidderminster, Worcs DY11 7HS. Tel: 0562 741515. Telex: 339821.
UK: Autograph Sales Ltd, Stable 11, British Rail Camden Depot, Chalk Farm Road, London NW1 8AH. Tel: 01-267 6677.
USA: Klark-Teknik Electronics Inc, 262A Eastern Parkway, Farmingdale, NY 11735. Tel: (516) 249-3600.

Realtime ⅓-octave spectrum analyser and optional reverb analyser accessory.

LEADER (Japan)
Leader Electronic Corp, 2-6-33 Tsunashima Higashi, Kohoku-Ku, Yokohama 223.
UK: Cybervox Ltd, 105/107 Oyster Lane, Byfleet, Surrey KT14 7JH. Tel: 09323 51051. Telex: 262525. Martron Ltd, 20 Park Street, Princes Risborough Bucks. Tel: 08444 4414.

Audio system analyser, audio tester with signal generator and AC millivoltmeter, frequency response chart recorder, equalising amplifier, distortion meter, wow and flutter meter, tape speed checker, audio generator, low distortion audio generator, AC millivoltmeter.

LEVELL (UK)
Levell Electronics Ltd, Moxon Street, Barnet, Herts EN5 5SQ. Tel: 01-440 8686/449 5028.

Function generator, RC oscillator, AC microvoltmeters, electronic null detector and batter powered insulation tester.

LINDSAY (UK)
Lindsay Electronics Ltd, Ifton Hill House, Portskewett, Newport, Gwent NP6 4TT. Tel: 0291 420517.
UK: Scenic Sounds Equipment Ltd, 97-99 Dean Street, London W1V 5RA. Tel: 011734 2812. Telex: 27939.

Realtime ⅓-octave spectrum analyser.

LINDOS (UK)
Lindos Electronics, Sandy Lane, Bromeswell, Woodbridge, Suffolk IP12 2PR. Tel: (Eyke) 03947 432.

Portable audio analyser and wow and flutter set.

LOFT (USA)
Phoenix Audio Laboratory Inc, 91 Elm Street, Manchester, CT 06040. Tel: (203) 649-1199.
UK: Turnkey, Brent View Road, London NW9 7EL. Tel: 01-202 4366.

Portable test set for basic audio alignment, calibration and testing.

LYONS (UK)
Lyons Instruments Ltd, Ware Road, Hoddesdon, Herts EN11 9DX. Tel: 09924 67161. Telex: 22724.

Sine/square oscillator and distortion meter.

MARCONI (UK)
Marconi Instruments Ltd, Longacres, St. Albans AL4 0JN. Tel: 0272 59292.
USA: Marconi Electronics Inc, 100 Stonehurst Court, Northvale, NJ 07647. Tel: (201) 767-7250, Telex: 710-991 9752.

AF signal source, two tone signal source, AF oscillator, wave analyser, distortion factor meter, automatic distortion meter, AF power meter.

McCURDY (Canada)
McCurdy Radio Industries Ltd, 108 Carnforth Road, Toronto, Ontario M4A 2L4. Tel: (416) 751-6262. Telex: 06963533.
USA: McCurdy Radio Industries Inc, 1711 Carmen Drive, Elk Grove Village, IL 60007. Tel: (312) 640-7077 Telex: 910-222 0436.

Audio level meter.

3M/MINCOM (USA)
3M/Mincom Division, 3M Centre, St Paul, MN 55101. Tel: (612) 733-1110.
UK: 3M UK Ltd, PO Box 1, Bracknell, Berks RG12 1JU. Tel: 0344 26726. Telex: 849371.

Wow and flutter meters, wideband sweep generator, and audio test set.

NAKAMICHI (Japan)
Nakamichi Research Inc, 1-153 Suzukicho, Kodaira, Tokyo. Tel: 0423 42-1111. Telex: 2832610.
UK: Natural Sound Systems, 10 Byron Road,

product reference

Wealdstone, Harrow, Middx HA3 7TL. Tel: 01-863 8622. Telex: 922573.
USA: Nakamichi USA Corp, 220 Westbury Avenue, Carle Place, NY 11514. Tel: (516) 333-5440. Telex: 144513.

Audio analyser.

NEPTUNE (USA)
Neptune Electronics Inc, 934 NE 25th Avenue, Portland, Oregon 97232. Tel: (503) 232-4445.
UK: Court Acoustics (Sales) Ltd, 10-16 Mercer Street, London WC2. Tel: 01-240 3648.

Realtime ⅓-octave spectrum analyser.

NEUTRIK (Liechenstein)
Neutrik AG, FL-9494 Schaan. Tel: 075 263.83. Telex: 77771.
UK: Eardley Electronics Ltd, Eardley House, 182-184 Campden Hill Road, London W8 7AS. Tel: 01-221 0606. Telex: 299574.
USA: Philips Audio Video Systems Corp, 91 McKee Drive, Mahwah, NJ 07430. Tel: (201) 529-3800.

Portable automatic level recorder and modular audio measuring system.

NTP (Denmark)
NTP Elektronik A/S, 44 Theklavej, DK-2400 Copenhagen NV. Tel: 01 10.12.2. Telex: 16378.

Stereo monitor oscilloscope, and gate/burst generator.

PHILIPS (Netherlands)
Philips, Eindhoven, Netherlands. Tel: 040 79.11.11. Telex: 511121.
UK: Pye Unicam Ltd, York Street, Cambridge CB1 2PX. Tel: 0223 358866. Telex: 81215.
USA: Philips Test and Measuring Instruments Inc, 85 McKee Drive, Mahwah, NJ 07430. Tel: (201) 529-3800.

Lindos LA1

2-pen chart recorders, portable single-line chart recorder, single and dual pen X-Y chart recorders, LF generator, sweep generator, wow and flutter meter.

POTOMAC (USA)
Potomac Instruments Inc, 932 Philadelphia Avenue, Silver Springs, MD 20910. Tel: (301) 589-2662.

Audio generator and audio analyser.

PYRAL (France)
Pyral SA, 47 rue de L'Echat, F-94001 Creteil. Tel: (1) 207.48.90. Telex: 23742.
USA: Gotham Audio Corp, 741 Washington Street, New York, NY 10014. Tel: (212) 741-7411. Telex: 129269.

Realtime 28-band ⅓-octave analyser.

RACAL-DANA (UK)
Racal-Dana Instruments Ltd, Duke Street, Windsor, Berks SL4 1SB. Tel: 07535 69811. Telex: 847013.
USA: Racal Dana Instruments Inc, 18912 Van Korman Avenue, Irvine, CA 92715. Tel: (714) 833-1234.

2-tone signal generator and true RMS voltmeter.

RE (Denmark)
Radiometer Electronics A/S, Frederikssundsvej 254, DK-2700 Bronshoj.
USA: Radiometer Electronics US Inc, 811 Sharon Drive, Cleveland, OH 44145. Tel: (216) 871-7617.
UK: Danbridge (UK) Ltd, Sherwood House, High Street, Crawthorne, Berks RG11 7AT. Tel: 03446 2369.

Wow and flutter meter, and analyser.

RCF (Italy)
Radio Cine Forniture, 43029 S Maurizio, Via Notari, Milan. Tel: 0522 24.01.42.
UK: Covemain Ltd, Dunchurch Trading Estate, London Road, Dunchurch, Rugby CV23 9LL. Tel: 0793 486945. Telex: 837537.

Realtime ⅓-octave spectrum analyser.

SENNHEISER (West Germany)
Sennheiser Electronic, D-3002 Wedemark 2, Hanover. Tel: 05130 8011. Telex: 0924623.
UK: Hayden Laboratories Ltd, Hayden House, Chiltern Hill, Chalfont St Peter, Gerrards Cross, Bucks SL9 9UG. Tel: 0753 88447. Telex: 84969.

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product reference

Test equipment

USA: Sennheiser Electric Corp, 10W 37th Street, New York, NY 10018. Tel: (212) 239-0190.

Universal levelmeter and portable impedance tester.

SOLIDYNE (Argentina)
Solidyne SRL, Tres de Febrero 3254, 1429 Buenos Aires. Tel: 701-8622.

Audio frequency generator.

SOUND TECHNOLOGY (USA)
Sound Technology Inc, 1400 Dell Avenue, Campbell CA 95008. Tel: (408) 378-6540. Telex: 357445.
UK: Precision Audio Marketing, Bimini House, Christchurch Road, Virginia Water, Surrey. Tel: 09904 4416.

Tape recorder test system, signal generator and distortion measurement system.

JE SUGDEN (UK)
JE Sugden & Co Ltd, Carr Street, Cleckheaton, West Yorks BD19 5LA. Tel: 0274 872501.

Signal generator, AC millivoltmeter and distortion measuring unit.

SURREY ELECTRONICS (UK)
Surrey Electronics Ltd, The Forge, Lucks Green, Cranleigh, Surrey GU6 7BG. Tel: 0483 275997.

Single and 2-channel chart recorders to PPM characteristic.

TEKTRONIX (USA)
Tektronic Inc, PO Box 500, Beaverton, OR 97077. Tel: (503) 644-0161.
UK: Tektronix (UK) Ltd, Beaverton House, PO Box 69, Harpenden, Herts. Tel: 05827 63141. Telex: 25559.

Bandpass filter/amp, oscillator and spectrum analyser.

TECHNICAL PROJECTS (UK)
Technical Projects Ltd, 63 Victoria Street, Windsor, Berks SL4 1EH. Tel: 07535 58154. Telex: 849988.

Audio measuring system test set and automatic reverb timer.

UREI (USA)
United Recording Electronics Industries, 8460 San Fernando Road, Sun Valley, CA 91352. Tel: (213) 767-1000. Telex: 651389.
UK: FWO Bauch Ltd, 49 Theobold Street, Boreham Wood, Herts WD6 4RZ. Tel: 01-953 0091. Telex: 27502.

Mainframe X-Y plotter with wide range of modules.

WAYNE KERR RADFORD
Wayne Kerr Radford Ltd, Durban Road, Bognor Regis, West Sussex PO22 9RL. Tel: 0243 825811. Telex: 86120.

Audio measuring test set. RMS noise meter, frequency response analyser, oscillator and portable harmonic distortion measuring sets.

WHITE (USA)
White Instruments Inc, PO Box 698, Austin, TX 78767. Tel: (512) 892-0752.
UK: Scenic Sounds Equipment Ltd, 97-99 Dean Street, London W1V 5RA. Tel: 01-734 2812. Telex: 27939.

Realtime 27-band, ⅓-octave and 30-band ⅓- or 1/6-spectrum analyser.

WOELKE (West Germany)
Woelke Magnetbandtechnik GmbH, Woelkestrasse 2-3, D-8069 Schweitenkirchen. Tel: 08444 394. Telex: 55547.
UK: Lennard Developments Ltd, 206 Chase Side, Enfield, Middx EN2 0QX. Tel: 01-363 8238.
USA: Audicon Inc, 1200 Beechwood Avenue, Nashville TN, 37212. Tel: (615) 256-6900. Telex: 554494.

Wow and flutter meters, wave analyser and automatic distortion meter.

XEDIT (USA)
Xedit Corp, 133 South Terrace Avenue, Mt Vernon, NY 10550. Tel: (914) 668-0388.
UK: Scenic Sounds Equipment Ltd, 97-99 Dean Street, London W1V 5RA. Tel: 01-734 2812.

Portable drift and flutter meter. ■

Test tapes

AGFA (West Germany)
Agfa-Gevaert AG, D-509 Leverkusen.
UK: Agfa-Gevaert Ltd, 27 Great West Road, Brentford, Middx TW8 9AX. Tel: 01-560 2131. Telex: 28154.
USA: Agfa-Gevaert Inc, 275 North Street, Teterboro, NJ 07608. Tel: (201) 288-4100. Telex: 0134410.

Range of recording test tapes in a variety of widths and speeds to the DIN/IEC format only.

AMPEX (USA)
Ampex Corp, 401 Broadway, Redwood City, CA 94063. Tel: (415) 367-2011. Telex: 348464.
UK: Ampex Great Britain Ltd, Acre Road, Reading RG2 0QR. Tel; 0734 875200. Telex: 848346.

Test tapes in all size formats between ¼ and 2 in in full and separate tracking; 30, 15, 7½ and 3¾ in/s; EQ to DIN or IEC (30 in/s uses AES).

BASF (West Germany)
BASF AG, Carl Bosch Strasse 38, D-6700 Ludwigshafen/Rhein. Tel: 0621 601. Telex: 464811.
UK: BASF UK Ltd, Haddon House, 2-4 Fitzroy Street, London W1P 5AD. Tel: 01-388 4200. Telex: 28649.
USA: BASF Systems Inc, Crosly Drive, Bedford, MA 01730. Tel: (617) 271-4000.

Test tapes in all size formats to IEC/DIN specification only.

CAMFORD (UK)
Camford Productions, 4 Cambridge Drive, Eastcote, Ruislip, Middx HA4 9JS. Tel: 01-866 3790.

IEC format ¼ in test tapes; full track 7½ or 15 in/s.

