August 1975 25p

studio sound

AND BROADCAST ENGINEERING

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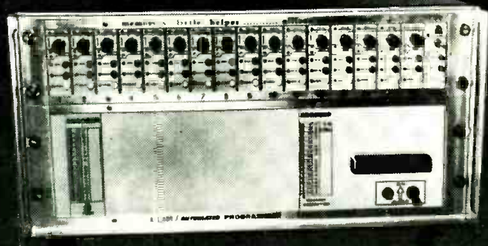

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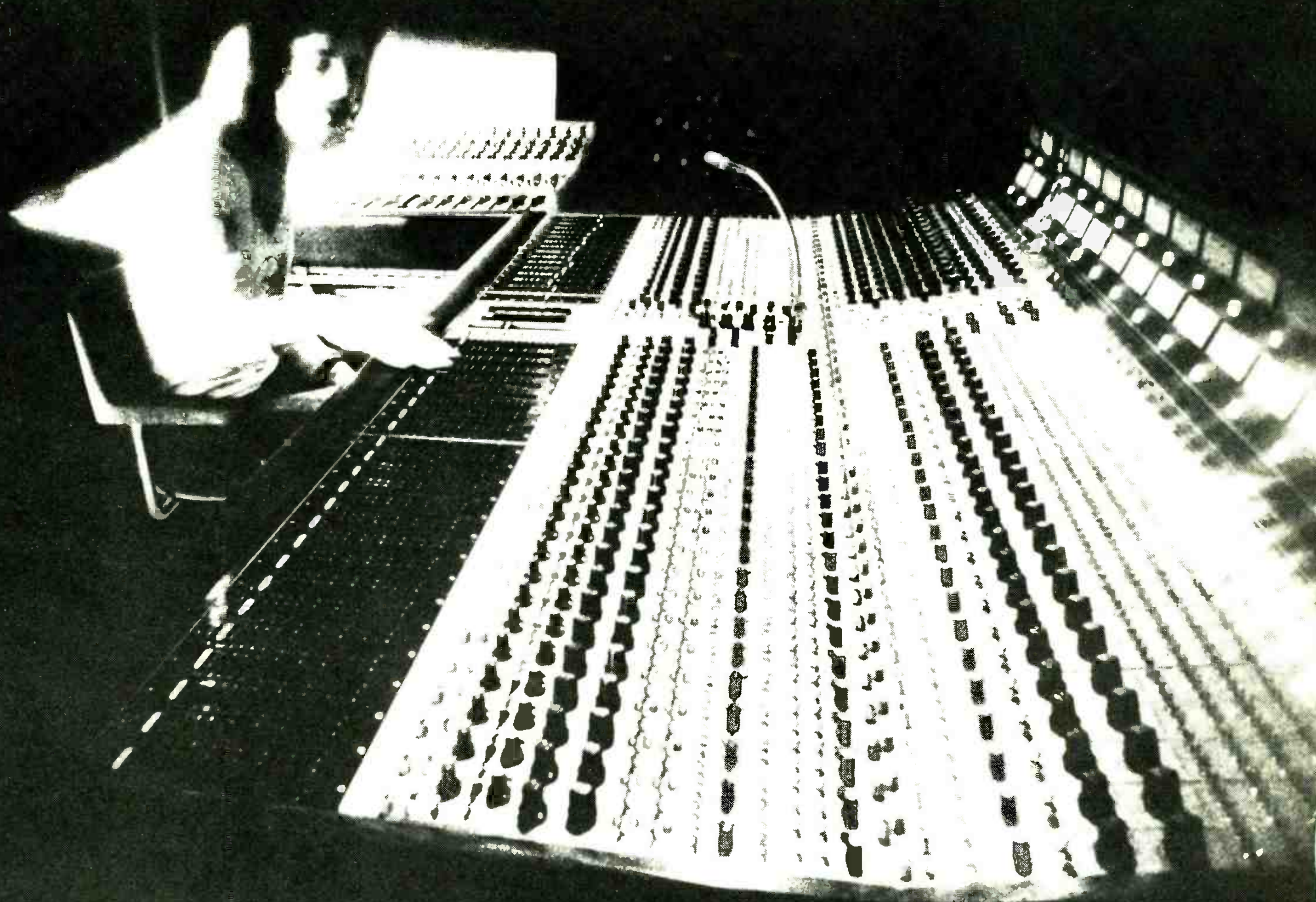

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AUGUST 1975 VOLUME 17 NUMBER 8

CONTENTS

HEARING damage affects us all in some form or another. Superimposed on typical aging processes appears to be an additional factor dependent on exposure, as discussed elsewhere in this issue. The actual extent of the difficulties and the likelihood of trouble is something on which few have had the arrogance to pronounce in definite terms. The decision then becomes a moral one.

The discussion is complicated by its division into two areas, each of which is dragged up if the other is invoked. One is the issue of industrial hearing damage; in other words, the problems of a sound engineer in unusually high ambient levels. The other is a quite separate issue and is the likelihood or otherwise that people will suffer hearing loss due to high pa levels.

In the UK we are protected from ourselves: we have to wear our crash helmets and now often have electric concerts limited, to levels in some cases below those found in acoustic ones (for full dosage discussions, again see elsewhere). In the US, no easy rider would care for any such imposition on his freedom; even if states are now introducing crash helmet laws and some limits to auditorium levels, the latter tend to be more realistic. In the UK, attempted suicide used to be a crime, the repeal of that law acknowledging further an individual's own responsibility to himself and to look after himself. On the present less mortal issue, the tendency to choose legislation rather than education does not encourage thought.

However, the main concern here is for engineers whose hearing may suffer simply because of their work conditions. Funny jokes about ear defenders too easily miss the point. There is no commonly agreed interpretation of the physiology, so any studio engineer must take the risk with him at his work. High monitoring levels are an essential part of most people's technique. One pedantic German approach has been to instruct engineers to leave the room if the level exceeds a certain threshold. So we return to the dispute as to whether protection should be internal or external. With the industry on both sides of the Atlantic functioning the way it is, there seems little doubt which way the battle will go, such as it is. If that job is done then later the engineer may find himself to have been at risk, possibly irrevocably. The choice is the engineer's, not the physiologist's. So he must know about it. Soon.

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

DISTRIBUTION
STUDIO SOUND, published monthly, enables engineers and studio management to keep abreast of new technical and commercial developments in electronic communication. It is available without charge to qualified readers: these being directors, managers, executives and key personnel actively engaged in the sound recording, broadcasting and cinematograph industries. Non-qualifying readers can buy STUDIO SOUND at an annual subscription of £4.17 (UK) or £4.20 overseas.

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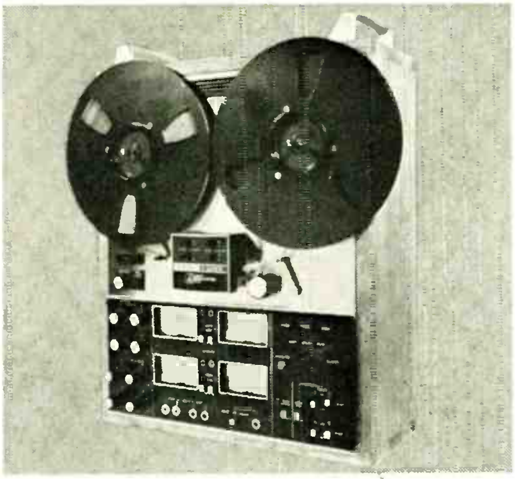

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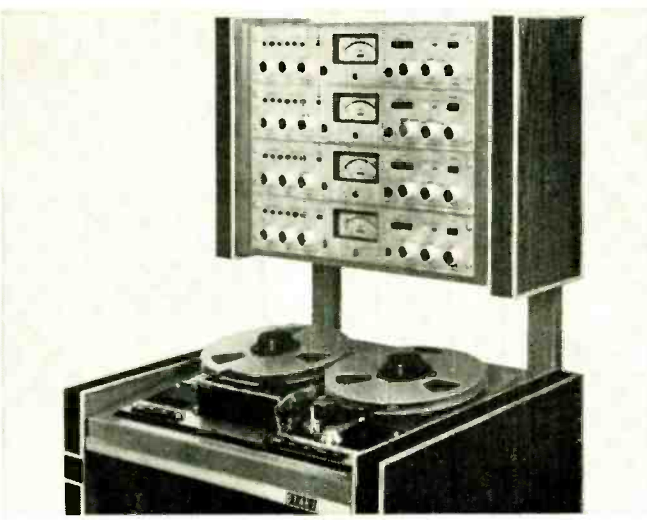

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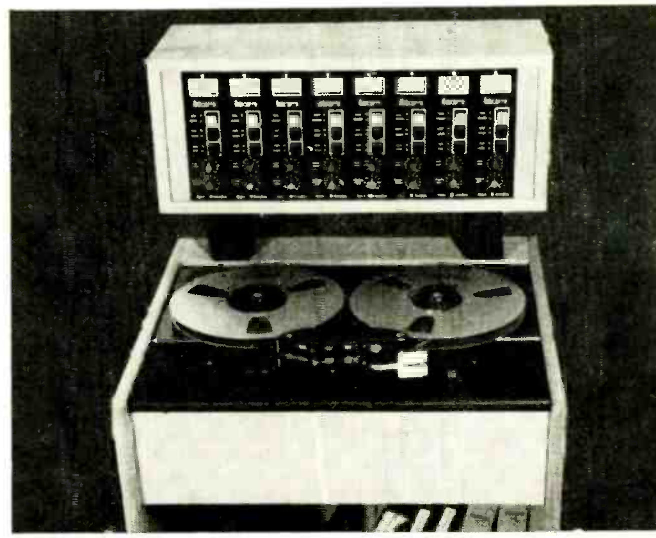

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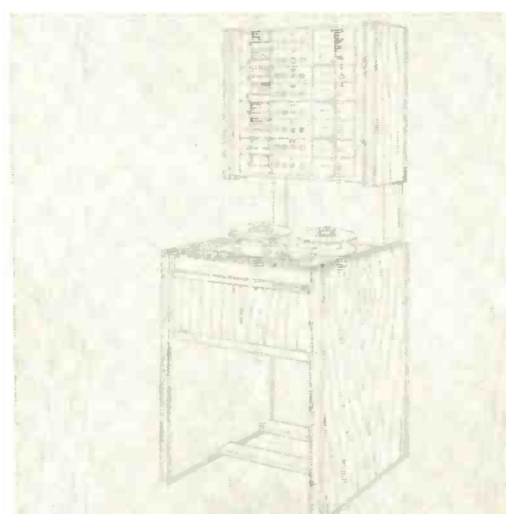

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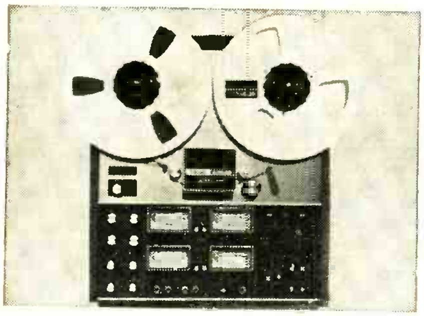

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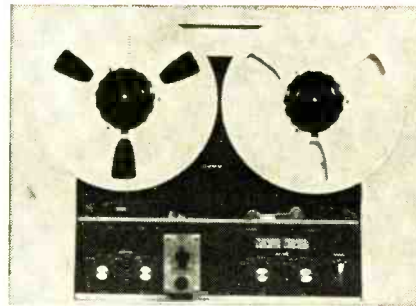

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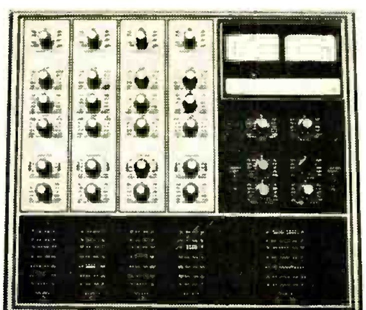

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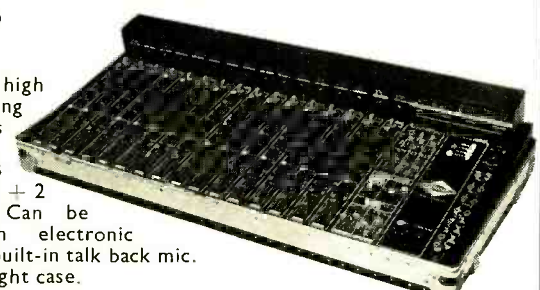

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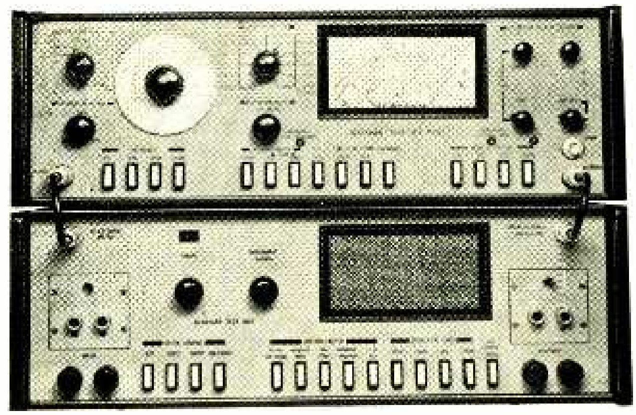

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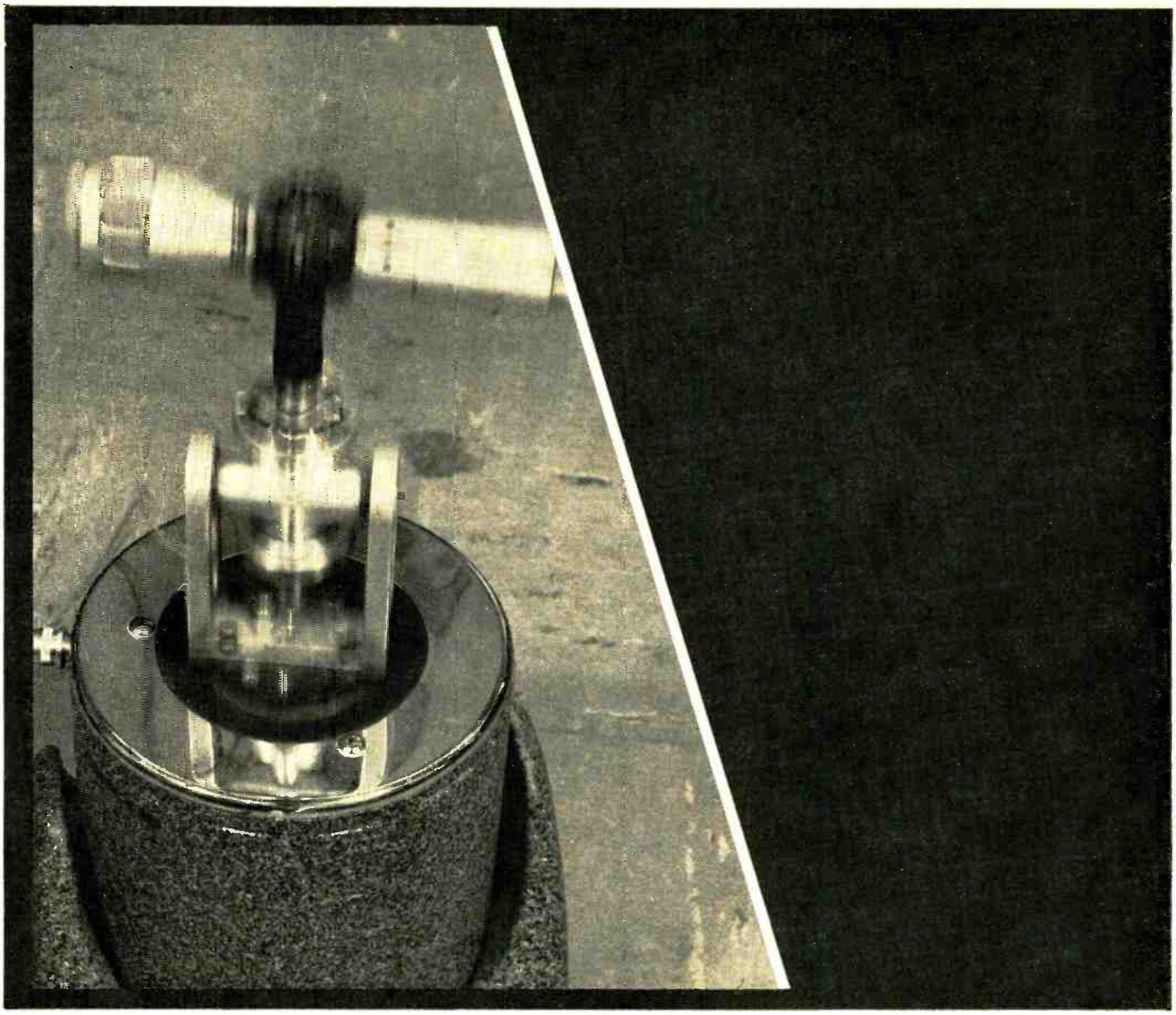

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The recent economic problems of the British film industry, and in particular Elstree studios, have received wide daily coverage. The background to the studio and its record of technical innovation are covered, together with a summary of recent improvements in optical soundtrack techniques with which they have been involved. These include the application of Dolby noise reduction to optical tracks in mono and stereo.

Elstree Film Studios

JOHN DWYER

Back row: *Chris Anderson (2nd assistant dubbing mixer).* **Front row L to R:** *A. W. Lumkin (Executive technical services), Ray Merrin (1st assistant dubbing mixer), W. Rowe (chief dubbing mixer).*

THREE SHORT PARAGRAPHS in EMI's annual report, published last autumn, signalled another blow to an already reeling British film industry. 'Last year,' said Sir Joseph Lockwood, the retiring chairman, 'I reported that production capacity at our Elstree studios continued to be under-utilised—in common with other UK film studios—and that Elstree had made a substantial loss as a result. In November 1973, as part of our continuing effort to make Elstree viable, we agreed upon a reduced scale of operations with the trade unions concerned. This resulted in a reduction of our permanent manning from 518 to 261 employees. Other economies to reduce overheads were also put into effect. Despite these measures, Elstree's position has not improved. The level of film production is still unsatisfactory, and while we are continuing to make every effort to put the studios on a viable basis, we cannot be sure of its future unless the position improves substantially in the coming year.'

Elsewhere the report said that only eleven feature films were wholly or partly serviced at Elstree. Yet the dubbing theatres seemed never to have been busier—either that or the executives at Elstree were masterly when it came to looking as if they hadn't got a minute to spare. None of them wanted to say much about the situation. The then studio manager Freddie Barbank said last December: 'The whole of the British film industry has been living from hand to mouth for years. We've got plenty of work going on; we're building again for shooting in January.' Nevertheless the report did say . . . 'We've had some good months this year, we've had some bad months. It's happening in every British business,' and he cited British Leyland. He thought it encouraging that *Orient Express* was now breaking all records.

Alan Sapper, General Secretary of the ACTT told me shortly after he would be asking for a meeting between the Prime Minister and representatives of the Federation of Film Unions to discuss Elstree's future. They had already met Sir Bernard Delfont to protest that they would oppose by all means any closure at Elstree or any reduction in its staff or facilities, and they would tell the Prime Minister the same at any future meeting. They clearly did not believe Elstree would be in that much financial trouble, bearing in mind the success of *Orient Express* and *Confessions of a Window Cleaner* and asked for all the financial records of the studios to be made available to them. 'I doubt whether they would close it completely because it's one of the best technically equipped studios in the country,' said Sapper, 'and their post-production facilities are a real money-spinner.' I asked him whether the large acreage at the site was a possible reason for EMI's wish to make it appear that Elstree was losing money, and he said he thought it was nothing to do with that at all.

Yet when the bad news eventually came the Guardian described it as 'sudden'. At the end of

January, EMI announced that the staff would be further reduced from 251 to 48, a reduction of over 90 per cent within 15 months. Six of the studio's nine stages were to be closed. The staff had a mass meeting and the ACTT said they would fight the closures. Despite their efforts, the staff had left by March 27. Freddie Barbank, formerly studio operations manager, was replaced by former chief engineer John Skinner who was given the title of studio manager.

Perhaps it is true that what are now regarded as some of the greatest days of movies coincided with the Depression. Long before that, in 1913, a young film director named Percy Nash had built a studio in Borehamwood. He had wanted a site on a hill, above the London fog. He made 90 films there, mainly one reel comedies and three reel dramas.

In 1926 an American producer, J D Williams, asked Nash where he should build a studio and Nash suggested nearby Elstree. Williams began building British National Pictures but ran out of money before he could finish it so the studios were taken over by John Maxwell, a solicitor who owned a chain of cinemas in Scotland. The studios were busy, and Alfred Hitchcock made the first British talkie, *Blackmail*, at what was then called British International Pictures.

Elstree was shut down during the war and used by the army. Rebuilding started in 1946 and the studios were reopened in 1948 as the Associated British Picture Corporation. The present executive head of technical services, Tony Lumkin, arrived in May that year. There were only two sound stages ready: 'There was no sound building—the bricks and mortar were up but it was a shell.'

Lumkin considers that any edge Elstree had over other studios from this time on was partly attributable to their association with Warner Brothers, who had had a series of firsts over the years from *The Jazz Singer* (1927) through colour (1933) and onwards. 'Our initial sound installation was jointly planned between ourselves and Warner Brothers so that we inherited techniques which were not in use in other studios in England.'

In the early fifties Elstree was one of the first studios to change to magnetic recording from recording directly on to optical film. Although the film industry followed the recording industry in using magnetic recording, the recording industry was well behind in multitrack recording. Even before the change to magnetic the studios were using multitrack techniques. It wasn't possible to record three optical tracks on one film so three recorders had to be synchronised. They recorded the orchestra on one, the vocal on another and the chorus on another. In the rerecording the balance between orchestra, vocal and chorus could be altered.

Similarly in rerecording two optical recorders were used simultaneously, one recording the composite track and one the minus-dialogue track. When magnetic 35 mm film began to be used Elstree recorded on three tracks on the same piece of film, as is still done, using one track each for dialogue, music and effects. Other studios, Lumkin says, were still doing composite dubs in English and had to redub for the music and effects track.

During the early fifties Elstree devised a number of technological advances. One was a system called silent turnover, which enables directors to work without a clapper board. Directors, particularly those from America, felt that the clapper board disturbed artists and destroyed spontaneity. Another was silent playback, a now familiar system which used an induction loop running round the sound stage to play music back to actors through a concealed earpiece. This enabled actors to hear the music and record dialogue at the same time without interference from playback speakers.

Elstree say they are the only major studio equipped with Add-A-Vision, a system developed by Livingston Laboratories with advice and help from Elstree and ABC TV, which was an associate company of Associated British Picture Corporation Ltd. ABC helped with the video side and the Elstree camera and sound departments developed the equipment as an attachment to the Mitchell BNC 35 mm camera. The system was first used by Gerry Anderson in Slough when he was making those tv puppet adventure films.

Add-A-Vision is integrated into the zoom lens. Most of the light goes through on to the film but a small part comes off through a prism into a plumbicon video camera which gives a broadcast quality picture of what is going on to the film. The director, the lighting man, the camera operator, the sound mixer and the continuity girl each have a monitor. The director does not need to turn the camera on until the shot is right. He need not look through the camera viewfinder and, if someone makes a fluff not normally noticeable until the rushes are shown, he can see it immediately and cut camera. One estimate put it that the equipment results in a ten per cent saving in shooting time and so almost a ten per cent saving in production costs. The system also keeps people off the floor—the continuity girl, for example, does not have to keep dashing up to the camera operator or the director because she can see what is being shot on her monitor.

These and subsequent developments were made to reduce costs. ABC TV were making telerecordings in the late fifties and involved Elstree in 16 mm work. Elstree say they are the only major studio to be involved in 16 mm recording. Television series were once shot entirely in 35 mm but a large end product of 16 mm was also required, so they had to transfer the sound not only to 35 mm optical and magnetic but also to 16 mm optical, and to 16 mm magnetic for foreign versions.

So Elstree looked for more efficient transfer methods. The solution was to use a 6.25 mm Telefunken *M10* tape machine. The English dialogue version would be recorded on track one, the mixed music and effects (M&E) would be on track two and between them would be an FM pulse system which synchronised the tape to film. They could store one television show with both its sound end products on a 75 Am NAB spool of 6.25 mm tape instead of storing it on six rolls of 35 mm magnetic film.

The system had two advantages. The first was that the film rolls could be erased, once they had transferred the end product on 35 mm to tape, and then re-used, reducing the studio's investment. In addition, the producer could be given a credit for the re-usable magnetic film, reducing the cost to him from around £50 for six rolls of 35 mm film stock to that of around £2.50 for a reel of tape.

The second advantage derived from the servo-controlled playback function of the Telefunken machine. This meant that it would hold itself in lock to the recorded pulse so, without stopping, the whole of the tape could be transferred on to 750 m of 16 mm magnetic film or, with only one stop, on to two reels of 16 mm film. Elstree say this enabled transfers to be done in continuity instead of individual ten minute reels of 35 mm after which they had to stop and reload and then start the machine again. The new system was much cheaper.

The next development was to use a 12.5 mm four track machine and use tracks one to three for dialogue, music and effects and the fourth for a synchronising pulse. This enabled producers to redub easily, if one hour television shows had to be broken down into half hour shows, by using the separated tracks. Most of this work was being done for ATV's film company, ICT, and was networked in the States on ABC, CBS and NBC. Elstree say they have had as many five television shows shooting in the studio at the same time.

It was inevitable that 16 mm colour film would be used for shooting and the man responsible, it seems, was television producer Monty Berman, who decided that the only way to produce a television series economically was to shoot in 16 mm.

The studios had been taken over by EMI in 1969, so the following year Elstree were able to invest in 16 mm equipment worth about £¼ million. They bought camera equipment and applied Add-A-Vision to 16 mm cameras. They also bought additional 16 mm sound recorders, dubbers and picture projectors for all their recording theatres and review theatres. Elstree say they are able to handle more tracks for 16 mm dubbing than any other facility in the country. Now 12 magnetic 16 mm tracks can be mixed at a time to 16 or 35 mm picture. They can record on to 35 mm from 16 mm tracks, as they do for television, and they can transfer from the three 35 mm tracks, recorded on 2000 ft reels of 35 mm, to 12.5 mm tape as well as to 16 mm.

All the recording areas were equipped with RCA *FR10* four track recorders and a bank of dual gauge 35 and 16 mm re-recorders from Magnatech in New York. During the reinvestment period they also bought a new sound console jointly designed by Elstree and Neve. It has 36 inputs and is capable of eight track outputs. Although the desk works mainly as a multitrack mono desk it has been used for three track stereo recording.

Possibly the most important development, however, was that of anticipatory noise reduction. An optical sound recorder has a mechanical noise reduction system fitted to it. The sound on a variable area sound track is recorded by varying the width of a beam of light which shines on to the light sensitive film. The beam of light is narrow during low level passages and wide during high level passages. On replay a light shines back through the sound track on to a photocell or solar cell. Without the noise reduction system, the black areas on either side of the stripe would be wide, so that the photocell pickup could read scratches and dust which would produce noise when the track was replayed. Noise reduction acts so that when the track is unmodulated a dc bias reduces the width of the clear area to about 0.08 mm, and shutters reduce the width of the dark area, thus reducing the amount of noise.

The problem with the system is that it takes

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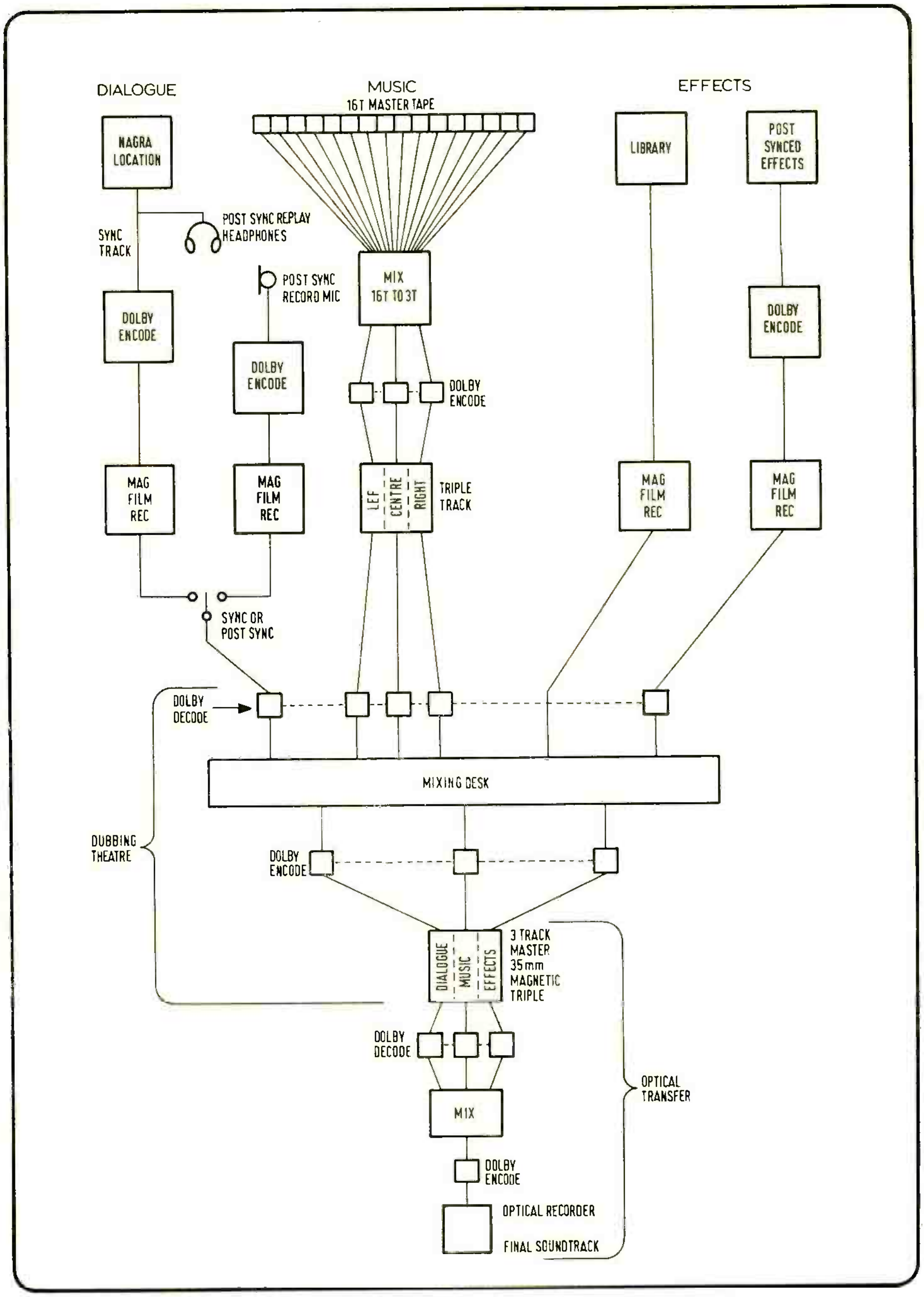
a finite time for the track to re-open and, if a transient arrives, the top of the transient may be clipped, a problem known as low level slipping. 'Depending on the type of transient it may be objectionable or it may not,' said Lumkin. 'You may hardly hear it but most of the time a trained ear will notice it, particularly on dialogue.' Elstree say they have overcome the problem by 'anticipatory noise reduction'. They have developed a system which uses two magnetic heads on the transfer machine, one feeding the galvanometer that records the sound modulations and the other head, in front of the first, feeding the noise reduction amplifier that operated the galvanometer noise reduction system.

In recent years they have found it much more economical to record on magnetic film only in the rerecording theatre at the time of rerecording. The end magnetic recording can then be transferred direct, without further adjustment, on to optical sound negative. They then transfer this final magnetic recording, one to one, in the transfer department. The correct transfer level is adjusted by an accurate 1 kHz tone recorded on the front of each reel of magnetic film. 'We have been using it for the last four years with the knowledge that we have no low level clipping in our recording.'

Anticipatory noise reduction was important, Tony Lumkin believes, because the Dolby encoded sound track couldn't have worked, he says, without it. Nevertheless he described the Dolby encoded optical soundtrack as the 'first real improvement in 35 mm optical sound to happen in the last thirty years'—pressed to admit that perhaps he might be exaggerating a little, he stuck to his statement.

The team at Elstree stress that they only introduced the Dolby optical soundtrack to the producers after making sure that it was worthwhile, technically sound and in the interests of good sound reproduction in the cinemas. In the early sixties they had tried to improve cinema sound by developing a monophonic sound system using magnetic stripes.

Elstree's chief dubbing mixer, Bill Rowe, who has worked brilliantly (in my opinion) on the sound tracks for such films as *Steppenwolf*, *That'll Be The Day*, *Stardust*, *A Clockwork Orange*, *Murder on the Orient Express* and many more, explained the reasons why magnetic sound, which offers three track stereo and a bandwidth of up to 15 kHz, had never caught on: 'You have to overcome the economic disadvantages of getting a good sound, which means you have to persuade the theatres to re-equip to start with. Then when it's in you have problems with head wear—there's not just one head but a cluster of them and some of the heads wear quicker than others—there are problems of misalignment, theatre managers complain about having to have two sets of equipment, one optical and one magnetic, as well as extra equipment behind the screen for three, or four track stereo—four sets of amplifiers, preamplifiers and loudspeakers. On top of all that you get problems with oxide dust and head clogging.' Lumkin makes the point that release prints with magnetic stripes cost 50 to 60 per cent more than optical release prints.