FERROGRAPH (UK)
Audio Video Marketing, Unit 21, Royal Industrial Estate, Jarrow, Tyne & Wear NE32 9HR. Tel: 0632 893092. Telex: 537227.
USA: Neal-Ferrograph (USA) Inc, 652 Glenbrook Road, Stamford, CT 06906. Tel: (203) 348-1045. Telex: 643678.

Series of ¼ in test tapes including 0 VU DIN + 70µs, ¼-track alignment; NAB, DIN, IEC and CCIR EQ.

LENNARD (UK)
Lennard Developments Ltd, 205 Chase Side, Enfield, Middx EN2 0QX. Tel: 01-363 8238.

Manufacture and distribution of test tapes.

MRL (USA)
Magnetic Reference Library Inc, 229 Polaris Avenue, Suite 4, Mountain View, CA 94043. Tel: (415) 985-8187.
UK: FWO Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts WD6 4RZ. Tel: 01-953 0091. Telex: 27502.

Wide range of test tapes, each with calibration graph; most available in ¼ in, ½ in, 1 in and 2 in and at 7½, 15 and 30 in/s speeds (with three tapes at 3¾ in/s); NAB, IEC and AES EQ.

STL (USA)
Standard Tape Lab Inc, 26120 Eden Landing Road, No 5, Hayward, CA 94545. Tel: (415) 786-3546.
UK: Precision Audio Marketing, Bimini House, Christchurch Road, Virginia Water, Surrey. Tel: 09904 4416.

Range of test tapes, ¼ in; 3¾, 7½ and 15 in/s NAB or IEC, also 30 in/s AES; mono or 2-track. Other widths to order.

WEBBER (UK)
Webber Tapes Ltd, Coburg House, Western Road, Wood Green, London N22. Tel: 01-889 9347.
UK: Pangbourne Musical Distributors Ltd, PO Box 19, Stratford-on-Avon, Warwickshire CV37 6SA. Tel: 0789 88579. Telex: 317148.

Range of tapes with format and tone durations NAB or IEC EQ available in ¼, ½, 1 and 2 in widths, variously at 7½, 15 and 30 in/s. ■

Cables

ALPHA (USA)
Alpha Wire Corp, 711 Lidgerwood Avenue, Elizabeth, NJ 07207, USA. Tel: (201) 925-8000.
UK: Alpha Wire Ltd, Central Way, North Feltham Trading Estate, Feltham, Middx. Tel: 01-751 0261. Telex: 8813660.

Extensive range of wire and cables suitable for audio and transmission use.

AUDICON (USA)
Audicon Marketing Group, 1200 Beechwood Avenue, Nashville, TN 37212, USA. Tel: (615) 256-6900.
UK: Trad Electronic Sales Ltd, 149b St Albans Road, Watford WD2 5BB. Tel: 0923 47988. Telex: 262741.

Range of multicore cable available in 32, 24, 10, 8, 4 or single pair configurations.

BELDEN (USA)
Belden Corp, PO Box 1331, Richmond, IN 47374, USA. Tel: (317) 966-6661.
UK: Leonard Wadsworth & Co (Electronics) Ltd, Warehouse Block F, Imber Court Trading Estate, Orchard Lane, East Molesey, Surrey KT8 0DA. Tel: 01-398 4288. Telex: 264028.

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product reference

Cables

Vast range suitable for most electrical and electronic applications.

BICC (UK)
BICC General Cables Ltd, Helsby, Warrington, Cheshire WA6 0DJ, UK. Tel: 092-82 2700.

PVC and polythene insulated cables including multipairs, mic and loudspeaker leads.

BOFA (Sweden)
Cliff Electronic Components Ltd, 97 Coulsdon Road, Caterham, Surrey CR3 5NF, UK. Tel: 0883 47713. Telex: 8813346.

Low cost aluminium foil screened cables with integral drain wire (not flexible) and overall screened multicore cables and stranded conductors.

BIW (USA)
Boston Insulated Wire & Cable Co, 65 Bay Street, Boston, MA 02125, USA. Tel: (617) 265-2102. Telex: 940604.
UK: Boston Insulated Wire (UK) Ltd, 1 Canbury Park Road, Kingston-upon-Thames, KT2 6JY. Tel: 01-546 3384. Telex: 21885.

Specialist manufacturer of cables for OB and studio use.

CANFORD AUDIO (UK)
Canford Audio, Stargate Works, Ryton, Tyne and Wear NE40 3EX, UK. Tel: (091) 413 7171. Telex: 537792.
USA: Canford Audio (USA) Inc, 652 Glenbrook Road, Stamford, CT 06906, USA. Tel: (203) 324-2889. Telex: 643678.

3-way audio cable tester with seven test sequences.

CONNECTRONICS
(UK) Connectronics Ltd, 20 Victoria Road, New Barnet, Herts EN4 9PF. Tel: 01-449 3663/4044. Telex: 8955127.
USA: Connectronics Inc, 652 Glenbrook Road, Stamford, CT 06906. Tel: (203) 324-2889. Telex: 643678.

Coloured mic cable and multicore cable for stage boxes; modular stage link systems including cables, connectors and stage boxes; multipair cables available in six to 31 pairs.

DAVU (UK)
Davu Wire & Cables Ltd, Harrow Manorway, Abbey Wood, London SE2 9AA, UK. Tel: 01-310 7036. Telex: 896767.

Mic and subminiature cables.

EDCOR (USA)
Edcor 16782 Hale Avenue, Irvine, CA 92714. Tel: (714) 556-2740.

Mic cable transmission system accepting up to eight audio signals over a single mic cable.

EMT (Switzerland)
EMT Franz GmbH, Postfach 1520, D-7630 Lahr, West Germany. Tel: 07825 512. Telex: 754319.
UK: FWO Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts WD6 4RZ. Tel: 01-953 0091. Telex: 27502.
USA: Gotham Audio Corp, 741 Washington Street, New York, NY 10014. Tel: (212) 741-7411. Telex: 12969.

Specially designed range for audio applications with 'Reusen' shielding.

FUTURE FILM (UK)
Future Film Developments, 36/38 Lexington Street, London W1R 3HR, UK. Tel: 01-437 1892. Telex: 21624.

Mic cables with 'Reusen' shielding and multipair cables — *M Series* to 51 pairs and *J Series* to 32 pairs.

GOTHAM (West Germany/Austria)
Gotham Audio Corp, 741 Washington Street, New York. NY 10014, USA. Tel: (212) 741-7411. Telex: 129269.
UK: FWO Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts WD6 4RZ. Tel: 01-953 0091. Telex: 27502.

High quality mic cables with double layer 'Reusen' shielding, multi-pair snake and RF-proof shielded cable.

ILLINOIS (USA)
Illinois Cable Company, 8225 N Christiana, Skokie, IL 60076, USA. Tel; (312) 679-0160.

2- and 3-conductor shielded cable, and multipair cable available in three to 27 pairs in 7×30 or 16×30 gauge.

LECTRIFLEX (UK)
Lectriflex Cables & Accessories Ltd, The Paddocks, Frith Lane, Mill Hill, London NW7 1PS. Tel: 01-349 2011. Telex: 28915.

Instrumentation cables in single to 100 pairs.

LEMO (UK)
Lemo (UK) Ltd, 12 North Street, Worthing, Sussex BN11 1DU. Tel: 0903 34543.

Range of coloured tapered cable sleeves and socket identification washers for standard and B range connectors.

KEITH MONKS (UK)
Keith Monks (Audio) Ltd, 26-28 Reading Road, South Fleet, Aldershot, Hants, UK. Tel: 02514 20568. Telex: 858606.
USA: Keith Monks (USA) Ltd, 652 Glenbrook Road, Stamford, CT 06906. Tel: (203) 348-4969.

Stackable cable drums.

NEK (Norway)
Norsk Elektrisk Kabelfabrik, Etterstadkroken 9, PO Box 23, Bryn, Oslo 6. Tel: (02) 67.41.80. Telex: 18001.
UK: NEK (UK) Ltd, 88 Easton Street, High Wycombe, Bucks, Tel: 0494 447024.

Wide range of mic and multipair cables from two to 10 pairs.

PANDUIT (UK)
Panduit Ltd, Lordswood Industrial Estate, 61/65 Revenge Road, Chatham, Kent ME5 8YT. Tel: 0634 660811/5.

Range of cable ties, cable ducting, wiring aids and accessories.

PLAN AUDIO (UK)
Plan Audio, 27B Bell Street, Reigate, Surrey. Tel: 07372 22249.

Powerline: range including instrument cables with jacks and mic and speaker cables.

PRO-CO (USA)
Pro-Co Sound Inc, 135 E Kalamazoo Avenue, Kalamazoo, MI 49007. Tel: (616) 342-0269.

Mic and line level cables using Belden cable.

PRO SOUND (USA)
Pro Sound, 13717 S Normandie Avenue, Gardena, CA 90249, USA. Tel: (213) 770-2330.

Coloured mic cables with Switchcraft *XLR*-type or miniature *QG* connectors.

PROPHON (UK)
Prophon Sound Ltd, 90 Wilsden Avenue, Luton LU1 5HR. Tel: 0582 30726.

Active stage boxes with jack or *XLR* connectors.

SOUND APPLICATIONS (USA)
Sound Applications Ltd, 342 Lexington Avenue, Mount Kisco, NY 10549, USA. Tel: (914) 241-0034.

Coloured audio cables 20- or 24-gauge, for guitars, headphones, mics and speakers.

STATESIDE (USA)
Peavey Electronics Corp, 711 A Street, Meridan, MS 39301, USA. Tel: (601) 483-3565.
UK: Peavey Electronics (UK) Ltd, Unit 8, New Road, Ridgewood, Uckfield, Sussex TN22 5SX. Tel: 0825 5566.

Straight or curled stage leads using Belden cable and Switchcraft jacks.

TECHNICORD (UK)
Technicord Ltd, Melbourn House, 2 Black Bank Road, Little Downham, Ely, Cambs CB6 2TZ, UK. Tel: 035387 721.

Coloured audio leads with Switchcraft *XLR*-type connectors; 'Reusen' screened ultra-flexible equipment cable; equipment lead.

TROMPETER (USA)
Trompeter Electronics Inc, 8936 Comanche Avenue, Chatsworth, CA 91311. Tel: (213) 882-1020.
UK: Lee Engineering Ltd, Napier House, Bridge Street, Walton-on-Thames, Surrey KT12 1AP. Tel: 09322 43124.

Range of patch cords, cable assemblies, plus twinax, triax, and quadrax cables.

WHIRLWIND (USA)
Whirlwind Music Inc, PO Box 1075, Rochester, NY 14603, USA. Tel: (716) 663-8820.
UK: Atlantex Music Ltd, 1 Wallace Way, Hitchin, Herts SG4 0SE Tel: 0462 31511. Telex: 826967.

Straight or curled instrument and mic cables with high quality jacks; patch cords from 1 ft length, multiway systems with stage boxes, multicores and multiple connectors for mixer.

WIREWORKS (USA)
Wireworks Corp, 380 Hillside Avenue, Hillside, NJ 07205, USA. Tel: (201) 686-7400. Telex: 710-985 4675.

Range of hardwired mic multicable systems comprising stage box, multicore and individual tails for mixer; mic cables with *XLRs*; cable testers and cable marking system. ■

COMPACT disc DIGITAL AUDIO

A technical introduction

Following the two articles on aspects of *Compact Disc* which we carried in the July issue, Hugh Ford now completes our current overview of the system with further technical comments, and summarises aspects of the system covered in our previous articles.

THE *Compact Disc* is currently being marketed solely as a source of very high quality stereophonic audio, but there's more to it than that, the use of some facilities as yet being undecided by the Sony/Philips originators.

Like an analogue disc there is a run-in section, *the* music section and a run-out section all of which may contain information in a digitally encoded form. Within the run-in section *Compact Discs* have a table of contents recorded (known as TOC). The TOC includes the number of recorded tracks together with their time from the start of the disc in minutes, seconds and frames—a frame being 1/75th of a second and not a SMPTE type frame. In addition the TOC includes the time from the end of the lead-in area to the start of the lead-out area, plus the identification number of the disc which corresponds to its catalogue number.

Within the music sections of the disc there is the potential to record (and recover) eight separate sub-codes known as P, Q, R, S, T, U, V, and W. The data contained in each of the sub-code channels, which are identical, is multiplexed into the digital audio data.

As yet only sub-code channels P and Q have allocated uses, the P channel being used for the pause signal between music tracks and at the beginning of the lead out area. The Q channel being divided into a number of sections which include instructions to tell the player if a particular section is with or without pre-emphasis and if it is a 2-channel or 4-channel recording.

The data section of the Q channel includes track number (TNO), time in minutes, seconds and frames and the International Standard Recording Code (ISRC) for the recording, this including the country of origin, the owner, the year of recording and the serial number of the recording.

This is a rather simplified summary of the sub-code channels, as for instance the Q channel has three different modes.

Laser disc

Like a conventional record the *Compact Disc* has a spiral of tracks, but on a 1.6 µm track pitch starting at the inside of the disc and working outwards—this allowing smaller diameter discs to be produced in the future. The current 120 mm diameter disc has about 20,000 information spirals in the programme area which covers 50 mm to 116 mm diameter with the lead-in area occupying 46/55 mm diameter.