The Elstree stripe system, however, needed only one magnetic head and the same equipment could be used from the head amplifier onwards as had been used for optical tracks. 'We made nine movies that way,' said Lumkin. 'The unfortunate thing was that the cinemas were not in a state to take it, because when I went up and down the country visiting our theatres I found that in every case I had personally to adjust and set up the equipment to get the correct effect.' He knew that the rest of the industry just wouldn't have accepted it: 'One man couldn't go up and down the country adjusting all the goddam cinemas. So I gave up the effort until I could get the cinemas in line.' Bill Rowe said that some of the cinemas haven't had any maintenance since *The Jazz Singer*.

The magnetic track wasn't the end of their campaign. They also worked on a method of measuring sound output in cinemas, and applied it to their dubbing rooms, and to some of their (EMI) cinemas to very good effect. 'This enabled a sound balance to be attained in fairly short time which would have been impossible using subjective methods which had been necessary in the past. 'We tried then to line up the theatre to sound like the dubbing theatre in which the sound had been made.' A paper describing the system, which applied to normal optical soundtracks, was published in the SMPTE journal in the late sixties.

It was because Tony Lumkin had tried to improve sound reproduction in the cinemas and found that he didn't have the extra staff needed to do it that he welcomed the Dolby system when it arrived. It not only improved the signal to noise ratio and frequency response of the soundtrack, both for Dolby equipped and non-Dolby equipped cinemas, but also

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Pyral tapes

BASED IN FRANCE, Pyral SA intends a sales drive in the professional recording products market through the UK subsidiary, Pyral (UK) Ltd. Further faith in an expanding market has been demonstrated by the establishment of a satellite tape manufacturing plant situated at Eastbourne, Sussex; this is the first built outside France. To date, capital expenditure in the British division exceeds £½M, but by the end of the year this will have reached £1M.

The present product line includes mastering lacquers, magnetic tapes in widths between 6.25 mm and 50 mm, instrumentation and computer tapes, and other specialist magnetic software. The company also manufactures a range of domestic magnetic tape products. Pyral SA, 47 Rue de L'Echat, 94001 Cretil, France. Phone: 1207 4890. Pyral (UK) Ltd, Airport House, Purley Way, Croydon CR0 0XZ. Phone: 01-681 2833.

Tunable band pass filter

INTENDED FOR USE with noise and vibration measuring instruments, the latest B & K band pass filter offers continuous coverage by calibrated panel control in five bands from 0.2 to 20k Hz. The *1621* consists of a tunable single pole Butterworth filter, variable bandwidth and an integral battery power supply.

The front panel selector switch allows the bandwidth to be switched to 3% or one-third octave response measured at the −3 dB drop off points. The unit can deliver a control signal to a B & K portable level recorder *2306* enabling the chart movement to be synchronised accurately with the frequency control of the filter. B & K Laboratories Ltd, Cross Lances Road, Hounslow, Middlesex. Phone: 01-570 7774.

Sweep analyser

THE INSTRUMENT PROVIDES a real time graphical sweep of the response of any channel in the frequency range between 20 to 20k Hz. Manufactured by ROR Associates of Ontario, Canada, the ROR 303 incorporates a sweep audio frequency generator and receiver locked in sync; the rectified output operating the y axis of a storage oscilloscope. In addition, an autoranging led digital meter provides absolute measurement of dBm, dBrn, kHz and percentage total harmonic distortion. Accessories are available which provide return loss measurement, remote control unattended sweep facility and phase shift measurement for interchannel comparison.

The manufacturers state that the analyser finds applications in the examination of telephone lines, data channels, tape recorders and other recording systems, equalisers, amplifiers and companders. ROR Associates Ltd, 21 Rolark Drive, Scarborough, Ontario M1R 257, Canada. UK agents: Wandel & Goltermann (UK) Ltd, 40/48 High Street, Acton, London W3. Phone: 01-992 6791.

Change of address

SOUNDCRAFT ELECTRONICS LTD has moved from their former premises in Tottenham Court Road. The new address is: 4th Floor, 5/8 Great Sutton Street, London EC1. The phone no. has also been changed and is now: 01-251 3631/2/3.

Cadac news

THE COMPANY CONFIRM the appointment of Frank Woodington as sales manager. He brings much experience gained from within the broadcast and sound recording industry; Frank, in his own right, has engineered sessions at many studios in this country and abroad. It is hoped that the new appointment will relieve Clive Green of much of his work-load, enabling more time out for design and development.

Cadac have recently announced the availability of an automated mixdown system for use with their consoles. Based on the Allinson Automation design, it will be available for retrospective fixture to existing desks as well as new ones. Cadac (London) Ltd, 141 Lower Luton Road, Harpenden, Herts AL5 5EL. Phone: 05827-64351.

Macinnes France

A NEW PARIS-based company has been established to handle distribution of the Amcron range in France. In addition, the new company will handle certain other agencies along with their own products. The address for Macinnes France is 50 Bis Rue Labrouste, 75015 Paris. Further details are available from I. M. Marshall, Macinnes Laboratories, Macinnes House, Carlton Park Industrial Estate, Saxmundham, Suffolk. Phone: 0728-2262/2615.

ATC loudspeakers—addenda

IN THE SOUND 75 show report (June p16) we stated that the Acoustic Transducer Co is the only British manufacturer 'to produce loudspeakers with edge-wound copper ribbon voice coils'. Goodmans Loudspeakers inform us that this is not so; they have been marketing such a drive unit since May 73 and have subsequently launched a further (35 cm) model. Both speakers feature 10 cm dia edge-wound voice coils, the sensitivity for the 30 cm version quoted as 0.12W for 96 dB at one metre.

Didn't they do well?

IN A RECENT jicrar survey conducted between April 21 and May 4, figures disclosed indicate a further million Londoners listen to the combined outputs of Capital and LBC—the London-based independent radio stations. The last survey, conducted eight months prior, showed that both stations drew an indicated total of 4 475 000 listeners compared to the most recent figure of 5.5M. The stations interpret the results to mean that 46% of Londoners now listen to the combined ilr broadcasts each week within the main listening area, comprising the GLC and immediate surrounding areas within the reach of the vhf transmitters.

Capital and LBC claim to command 23% of all radio listening time—an increase from the 15% share of audience time reported as recently as October 74. They further claim that the corresponding share for the BBC audience has dropped by 8%.

Servo Scully

THE LATEST SERIES of *280* machines offer an increased reel size up to 35.5 cm and dc servo drive of capstan. Using a printed armature, the new motors are offered as an optional extra on the basic machine. According to the manufacturer, the increased reel capacity corresponds to a trend towards the use of 76 cm/s for mastering; this requires double the spool capacity for a given programme length.

The basic Scully *280* range comprises *280B*, *284B* and *284B-8* offering two track 6.25 mm, four track 12.5 mm and eight track 25 mm width tape format respectively. All models feature motion direction sensing control, dynamic braking and illuminated pushbutton controls. Available in rack or console mounted form, the machines provide easy operator control from a remote location. In addition, optional extras include a varispeed system with led readout of actual tape speed. Scully/Metrotech division of the Dictaphone Corporation, 475 Ellis Street, Mountain View, Ca 94040, USA. Phone: (415) 968 8389. UK agents: Lee Engineering, Ashley House, Ashley Road, Walton-on-Thames, Surrey KT12 1JE. Phone: Walton-on-Thames 28783/4.

Stellavox in W Germany

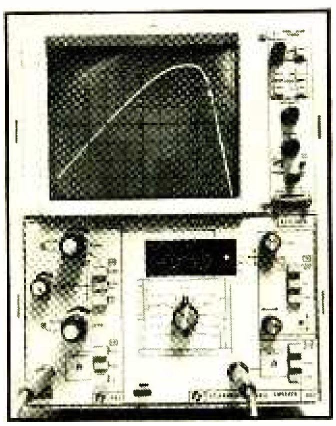
THE WEST GERMAN agency for Stellavox professional, audio and data storage and handling products has been given to the Akustische und Kino-Gerate GmbH (AKG).

In addition, the same company will distribute Tannoy professional loudspeakers and Lyrec tape recorders and cassette tape duplicators.

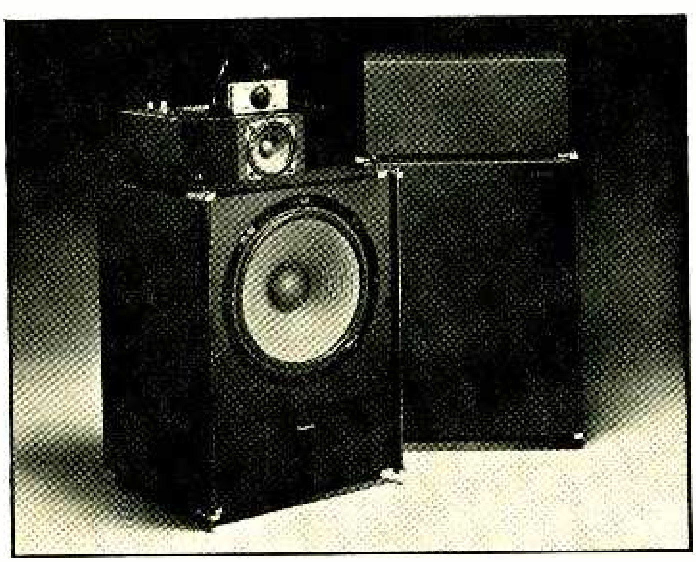
Technical specifications and price lists can be obtained directly from Studiotechnik Retail Sales, AKG, 8 Munchen 60, Bodensee Strasse 226/230, West Germany. Phone: 0 89-87 00 11. Stellavox, Georges Quellet, Engineer EPZ, 2068 Hauterive/Ne, Switzerland. Phone: 038 33 42 33.

Coffee pot

THE ADVANTAGES OF a sealed rotary attenuator and the convenience of a slider are claimed to be combined within the 'Rotary Slider' produced by Robins-Fairchild. Officially described as 'coffee proof', the units feature two separate resistive elements driven by a common slider arrangement. The makers state that the mechanism is rugged and simple to provide continuous, trouble-free operation without the maintenance normally expected with conventional slider faders. Robins-Fairchild, 75 Austin Boulevard, Commack, New York 11725, USA. Phone: (516) 543 5200.



Left: The ROR 300 audio sweep analyser available from Wardel & Goltermann



Below: A new speaker from Technics. The SB 7000P described as a linear phase loudspeaker.

Follow that man

PYE TVT LTD announce the sale of an ob vehicle to the Egyptian broadcast network specifically 'to perform a unique function following the movements of President Sadat for both on the move and on location live broadcasting and recording'.

Powered from a local mains supply if available, the ob truck can operate off its own batteries for up to three hours before reconnection becomes necessary. The vehicle is fitted with vhf radio telephone to provide cueing from the base station for programme direction purposes. Pye TVT Ltd, PO Box 41, Coldhams Lane, Cambridge CB1 3JU. Phone: 0223-45115.

Ferrograph salesman

TED FARNON HAS been appointed as sales manager of the Ferrograph Professional Recorder Co. He joins them after ten years' experience with RCA selling broadcast equipment to radio and tv stations. Ted will assist marketing manager Paul Heelas in the sales and promotion of the new *Studio 8* professional tape recorder. The Ferrograph Company Ltd, Auriema House, 442 Bath Road, Cippenham, Slough, Bucks SL1 6BB. Phone: 062-86 62511.

Synthi follower

THE LATEST BLACK box from Omniphon offers pitch and envelope control of internal generation and processing by reference to the pitch and shape of an externally applied audio signal. This can be derived from either mic, electromusical source or another synthesiser.

In operation, the Metamorphoser translates the input control audio voltage into control voltages proportional to the lowest pitch, level and timing. These are applied to conventional synthesiser functions to produce new sounds which bear a limited relationship to the original audio signal input. The basic functions incorporated within the unit include a pitch follower, envelope follower, noise generator, multiplier, low pass filter and amplitude shaper.

The manufacturers suggest applications in synthesis for voice and instrument accompaniment, incorporation at mix-down stage to lay new tracks from existing ones, pseudo frequency shifting (offset to the pitch generator) as well as many others. The basic unit costs $920 from Omniphon, Box 166, Churchill Road, Mason, New Hampshire 03048, USA.

Latest ilr station

PLYMOUTH SOUND, the first local radio station in the south-west of England, has begun transmissions using the transmitters of the Independent Broadcasting Authority. With an expected coverage of 320 000 people, the service area extends over a 12-mile radius around the town of Plymouth. Initially, the programmes start at 0600 hours running through until 2200 hours.

Plymouth Sound is the eleventh ilr service to open, bringing the total number of potential listeners within the specified service area to over 20M people. There were three applications for the station franchise, the successful consortium being headed by The Earl of Morley, chairman of Plymouth Sound Ltd.

THE DICTAPHONE CORPORATION, parent company of Scully-Metrotech, have begun a 'cost-reduction program'. Part of the reason, we understand, apart from the usual 'cash flow' difficulty, is that sales have fallen. Thus it seems strange that they should sack John Didlock, who in 1973 was the division's best salesman, having achieved 125 per cent of the sales target he was given that year, for which he was rewarded with a trip to Hawaii for himself and his wife.

A matter of weeks ago, Dictaphone failed in an attempt to take over an American dental supplier called Sterndent. Sterndent had been resisting bids by the American company Cable Funding, and Dictaphone agreed to pay $19 in cash for each of the 2.1 million outstanding shares in Sterndent, according to the *Financial Times* of February 26 this year. If it had been successful, the bid would have doubled the size of Dictaphone; one of the reasons for making the bid was the large cash value of the precious metals held by Sterndent. In the event, Dictaphone couldn't fund the takeover.

It's even been reported that MCI were visited by Scully emissaries interested in taking over MCI, this at a time when Scully don't have a flying sales representative in Europe or North Africa. In October last year Dictaphone were, themselves, the object of a takeover bid by the Northern Electric Company of Canada. Dictaphone filed a lawsuit to fight the $12 a share offer, accusing NEC of 'fraud'.

Didlock's disappearance has not changed the Scully dealerships, and their equipment is still available from Lee Engineering.

PATENTS

THE FOLLOWING list of Complete Specifications Accepted is quoted from the weekly *Official Journal (Patents)*. Copies of specifications may be purchased (25p) from The Patent Office, Orpington, Kent BR5 3RD.

May 7

1397662 Siemens AG
Electroacoustic transducers.
1397668 Singer Co
Digital tone generator.
1397755 Philips Electronic & Associated Industries Ltd
Synchronisation of a radio signal receiver.
1397758 Siemens-Albis AG
Telecommunications exchange systems.
1397759 Siemens-Albis AG
Pcm telecommunications exchange systems.
1397760 Siemens-Albis AG
Pcm tdm telecommunication network systems.
1397828 International Business Machines Corporation
Current generator.
1397856 Oak Industries Inc.
Converter.
1397900 Sansui Electric Co Ltd
Encoding method for converting multichannel sound signals into two-channel composite signals.
1397972 Blaupunkt-Werke GMBH
Magnetic tape machine.
1397973 Kokusai Denshin Denwa Co Ltd and Post Office
Time division multiple access satellite communications system having special reference bursts.
1398152 Fuji Xerox Co Ltd
Circuitry for reducing the bandwidth of an information signal.
1398171 Industrial Research Products Inc
Diaphragm assemblies for electret transducers.
1398172 Industrial Research Products Inc
Support plate assemblies for electret transducers.
1398237 Cambridge Consultants Ltd
Liquid crystal display means
1398262 EMI Ltd
Aerials.
1398318 Electonique Marcel Dassault Sa
Radio signal receivers.
1398330 British Broadcasting Corporation
Acoustics of studios and the like.

May 14

1398607 Soc Italiana Telecomunicazioni Siemens Spa
Speech interpolation system for time-division multiplexed signals.
1398614 Froidevaux A
Sound recording methods and apparatus.
1398647 Motorola Inc
Sequential tone signalling system.
1398665 Suzuki, T
Magnetic head height changing device.
1398689 Ted Bildplatten AG AEG-Telefunken Teldec
Method of and device for producing a readable identification mark in the central area of a disc-shaped information carrier particularly in a first stage for an audio disc.
1398732 Sony Corporation
Signal processing system.
1398733 Sony Corporation
Variable filter.
1398786 Sony Corporation
Multisignal transmission apparatus.
1399179 Nippon Gakki Seizo KK
Electronic musical instrument capable of providing a third type of musical tones by operation of two keyboards in addition to the ordinary melody and chord tones.

May 21

1399365 Boeing Co
Apparatus for coding audio signals.
1399393 Sony Corporation
Phase comparator circuits.
1399433 Nihon Denshi KK
Apparatus for recording and reproducing picture signals and a medium for carrying said picture signals.
1399464 EMI Ltd
Methods of shaping styli.
1399511 Matsushita Electric Industrial Co Ltd
Quadraphonic devices.
1399512 Martin Marietta Corporation
Method and circuit for timing signal derivation from received data.
1399525 Rank Organisation Ltd
Record playing machine.
1399534 Pioneer Electronic Corporation
Automatic cassette changing mechanism for a tape recorder or reproducer.
1399559 Synaps Co Ltd, and Yamamoto, H
Method of and apparatus for reproducing a gramophone record.
1399766 Motorola Inc
Acoustic transducer including piezo-electric driving element.
1399781 International Standard Electric Corporation
Headset.
1399819 Marconi Instruments Ltd
Ramp voltage generators.
1399844 Coal Industry (Patents) Ltd
Radiating transmission lines.
1399846 AKG Akustische U Kino-Gerate GmBh
Artificial reverberation device.
1399950 Bosch Fernsehanlagen GMBH, Robert
Television apparatus.
1399961 Asahi Glass Co Ltd
Method of forming a patterned transparent electro-conductive film on a substrate.
1399980 Okikiolu, G O (trading as Okikiolu Scientific & Industrial Organisation)
Scanning systems employing electromagnetic wave energy.

DECCA LTD, IN two new patents (BP1373511 and BP1373512) describes an interesting new approach to the production of gramophone records. Although the patents are concerned mainly with the manufacture of video discs, they do contain clear statements to the effect that the claimed technique is applicable to conventional gramophone records for playing with conventional pickups.

The technique described relies on cutting a groove in a disc blank with a modulated electron probe. The disc blank is formed of a conductive metal, coated with a thin layer of thermoplastic. This disc is rotated on a turntable beneath an electron probe and the electron beam is modulated by the signal to be recorded. Thus as the disc rotates there is laid down on its surface a spiral track of varying electrical charge. This charge creates a force on the thin thermoplastic layer which separates it from the conducted disc. Especially if the thermoplastic is heat-softened, it will deform in direct relation to the strength of the charge, to produce a groove modulated in hill and dale fashion.

The master thus produced is of course unplayable, but if it is coated with a thin layer of metal by evaporation techniques, it can be played back for checking by rotating it under an electron gun and picking up the electrons scattered from the groove. Pickup is via an electron collector. The output from the collector is a signal which varies as the groove depth varies in wavelike motion to give an accurate reproduction of the original recorded signal.

Decca suggests that the metal-coated master can be used to grow mothers and stampers in generally conventional manner for production runs of disc copies. The claim is that discs produced this way will have a band width capability of up to 50 MHz. The pressed discs can be played back either with conventional styli or other forms of pressure transducer. Probably the technique is already in use as part of the Teldec video disc system, but the hint that records made in this way can be reproduced on semi-conventional gramophones does suggest that Decca has thoughts, however vague, of producing wide band width audio discs. Of course with band widths of the order claimed it becomes possible to record large numbers of discrete sound channels in a single groove.

Adrian Hope

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stereo-phase broadcast cartridge

Finally,

the first truly stereo-phase broadcast cartridge:

- ★ No cartridge adjustments ever needed
- ★ Individually tested – 100% – for stereo phase, wow and flutter, tension, output and azimuth
- ★ Guaranteed ± 90° phasing up to 12.5 KHz
- ★ Made completely from prescreened components
- ★ Arrives ready to use; no test tones to erase
- ★ Guide is molded into base; correct phase and azimuth are permanent
- ★ Available in these time configurations, each guaranteed:
  20, 40, 70, 90, 100 and 140 seconds
  2.5, 3.5, 4.5, 5.5, 7.5, 10.5 and 12.0 minutes

Ambisonics is a technology for surround-sound which aims specifically at not *making four (or any other number) of loudspeakers audible as separate sources of sound. It is designed using appropriate engineering methods and psycho-acoustic theory that has shown good predictive value to make best use of available channels of communication (two or more), and of loudspeakers (a limitation often forgotten), to give stable and uncoloured acoustic images in any position, keeping the physical means of reproducing the sound as unobtrusive as possible. It claims wide freedom of recording methods and of source material, as well as protection of recorded material from obsolescence.*

Ambisonics. Part one: general system description

PETER FELLGETT*

Ambisonics in the perspective of surround-sound technology

MONOPHONIC REPRODUCTION provided information about direction and distance only implicitly, through ambience labelling. Stereo added explicit directional information over a front-sector not exceeding 60° in width (ie ±30°, although some discriminating listeners prefer to set the limit for really satisfactory stereo-blending at ±15°).

Beyond stereo, the technology can be developed in several ways:

1. By using more loudspeakers.
2. By using more channels of communication.
3. Making better use of the available number of loudspeakers and channels.
4. Extending directional information from the 60° front-sector of stereo to a full 360° surrounding the listener in the horizontal plane, or to complete spherical surround reproduction including height.

These ways are distinct, but of course the greatest opportunities for enhanced capability lie in combining them as an integrated whole. In general terms, this is the aim of the NRDC Ambisonic technology.

In ordinary life we are bathed in sound from all directions; so much do we take this for granted that it often passes unnoticed until it is cut off, eg in an anechoic chamber, when its loss is keenly felt. Except in so far as the reverberation of the listening-room can supply the deficiency, stereo reproduction subjects us to this deprivation. A major aim of developments beyond stereo has therefore rightly been the extension to surround-sound reproduction.

The first attempts at surround-sound (apart from some early experiments) used an approach generally called 'quadraphonic'. This term has not of course been precisely defined, and usage is not always consistent. We shall therefore use, as a label for this general approach, the more accurate term *quadrifontal*, meaning 'four-source'. This will be taken to mean that there are assumed to be just four signal sources which are to be connected to exactly four loudspeakers in a one-to-one manner through four respective channels.

Based on existing practice relating to four track master tape, and on the probability that most surround-sound listeners will (at least at first) be constrained by the size of their pockets and the shape of their rooms to use four loudspeakers, these assumptions have a superficial plausibility, but further consideration suggests them to be inadequate in several important ways:

1. Four track master tape is by no means the only source of signals to be considered: there is multitrack and multi-microphone material available for surround pan-potting, and of course the natural sound-field of performed music including reverberant as well as direct sound.
2. There are very good reasons (see Part Two) for not being restricted for ever to some fixed number of loudspeakers, especially not to four.
3. The assumed objective can be attained only if four channels are available, and in their absence can only be imitated more or less unsatisfactorily. This requirement precludes the direct use of the many two-channel recording or broadcasting media at present used for stereo, whereas satisfactory surround-reproduction is perfectly practicable in a system designed from the start to use two available channels.
4. Independent access to the signals reaching each loudspeaker appears at first sight to give the producer or recording engineer maximum freedom, but in fact denies it to him because it presents him with a problem analogous to opening a lock without having the key. *Except in the special case of an image in the direction and at the distance of one loudspeaker* it does not suffice simply to squirt independent sounds from each speaker. In general each loudspeaker should radiate a wave of amplitude and phase carefully calculated to combine in the listening-space so as to reconstruct a simulacrum of the intended surround-field fulfilling relevant psycho-acoustic criteria.[1] This reconstruction is in some ways analogous to an acoustic hologram, and account must be taken of the size and shape (unknowable at the time of recording) of the individual listener's loudspeaker array.

   A competent system takes care of these precise interrelations automatically, just as a key automatically brings the levers of a lock into register so that the bolt can slide freely. Unless the system does this, there is virtually no chance of achieving clean stable images other than in a restricted set of directions. The result is the familiar practical restriction of 'quadraphonic' reproduction to corner positions, front sector, and perhaps rear centre, with side positions virtually unusable (see illustration).

A particularly unfortunate form of the quadrifontal approach, which may perhaps be called the 'full quadrifontal' form, assumes in addition that the four source-signals are pairwise blended. This imposes further restrictions and disadvantages:

1. It makes less than full use of the information capacity of the available channels; it is possible to do as well or better with less than four channels.
2. The implied directional coding, having discontinuities of slope, cannot be realised by pick-up from any combination of ordinary directional microphones. Natural sound, including its indirect reverberant content, is therefore excluded.
3. The format gives poor results when replayed directly through four loudspeakers (see Part Two). It is therefore particularly inappropriate to take this unsatisfactory form of playback as the standard of comparison for surround-sound.
4. It places undesirable restrictions[3] on the encoding loci that can be realised subsequently, particularly in two channel format; for example the Japanese 'Regular Matrix' definitions[2] cannot be implemented by matrixing pairwise blended material. This (and other) criticisms of this widely-used four track format were at first strongly resisted (using blanket 'commercial' assertions) but are now recognised even in the so-called 'pairwise' and 'optimum' loci incorporated in the provisional 'matrix quadraphonic' standards of the USA RIAA.[4]

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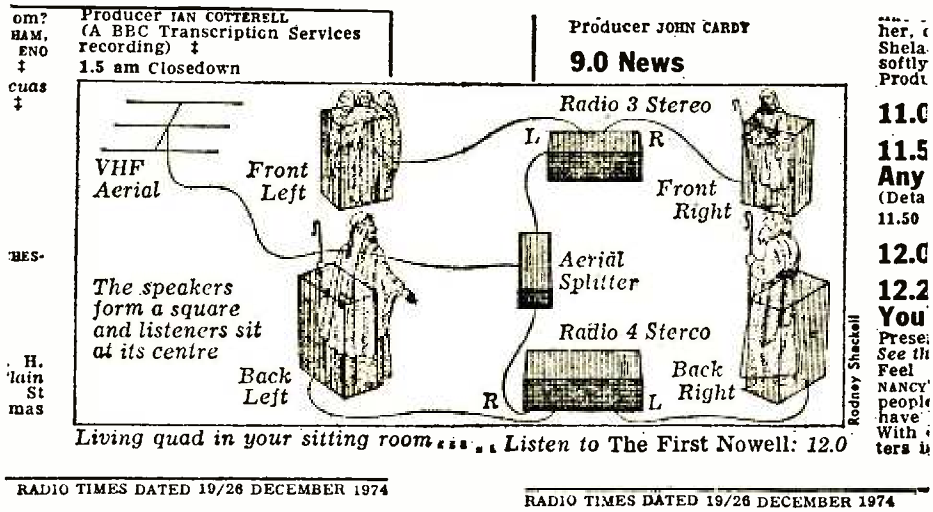


Above: *An illustration of the restrictive limitations of the four-source 'quadrifontal' approach to surround-sound.*

The basic fault of pairwise blending is that each musical instrument (or other source) considered by itself activates only one pair of channels or loudspeakers. This is not beyond stereo in concept or capability, but merely extends stereo to less and less suitable speaker-angles and hearing sectors as we go from front, to back, and to the sides.

Quadrifontal assumptions underlie the regrettable practice of using 'four channel' (or even 'quad') as if it were a synonym for surround sound. Two channel surround systems are then called 'matrixed four-channel', creating the need to distinguish systems that do actually use four channels as 'discrete four-channel' (although the channels are in fact continuous, blended and frequently multiplexed!); we eschew such misleading terms. Any reference to 'the original four-track tape' lies of course entirely within quadrifontal assumptions; in reality *the original to be reproduced is nothing else than the producer's or recording engineer's intentions, and any intermediate format is to be adjudged good or bad according as it helps or hinders the realisation of this original.*

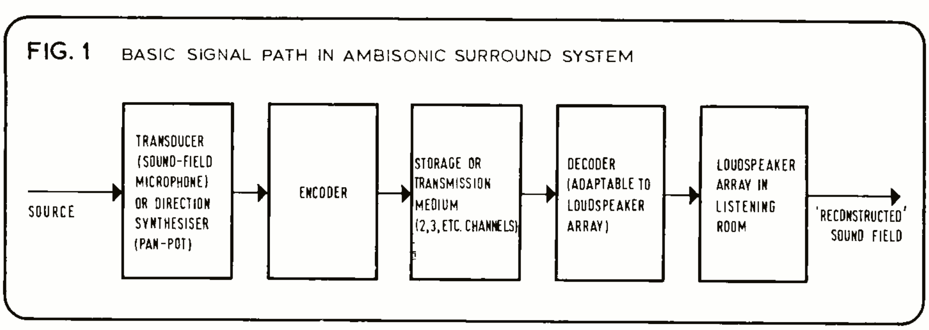
Against this background, Ambisonics may be seen as a basically straightforward technology for surround-sound reproduction, designed from the beginning to accept all competent source material, and to make the best use of the available resources in channels (two or more) and loudspeakers (any reasonable number), neither seeking to reproduce a derived 'original' nor attempting or pretending to communicate more channels-worth of information than there are channels in the system. Its methods conform to established principles of sound engineering, applied in new ways and making use of newly acquired knowledge of psychoacoustics. It is not of course perfect, since perfection would require many thousands of channels and a million or so loudspeakers.

Requirements for a surround-sound system

Necessary or desirable requirements in a viable surround-sound system include the following:

1. Ability to accept any competent source material. This includes at least:
   (a) Natural sound-fields. This is important for all kinds of performed music, and must include reverberant as well as direct sound. It does not suffice to provide merely a vague splash of reverberation having an appropriate decay time. There should be a structured association of direction and delay of indirect sound giving specific information about the acoustic ambience of the performance, including definite impressions about the size and shape of the hall. Recent research has shown that ambience labelling according to place of origin of each sound is an important aid both to image localisation and to the ability to discern inner lines in a musical texture despite differences of intensity level. Balance is thus made less critical and (particularly in pop) greater musical complexity becomes acceptable by a given audience.
   (b) Multitrack and multi-microphone material for pan-potting; that is to say, mono signals on which synthetic directionality is to be imposed. There is never, of course, any difficulty in principle in building pan pots to conform to any encoding standard whatsoever in any system. The more demanding requirement is for a means of adding artificial reverberation having subjectively smooth and uncoloured characteristics. (In the present state of technology artificial ambience, as distinct from mere reverberation, is best obtained naturally, if this paradoxical way of putting it can be excused.)
   (c) Existing pairwise-blended material. This should be seen as a rescue operation for historical material, optimising the compromises inseparable from the limitations (discussed in the opening section) inherent in this format, which should therefore not be used for new recordings where alternatives are available. This is nevertheless an important requirement in view of the large investment of the industry in material recorded in this form.
2. Availability of a format, for studio use, robust to the inevitable small errors of intermediate recording and providing good facilities for processing, including a versatile gamut of 'effects'. This format should above all preserve explicit directional information, and thus preserve options for the future.
3. Encoding standards, for public issue, having at least the following properties:
   (a) Unambiguous encoding of *every* possible sound-direction.
   (b) Low sensitivity to errors of transmission and of decoding.
   (c) Freedom for the listener to decode into any reasonable number of loudspeakers in any reasonable array. In particular, rectangular speaker arrays should be catered for, since few rooms are square. The desirability of not restricting the number of loudspeakers to the conventional four has already been indicated, and is further discussed in Part Two.
   (d) Capable of being decoded so as to give accurate and stable localisation, and freedom from coloration, according to the best available psychoacoustic criteria.
4. Mono and stereo compatibility. In one sense, this is a special case of the listener's freedom (as in 3(c)) to use any number of loudspeakers, ie one for mono and two for stereo. The special difficulty is that mono and stereo represent methods of decoding (representable indeed by matrices) prescribed by useage, which are nonetheless definite for being trivial in the sense of requiring no explicit decoder but only suitably connected pieces of wire. Unfortunately the implied decoding matrices ('obvious' though they seem) can be shown to be incompatible in any context of two channel surround sound encoding.

FIG. 1 BASIC SIGNAL PATH IN AMBISONIC SURROUND SYSTEM



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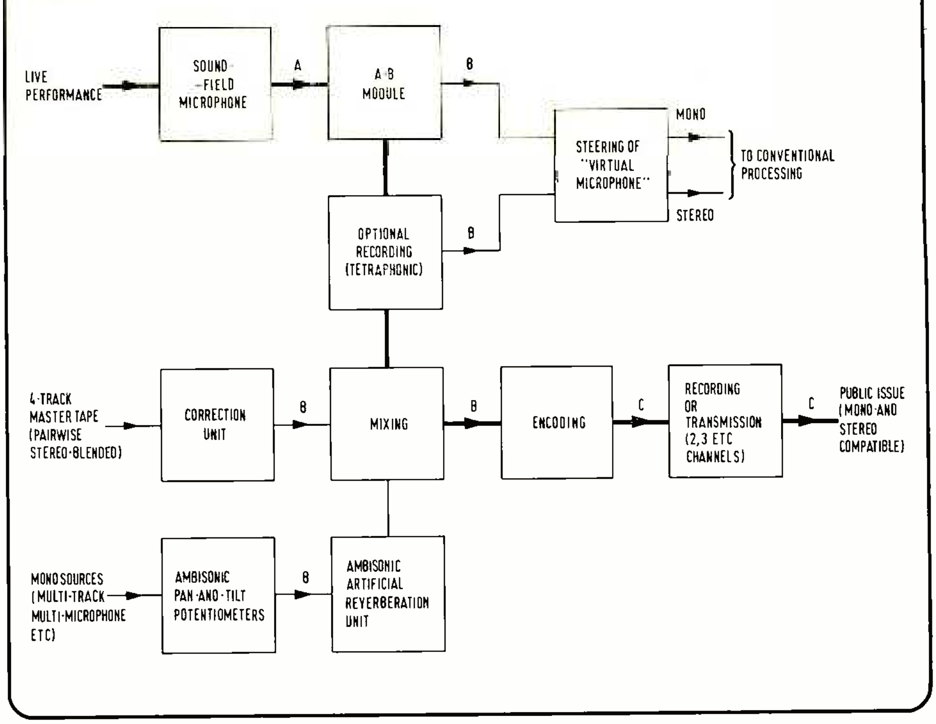
This is not the 'fault' of any surround sound system (not even quadrifontal) but is the result of an unhappy historical accident. Some compromise therefore has to be made between mono and stereo compatibility in *any* two channel surround system. The available means of effecting this compromise are fortunately sufficient to reduce the technological incompatibility to the level of the inevitable artistic compromises between mono and stereo; they need not affect the surround reproduction characteristics, essentially because the choice of surround decoder is still open at the design stage.