The digital recording takes the form of a series of laser cut pits 0.5 µm wide in eight different lengths between 0.833 µm and 3.56 µm as shown in **Fig 1**.

As can be readily appreciated it is no simple matter to follow the very fine tracks on the disc. Whilst it would be impossible to follow the tracks by pure mechanical means the specified eccentricity of the disc is ±50 µm about its 15 mm centre hole. When replaying a disc this permitted eccentricity is corrected by a track following servo system.

How is the disc made

Whilst the original recording may take any form, the recommended master for transfer to *Compact Disc* takes the form of a digital recording on a ¾ in *U-Matic* type video cassette recorder using a PCM adaptor such as the Sony *PCM 1610* which handles 16 bits at a sampling frequency of 44.1 kHz. This is identical to the *Compact Disc* technical requirements.

SMPTE type timecode is recorded on analogue track 1 of the video tape (the maximum music duration being 60 min) with the analogue track 2 being used to record the P and Q sub-code information (no format being defined for the Q, R, S, T, U, V, and W sub-code channels).

The video cassette is then used at the start of the mastering process where the audio and data from the video cassette are electronically formatted into the compact disc code and fed to a laser beam recorder **(Fig 2)**.

The master disc starts life as an optically flat glass disc on to which is applied an adhesive layer followed by a layer of photo resist which is cured by heating—the resist master disc is then ready for recording. Under climatically controlled dust-free conditions a laser modulated by the encoded digital data is focused on to the disc using a servo system which controls the laser's focus by examining the reflected spot from the disc's surface. The formation of

FIG. 2
RECORDING ENCODER

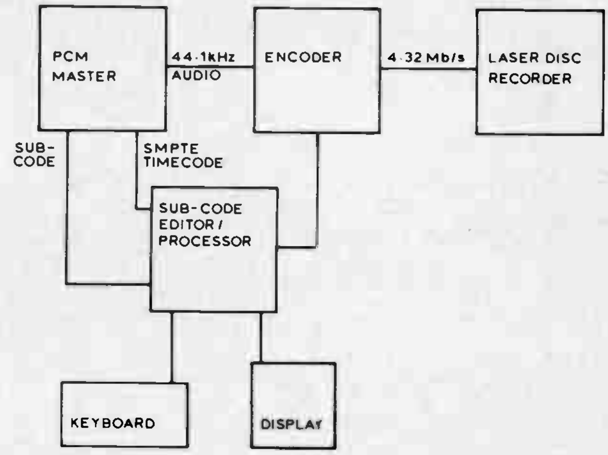
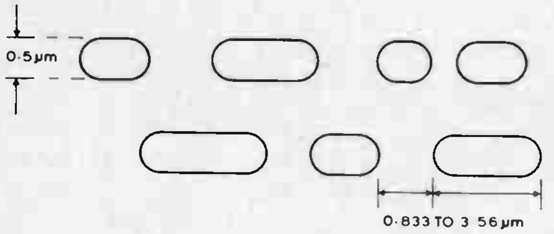


FIG. 1
RECORDED PITS



to Compact Disc

Hugh Ford

the spiral and the required constant (1.2 m/s) linear velocity of the disc are under computer control.

In the next process the recorded resist master is developed in an etching process during which the transmission of a laser beam through the disc is used to monitor the geometry of the pits being etched in the disc.

Once development is complete the glass resist master disc receives a thin silver plating allowing final mechanical and initial electrical inspection before the preparation of a nickel shell by electroplating. As with analogue disc production this master is known as the 'father'. By further plating processes 'mothers' are made from the 'father' with the mothers being plated to produce 'sons' or stampers as shown in **Fig 3**.

The final product is injection moulded from transparent plastic using the stampers and an aluminium layer is evaporated on to the indented side of the plastic to provide a reflective surface for the readout laser. This surface is then provided with a protective film 30 μm thick with the overall thickness being 1.2 mm **(Fig 4)**.

Labelling is done on the protective layer with readout being through the thickness of the transparent disc which has a refractive index of 1.5.

Reading the disc

The digital readout of the pits in the disc poses a number of problems in view of the minute dimensions involved—0.5 μm wide pits on a 1.6 μm track pitch. Basically the laser optical system has to be accurately focused on to the disc whilst tracking the spirals with the disc run at a constant linear velocity.

Constant linear velocity is obtained by locking the disc rotation servo motor to the data rate from the disc during replay, but the run-up to the correct speed is a rather complicated process.

Focusing and tracking are further problems which require a sled motor to move the optical pickup system across the disc in conjunction with a 2-axis servo device which moves the optical system vertically for focusing and laterally to provide fine control of the tracking.

The two axis control is achieved by moving the optical system with electromagnetic transducers which work in a similar way to a loudspeaker, one for each axis.

The optical system is arranged such that light patterns, as shown in **Fig 5**, are obtained when the optical system is too far from the pits, too close or correct. These patterns are detected by four detectors 1, 2, 3 and 4 which are combined as follows to control the focus servo coil:

$(1+3)-(2+4) > 0$ Optics too close
$(1+3)-(2+4) = 0$ In focus
$(1+3)-(2+4) < 0$ Optics too far

The added outputs of these four detectors also provide the digital readout from the disc in addition to working with two further side spot

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FIG. 3
REPLICATION

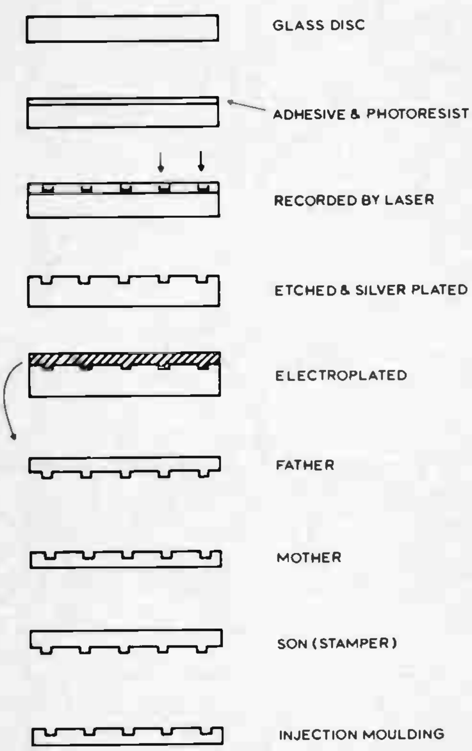


FIG. 4
THE FINAL DISC

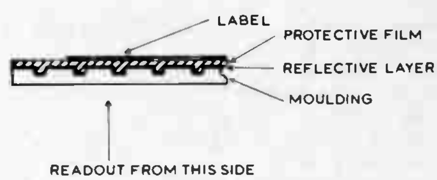
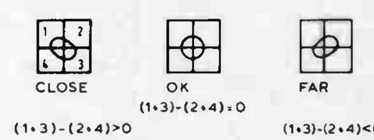


FIG. 5
FOCUS MECHANISM



Compact Disc introduction

detectors which detect the pit positions as shown in **Fig 6**. Sensing the three outputs provides information for the 2-axis servo and the sled motor to track the spiral on the disc.

Remembering that the recorded surface of pits is buried in the plastic mouldings of the disc a significant distance below the surface, the surface itself is well out of focus. This means that surface defects including fingerprints and debris will be well out of focus and thus have a minimal effect upon the read-out of data.

Signal processing

Normal sources of digital audio for transfer to *Compact Disc* take the form of a continuous stream of digital data based on sampling at 44.1 kHz with 16-bit resolution per channel for the left and right channels. This data arrives without any form of error correction or detection.

The requirement for the *Compact Disc* system is to reformat this data in a suitable form for recording onto disc whilst adding error detection and correction and also the control data channels P, Q, R, S, T, U, V and W.

In order to reduce the frequency of transitions whilst reducing the DC content of the code and providing a suitable self clocking element in the code, a system known as eight to 14 modulation (EFM) is used, the recorded data being in the form of blocks of data known as frames.

EFM works such that there is a one recorded at least once in every 10 digits with consecutive ones being separated by at least two zeros. **Fig 7** shows the relationship between the EFM data and the pits, a one being represented by the edges of each pit.

Reference to **Fig 8** shows how the digital audio is transformed for recording onto disc. The original audio signal is first divided into symbols each of eight bits, a stereo signal consisting of $2\times(8\times2)=32$ bits or $32/8=4$ symbols.

At this stage six samples from each of the left and right channels are combined to form $6\times4=24$ symbols which form the audio part of each frame. From here the digital audio passes to the error correction part of the system in the form of a Cross Interleave Reed Solomon Coder (CIRC) which adds redundant P and Q parity data (not to be confused with P and Q control data) adding a further 8 symbols to the frame now consisting of $24+8=32$ symbols each of 8 bits. This system allows subsequent detection and correction of data errors on replay.

Before the EFM encoder a further symbol of 8 bits is added, this consisting of 8 control bits, one for each of the P, Q, R, S, T, U, V and W channels. At this stage each frame contains the data shown in **Table 1** at a frame rate of 7.35 kHz.

This symbol stream is passed to the EFM modulator where each 8-bit symbol is converted to 14 bits with the addition of 24 synchronisaton bits and 102 coupling bits to each frame, three coupling bits being used to join each of the 33 symbols and the synchronisation signal, the final frame to be recorded having 588 bits at a data rate of 4.32 Mb/s.

Replay

Different disc players use different methods to recombine the audio signals, but all players have to deal with the same recorded format. Basically the differences between audio replay chains lies in the digital to analogue conversion methods and the subsequent filtering which effects the phase shift and overshoot, plus the amount of sampling frequency related components in the output.

With the exception of the P and Q sub-codes no current players use the full set of sub-code channels, the P channel being used to mute the audio output between tracks and the Q channel to switch the pre-emphasis circuits.

Overview

The *Compact Disc* system is capable of an excellent performance given good original recordings—something that the record industry seems to find difficult at the moment!

Experience to date shows that most discs have acceptable error rates with few uncorrected errors being apparent as 'spits' in the recorded material. Unfortunately there appears to be some confusion about the timing of the P sub-code, with the result that premature mutes occur on some discs.

Another factor is that mistracking is not a thing of the past and players vary in their tracking capabilities.

Given good recordings there is in my opinion no comparison between the sonic qualities of analogue media and the *Compact Disc*. ■

Table 1

	Bits	Symbols
Left and right audio	192	24
CIRC parity P + Q	64	8
Sub-code channels × 8	8	1
Total	**264**	**33**

FIG.6
TRACKING DETECTOR

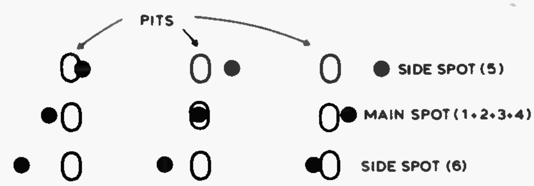


FIG.7
DATA FROM DISC

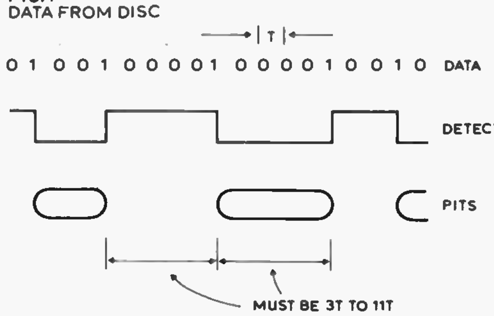
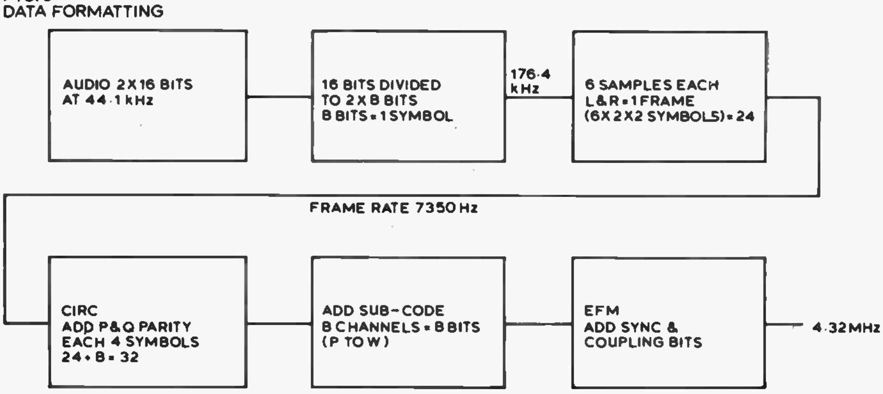
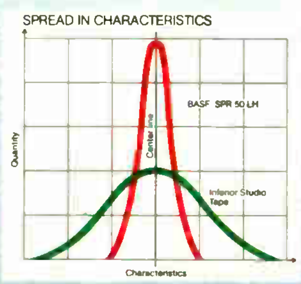


FIG.8
DATA FORMATTING



From reel to reel from batch to batch from delivery to delivery quality and consistency.

Compelling characteristics of SPR 50 LH are not only its excellent and well balanced electro-acoustical properties but especially also its consistency. (Narrow tolerances for all characteristics.) You know what it means when things go fast and furious in the studio: No time for adjusting or aligning.