5. Capability of growth to give protection against obsolescence. Primary interest should be (and probably is) in two channel systems, because of the extensive ready-made commercial outlets available in two channel media of recording and broadcasting originally developed for stereo use. It is important however for the two channel technology to be compatible with extensions into more channels as they come into wider use (as without doubt they will, sooner or later), eg three channel fm broadcasting making full use of the triple audio bandwidth of the Zenith-GE system, multiplexed vinyl discs, multi-track magnetic tape, and the use of video-disc technology. As soon as at least three channels become available, the possibility of including height information has to be considered. even if only as a contingency for when the public may be ready for it. It is particularly important to hold master-tapes in a format that will not be prejudiced by such developments in the foreseeable future.

FIG.2



Ambisonic systems and characteristics

The basic NRDC Ambisonic realisation is a two-channel pantophonic system, ie giving 360° horizontal surround and needing only stereo recording or broadcasting media for dissemination. It is extendable to three channel pantophony, and to three or four channel periphony (ie with height). Particular attention has been given to the use of a third channel of reduced bandwidth (as in the Nippon Columbia TMX system). Five channel pantophony and nine channel periphony have also been studied theoretically; although these are not of current commercial interest, it is reassuring to know that compatible developments are possible well beyond presently foreseeable needs. All systems share a uniform technological design, which includes the following essential steps and signal formats:

1. Transduction or synthesis of signals representing both the desired sound waveform and its directionality. A signal format directly related to cardinal directions has been standardised as *A-format*.
2. Conversion, where a separate step is required, into studio and recording *B-format*.
3. Encoding for public dissemination; this coded form is defined as *C-format*.
4. Decoding into signals suitable for driving loudspeakers. This *D-format* cannot be precisely standardised since it necessarily depends on the number and layout of the listener's loudspeakers; suitable options and adjustments are provided in Ambisonic decoders.

It is hoped shortly to release a set of Reports* giving details and specifications, which the present article is of course too small to contain. To the best of our knowledge the NRDC Ambisonic system alone fulfils some of the individual requirements previously set out, and is almost certainly unique in fulfilling all of them.

The basic features of an Ambisonic surround-reproduction chain are displayed in **fig. 2**, together with some of the facilities that can be provided. The following aspects may be particularly noted:

1 Sound-field microphone. This is an omni-directional microphone in the true sense, which is the *opposite* of non-directional; it characterises in a symmetrical manner the waveform and directionality of sound arriving from any direction (including vertical components). In its present first-order implementation it does so in terms of four signals corresponding to the spherical harmonic of directionality of order zero, and the three of order unity. Recordings of these signals (or their equivalent), especially in B-format, are called *tetraphonic* (there is of course no correspondence with the four signals assumed in quadrifontics). An important by-product of recording in tetraphonic mode is that the complete capture of first-order directional information enables *any combination of non-directional, figure-of-eight, cardioid or hypercardioid microphones to be simulated and their directions steered* (including vertically) *after the recording session.* Although remote real-time adjustment of directionality has long been available, for example in the AKG *C24* microphone, post-session freedom of adjustment is believed to be new. In addition the virtual microphones are *truly coincident* (see Part Two), a requirement of conventional stereo hitherto unfulfilled. (It is worth noting that the sound-field microphone depends on placing capsules in accordance with Sampling Theory on a sphere, and the associated circuits are an integral part of it; the superficial resemblance of the lowest-order form to the well-known tetrahedral array of separate microphones is mainly misleading.)

2. The choice of a C-format encoding standard is central to the whole design. It must be mathematically compatible at the two interfaces respectively to the source-material and to the listener's equipment so as to be capable of correct decoding. A basic tool for design and characterisation of two-channel encoding is the Poincaré-Stokes sphere, first used in this connection by Scheiber[5] and much developed by Gerzon.[3] Like a circuit diagram, it gives a geometrical picture from which system properties may be inferred (including the weaknesses of systems claimed to be 'quadraphonic').

It is now known that for surround-reproduction the horizontal pan-locus on the Poincaré-Stokes sphere should be nearly a great-circle. The Nippon Columbia BMX system uses a great-circle locus, and a different one is defined by the Japanese RM specifications. The Ambi-

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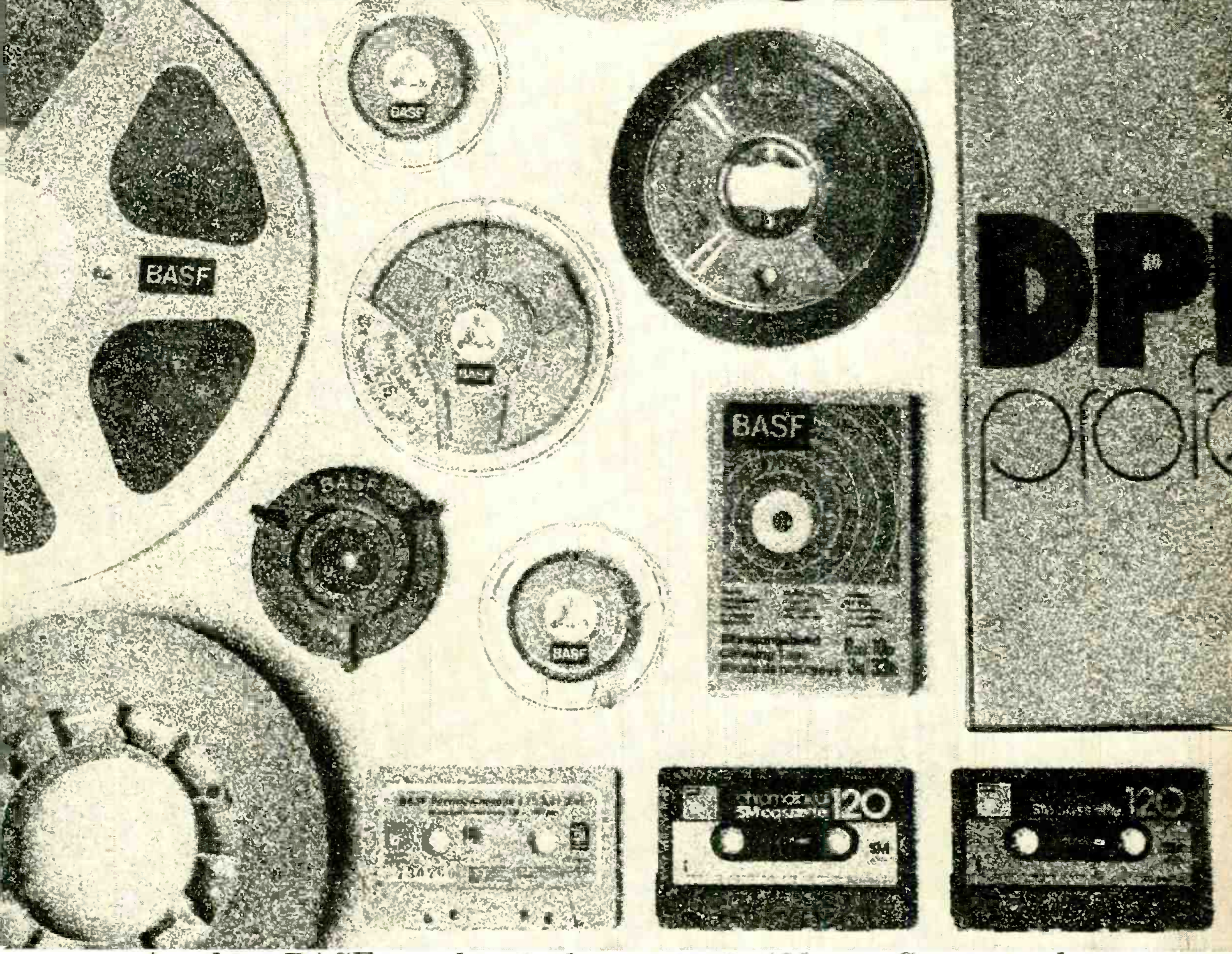
*Enquiries can be made Attn. P. Thompson Esq, National Research Development Corporation, PO Box 236, Kingsgate House, 66/74 Victoria Street, London SW1E 6SL.

THE 2-DAY WONDER.



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Conventional methods of 'quadraphonic' reproduction may not convey the original sound field to best advantage. The studio techniques for ambisonics and its applications are discussed, in the light of both accepted 'quadraphonic' techniques, and the requirements of further accurate reproduction of the sound field. Areas of compatibility and of disparity are discussed, to be read in the light of Peter Fellgett's system description on page 20.

Ambisonics. Part two: Studio techniques

MICHAEL GERZON*

The main aim in the development of NRDC ambisonics technology has been to record, to convey to the consumer, and to reproduce an accurate and repeatable surround sound directional effect. It is now well known, both from controlled experiments and from the experience of recording engineers and producers, that existing surround sound approaches (including the four channel 'discrete' approach) give extremely poor image stability for all positions except the four corners, even under ideal conditions. With 'discrete' techniques, the front stage suffers from the 'hole in the middle' effect, and the sides are virtually unusable in any less-than-ideal situation (eg when the listener is not at the centre of the speaker layout, or when the layout is non-square).

The impracticality of existing approaches has led to a careful study of each stage of the multichannel recording and reproduction of a sound field. [1 2 3 4]. The aim of a surround sound system is to reproduce at the listener's ear accurately, reliably and repeatably, the directional sound field created in the studio either by a sound field encoding microphone array, [1] or by artificial directionality encoding devices (pan-pots) or artificial surround-reverberation devices. This aim contrasts with the aim[2] of quadraphonic systems, which is to duplicate in the home the defects of a pair-wise mixed mastertape. Without accuracy and repeatability of directional effect, the recording producer's work will not be heard correctly by the domestic listener, and artistic communication will be compromised.

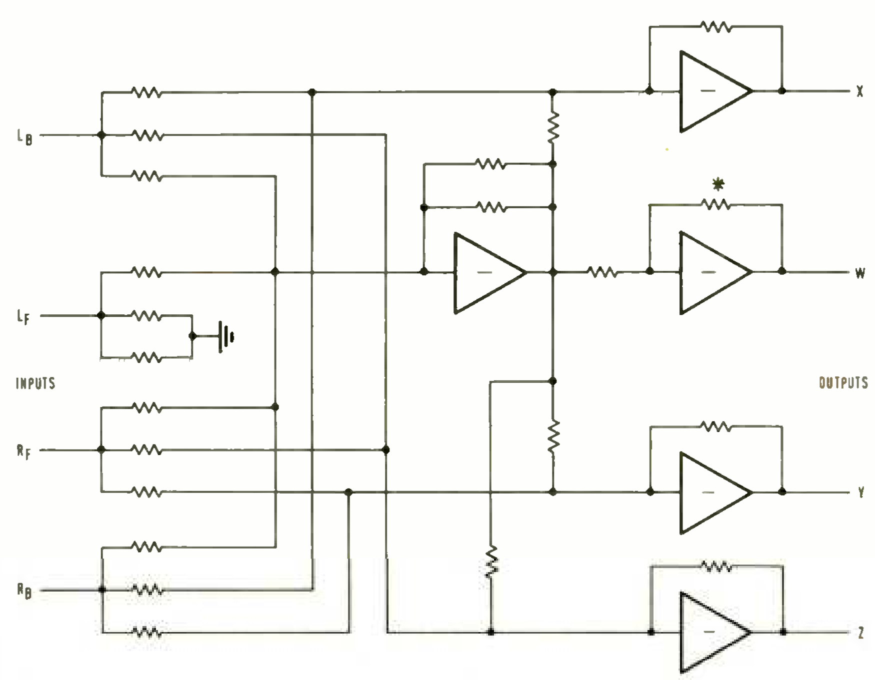
In order to maintain accuracy of effect, the process of encoding the sound field on to a mastertape must be accurately specified, and the specification accurately followed in either the microphone arrays or the pan pots. Existing 'pairwise' pan pots do not give a satisfactory encoding specification[3]. Similarly, most microphone clusters use microphones with poorly defined polar diagrams that are frequency-dependent and spaced apart, and so fail to satisfy a reasonable encoding specification. Conventional mastertape encoding assigns the four speaker feed signals to four tracks of a tape, but it is obvious that this is a sub-optimal procedure, even with correctly designed microphones and panpots. In order to recreate the illusion of a given directional field, it is obvious that the speaker feed signals will not be the same for a rectangular speaker layout as for a square one. Thus if we are to accommodate a variety of shapes of speaker layout appropriate to differently shaped listening rooms, we need to use a decoder to derive the speaker feed signals appropriate to the layout used.

As we shall illustrate later in this article, the optimal decoder even for a square speaker layout is a rather complex frequency-dependent matrix, and so we must face the fact that the mastertape merely encodes the sound field information, and not speaker feed signals.

Studies[3] in the design of decoders for four-speaker rectangle layouts show that three channels of information are optimal for accurate image localisation. The addition of a fourth channel always degrades image localisation quality (eg by giving a 'hole in the middle' effect). Thus, the basic horizontal encoding specification has to be three-channel. Most studio equipment used for surround sound mastering has four available channels, and so the problem arises of how to use this fourth channel. Since no useful extra horizontal information may be encoded in the fourth channel, it may most fruitfully be used for encoding height or elevation information.

It is not suggested that periphonic (ie with-height) reproduction will be a serious commercial proposition at the present time, but periphonic technology is now understood, and

FIG. 1 AB MODULE. ALL RESISTORS SHOULD HAVE AN IDENTICAL VALUE, SAY 33kΩ.



*Mathematical Institute, University of Oxford

not much more complex than horizontal-only technology. The adoption of a periphonic standard at this stage will prevent the premature obsolescence of valuable mastertapes in ten or fifteen years when periphony becomes commercial, and meanwhile will permit producers to gain periphonic experience without premature commercial pressures. It is also wise to ensure that existing media can change over smoothly to a periphonic standard in the future, so as to prevent a repetition of the chaos caused by quadraphonics. At the present time, the height information gives useful additional mixdown flexibility for stereo or horizontal surround effect. If height is not required, it may be omitted, as in most of the equipment described subsequently.

For studio use, there are two four channel signal formats, termed A-format and B-format. A-format consists of four channels L_B, L_F, R_F, R_B compatible with existing 'discrete' practice for the four corner positions. Technically, the A-format signals may be described for horizontal only sounds as the outputs of four hypercardioids each having nulls 120° off-axis (or their panpot equivalent signals) pointing in the four corner directions. When height is included the A-format signals are the outputs of four hypercardiods with nulls 114.1° off axis pointing respectively 35.3° below, above, below and above the four corner directions (ie towards regular tetrahedral axes[5]).

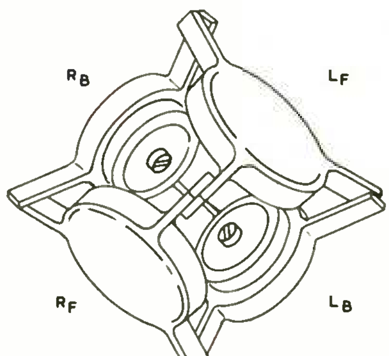
The second format is B-format, consisting of the four signals X, W, Y, Z, where X is a forward facing figure of eight signal with frontal gain $\sqrt{2}$, W is an omnidirectional signal of gain 1, Y is a sideways-facing figure-of-eight signal with leftward gain $\sqrt{2}$, and Z is an upward figure-of-eight signal with upward gain $\sqrt{2}$.

The circuit to convert A-format to B-format, known as an 'AB module' is shown in **fig. 1**, and performs the following matrixing:

$X = \frac{1}{2}(-Lb + Lf + Rf - Rb)$
$W = \frac{1}{2}(Lb + Lf + Rf + Rb)$
$Y = \frac{1}{2}(Lb + Lf - Rf - Rb)$
$Z = \frac{1}{2}(-Lb + Lf - Rf + Rb)$

It is important to note that for horizontal only signals, the signal Z is zero, and so may be omitted, giving a three channel B-format signal in the horizontal case.

FIG. 2 ARRANGEMENT OF CAPSULES IN SOUND FIELD MICROPHONE (VIEW FROM FRONT - NOT TO SCALE)



The important thing about AB modules is that exactly the same circuit converts back from B-format to A-format. Thus, if one puts X, W, Y, Z into their respective inputs, L_B, L_F, R_F, R_B comes out. If one feeds a conventional 'discrete' or pairwise mixed signal into an AB module and the discards the Z output, then the X, W, Y signals are correctly encoded B-format signals for the four corner positions, with slight deviations from the correct encoding elsewhere. (This deviation is one of the causes of conventional discrete reproduction giving poor non-corner images—the B-format signal will not make this defect worse).

There are two main ways of producing correct B-format signals. The first is the Calrec sound field microphone (which is still undergoing evaluation and development). This has been developed by the present writer for the NRDC and uses (see **fig. 2**) a tetrahedral array of cardioids to feed a frequency-dependent matrix circuit. The matrix circuit fulfils the dual function of converting to B-format and of providing electronic compensation for the spacing of the capsules, so as to give outputs that are effectively coincident and satisfy B-format encoding accurately[1]. The result is to give B-format outputs that are characterised by accurate and precisely coincident polar diagrams up to around 7.5 kHz (as compared to less than 1.5 kHz for the best existing microphone arrays). The behaviour above 7.5 kHz is arranged to be subjectively smooth, although deviating from the ideal. In this way, the directional properties of a sound field may be captured with the minimum possible departure from the objective ideal. The microphone system should not be regarded as four microphones on a tetrahedron, but as a complete sound field transducing system. The tetrahedral configuration is purely a matter of design convenience[1], and has nothing to do with the desired form of B-format sound field encoding.

A second method of producing B-format signals is to use a panpot. **Fig. 3** shows a circuit of a panpot (feeding a virtual earth mixing stage) that uses a joystick control to meet accurately the encoding specification for B-format for horizontal sounds (so that the Z signal is zero). The 'X-pot' and Y-pot' of fig. 3 are the potentiometers that respond to the 'up-down' and 'left-right' motions respectively of the joystick (see **fig. 4**). For correct results it is vital that the travel of the joystick be restricted by a mask or cut-out to that range of X-pot and Y-pot resistances in fig. 4 such that $x^2 + y^2 \leqslant 1$. In other words, the corner travel must be restricted to ± 0.707 of the way from the centre to the end of the pot tracks, although the full range of each pot may be covered when the other is centred.

It is also possible to convert existing pairwise pan pots to give optimal ambisonic encoding. This is clearly a worthwhile option for use with existing equipment. The modifications involve fitting a mask to the joystick control to limit

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FIG. 3 HORIZONTAL PAN POT

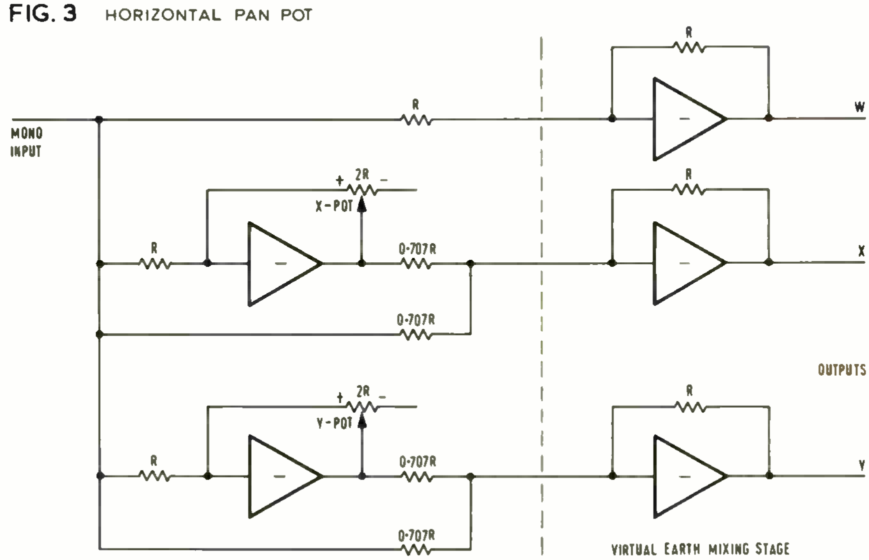
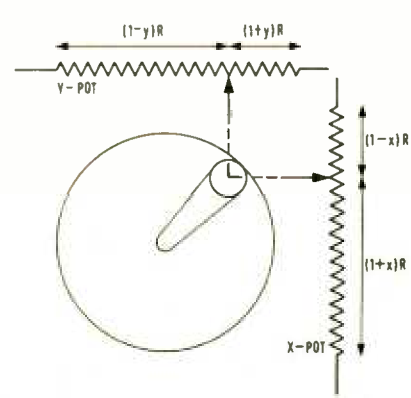


FIG. 4 JOYSTICK CONTROL ACTIVATING 'X-POT' AND 'Y-POT' ALONG ORTHOGONAL AXES, SHOWING RESISTANCES OF EACH PART OF THE POTENTIOMETER TRACKS.



its travel, and a matrix circuit positioned after the four output channels of the mixer. The matrix circuit is exactly the same as an AB module (fig. 1), except that the gain of the W output channel is reduced to 0.707 (by reducing the resistor marked* in fig. 1 to one equal to 0.707 of the value of the other resistors), and the Z output is not used. This gives a B format output. The masking of the joystick controls is necessary to prevent undue exaggeration of directionality of the corners. The mask for a joystick control normally travelling in a square aperture would as be illustrated in **fig. 5**. The side positions remain unaffected by the mask, but the corner positions are masked so that the corner-most joystick positions in the mask give equal outputs on the X, W, and Y outputs. Because most joystick pairwise pan pots are not well designed as regards constancy of sound level with direction, no guarantee can be given that the ambisonic modification will be good in this respect either.

The pan pots described give full 'interior' effects as well as a 360° azimuth coverage with accurate encoding according to B-format specifications. A similar design of about twice the complexity prior to the mixing stage, using an additional slider pot for elevation gives full-sphere periphonic encoding. Other devices of a similar nature allow the full rotation of a whole encoded sound field ('waltz' control), a facility not possible with deiscrete approach. When sounds are 'circled' with a B-format pan pot, the motion is smooth rather than the jerky jumping from speaker to speaker given by existing pan pots. A design is also available for a 'width' control that alters the width of the front of a sound field relative to the back without destroying the correct encoding specification.

Having obtained a horizontal or periphonic B-format signal, either it can be converted to A-format (by the AB-module of fig. 1) to go through existing quadraphonic equipment, or it can be recorded in B-format. There are considerable advantages gained by staying in B-format in the tape recording stage. If one records in A-format then the effects of noise reduction systems are quite audible when the signal is played back. Existing stereo covers only a 60° stage, and the small 'pumping' effects inevitable even with a well adjusted noise reduction system do not cause noticeable movements in the stereo image. Similarly, while conventional discrete material covers 360° its very poor image quality means that pumping effects are not noticed. However, once the image sharpness is improved by ambisonic encoding, the varying image shifts (which subjectively seem to be around 15°) start becoming comparatively objectionable. It is found that recording in B-format renders the signal much less susceptible to all forms of image degradation whether due to channel imbalances, phase errors, or noise reduction pumping. In fact, it seems likely that B-format recording should reduce signal degradation significantly even for conventional 'discrete' pan pot recordings.

Ambisonic B-format signals may be converted to A-format by an AB module, and may be used, if necessary, for feeding existing 'quadraphonic' systems via existing commercial

FIG. 5 TYPICAL MASKING OF PAIRWISE PAN POT (A) AND THE PROCESSING AT THE MIXER OUTPUT (B)

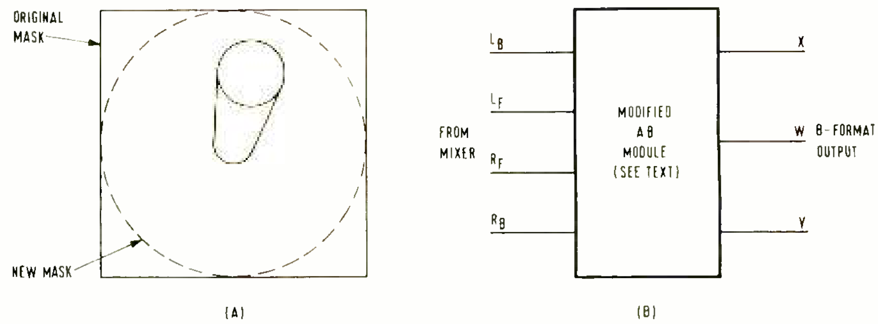


FIG. 6 THREE-CHANNEL, FOUR LOUDSPEAKER DECODER FOR HORIZONTAL STUDIO MONITORING. THE SHELF FILTERS HAVE MATCHED PHASE RESPONSES AND GAINS AT LOW AND HIGH FREQUENCIES AS IN TABLE ONE. RESISTOR VALUES GIVEN ASSUME AN 11KΩ INPUT IMPEDANCE FOR THE AB MODULE.

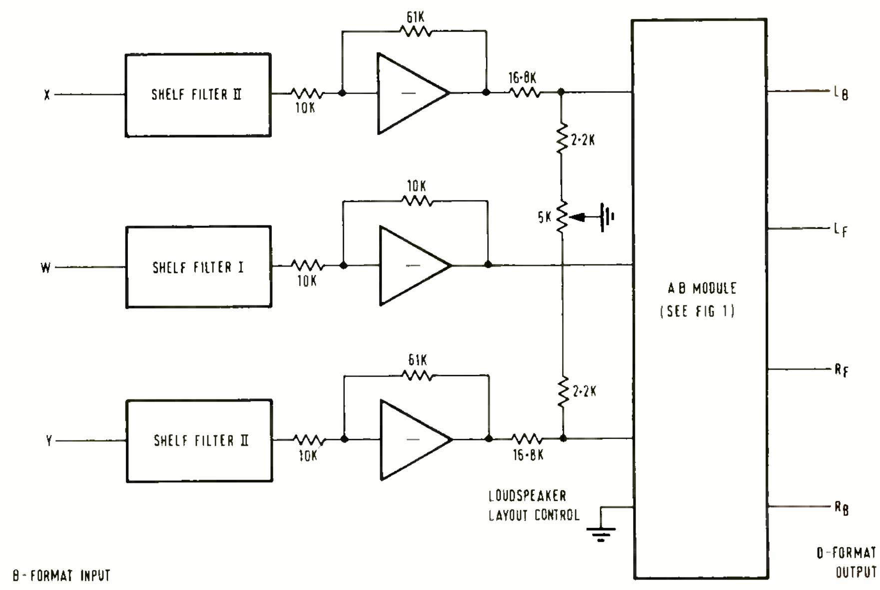


Table 1 Gains of shelf filters in three channel decoder of fig. 6.

	Shelf filter 1	Shelf filter 2
low frequencies	0 dB	0 dB
high frequencies	+1·76 dB	—1·25 dB

encoding equipment (with the exception of the SQ system*), provided that the Z signal of the B-format is omitted. While the results should generally be better than with existing mastertape encoding methods, they will not be as good as they might be, except for the UD-4 system which will give correct TMX encoding.

For each of the following systems: CD4, UD4, RM and the BBC matrix systems, there is an optimal encoder design available working straight from B-format. It is understood that the BBC has evolved an encoding technique similar to B-format. The use of an optimal encoder ensures that the consumer-encoded format (C-format) accurately follows the correct specification. At the time of writing, no existing system is considered by broadcasting organisations and independent record companies to fulfil the necessary compatibility requirements adequately along with good four speaker results, and it is expected that industry discussions will be held regarding the choice of a generally acceptable system. However, ambisonic studio technology is compatible with all systems capable of good localisation for all directions from four speakers.

It is, of course, necessary to monitor the results of an encoded A-, B- or C-format signals, and no existing decoder design is

*However, an SQ encoder may be used if it is set to 'interior' encoding mode. The results with SQ cannot be optimal.

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■ AMBISONICS—PART TWO

sources than one would wish to see the individual phosphor dots on a colour tv screen. The speakers are purely a means of feeding information into the room to create a convincing (or otherwise) illusion of sounds from all directions around the listener. If the shape of the speaker layout deviates from a perfect square, the image stability and directional effect from the loudspeakers would alter unless the decoder is modified to compensate for a non-square speaker layout.

Other problems in designing decoders arise from the fact that the ears localise sounds by different mechanisms at low frequencies (< 700 Hz) and high (> 700 Hz). This means that the optimum design for a decoder is different at low and high frequencies. Moreover, when speakers are fed with signals from a matrix with no frequency variation, it is found that the tone quality of reproduction is very coloured and 'thumpy' in the bass (below 350 Hz). This is because at low frequencies the intensity at the listener is the sum of the pressures due to the four speakers, while at high frequencies it is the sum of the energies.

A design of three channel horizontal studio decoder, working off a B-format input is shown in **fig. 6.** This is intended to feed a rectangular speaker layout, and the 'layout control' adjusts the decoder to compensate for the actual rectangular shape used. The two types of 'shelf filter' used have gains as in Table 1 at low and high frequencies, and are 'phase compensated' to have identical phase response. The transition between low and high frequency gains in the step filters is gradual (using simple RC type circuits) to avoid coloration, and is centred on 350 Hz approximately.

It is found that a correctly encoded B-format signal fed to the three channel studio monitor gives stable and sharp images even at the sides of the listener and for listeners well away from the centre of the listening area. The four loudspeakers used should be matched both in frequency and phase response, and should be reasonably 'omnidirectional' in their polar diagrams over $\pm 45°$ off their respective axes. The layout control requires careful adjustment, but once set need not be changed.

The three channel/four speaker studio decoder fed by B-format gives what we believe is the most accurate reproduction of sounds from any desired direction around the listener possible with existing technology via four speakers. It is not perfect. In particular, it was predicted (in advance of construction) by a new 'bispectral' model for human hearing that sound waveforms with a very high degree of asymmetry would still tend to be 'pulled' to the nearest speaker position, and this is quite noticeable on clapping. Experiment and theory agree here, and theory shows that there would be no way of overcoming this fault other than going to a five speaker decoder. Many critical listeners would possibly regard this as 'hair-splitting' by comparison with many existing four speaker systems, such as 'discrete' encoding.

It is not claimed that there is any decoder capable of giving really accurate decoding in a very large room or auditorium via four speakers. Ambisonics is essentially designed for domestic or studio listening conditions, although results

FIG. 7 DECODER FOR BMX ENCODED SIGNALS

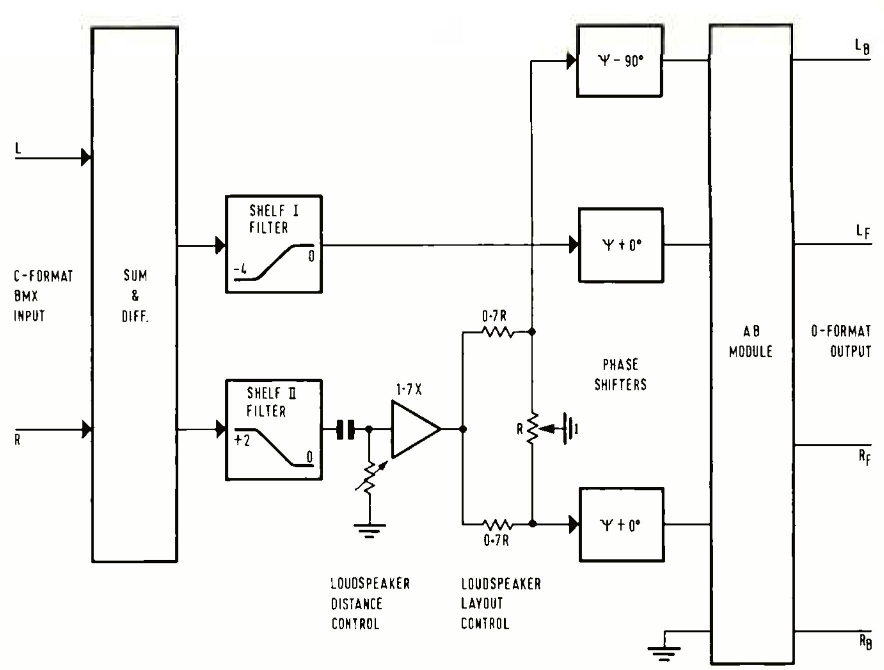

Table 2 Gains of shelf filters in two channel decoder of fig. 7.

	Shelf filter 1	Shelf filter 2
low frequencies	−3·98 dB	+2·04 dB
high frequencies	0 dB	0 dB

in a large auditorium can be quite reasonable. Domestic decoders have been designed according to a range of psychoacoustic theories[3] and at various levels of cost and complexity for all the major existing or proposed surround sound systems other than SQ. It is not possible to design an SQ decoder to satisfy the psychoacoustic criteria established by the the author in ref. 3. Decoders, including layout controls and frequency dependence, are rather similar to that of figure 6 and have been designed for two channel C-format decoding, 2½ channel decoding (as used in UD-4) and three channel decoding. As an example, **fig. 7** shows a basic decoder for the BMX system, with phase-matched filters centred on 350 Hz with gains as in Table 2. This is not the most refined version under development; improvements to reduce 'phasiness' will be announced shortly.