You have to be able to rely on a tape whose characteristics remain; both unchanged and top quality.

BASF's SPR 50 LH gives you this surety.

Reliable in operation
BASF SPR 50 LH.

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The recording industry changes at quite a rate. New techniques take over from old, and new fashions overshadow more traditional approaches. Sometimes it is tempting to say that things change too much, too fast. Or is it merely that sometimes we get left behind? If you are worried that perhaps things are changing just a little too fast for you, try this checklist of answers to the question: 'Am I too old for the job?'...

You're too old if...

1 The producer asks you where the other 10 drum tracks are.
2 Session drummers ask you where the rest of the mics are (if they ask you why you don't use a snare mic, score five bonus points).
3 The session drummer ignores your studio full of mics and asks where he can plug his box into some DI boxes in the control room.
4 Drummers complain that your snare sound 'isn't nasty enough'.
5 The drum machine (sequencer, micro-composer, synchroniser) refuses to sync to your timecode track.
6 You are called on to produce your tuning fork because neither of the guitarists can agree on which of their tuning boxes is giving a true A = 440 Hz.
7 You think that 16-track on 2 in is quite sufficient and offers better quality.
8 You think that 24-track is an excuse for producers to avoid taking decisions at the right time.
9 You refuse to use Dolby and record at 30 in/s *not* because you went off Dolby as it changed the sound, but because your studio never quite liked the idea of getting any.
10 You discover that no other engineer in the building remembers what a coincident pair is (if they never knew in the first place, you're mixing with the wrong people).
11 You express the view that all engineers should be capable of recording the band straight to stereo.
12 You habitually point out to the MD that there was a bum note on the first violins on the third beat of the eighth bar of Letter B (if you *can't* read music but still do this, claim the Bullshitter of the Year Award).
13 You spend half an hour looking for the remotes for the EMT plates and are about to go off in search of the plate room before you ask the assistant engineer, who introduces you to the digital reverb unit in the rack.
14 You reach for two (or more) tape machines when the producer suggests phasing or flanging (some may say that if the producer asks for phasing or flanging, *he's* getting too old).
15 You haven't liked any British record in the UK charts since 1976.
16 You think that all the best records made since 1976 have been made in the USA (if you are British).
17 You think that all the best records are made by ex-patriate English engineers and producers (if you are American).
18 You don't believe that microtonal vocal lines have any application in pop music (if you are prepared to suggest that they are in reality out of tune, add 10 points).
19 The motorised faders on the automation system won't let go when you try pushing up the guitar track in the solo.
20 You object to having to crossfade between eight lead vocal tracks during the mix.
21 You know absolutely anything at all accurate about disc-cutting (if you are a cutting engineer or have cutting experience, add 10 points).
22 You think that the studio is so dead that you *need* more than four mics on the drums.
23 You don't know much about using noise gates because you never had much trouble with noise when cutting direct to disc/recording straight to stereo/working full-track mono/using 4- (or 8- or 16-) track equipment (delete as appropriate).
24 You have trouble with modern consoles of the in-line type when main fader 6 controls the bass guitar level and the fader above it controls the left-hand-side of the acoustic piano monitor level (UK only?).
25 You use rather a lot of track-sheets because you keep scribbling unreadable hieroglyphics on them, and nobody can read your box labels (the tape-op ought to be doing it, but there isn't one).
26 You can't find the last track on the reel, the one called 'Non-Dolby'.
27 You wonder why there are only two musicians in the studio while the rest of the band are cluttering up your control room and you're supposed to be recording basic tracks.
28 Everyone in the studio shrieks in anguish when you suggest editing the multitrack.
29 You can't find any razor blades.
30 The 2 in splicing block is apparently: missing, presumed dead/somewhere in maintenance/only there for show ("Actually, we use it to put out lines of DeLorean, because there isn't a flat bit on the desk which isn't finished in padded Naugahide, and unfortunately it gets stuck in the groove. You might get a good buzz out of it, though.")
31 All the available razor blades are: coated with coke (sorry, Coke™) or ruined by sharpening Chinagraph pencils (not for edits, of course, but for the writing strip).
32 You *still* can't find any razor blades.
33 The studio invoicing computer keeps charging *you* with all manner of extras that you don't remember having had the benefit of during the session ('*How many* cans of Coke™?!').
34 You get dirty looks and ruin the atmosphere of the session by suggesting that studios are rather expensive rehearsal rooms and that *House of the Rising Sun* was recorded in one take for under £2.

Remedies and excuses

If the problems presented above cause you embarrassment, here are some excuses and remedies which might get you out of trouble:

1 "I think that this drummer has such a good acoustic integration and overall 'feel' that the sound would benefit from recording straight to stereo. It also means that I can patch in a stereo compressor on the mix without tying up all 24 subgroups, which I'll need for the vocals."
2 "You have such a good acoustic output level from your kit—the sound must be absolutely *amazing* live—that these three mics alone will give us a really excellent live 'feel'. You'll like it."
3 "I thought we would get a really interesting sound by putting the drum machine through the guitar amps and miking them up. But if you prefer . . ."
4 "I think you should try taping it up/detuning/tuning it—it doesn't sound particularly nasty out here either." (Standing next to the kit.)
5 "I think there's a fault on your (. . . .)—it won't sync to timecode. It *is* SMPTE, isn't it?"
6 "I checked this tuning fork against my quartz-controlled reference this morning and it's definitely in. Your boxes use simple L-C circuits and drift with temperature. If I turned the air-conditioning down, they'd both be right, but you wouldn't like working at 0°C, which is how they calibrate those particular units."
7 ". . . but they don't make a 16-track headblock for this machine anymore, and ours got so much use that we wore out the

replay head on (*famous name*)'s last album. He swears by 16-track. Luckily we have the new Mk 5 machine here, which has excellent 24-track performance."

8 Don't tell anybody.

9 "It changes the sound. Besides, 30 in/s tightens up (ie reduces) the bass end, and gives much better performance. It's as much a difference as 15 is from 7½."

10 Keep it to yourself and use it on drums or for ambience for stunning results.

11 "It teaches you a great deal about handling stereo pairs on 24-track and enables you to get a monitor mix together really fast." If this isn't good enough, don't express the view.

12 "I think there was a funny note somewhere . . . I think it was . . . er . . . after that guitar break, you know, just before he sings '. . . and the something something . . .' I'll point it out when we play it back . . ." If you are merely bullshitting, keep it up.

13 "But don't you think the (name of reverb unit) is a bit clinical? You know, when you put something like a glockenspiel into it on 10 s decay time you get all kinds of quantisation errors. I think a plate would have sounded really good in that point between the second and third verses. Can we hire one?"

14 "I really think that your money would be better spent getting the tape machines together now, rather than you having to book another session to remix it next week because you don't like the lack of cancellation from the MexiMegalon *Multiflanger*. I wouldn't want you to go over-budget. Look, I'll set it up over lunch and we'll do two mixes, one with each. I promise you'll prefer the tape. You just order me a beer and a club sandwich . . ."

15 Nor did anyone else.

16 Perhaps they were.

17 See above.

18 American studios regard British engineers very highly. Are you working in the wrong country? See above.

19 "It didn't go into 'Update' when I pressed the button—either that, or it dropped straight out again. Look, the LED isn't lit. I think someone has spilled something on the keypad: it's the only flat place on the console that isn't covered with Naugahide. Could someone call maintenance? I'm sure they'll take 1½ hours off the bill. You go to lunch, and I'll follow you when they've sorted it out. Order me a beer and a . . ." (See elsewhere.)

20 "But the vocal on track 17 has a really nice feel. It's a complete performance, no drop-ins, no nothing. I know he sings the wrong words in the second verse, but they can always change the lyric sheet and the inner sleeve . . ."

21 Good for you. Please try and educate your colleagues, especially on how to do stereo effects on the bass guitar without ruining the cutting stylus, so that you don't need to put that horrible elliptical equaliser in the way.

22 You probably do. When you go freelance, you will be able to record somewhere else. Many British studios are quite live, these days, and with the exchange rate being what it is, it could be really economical. It will also give the band a chance to see a really nice country which they are *bound* to tour when the album you are going to do here becomes a smash hit. Make sure you are on a percentage.

23 "I think it's those XYZ guitar amps. They really hiss quite a lot. You know, I've never heard an amp that is so noisy. The sound's great, though. I'll use the gates, but don't be surprised if the sound of the . . . changes for the worse."

24 "European-style consoles with separate monitor panels are very fashionable these days. I've done a lot of work at Bloggs Sound down the road, and it's surprising how easily you become accustomed to that way of working. It takes a bit of time to get back into using this one again. But that bass sound is really great, don't you think? I love the EQ here . . ."

25 "It was a really exciting session, you know . . . we got such a buzz going that we did all the backing tracks in the first morning, and all the basic overdubs were completed in the first week. I'm sorry to hear that the sessions didn't go so well after you took over. No, we didn't really have the time to write much on the tracksheets or the boxes. The producer did most of them, I was so busy. The tones are on the *very end* of the last reel, after the long Chinagraph mark on the tape." Simply saying "I didn't write out the labels" is not good enough on its own, as everyone will know your writing. Use plenty of different-coloured pens, pencils and so on. A few drops of blood on one of the tracksheets might help.

26 "I thought they did a version of Bruce Springsteen's 'Ain't got no Dolby' on the session and you didn't have the time to write down the full title. Or was it by the Stones? You know, the one with the screaming guitar intro and . . ." *Or* ". . . Then why did you put a number next to it?" This latter excuse needs a little preparation and assumes that the previous engineer didn't use his own pencil. In any event, the pencil should be found next to the EQ knobs between channels 13 and 14.

27 Suggest that all the 'spare' musicians line up and take turns on the *Asteroids* machine in the corridor outside Studio One. Ask the studio manager for a cut of the profits: the musicians will have plenty of time, and 10% will double your income.

28 Do the edit during lunch. When you have finished, go to the pub and buy everyone doubles, except you (you will need a clear head). When you all get back, say either, "It's a copy, don't worry", or something like. "But don't you remember? You didn't play the solo on the master take: the autolocator has a problem, and I think we were listening to Take 27 before lunch." These excuses both assume a novel and as yet undiscovered method of making splicing tape invisible or at least black (brown? pink? *yellow*?), so are risky to say the least. If the others are sufficiently drunk, therefore, you might try persuading them (or at least the producer, who will then be on your side) that they already agreed that an edit was the best solution, rather than doing something more hazardous (eg dropping in on all 17 tracks). Best, though, to really persuade them, honestly.

29 You may also use this as an excuse to bow out of the above problem gracefully, in which case you should point out the fact that there aren't any razor blades. If you need them, of course, the real remedy is to bring your own.

30 Splicing blocks of any larger width than ¼in are expensive, so you can't really be expected to bring your own. The producer probably hid it last time you went out to adjust the vocal mic (remember it was *he* who suggested that the vocalist wasn't together enough to adjust it himself?) because he knows you have a perverse liking for slicing rusty plastic. He also hid the razor blades, like as not, for the same reason. You obviously have a good working relationship: he knows you very well and you have been making hits as a team for years. In which case *he* will OK the expenditure and the cab fare to send someone to get one.

31 We have already covered this topic, I believe; try up the page a bit.

32 This is now your problem. OK?

33 Sneak into the computer room. Access the appropriate record in the billing system which has *your* name and address in it. Change it so that it bills the studio . . . On second thoughts, don't do this. Simply don't bill *anyone* for the sessions until they have all finished billing you. To avoid cash-flow problems, get some of the money up-front.

34 FAIL—leave course. ■

With every form of public performance having its own dedicated style of sound system, it's interesting to find a new genre with different requirements. Cinemas, live concerts, and discos have been around long enough to have created whole industries devoted to their own peculiar needs, but we think we've uncovered something that combines a bit of all three.

LASER concerts have only been around for about 10 years, and they're still too new to have made a big impression on the public's consciousness. Part of the problem is the type of venue required, for the laser concert—unlike a straight-ahead musical performance—needs something more than either a large hall or conventional theatre. It works best in a planetarium-styled dome, which limits its application to whatever large cities have such facilities. In London, Laserium, the world's leading laser concert operation, has set up a permanent display in the city's Planetarium and it was here that we got a close look at an unusual approach to public-address level sound reproduction. What's unusual is that mere volume isn't a major requirement. This crew wants to retain sound quality of a hi-fi calibre.

That remark isn't intended to get all of you PA systems vendors up in arms but most live concerts—regardless of venue—offer sound quality that would have the average audio loony up in arms. The levels of distortion and colouration that are considered acceptable by the sound people at concerts would, if found in a piece of domestic hi-fi gear, deem that component as totally unworthy of public consumption. Face it: when live concerts are the topic, volume, not sound quality, is still the order of the day.

Discos are just as guilty and it's only since the appearance of Dolby soundtracks that cinemas have given more than a passing thought to TIM, THD, or whatever other acronym is in current usage. Fortunately for the live concert promoters, most regular rock concert goers already have terminal hearing problems, and it's unlikely that anyone would complain about 'wooden bass' or 'strident treble'.

The laser concert, though, is a different issue entirely. Like disco, it relies on pre-recorded material, but unlike disco—where the music is there to provide little more than a metronome-like beat—the music is an integral part of the programme, designed to fully complement the visual display.