Other decoders have been designed adjustable for cuboid (box-shaped) with-height speaker layouts for periphonic reproduction. At the present time, this would be confined to experimental and in-studio use, where producers might find it worthwhile to explore the artistic possibilities of full-sphere directional effects well before they are pushed into premature commercial exploitation. Three and four channel C-format encoding has been designed for periphony compatible with existing or proposed horizontal C-format encoding, and it would even be possible to release periphonic material on disc (without announcement) to avoid inventory troubles at a future time.

Ambisonic technology also offers new opportunities for existing mono and stereo recording. The sound field information from a sound field microphone may be recorded in B-format on four channel tape, and be mixed down later to any coincident stereo microphone technique that may be required. Any image width and microphone polar diagrams may be selected off tape, along with any vertical angle of tilt. A control unit to perform these functions in an intuitive and easy to grasp fashion has been designed, and also gives adjustable 'quadraphonic' outputs for four speaker use. Due to their very good polar diagrams in the mid-treble frequency region, the sound field microphone technology also gives stereo with a particularly 'clean' and uncoloured quality of sound.

We have here only been able to skim over a few aspects of ambisonics studio technology. Other devices include an apparatus to convert certain existing types of artificial stereo reverb units to full surround reverb, and devices for compensating for and improving non-ideal microphone techniques that may have been used on any existing surround sound recordings.

Details of these and other devices will be released at a future time.

Ambisonic technology can, of course, be used as part of existing 'quadraphonic' systems (excluding SQ) by treating the A-format horizontal-only signals as if they were 'discrete' signals. Similarly ambisonic decoders may be used with existing quadraphonic systems (again excluding SQ). However, it will be appreciated that the inherent faults of the quadraphonic systems will be apparent in such cases, as the whole system, from microphones or pan pots to decoders and loudspeakers has to be designed correctly for correct results. When parts of the system are incorrect, ambisonic technology will not make the system any worse, and so a

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AMBISONICS—PART TWO

capable of optimal results. It must be remembered that it is no more desirable that the four speakers should be heard as direct sound compatibility exists between ambisonics and quadraphonics—ie ambisonic material can be used for quadraphonic results, although the converse is not true—just as a poor colour film cannot be made good by good projector optics.

In conclusion, the ambisonic technology developed for the NRDC, and in particular by Professor Peter Fellgett, the present author, and John Wright of IMF, is compatible with several existing and proposed encoding systems. It gives enhanced creative possibilities to the producer both by ensuring that what he hears will be substantially passed on to the consumer despite differing loudspeaker layouts and seating positions, and by giving him convincing side localisation and smooth 'circling' effects. In addition to existing 'interior' or 'in the head' effects, new 'waltz' (rotation) and 'width' effects are available as well as the first practical control over with-height periphonic effects, if required. When required, ambisonic equipment can cope with existing recordings and equipment, but of course cannot remove the faults in existing material. Besides these 'creative' possibilities, the sound field microphone allows uniquely accurate recording, storage and playback of natural sound fields, with all their attendant advantages. The 'ambient labelling[1]' given by the sound field microphone in particular permits remarkably good sound localisation as well as the ability to separate by ear musical lines that would be completely masked by other lines in a pan pot recording.

References

1. Michael Gerzon 'The Design of Precisely Coincident Microphone Arrays for Stereo and Surround Sound' Preprint of the 50th Audio Engineering Society Convention, London, 4th March 1975.
2. Michael Gerzon 'What's Wrong with Quadraphonics?' Studio Sound May 1974.
3. Michael Gerzon 'Surround Sound Psychoacoustics' Wireless World, December 1974, pp483-6.
4. P. B. Fellgett, 'Ambisonic Reproduction of Directionality in Surround-Sound Systems'. Nature, vol. 252, pp 534-8. December 13, 1974.
5. Michael Gerzon 'Principles of Quadraphonic Recording Part Two: The Vertical Element'. Studio Sound, September 1970.

ELSTREE STUDIOS

encouraged a large programme of standardisation and correct alignment to be undertaken in those cinemas which were to be equipped with Dolby.

Elstree first became acquainted with the Dolby system through Stanley Kubrick, who used the system for *A Clockwork Orange*. Kubrick had only used the system to keep generation noise down in the multiple recording operation of the rerecording sessions.

Dolby had already designed a cinema noise reduction unit that could reduce the effects of dirt, dust and scratches on the film, giving a noise reduction of 10 dB. It was also capable of decoding an optical track that had been recorded Dolby processed, but such a track had not yet been produced. Eventually a demonstration film was made at Pinewood with advice and help from Elstree. The first such film demonstrated only the clean up process, but at the end of it, there was a pop number that had been put on to the track in encoded form. 'This had everything in it—transients and all the rest of it—which normally on optical soundtrack would sound rather mediocre. But when recorded wide open, Dolby encoded and Dolby decoded, it sounded like a pop record. It was out of this world, it really was,' Lumkin recalls.

He saw the potential: 'I knew that Rank were selling these equipments to the cinemas and I knew that by a commercial exercise at last one might get a chance to control the quality in cinemas when these units went in, and this was something I'd been wanting to do all my life.'

Ioan Allen of Dolby wanted to do more than use the system to clean optical tracks up: he wanted to produce commercial films with the sound track encoded, as the pop number on the demonstration film had been. He asked Tony Lumkin to help him apply the already established Dolby noise reduction system to optical film sound recording. Lumkin agreed but said he could see three problems, which had to be overcome before he could recommend it to producers: could the sound track, which had up to then been cut off at 7.5 kHz or thereabouts, be resolved in the laboratories; was the operation repeatable on one film copy after another; and was the track compatible with sound tracks that hadn't been processed?

After eighteen months they had overcome the problems. Phil Boole of Dolby, who used to be a sound engineer at Elstree said: 'One outcome of all this has been that the processing of sound tracks in the laboratories has improved immeasurably since December 31, 1973.' Ray Dolby has said that the experience with the motion picture system had been a good example of how long it takes to go into a field, investigate the problems and learn to talk the same language as the people using the technology under study: 'We've worked on this now for several years and we're still uncovering new and unexpected problems all the time, not only in the application of our technology but in doing what's necessary to produce a really high quality sound'.

One problem that had to be overcome was that the system had to be compatible with the academy roll-off. 'The de-emphasis takes care of all the effects of encoding frequencies above 1 kHz but it doesn't do anything about the frequencies below and the Dolby system is doing something to the frequencies below as well—if the level of sound drops below a certain level it does something to them, so that if you're not careful you could have some low level traffic rumble running in a movie Dolby encoded which sounds good but when you play it back not decoded all those low level signals come up 10 dB and you've got excessive traffic noise now, the wrong balance.' The solution is, as always, at the desk. 'You can equalise it in such a way that the Dolby sound is right and so is the academy sound. That's the only bit to worry about in actual fact.'

Various producers had allowed them to use bits from movies they were making, but the first producer to use the system for an entire production was Stanley Donen for *The Little Prince*. He used Dolby throughout even on his Nagras. Elstree invited Donen round to the dubbing room to demonstrate the system. They showed him two dubs of a number from The *Little Prince*, one encoded and one not encoded. They played the encoded number back Dolby decoded and academy and the non encoded

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AGONY COLUMN

The md wanted bongos and congas on the session, and the fixer, being from another world and age, didn't really have too many contacts in that area. So someone else booked them for him and the session went off well. At the end, the fixer came in to pay everyone, including the two ethnically robed and happy-go-lucky percussionists.

'Good afternoon,' said the fixer, 'I am the fixer. Are you on VAT?'

'No, man,' said a voice from behind a conga, 'but if you've got some I'd love to try it'.

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REVIEWS

ACOUSTIC RESEARCH LABORATORY STANDARD TRANSDUCER

John Fisher

MEASURED PERFORMANCE
On axis sensitivity
Terminal voltage for 74 dB SPL at 1m from centre grille

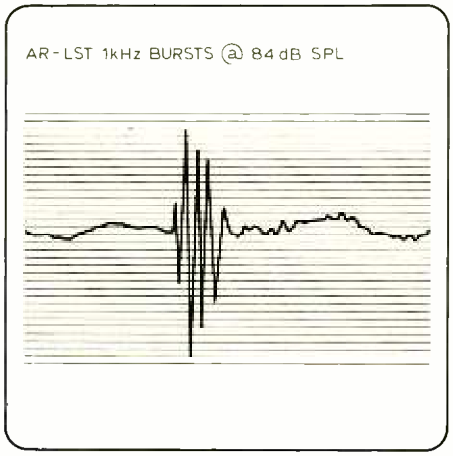
Speaker	No	Rms voltage	Stereo balance
AR-LST	1457	0.82	1.5 dB
	1579	0.69	

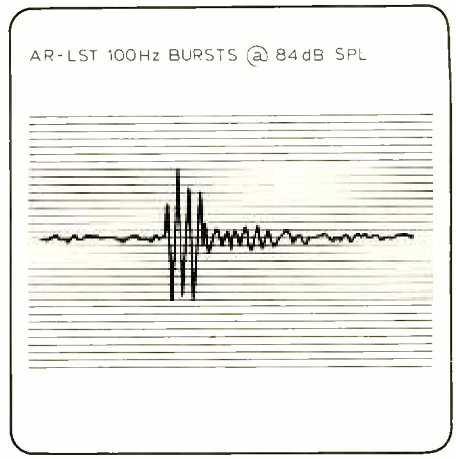
Intermodulation distortion
To SMPTE method with 50 Hz and 7 kHz in voltage ratio 4:1

Speaker	IM at SPL		
	74 dB	84 dB	94 dB
AR 1457	0.45%	0.5%	1.1%

Frequency response data
Measured on tweeter axis 1m from centre grille at 74 dB SPL at 1 kHz under anechoic conditions with B & K equipment. Both speakers of stereo pair measured.
Impedance
Measured at constant current (100 mA) under anechoic conditions.
Acoustic Research, 24 Thorndike Street, Cambridge, Mass. 02141, USA.
Acoustic Research, High Street, Houghton Regis, Bedfordshire.

Hugh Ford





THE ACOUSTIC RESEARCH Laboratory Standard Transducer is designed for applications that require 'repeatable, accurately known spectral energy profiles, including a flat response'.

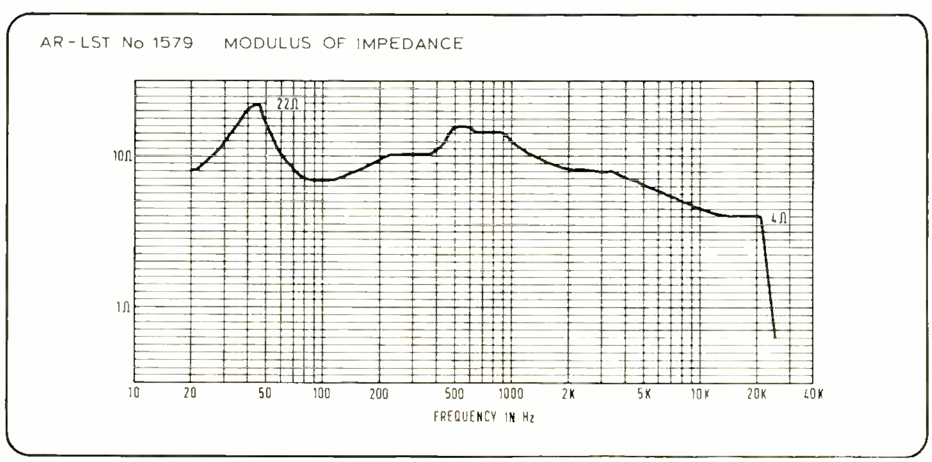
The *AR-LST* is a high-quality, high-priced loudspeaker of relatively modest dimensions. For drive unit complement, the *LST* uses one 300 mm acoustic-suspension lf unit, four 38 mm mid-range hemispherical units and four 19 mm hemispherical hf units. The individual drive units are identical to those of the earlier and well known *AR-3a* system. Crossover frequencies are 575 and 5000 Hz. The multiple mf and hf units provide greater power handling than the *AR-3a*, each of the combinations of mf and hf units being wired in series/parallel (see circuit). The *LST* contains an autotransformer with taps at 1 dB steps. Each of the drive units is connected through its crossover filter and a six-position selector switch to the transformer taps, so that the relative output levels can be adjusted as desired. A large capacitor in series with the autotransformer prevents excessive amplifier loading (and also excessive bass unit excursions) at sub-audio frequencies where the transformer's inductive reactance decreases.

Switch position one provides an acoustic response that rises slightly with frequency. The lf unit output is then nominally 2 dB lower than that of the hf units. Position two is the nominally flat position. Positions three to six provide increasing lf output and decreasing hf output; in positions five and six the frequency balance is nominally similar to that of an *AR-3a* with its controls set to the 'normal position'. Output from the mid-range units is held relatively constant in all six positions to maintain the same overall impression of loudness at all switch positions.

It is intended that the speaker should be used flat against a wall. Low-frequency output will be increased if the cabinet is placed across a corner, and decreased if the system is not close to a wall. Despite the increase in the number of hf units compared with the *AR-3a*, care must be taken to avoid excessive hf energy input to the *LST* during, for instance, tape searching. The speaker will withstand very high power inputs of short duration without damage (180W for 10s; 64W for 30s) and a fuse/thermal cutout protection system restricts the maximum duration of a high level input. A relatively modest 23W continuous rating is given to the speaker. A replacement fuse unit is provided; spares may be ordered through *AR*. Fuse failure does not cause the speaker to go open-circuit but reduces the output by some 30 dB; replacement of the fuse cartridge is a simple matter.

The *AR-LST* is covered by a highly ethical five-year guarantee covering parts, labour, freight and if necessary packaging, but excludes thermal damage to speaker voice-coils. The fuse does not provide protection for very short-term high-level inputs, and to quote *AR:* 'will not protect the lf cone if the system is plugged into the mains'. They also warn that the speaker may be damaged by attempts to reproduce 'discotheque sound levels which can destroy high-fidelity speakers as well as damage your hearing'. AR go on to recommend the use of speakers designed for maximum output rather than fidelity for such applications.

The nominal input impedance drops to about 4 ohms at various response control settings. This means that a heavy connecting cable should be used to handle the high currents and also infers that some care is needed in choosing a power amplifier for use with the *LST* at high levels. This situation is somewhat aggravated by the fact that the sensitivity is low. 34 ▶



AR-LST

The speaker is available in a variety of wood and paint finishes. The test samples were finished in attractive semi-matt black, with pale grey grille cloth and brushed aluminium control knob. A screw-terminal plug is provided for connection to the recessed socket at the rear. With reservations about the price, the *LST* also makes an attractive domestic loudspeaker in that it departs from the usual box shape and will go flat against a wall; certain features of its performance, detailed below, may also commend it for domestic use as a quality loudspeaker. Its weight would probably discourage use of the speaker as a monitor speaker for location work.

Test Conditions

The performance of the *AR-LST* was assessed subjectively using direct comparison between live and reproduced sound, live broadcast material and tapes considered to be of good quality. The material included speech, applause, music of all kinds and a musical box. The speakers were also used for some months for general listening—including discs, broadcasts and tapes. Comparisons were made with other high quality loudspeakers, in particular the Spendor *BC1*.

The performance notes include the views of a number of listeners; some with musical or technical backgrounds, some without. Some of the comments were solicited, some unsolicited, and listening was done by individuals rather than a formal panel. While this method suffers the disadvantage that the same material was not necessarily heard by all those commenting, it had the advantage that all the listeners could enjoy similar listening positions and that the reviewer could also hear more items of material in the process. Objections can be raised to either method, the one adopted being chosen as the more practical in the particular circumstances. Listening tests were carried out in a fair-sized room, carpeted and curtained and with domestic furnishings; tests were also carried out in the garden to eliminate the effects of walls and room characteristics.

The speech tests were carried out using recordings made with various capacitor microphones under nearly anechoic conditions, to enable a good comparison to be made with the live voice. Similar comparisons were carried out with a small musical box.

Performance
General

Initially the contour controls were set to the nominally flat position, which was expected to yield the most natural results, and the loudspeaker pair were used for a period of domestic listening. This confirmed that the units were capable of a high standard of reproduction, with a slightly 'distant' sound, and that uncomfortably loud levels could be reproduced with a Quad *303* power amplifier. After some experiment the speakers were mounted on some rough and ready stands about 25 cm off the ground; the contour controls were set at the positions one or two for subsequent listening, as higher settings produced a noticeable lack of high frequencies. Possibly as a result of the disposition of drive units, the *LSTs* seemed less conscious of room position than the Spendors.