Laserium's programmes are co-ordinated shows involving an hour's worth of laser imaging accompanied by a specific soundtrack. To date, there have been shows in a series called Laserock, made up of around 20 tracks from various artists, but the latest offering focuses on one band. This single theme approach turns the laser concert into a 50/50 package of music and visuals, whereas the various artists shows were 60/40 in favour of the moving lights.

The summer 1983 season at the London Planetarium sees the European debut of Laserium's *The Beatles*, commemorating the band's 20th anniversary in a far more tasteful way than has yet to be seen. It's obviously the work of a hard-core Beatles fan; in this case, Laser Images' president, Sam McGee.

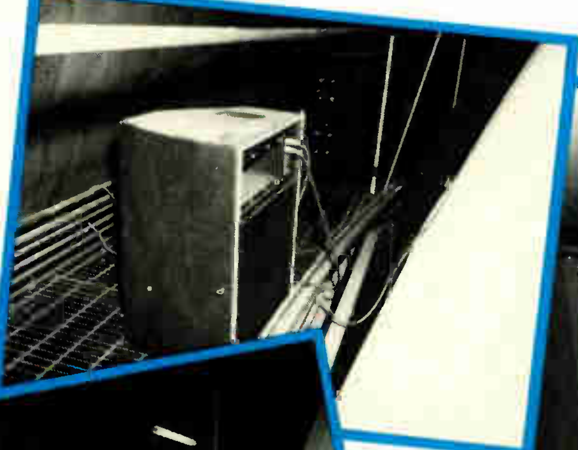
Laser Images is the company behind Laserium, a California-based organisation that is to lasers what Atari is to home games. Having perfected a workable water-turned krypton laser, the company decided that the device could serve as more than just an accessory at a rock concert, deserving concerts in its own right. This led to the Laserock concerts and their acceptance led to this one-band show.

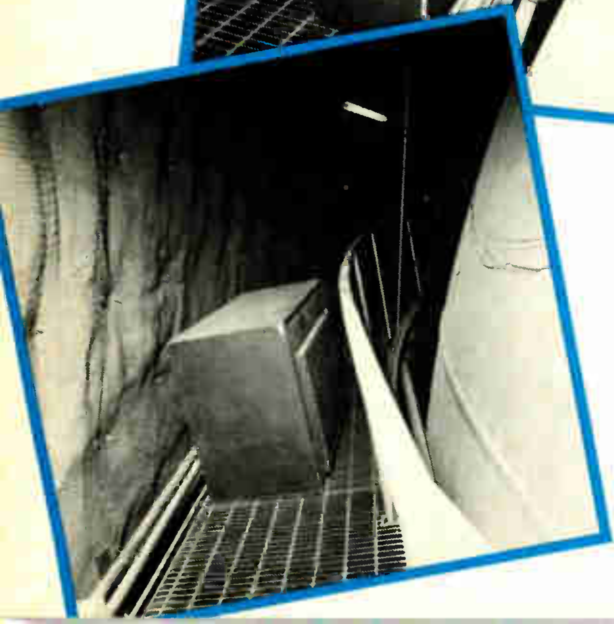
Because McGee is a Beatles fan, just as fed up as the rest of us with the tacky treatment they've received in the way of anniversary celebrations, he wanted to ensure that no adverse criticism could be heaped upon Laserium due to shoddy product. He sought and gained the permission of Capitol in the USA, and EMI in Great Britain, to use original Beatles recordings instead of cover versions. Gaining the labels' permission is no mean feat, because they are naturally protective about their most lucrative artists, and they rarely allow outside interests the use of their recordings. McGee must have found a pair of willing ears, because Capitol also gave Laser Images permission to make copies of their own master tapes. This meant that Laserium could treat its audiences to Beatles recordings of a calibre unknown outside of the audiophile pressings too dear (and too rare) for all but a few to hear.

The 23 tracks selected by McGee are presented chronologically to portray a mini-history of the Beatles, and the laser designs projected on the ceiling of the Planetarium enhance the music either rhythmically or aesthetically. The use of computer-generated graphics creates coherent images, and the laser operator has enough control over the proceedings to 'play' along with the music. Some of the designs are extremely subtle, others quite obvious, but it's the capabilities of the laserist that determine whether or not one sees a good show. What's guaranteed, though, is that everyone *hears* a good show.

The task of filling the Planetarium with high quality sound is complicated by the dome shape. Size is no problem, as it's smaller than most rock venues, but the circular seating arrangement and the use of 2-channel stereo recordings confuse matters. It's no problem giving some semblance of stereo when the audience is facing forward, but in the Planetarium it's 360° seating with all heads facing skyward.

Why don't we do it on the





To counter this, a clever multi-speaker arrangement is employed, with four channels of sound—two left and two right—placed at 90° points on the dome.

The sound system for the London Planetarium was put together by Martin Audio; on the speaker side, four pairs of bass and mid/high cabinets with Gauss drivers are positioned on maintenance gangways between the outer shell of the dome and the inner metal-mesh projection surface. The gangways are about 12 ft above the heads of the audience, and the speakers are mounted 90° apart as seen from the centre of the dome. Each opposing pair is driven by the same channel of the stereo, so that the arrangement of channels around the dome is left, right, left, right. This ensures that wherever listeners are seated they stand a reasonable chance of hearing a stereo pair.

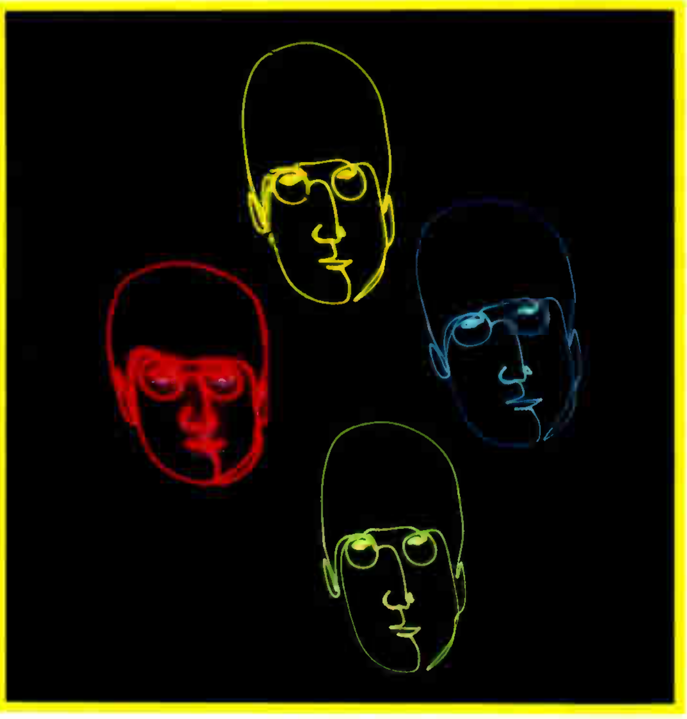
The equipment driving the loudspeakers is installed in a room adjacent to the dome, and consists of a custom unit designed to take the tape recorders, mixer and noise reduction, with storage areas in cupboards underneath, while the amplification and corrective EQ are installed in a 19 in rack. The console includes two Teac *A-3340S* 4-track machines coupled via a pair of dbx *124* Type II NR units to a Teac *3A* 8/4 mixer. All the tapes are dbx'd, the left-hand tape machine being used for lead-in and lead-out plus incidental music, while the right-hand deck holds The Beatles' master copies. At the time of writing, these recorders were being replaced by Otari *MX-5050* machines. Local monitoring is on a pair of Acoustic Research *AR-11*s, which are driven by a Crown *DC-300A* which also acts as back-up amp if one of the main amplifiers goes down. Primary amplification for the dome itself takes the form of a pair of HH *S500D*s for the mid/high cabinets and an HH *V800* FET amp for the bass bins. The monitoring in the operator's room is equalised by a UREI *530* 9-band stereo graphic, while the main system uses a pair of White *Series 4000* graphics to compensate for a no doubt somewhat unusual response curve in the dome. Also on the console is a Pioneer deck with preamp for playing intro and interval music. Next to it is a custom synchroniser which is used to tie the Planetarium lighting system to the audio. It is able to control the tape machines, which are specially modified for the purpose.

The sound produced by this combination was quite a surprise, for we were expecting the same low calibre of reproductions we've learned to live with in many other public situations. We anticipated the shrill highs of the migraine-inducing variety, a bottom-end of the 'boom, boom' type, and spatial imaging akin to plain, old mono.

On the contrary, we were knocked out.

There's something special about hearing an old, familiar song with a quality of reproduction never before experienced. To hear 23 of them, all as familiar as *God Save The Queen*, at realistic levels, devoid of noticeable distortion, in a listening environment of vast dimensions, is a near-overdose of nostalgia—precisely the hoped-for emotion McGee wanted to elicit. One doesn't have to be a Beatles freak to be swept away by a wash of their music reproduced to this high a calibre. Most of the audience at the Planetarium the night we attended weren't even born when *Sgt Pepper* hit the shops. But they, too, were captivated, and that's saying something because they're a generation with an attention span measured in milliseconds.

Maybe it's not Beatles 1, Atari 0, but it is a new form of entertainment that marries Atari-esque technology with that oldest of art forms, music. And if that's what it takes to get people to *listen* again, then bravo. ■



roof?

Ken Kessler

business

BARRY FOX

Ambisonics vs SQ

Since 1972 the NRDC (National Research Development Corporation), now part of BTG (British Technology Group), has spent £450,000 on the Ambisonics project. The specialist press, recognising the long term potential of Ambisonics technology, have bent over backwards to give it publicity. Engineers inside the BBC and IBA have lobbied their bosses on behalf of the system. Record companies like Unicorn and Nimbus have shown faith by releasing discs encoded in Ambisonics UHJ format.

So where does Ambisonics stand, after 10 years of goodwill and half a million pounds of someone else's money? There are six hardware licensees, you can buy a few UHJ records and the necessary decoding hardware has been demonstrated to the public at hi-fi shows, you still can't buy an Ambisonics decoder in the shops. A deal between Minim and Boots, to get hardware into the High Street, turned sour. The hi-fi press has given up writing about Ambisonics, because they have grown tired of recommending something that their readers can't even order from a shop. The best you can do, if you know where to send your money, is to buy a decoder by mail order.

Meanwhile SQ is coming back, thanks to surround-sound from video. Virtually every stereo video cassette or video disc version of a Dolby stereo cinema film has modified SQ information encoded in the soundtrack. It's there, whether the customer wants it or not, because Dolby Labs use a modified SQ system to get surround-sound into cinemas on an optical stereo soundtrack. The US electronics industry is just waking up to the fact that there's money to be made from selling SQ decoders to people who have bought a stereo video tape or disc system.

It has always been a claim of the Ambisonics team, that their decoder could be designed to handle SQ better than any of the original SQ equipment. Another claim, equally justified, is that an Ambisonics decoder with 'super stereo', can make most records sound better by synthesising surround-sound from stereo. The obvious way to get decoders into homes, and so generate a market for UHJ discs, was to push Ambisonics as a super stereo system first, and a UHJ decode system second. But it's never been done. Will anyone now sell an Ambisonics decoder for surround-sound with video? Frankly I doubt it.

In early May the BTG was promising 'big news' on the Ambisonics front 'within a few weeks'. So by the time this appears in print the big news should have broken. Surely they're not going to do something obscenely businesslike, like actually trying to sell hardware to the public?

Cable secrecy

What interested me most about the Government's White Paper on cable, and permission for 12 interim operators, was that the supposedly secret document had effectively been published long before the appointed time and day. *The Economist* and *Sunday Times* had already given the game away a couple of days in advance. At 8 o'clock in the morning of the afternoon press conference someone from *The Economist* was on the BBC's breakfast television show quoting what the White Paper said.

But despite all these leaks, the Home Office was still putting up a pretence of high secrecy. This had been forced on all Government departments, by Margaret Thatcher, after she blew her top when details of the Falklands awards got into print several days early. The only way anyone could get hold of a copy of the cable White Paper in advance of the afternoon press conference, was to go in person to the Home Office a few hours before, and sign on the dotted line for a copy, promising on pain of death, not to jump the gun. Inside the Home Office, security surrounding any press conference is always so tight that journalists are escorted to the toilets, lest they use a telephone and rummage through desk drawers en route!

At the press conference I asked Home Secretary Willie Whitelaw, whether he had deliberately leaked details of the White Paper ahead of official publication. Or, if not, was security inside his Home Office so slack that he couldn't keep secret documents secret. Whitelaw obviously wasn't pleased at the question. It certainly wasn't a deliberate leak, he blustered, but he couldn't say how it had got out. Perhaps it was from a different Government department.

Perhaps it was. But bearing in mind that the Home Office is responsible for state secrets, authorises phone tapping, controls the police and civil defence and moulds the future of sound and TV broadcasting in Britain, it's not very relaxing to know that Mr Whitelaw's empire is as leaky as an old battleship.

Broadcasting Parliament

Did you know that the BBC first asked for permission to broadcast parliamentary debates in the 1920's? They didn't get permission to go ahead until July 1977 and regular sound broadcasting from the House of Commons began on April 3, 1978. Almost immediately it ran into problems. When MPs are making speeches they are covered by parliamentary privilege. They can't be sued for what they say. But what about broadcasts? Even before transmission began, the Attorney General admitted that he didn't really know. But everyone was agreed that comments shouted from the public gallery certainly weren't privileged.

None of this is a problem where parliamentary proceedings are taped and edited for later transmission. Any risqué passages can be cut out. After a brief flirtation with reality, the broadcasters soon started to tape the vast majority of debates for later transmission. This was partly because one MP, the Rev Robert Bradford, was sued for libel about something he said on Northern Ireland, and partly because most debates are far too tedious to transmit live.

With the Falklands crisis live transmission started again and everyone concerned started to get edgy about libel. So the Government asked a Select Committee on Sound Broadcasting to come up with an answer. What they've suggested is that live transmissions should go through a tape delay of the type used by radio stations for phone-ins. If someone swears on air, then the producer just hits a panic button and the offending words are lost. But it's far easier to make a snap decision on a swear word or obscenity than it is on a potential libel. Here the Government Committee seems to have been badly misled.

In its published recommendations the Committee says that broadcasters should do exactly as they do for radio 'phone-ins' and insert a time delay in live broadcasts of the House so that the broadcast actually takes place a few minutes after the words are spoken . . . this is simply a normal editorial judgement. But as anyone who knows anything about phone-ins could have told the Government Committee, the tape delay is a few seconds, not a few minutes. The only way that a broadcaster can edit out potential libel in a few seconds is to play safe; if in doubt, cut it out. This could make live broadcasts sound like Gorgonzola cheese. And now that Parliament has voted to allow television broadcasting, how will they cope with that? To the best of my knowledge, no-one has yet devised a video recorder that gives a few seconds delay between recording and playback. The only practical solution would be to record a reel of video tape, rewind and load it on another machine, while at the same time recording on another machine with a fourth standing by for unbroken changeover. At broadcast video recorder prices, that would be a very expensive exercise.

Honorary MU member

Let's hope that Nelson Mandela, for many years a central figure in South African politics, doesn't harbour a secret desire to become a musician. The Central Branch of the British Musicians' Union has generously proposed that honorary membership be conferred on Mr Mandela. This is all very well, and doubtless a sincere political gesture. But if Mandela is musical and he becomes an honorary member of the British MU, he won't ever be allowed to perform in his home country, South Africa.

Arrangements II

Further to the item carried in the June issue, the recent agreement between the BBC, MU and Equity, to allow the video release of programmes made for broadcast TV, carries an important clause. After years of saying it was impossible, the BBC has now been forced to knuckle under and agree to pay the talent unions an up-front sum in advance of royalties. On average it's around £16 for a featured actor or musician and around £5 for any walk on parts, extras or members of the musical chorus. Not surprisingly the BBC is worried. So are the independent television companies, whose own agreement has run out and who feel they will now have to settle on the new terms. It means that only popular programmes will be worth releasing. It will also mean that only programmes with a small cast will be viable. Although the BBC and Equity have refused to talk about it, the MU makes the valid point that it's not fair for actors and musicians to get nothing, simply because they played a small part in a big production. "They must have been important, otherwise they wouldn't have been there in the first place," says the MU with irrefutable logic.

But the MU's real triumph in its video deal with the BBC is that arrangers now count as artists. They will get residual rights on videos along with the musicians and actors. The new deal makes the BBC the first major broadcasting authority in the world to recognise that the arranger, as well as the composer, has residual rights. It's no consolation for arrangers who have missed out in the past, but it means a better deal for arrangers in the future. ■

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Ursa Major 8X32

DIGITAL reverberation units are a more and more common addition to the modern studio or other pro-audio environment. Although plates still find favour among many engineers, there are often problems associated with them: modern studios tend to be more compact, while many plates are large; plates are sensitive to vibration in a number of ways; they do need to be looked after properly; they can be a touch noisy; and, above all, they produce only one basic sound. Digital reverberation units on the other hand offer compact, easily accessible facilities; a range of sounds (generally); and they can sound very good indeed. They tend to have one fundamental disadvantage, though, and that is cost. For the smaller studio, the choice of reverberation systems has generally been between one of the 'post-EMT' plates (if there is the room) and a spring-line system (many of which deserve more attention than they get). Ursa Major aim to widen the cost-conscious studio's reverberation horizons by offering a multi-function digital reverb at an affordable price.

Ursa Major, a small, but very well organised New England-based company, entered the reverberation field a few years ago with their first product, the *SST-882 Space Station,* which we reviewed in the August 1979 issue. The *Space Station,* while it had a few minor problems, was very successful, and established the company's current reputation. The *8X32* continues the line in the shape of a unit which aims to be versatile yet easy to operate.

Front panel and functions

The *8X32* is a 2U (3½ in) 19 in rack-mounting unit finished in a tasteful hard-wearing brown with white screened lettering, which doesn't come off easily. Modification controls are on the left, while selection and storage controls are on the right of the panel. Starting from the left we find at the top a row of five 7-segment red LED displays, under them being plus and minus incremental pushbuttons handling early reflections (delay and level); initial reverberation (delay and level); and decay time. Early reflections and reverberation onset delay are adjustable from 0 to 96 ms in 16 steps, and their levels are adjustable in eight steps (numbered 1 to 8) covering a range of 18 dB. The maximum main decay times vary with the program selected, ranging up to 20 seconds in one case, in 15 steps.

Beneath these pushbuttons we find two further sets of four buttons with LED indicators which control LF decay (20, 50, 100 and 200 Hz) and HF decay (1, 2, 5 and 8 kHz). These behave somewhat like rolloffs on the returns: the frequencies given are the 'corners'.

The right-hand side of the front panel is dominated by a smoked brown plastic panel behind which are level display LEDs and a twin green 7-segment display indicating the storage register selected, beneath which is a 'recall only' LED which indicates, when activated, that registers have been made 'read-only' to prevent tampering.

The level display section is arranged in a novel way: seven horizontal divisions are labelled (from the bottom) 36, 30, 24, 18, 12, 6 and 0 ('Overflow') and presumably indicate headroom in dB. To the right of these numbers is a column of LEDs, green up to 12, then yellow for six and red for 0, indicating the input level. A similar number of LEDs indicate the output level, but these are arranged in a curve which is somewhat exponential in character, giving a fair impression of the drop in output level over time.

To the right of this 'meter' is a 0-9 numeric keypad used for storage register selection. Beneath this area are three sets of buttons. The first group selects the reverb program. There are four reverb programs: the manufacturer's descriptions (which are quite accurate) may be paraphrased as follows:

Plate I: Explosive build-up; achieves high density within 30 to 50 ms. Quite uniform decay, with the highest density of all the programs. 'Moderate' colouration; short delays give 'small', slightly coloured sound. Very high early echo density—no discrete reflections. 6 s maximum decay.

Plate II: Moderately explosive build-up; high density achieved within 50 to 100 ms. Quite uniform decay; smooth, with high density. Colouration is moderate (less than Plate I but more than Hall or Space). Low early echo density, increasing rapidly. 8 s maximum decay.

Hall: Uneven, gradual build-up with softer attack after 70 to 100 ms. Overall uniform decay, but with more variation in fine structure and local echo density. Lower ultimate density than the Plate programs. Very slight colouration. Low early echo density in the first 80 ms. 10 s maximum decay time.

Space: Very slow build-up; open and uneven for the first 100 to 150 ms. Lowest echo density of the four programs. Some undulation may be audible. Very slight colouration. Low early echo density, although increased early reflection levels and initial reverb will fill in the first 150 ms with uncoloured discrete reflections. Maximum decay time 20 s.

Next to the program selection buttons are two pushbuttons offering input muting and 'reverb clear' functions, which are useful when dealing with long reverb times. To their right are two final buttons which store and recall register settings. Register storage is performed by punching in the register number (00 to 64) and pressing store and reverb clear together. All reverb parameters are remembered, and the registers are non-volatile. Register recall is similar: enter the number and press recall. A novel feature is offered here: entering the register number and pressing recall briefly loads the stored settings into the front panel controls. Pressing the recall button for longer, however, results in the original panel setting being restored when the recall button is released: useful for comparing stored programs with the setting you have just painstakingly made, without losing it. If you recall a register and then mess with the front panel controls to optimise the setting, two

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'decimal points' come up in the register display to remind you that you are no longer listening to the original stored setting.

To the far right of the unit is a push-on, push-off power switch.

Round the back

The rear panel is uncluttered, having the mains transformer fitted on the left, adjacent to a 3-pin IEC mains socket (well done, Ursa Major, although I couldn't see a fuseholder of any description); a centrally-mounted heat sink with a plastic-shielded (well done again) TO-3 can device (presumably the PSU regulator transistor); and with the *XLR-3*-style connectors on the right. Here Ursa Major deserve a little criticism. The *XLR*s present differential balanced ins and outs to the world (the outputs are not floating, it says here). While a panel above the connectors kindly tells you their impedances (which are sensible for interfacing with the average console), they are connected incorrectly, to the so-called (non-existent) 'American Standard', ie pin 3 hot. Of course, as a good deal of US gear is also connected wrongly, this might not matter, but several wrongs don't make a right and Ursa Major should really follow the international agreement that the USA signed on the subject (as should everyone else). This means that if you have an unbalanced jackfield on your console, and you have wired up your *XLR*s correctly, you would have discovered a novel way of shorting the inputs and outputs of the *8X32* for test purposes, were these sockets not balanced. Luckily they are, but this is not a very good excuse.

Between the two pairs of *XLR*s there is a screwdriver-adjustable input sensitivity control. Have you ever seen a miniature twin-gang trimpot? No, neither have I. Luckily Ursa Major don't need one as the two inputs are summed internally, so one of the input *XLR*s might as well not have been there at all. The unit has a mono input. Well, I suppose this saves you one of the parallel strips on your jackfield if you are the sort of person who likes to split one send into two for a stereo reverb unit. **Fig 1** gives a rough idea of what goes on inside the box, and the above will then be quite obvious to everyone.

Above the *XLR*s is a 15-way D-type connector into which plugs a very neat optional remote control unit which duplicates the entire front panel with the exception of the power switch in an nth of the space. I didn't have one of these with the review unit, but it looks very compact and easy to use. Above this is a blanking panel which looks suspiciously as if it might one day take a 25-way D-type of the sort used to talk RS232 at your computer. Ursa Major say that they'll develop this feature if people want it ("The people want it! They need it!"). This would be an interesting addition to your automation system. Please can the AES set up an Effects Unit Interfacing Unification Advisory Committee so that everyone does it the same way?

How does it sound?

The *8X32* interfaced quite happily to our trusty Soundcraft *2400* console despite the fact that there never seem to be quite enough Bantam-to-*XLR* leads in the world (or Bantam-to-anythings for that matter. Studio equipment rental people—Audio Rents in particular—get several bonus points when they ask you 'What leads would you like us to supply with your *Meximegalon Multiflanger*, Sir? Is your patchfield balanced or unbalanced? Is pin 2 hot?' etc). The input twiddler on the back allows you to set your echo send pots to the same level as you do to drive your valuable antique sheet of metal in the back room with all its warming, friendly thermionic devices, and get about the same amount of 'room' back up the channels. On which subject, the *8X32* is very nice and quiet when you don't send it anything to reverb with. I am still amazed at how quiet most digital reverb units are compared with even recent plate-like machineries—and how noisy they are compared with any digital recording system. This is going to be a problem one day, people, until digital desks can dispose of the D/A on the end of an effects unit (and that won't be this year, will it, O Mighty Accountants?).

Flicking through the programs, we rapidly discover, he says, changing tense rapidly, that each program falls neatly into place for different applications. Plate I is quite lively and bright and sounds very good on drums, particularly with very short decay times. This is probably the one to use for part of that snare sound that ensures plenty of airplay on KROQ, but it is a waste to try it for Phil Collins-style drum sounds where you might well slap them into echo, compress the outputs and gate them with your trusty Drawmer noise gates or whatevers, because that misses out on a very smooth decay characteristic which manages to fall away gradually without getting in the way. Unlike some units, which sound nice on their own but just don't seem to work on the mix (they either disappear or muddy the sound), the *8X32* integrates well with the overall picture, neither being too obtrusive or too subtle. Such problems are not entirely due to the return level in the balance; there is an innate quality (which probably relates to the 'curve' of the decay) which seems to result in a machine 'working' or not. The Ursa Major 'works' in this respect. The LF decay controls can be useful on heavier drum sounds so that the echo doesn't get too rumbling and remove the tightness of your mix's bass end, while the HF decay settings can be used to soften the top end it it's getting a bit too bright. Here, the fact that the unit has a frequency response that only extends up to 8 k is shown not to matter: this program is the one to use if you need top

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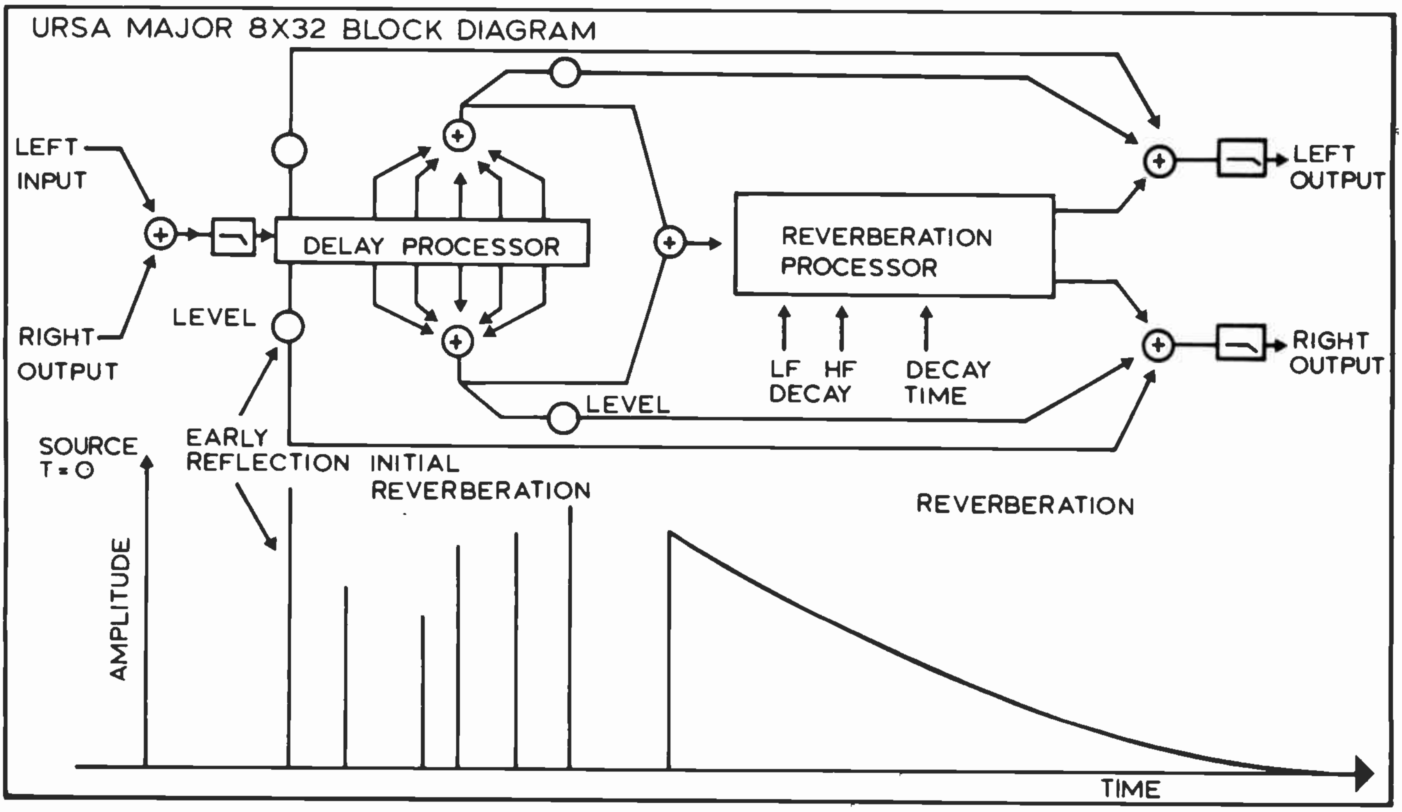


end on reverb, and there is quite enough of it. Digital reverbs which are flat up to 15 or so kHz are probably a good idea in principle, and desirable if you can do it cost-effectively, but not always necessary.

Plate II is a lot smoother and more 'rounded' (if you know what I mean). It is probably the setting to start on for most general reverberation applications where you would normally have used a plate. It will breathe life into dull vocals and helps an acoustic guitar if it is in a mix (but try Plate I on 12-string) although solo classical guitar sounds more natural on the next program, and so it should. Plate II is not called 'Plate II' to mislead us: it is what it says. If I were going to rename the plate programs I would probably call Plate II 'Plate' and Plate I 'Bright Plate', but that would take up more room over the button, so never mind. On Plate II, I never found the need to reduce the HF decay frequency, although the LF decay was useful, again to avoid loosening the bass end if certain instruments were a bit so-so in that area but needed reverb round them.

The Hall program is a reasonably good impression of a hall. It has the proverbial 'warm, natural concert-hall ambience' declared for it in the brochure. It is perhaps not quite as realistic as the Quantec, although it is somewhat warmer. This is reasonable, as the Quantec (reviewed January 1983) is a specialist at this type of characteristic, and the Ursa Major isn't. It doesn't cost as much either. One disadvantage of the *Space Station* was that it sometimes caused the note of a piano, for example, to wander in the course of the reverb, and that some transients, like piano notes, caused clicks to echo round the 'room', at long decay times. The *8X32* Hall program goes up to 10 s decay and does not exhibit these effects on piano, although you can confuse it slightly if you fire a glockenspiel at it on full decay time, an effect you may have discovered is rather attractive on the Lexicon *224*. Comparing the two on this specific effect alone (comparing further would be rather meaningless as they are quite different machines in many respects), the Lexicon sounds a bit 'granular' compared with the *8X32*, while the Ursa Major is not quite as happy with glockenspiel transients as the *224*.

Piano sonatas played in your dead, boring, lifeless studio with 100 dB/ft acoustic separation (quite unlike my place, but I seem to remember working in one once...) will be restored to their true BBC-broadcast-from-the-Festival-Hall likeness with this program, as will classical guitars, other traditionally-inclined solo instruments, and small groups, such as a string section (but I prefer the Plates on brass). Synthesisers also benefit from this setting, especially such sounds as the Yamaha *GS-1* 'digital pipe organ', and even more especially with some predelay dialled in. Initial reflections added in to this program can be used to good effect (as they can on the other programs). Indeed, one particularly endearing feature of this unit (although other devices have it too—it's a pretty obvious thing to do) is that the *8X32* itself will quite happily handle all the pre-reverb delays and single repeats that in earlier days would have required several Revoxes, reels of tape and a host of tape-ops to wind them back. Ah, but them were the Old Days. Neither do you tie up your limited supply of DDLs.

Finally on the Hall program, I didn't like to pull in the HF or LF decay fiddles as it sounded great at full blast.

The Space program sounds as if it is going to be really something else. You already know when you see this name for a program that it is going to be interesting, and the first thing you do is to look up its maximum decay time (well, I did anyway). It, as you already know, is 20 s. So you push 'Space' and dial in 20 s. There should perhaps be a note in the manual which says 'Don't do this first'. Oh, the effect is there all right, but if I were you I would creep up on it rather than plunging in at the deep end and trying it first. Just as there are some people who, faced with a new synthesiser, will turn to the back of the book and construct the patch therein, and not know what to do with it when they've got it (as opposed to most other people, mainly in top-selling chart bands, who open at Page One and never get any further; they get stuck on that sound—you know, the one that goes 'Deeeeoooouuuuuuwwwmmmm'—and insist on getting RIAA Certified Gold Records and lots of airplay on stations programmed by Rick Carroll), there are some who do the opposite. I am sometimes a member of this group.

The first thing you notice about this sound is that it is 'already there', before you send anything into it. If you push 'reverb clear' it goes away, but half a minute later it is there again. A kind of subtle roaring, as if you put your ear to a shell on the seashore at Brighton, Sussex, and heard the Pacific, long distance, about 30 dB down, via at least two communication satellites, without any top on it, but without the crackles that Mr Bell's (or even Ma Bell's) system generally adds, shells being digital of course... (you know the kind of thing). Aha. But if you push 'input mute' and also clear the reverb, it doesn't come back (unless you let go of the mute button). This gives you the unpleasant clue that what you are hearing is your quiet little echo send pushing loads of low-level rubbish into a 20-second reverb system in which the sound is coming in much faster than it leaves. Oops. Now, Soundcraft boards are very nice and quiet, so it can't be that...or can it? It can, because even little bits of noise add up, if they can't 'drain away' quickly enough. Well, that's my story and I'm sticking to it.

What this all boils down to is this. Twenty seconds of reverb time is a lot. The effect is large, echoey and unlike anything 'real'. It's 'Space' in the metacosmic sense rather than the 'open air' sense, and is quite usable, with care. Send it a reverb mix which is close to clipping (not *that* close), drop the master send level down so that it doesn't say 'overflow' at you, and then experiment with the HF decay buttons. The result is an excellent special effect with some very atmospheric applications. Try it on solo synthesiser lines which drift along in the distance over the subtle, Vaughan Williams-like chords of your *VP-330* set to 'human voice'. Lovely for library album tracks which have titles like *Passing Clouds* and descriptions like 'Soaring, airy movement with reflective theme', or 'horn statement to above'. Do not try it on tracks which will end up described as 'Insistent military underscore, transition at 1.47 to middle section with morse code pulse over rising background, to explosion at 2.27 and reprise'. Such things will sound uncommonly nasty and will not generate much in the way of royalties. The initial reverb and early reflection settings don't do too much with this particular effect.

But, of course, the Space program has 20 s as its *maximum* setting, not the only one. You can take it down to 0.2 s and it still has a certain speciality which is quite unique. And, of course, below about 10 to 15 s decay the effect of the send noise build-up doesn't really happen (unless it's time to get a new console).

Ah, and talking of effects, there is one which isn't in the manual. You can do it on any program, but on drums with Plate I it is particularly interesting. All the progams have decay times which go up to a certain value. The book says they go down to zero. But zero isn't any use to anyone, is it? 'Zero' means 'off' most of the time. But in this case, 'Zero' decay time actually means 'very short'. I discovered this by accident, as what the reverb clear button does in reality is not clear the memory but take the reverb down to 'Zero' to get rid of it. I had drums going through on a long decay time and pushed 'reverb clear' to clear it. It cleared the long decay all right, but left me (sends still attached) with a very exciting short reverb which is both interesting and very commercial. Setting the decay time to 'Zero', gives, as I have intimated, the same effect.

Conclusions

There is very little one can say against the *8X32* beyond criticising US companies in general for not following international *XLR*-wiring agreements. I couldn't find the mains fuseholder on the rear panel because there is a fuse in each side of the mains (not a good idea, as a fuse failure in the neutral line alone could render the unit live!) and these are mounted internally. Otherwise, safety aspects are excellent for a US manufacturer. The unit is very cost-effective, being one of the cheapest digital reverb systems around, as far as I know, and it behaves almost impeccably on the majority of signals, giving clicks only on very fast HF transients (as in the dreaded glockenspiel test) on the Hall and Space programs—which, to be fair, is a test that many, more expensive, units will fail equally well. The noise level is good, and the ergonomics—both control layout and what I term 'software ergonomics', the way the machine likes the operator to talk to it—are excellent. Indeed, ease of operation is as much as strong point of the *8X32* as the sound of the four programs—programs which, I gather, are to be expanded to eight later on at no cost to the owner.

There are a fair number of digital reverb units on the market today, some of which offer limited functions which they handle very well, while others offer many different effects besides reverberation. As I have suggested elsewhere, I feel that too many effects can be a disadvantage as they limit application on the mix (a unit will usually only do one or two things at a time), while too few can make the unit less cost-effective. The Ursa Major *8X32* succeeds in balancing these two extremes of the continuum and is a versatile, compact, easily-operated and approachably-priced digital reverb unit. The *8X32* is a device which should certainly be evaluated by any studio requiring such facilities when the more up-market (and, of course, even *more* versatile) systems are unrealistically priced to a budget-conscious studio manager. Of course, with any effects unit, the final appreciation of the sound and usability must be a personal decision, but the *8X32* deserves a hearing as part of such a decision-making process.

Richard Elen

Manufacturer: Ursa Major Inc, Box 18, Belmont, MA 02178, USA.

UK: Feldon Audio Ltd, 126 Great Portland Street, London W1N 5PH.

Drawmer dual gate DS 201

MANUFACTURER'S SPECIFICATION
Input levels: (key or signal) up to +22 dBm unbalanced.
Output: to +22 dBm unbalanced.
THD: at 0 dBm; gated; 100 Hz to 0.05%, 1 kHz to 0.03%, 10 kHz to 0.03%.
Noise: −95 dBm CCIR ARM, weighted at max attenuation; −86 dBm CCIR ARM, weighted at zero attenuation.
Bandwidth: 25 Hz to 40 kHz, ± 1 dB.
Key filter: LF 12 dB/oct slope 25 Hz to 4 kHz ± 3 dB. HF 12 dB/oct slope 250 Hz to 35 kHz ± 3 dB.
Threshold: −54 dB to infinity.
Attack: 10 μs to 1 s.
Hold: 2 ms to 2 s.
Decay: 2 ms to 4 s.
Range: 0 dB to 80 dB attenuation.
Key source: internal or external.
Function: gate or duck.
Output: key listen, gate, bypass.
Power: 220/240 V AC mains 8 VA (110/120 V by internal connections).
Fuse: T 80 mA for 240 V (T 160 mA for 110 V).
Weight: 3 kg.
Manufacturer: Drawmer Electronics, 183 Cobden View Road, Sheffield S10 1HT, UK.
UK: Recording Maintenance Services, 6 Manor Road, Teddington, Middlesex TW11 8BG.
USA: Harry Harris Services, 7138 Santa Monica Boulevard, Hollywood, CA 90046.

NOISE gates are not a recent invention. Many engineers have used them for years but they have become a good deal more fashionable recently for a number of applications.

First, of course, they can clean up a signal coming into the board, whether from a particularly noisy guitar amplifier or when, for some reason, there is a lot of noise on a tape track. But they also have applications in the mixing process for effects purposes—for 'tightening up' drums, or gating their reverb; and when a separate 'key' input is provided, they can be used to trigger one sound from another.

The Drawmer *DS 201* is designed to provide a highly flexible 2-channel (independent or stereo) gating system with a number of facilities not usually found, at a very reasonable price.

Consisting of a compact, 1U high, 19 in rack-mounting chassis, the *DS 201* is divided into two identical sections, which can be linked for stereo purposes with a linking toggle switch in the centre of the unit. As will be noted from the list of controls, the *DS 201* has a number of features which put it in a class of its own.

Functions and controls

On the left of each section is a pair of 'key source' controls. This consists of highpass and lowpass filters in the key circuitry, enabling the keying signal to be 'conditioned' for maximum effect. The filters have a 12 dB/octave slope, LF from 25 Hz to 4 kHz ±3 dB, and HF from 250 Hz to 35 kHz ±3 dB. Above these controls is a toggle switch which enables the key signal to be derived from the main signal or from an external input. The adjacent threshold control operates from −54 dB to infinity, and above this is a toggle switch selecting gating or ducking operation—basically inverting the 'envelope' of the gating circuitry.

Next along is a set of three controls: attack, hold and decay, with three LEDs in a group above them indicating which function is operating at any given time (red, yellow and green respectively). The attack time runs from very fast (10 μs) to 1 s; the hold time is adjustable from 2 ms to 2 s; and the decay varies between 2 ms and 4 s. These three controls give the keying envelope all the basic functions of a synthesiser envelope shaper, as one might find on a machine like the *Minimoog*. Unlike the average noise gate, which has simply attack and release times, where the latter indicates the length of time the gate is open before it cuts off rapidly, the Drawmer offers the possibility of allowing the gate to remain open for a set time (hold) and then closing gradually. This—with the frequency-conscious keying facility—gives the Drawmer a degree of flexibility which I have not found on any other gating system.

At the right-hand end of the section we find a range control, which alters the amount of attenuation provided when the gate is off. This offers from 0 to 80 dB—about twice the usual range one finds on a gating system. Above the range and decay controls is a 3-position toggle switch selecting bypass, gating or 'key listen'. This last makes it possible to audition the key source signal (whether external or otherwise) while adjusting the key filters to select the appropriate characteristics of the keying signal.

To the far right of the module is a power on/off toggle switch with LED indicator.

On the rear of the unit, inputs and outputs which are clearly labelled and have standard ¼ in jack sockets, which help to reduce the cost of the unit. *XLR* connectors are, I gather, available as an option. However, the inputs and outputs are unbalanced so the jacks are quite a reasonable method of interconnection, although you'll probably have to make up special leads to interface with the average console. The unit accepts and provides signals up to +22 dBm and is, of course, unity gain.

The DS 201 in use

As can be seen from the above, the *DS 201* is very simple to operate. The principal differences between this and other gating systems lie in the key filtering and the addition of the decay control. One application of these extra functions might be in generating a synthesiser pulse in time with a click track or percussion line (bass drum or hi-hat, for example). The way I would normally do this would be to use a simple sequencer like the *Spider/Wasp* combination, entering the appropriate pattern into the sequencer and driving it from the click track.

Doing it with the Drawmer is much easier: you simply patch the synth into the board, inserting the *DS 201* in the channel. You then take the tape return from the keying track to the key input, with the unit switched to external keying. You adjust the key filters in 'key listen' mode while playing the track down and pick out the best characteristic (on a bass drum, for example, you might want to roll off the bass end to get a good 'click' to key from, while on a hi-hat, say, you would want to roll top off to avoid mis-triggering on open hi-hat beats, while retaining the original attack) and adjust the threshold so that the attack light comes up reliably on each transient. Then you simply get a good sound on the synth—preferably with a fast attack, high sustain level and long release—and hold the right notes at the right time, adjusting the attack, hold and decay controls on the Drawmer just as you would a synth envelope shaper.

The same principle can be used to add a harmony line to an already existing lead line—say on synth again—to ensure that the harmony notes come in at exactly the same time as the lead lines notes, and hold for the right time.

The Drawmer has more conventional applications, too: but the availability of the key filtering makes triggering much more reliable than on other systems. While I did not use the 'ducking' facility extensively, it appears to offer a useful extra function.

Conclusions

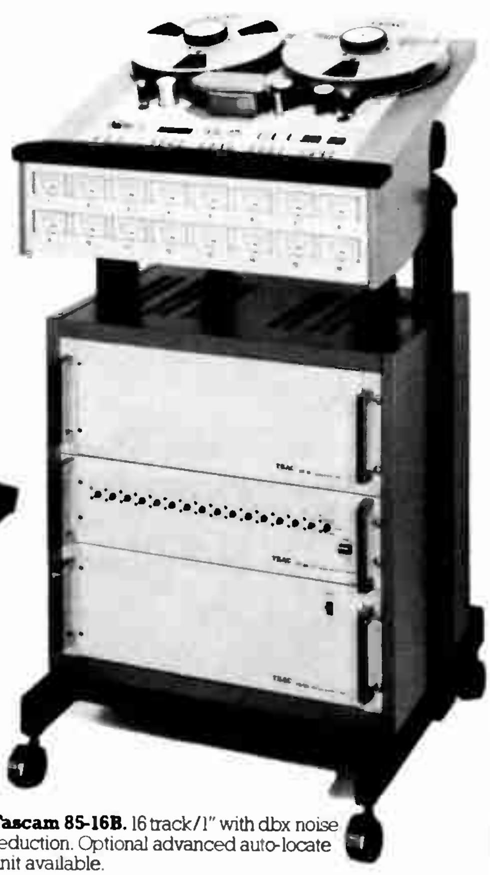
The Drawmer *DS 201* is easily the most useful gating system I have had the pleasure to use. Frequency-conscious keying and the attack/hold/decay characteristic make it easily the most flexible I've come across. The unit is also compact and offers two channels at a price that would give you about half a module from anyone else. There is also a single-channel module—the *DS 201*—which fits into an Audio & Design *Scamp* rack system. I would happily recommend the Drawmer system to any studio, big or small, which requires flexible gating facilities. Indeed, Drawmer didn't get their review unit back: I bought it! And it won't make much of a dent in the smallest of budgets. Heartily recommended.

Richard Elen

The great 16track package from MusicLab.

Tascam's deservedly successful **85-16B** 16 track/1" Recorder and Allen & Heath's sensational new **1616** Mixer. Each represents top value-for-money in its class; put them together and you have a professional performance recording team that will amaze even the most sceptical ear! The 1616 desk complements perfectly the 85-16B – the truly affordable multitrack package for the musician or studio with unlimited creative resources, but a not-so-unlimited budget.

Allen & Heath 1616.
16-8-2 format with flexible 16 track monitoring and metering. Comprehensive EQ with frequency switching. 3 auxiliaries. Phantom powering. External power supply. Fully compatible with all current recording equipment. Optional 8 input add-on expander module available.



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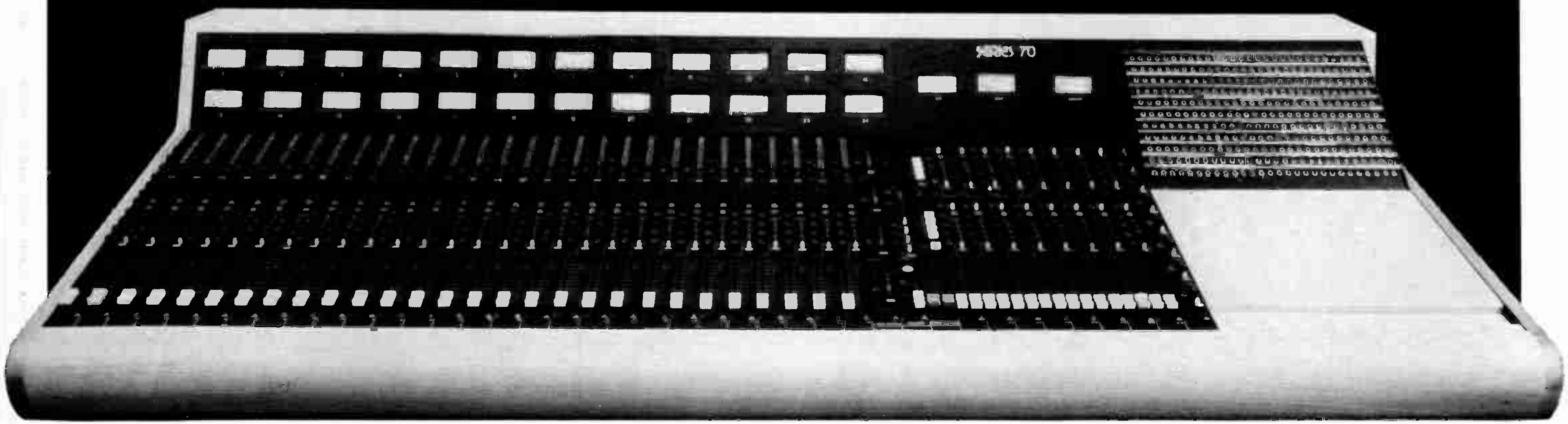

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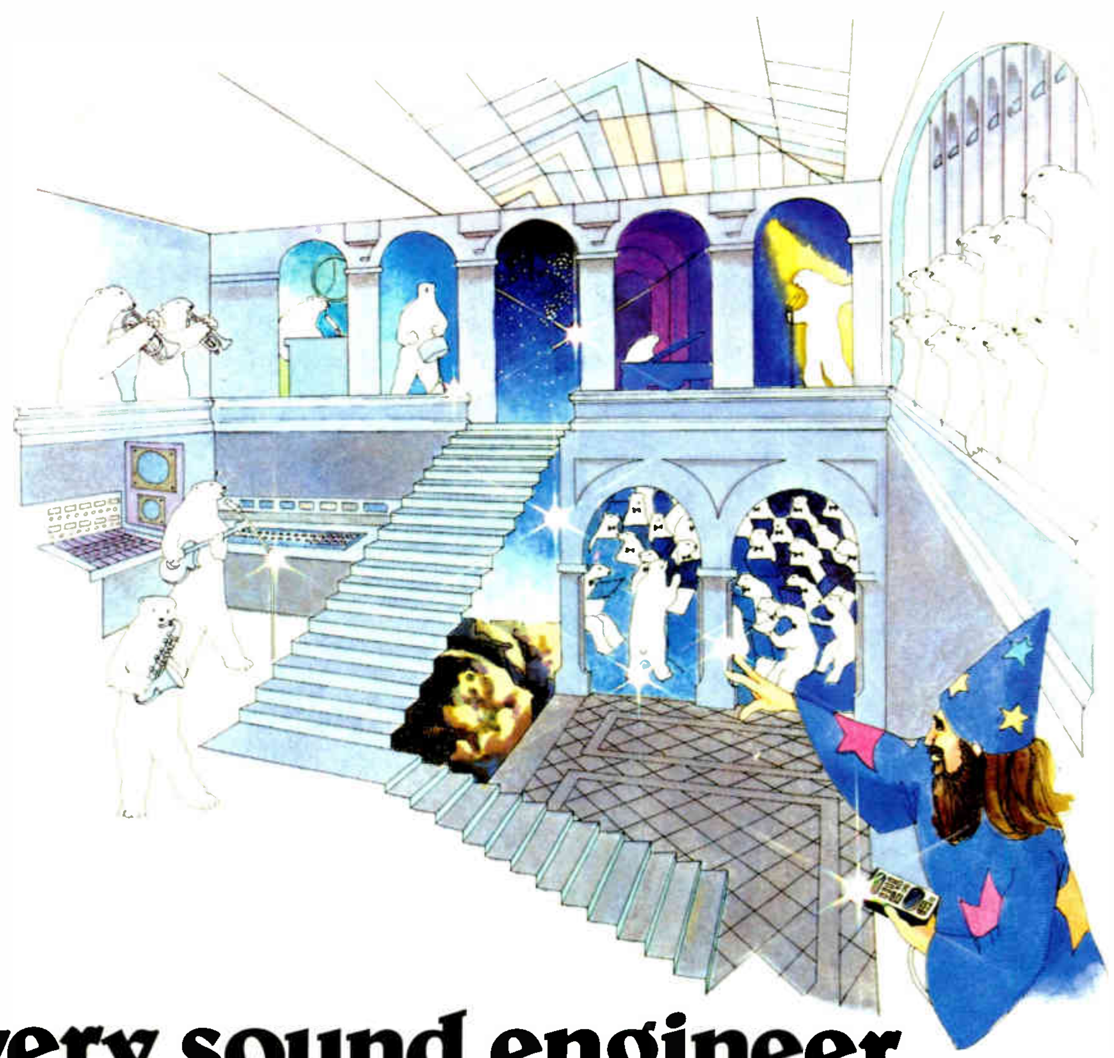

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