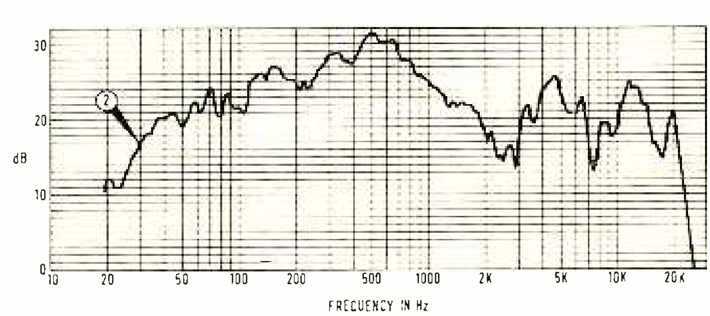
Balance

With the control at position two the general sound balance was pleasant and fairly natural. Direct comparisons with other speakers suggested a slight lack of high frequencies and a slight rise in upper middle frequencies; hiss and surface noise tended to become less noticeable than on some speakers, possibly in part due to smoothness of the response. Direct comparisons on speech gave the impression of a slight lack of warmth, slightly more so than with the Spendor *BC1*. The effect on music was masked by the apparent slight change in perspective already mentioned, and it was difficult to say whether or not a slight bass lift (Quad 1) was necessary. Music—particularly strings—was felt to lack bite; use of position one was felt to give the best results in conjunction with slight bass lift. No frequencies were found to be obtrusive and the general effect was of a relaxed and untiring, slightly dead sound. In many instances there was little to choose between the sound of the Spendor and the *LST* when placed in similar positions. The differences were more subtle than I had expected of a multi-unit American design; surprisingly little trouble from interference patterns was noticed on programme, and then only on certain material at less than 8ft distance from the speakers. Mid and high frequencies were well distributed in the horizontal plane.

Coloration

Other than subtleties of balance, there were

AR-LST No 01457 RESPONSE AT No. 2 SETTING (NOMINALLY FLAT WITH SPEAKER MOUNTED AGAINST WALL, MEASURED FREE AIR)



few vices apparent in the way of coloration. The bass was extremely 'tight' in sound, with little trace of booming even with bass lift and/or the speaker placed across a corner (however there was very slight coloration of white noise). The mid-range seemed particularly clear of obvious colorations on programme and white noise tests. There seemed little to complain of in terms of high-frequency coloration, though the apparent lack of top would tend to mask such coloration to some extent. With the contour control set at one, there was just a trace of coloration on sibilants.

It was nevertheless generally felt that the sound, particularly with solo instruments, solo voices, speech, etc, was subtly less transparent than with the Spendor *BC1*; it was never harsh, never 'cardboardy' or 'tinny' (how one has to rely on these emotive and very subjective descriptions!), but somehow slightly thicker—translucent rather than perfectly transparent. This difference was very much less obvious on large instrumental and choral works.

Image

Perhaps one of the most obvious characteristics of the *AR-LST* is the diffuse image produced. This is presumably due to the wide dispersion of mid and high frequencies, and to the fact that these originate from several sources spaced over a considerable width, rather than from virtual point sources arranged one above the other. This is particularly apparent on coincident pair recordings in stereo. Localisation of the sounds is difficult and stability of the image is poor; a small shift in listening position to one side produces a relatively larger shift in image than with, eg, the *BC1*. It would be more difficult than with many speakers to pan spot microphones into the proper position on a coincident image because of the diffuse effect produced by a pair of these *LSTs*.

From a consumer point of view, it could be argued that the diffuse image and slightly distant sound might be an advantage, in that they blur the worst effects of too-closely positioned multi-microphone classical recordings and give some spread to mono images. On the other hand this seems something of a cart-before-the-horse approach; I can see little disadvantage in producing a loudspeaker that gives sharp images, and some dangers in the use, particularly for professional purposes, of a monitor speaker which produces diffuse or shifting images. There would appear to be a danger that a multi-microphone recording balanced on speakers such as the *LST* could sound over-close and ill-positioned when reproduced through speakers producing a sharp image.

Sensitivity and power handling

Apparent sensitivity was on the low side, given the low impedance of the speaker. This need not be a serious disadvantage provided an amplifier capable of delivering high power levels into a low impedance is available; there are however a number of European commercial amplifiers designed for 8 ohm working which might prove unsatisfactory on grounds of distortion and power delivered.

Power handling is adequate to generate painfully loud continuous sound in a large listening room, and enables high levels of uncompressed speech and music to be produced in larger surroundings with appropriate amplifiers.

Similarity

The sound produced by the two review speakers, both on programme material and white noise, was virtually identical with the differences completely masked by variations due to positioning. Careful interchanging and comparisons failed to reveal any important difference in character. Without a much larger sample for comparison, it is hard to give any guide as to how well random pairs would match in sound, but the results on the review samples are encouraging.

Speech

Speech tests involving a comparison between live voice and a recording of that voice made under almost anechoic conditions gave very acceptable results; it was occasionally, but rarely, possible to be deceived as to which was which. The fact that it is at all possible is a good sign. Contour control position two was generally felt to give the best balance. On indoor comparisons a very slight lack of warmth by comparison with the live voice was noticed; this may in part be due to the differing radiation patterns of the human body and the *LST* at lower speech-band frequencies. Broadcast speech was felt to be entirely natural with the switch in positions one or two in mono, feeding one speaker only. Speech in stereo drama was well reproduced, but there was a lack of focus to the sound by comparison with the more analytical *BC1s*. Speech in double mono, ie, fed to both speakers of a stereo pair,

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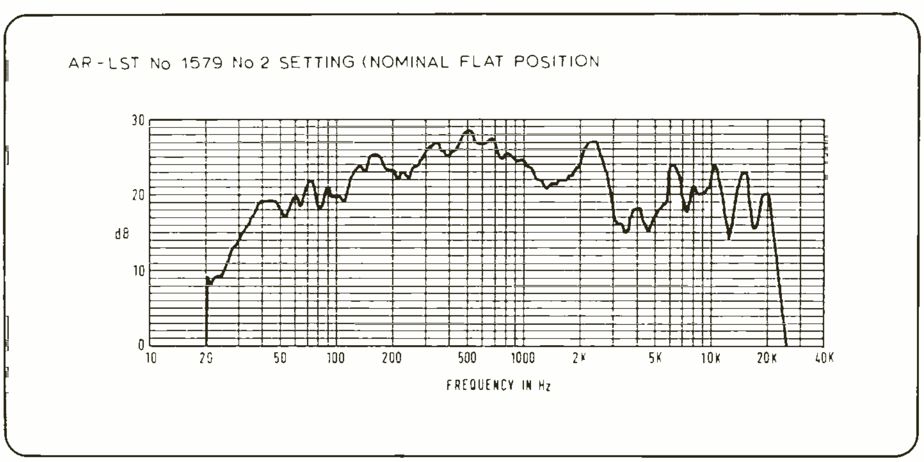

AR-LST

lacked focus and immediacy.

Musical box

Similar comparisons to the speech tests were made using a dead recording of a small musical box. Reproduction through a single speaker was good—clicks, stray noises and all—but it was rarely possible to be confused, even with slight adjustment of the Quad's tone controls to restore the top end and compensate for a slight extra warmth in the reproduced sound compared with the original; it was interesting to note that although the recordings were made under almost identical conditions, there was this discrepancy over the question of warmth of the reproduced sound. It should be said that the difference was very slight. No obvious vices in the speakers' upper range were shown up by the test.

Solo voice

Solo singing voices, male and female, reproduced well with the contour control set at one or two with no more than +1 on the Quad control unit. On much material the flat position of the Quad's control was preferable from a listener's point of view. As with the strings (below) there was a slight lack of bite evident to voices, male and female, but this was by no means always noticeable and not everyone mentioned the fact. Consonants rarely sounded unnatural, and when they did it was usually possible to detect the same feeling of questioning when one listened through other speakers. The speakers coped well with loud female and boys' voices where the transmission medium permitted.

Solo strings and string quartet

These were felt to lack bite and focus at setting two; setting one was considered an improvement, but the sound and focus of the image were preferred on the Spendor *BC1*, in stereo. The sound of violins was however always sweet, and the tone of double-bass, cello and viola firm.

Organ

The speakers gave a full and satisfying reproduction of organ music, handling bright baroque pipes and heavy Romantic timbres with equal ease. Pedal stops were reproduced well, except at extreme bass where listening room size and system cut-off combine to restrict the output of fundamental; no overloading problem was experienced up to amplifier clipping point (some 25W into 4 ohms). The sound was generally convincing.

Chamber orchestra

As with the string quartet and solo strings, reproduction was clean but lacked attack or edge on the strings on the two setting. Position one was preferred; woodwind, in particular clarinet and oboe, were also felt to be more natural at position one; while at this setting the sound was reasonably natural, it was felt by all but two listeners (who did not distinguish) that the focus and clarity of the sound were better on the Spendor *BC1;* equally it was generally felt that the sound was more distant and diffuse on the *LST*. One person commented that the sound was 'rather lifeless'. Horn, flute and trumpet reproduced well, the trumpet requiring the one setting to be convincing.

Choral music

Large-scale choral music was handled clearly, effortlessly and naturally, with the one position marginally preferred to the nominally flat position; the difference was subtle and required a direct comparison to illustrate. The effect was similar on small choirs, particularly where recorded using a coincident technique; the apparent slight lack of top and imprecise image contribute to set the sound farther back than with more directional speakers, and the sound, particularly in relation to its reproduced acoustic, seemed subtly less clear than with the Spendors. By comparison with a number of other speakers designed or used for monitoring purposes, the sound of the *LST* is much to be preferred, however.

Large orchestra

Handled well by the speakers. Little preference between the *LST* and Spendor *BC1*, except perhaps on sharpness of the image when listening at some 3.5 to 4.5m, where the *LST* was inferior. As mentioned earlier, for domestic purposes this might be no disadvantage in the reproduction of a number of companies' gramophone records; however it may be doubted whether it is generally desirable, particularly where the speakers are to be used for balancing and general quality monitoring purposes. The instability of the stereo image with small changes of listening position would also be a disadvantage.

Large works

Convincing reproduction of large-scale choral, orchestral and operatic works at high

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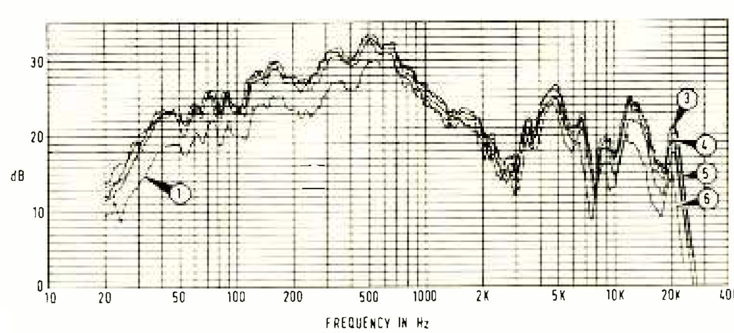
AR-LST No 01457 RESPONSE MEASURED AT REMAINING POSITIONS OF CONTOUR CONTROL



■ AR-LST

listening levels. Clean, tight and effortless sound, not matching that of electrostatics or a small number of moving-coil loudspeakers but capable of a higher sound level than most without distress, and of more natural reproduction than many. Contour positions one or two preferred.

Percussion

The reproduction of bass drum and other percussive sounds was particularly good, as were effects in radio drama in a few instances. Despite criticisms elsewhere of a lack of high frequencies, instruments such as triangle, brushes, cymbal etc were most realistically reproduced, particularly with the contour at one. Percussive bass sounds remained clean and free from boom or obvious distress in the transducers.

Plucked instruments

Apart from a slight clouding of the sound, harpsichord and guitar were well reproduced; it is difficult to find harpsichord material, in particular, where faults in the transmission medium, whether live broadcast, tape or disc, do not lead to uncertainties. More reliance was placed on the musical box test.

Piano

Good piano recordings produced a very acceptable sound. Perversely I found it virtually impossible to express a preference as between the sound produced by the *LST* and the *BC1*, either singly or in pairs, despite the fact that the piano appeared to accentuate the slight tonal differences between the speakers, the *LST* producing a slightly brighter sound on settings one and two, yet lacking the attack that went with the apparently fuller tone of the *BC1;* I must emphasise that the difference was extremely subtle, and neither speaker produced a wholly convincing sound, though part of the blame for this may lie with intermediate transducers and transmission media. Setting two preferred, particularly in mono.

Pop music

I tend to agree with AR on the subject of pop monitoring loudspeakers, this being an imperfect world in which the loudest loud-

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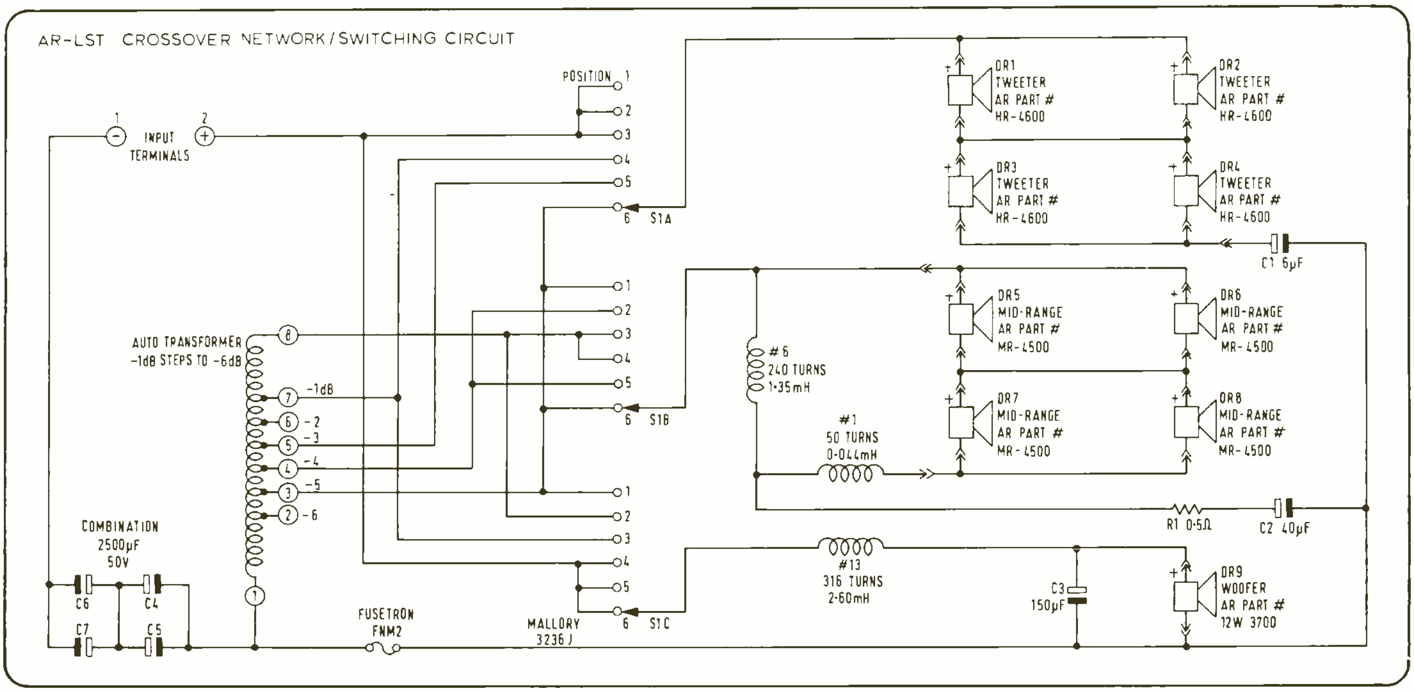

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Send for details to Dept SS, Acoustical Manufacturing Co Ltd, Huntingdon PE18 7DB Tel: (0480) 52561

AR-LST

speakers do not necessarily produce the most realistic or pleasing sounds at normal listening levels with a good microphone source of signal. Nevertheless, with these reservations, the *LST* can produce a very good account of pop music to the loudest levels which I can tolerate for any length of time. I find it impossible to assess the *LST* further in this context, except to say that it will handle quite prodigious amounts of bass guitar. AR would doubtless advise on use of the *LST* for pop monitoring.

Conclusions

Regardless of any preconceived notions—about the use of multiple mf and hf units, about mounting them in a vertical line or spreading them to diffuse the sound and produce a response that is more nearly omnidirectional over a hemisphere than most current loudspeaker designs—it must I think be admitted that the *LST* produces a very clean and mostly natural quality of sound, combining this with large signal-handling capabilities. The better monitor loudspeakers, and listening loudspeakers, are beginning to sound more and more like each other and like the real thing; subtle differences, however, remain, and it is these as much as power handling or appearance that must still make a final choice a personal one to some extent. I feel that the *LST* just lacks the sheer transparency of sound that a small number of other loudspeakers by a smaller number of manufacturers produce, yet in its own way it compensates by offering other subtle advantages; the wide dispersion at all frequencies may be felt to be one. My greatest personal reservation would probably be over the limp sound image.

The facility of switching the hf response is a commercially useful one, since it allows the same speaker to be acceptable to the US and European markets and tailored, to some extent, to local conditions. I would however have preferred separate bass and hf adjustments so that raising the hf output did not necessitate reducing the bass, and vice versa; failing that I would prefer to modify the existing switching arrangement to affect the hf alone. Visually I would have preferred the control knob recessed, as the projecting knob spoils an otherwise simple and pleasing appearance; in view of the weight of the units I am very pleased that the control is not tucked away behind—though in order to discourage knob twiddling, perhaps it should be!

While I have expressed some reservations about the *LST*, it would be too easy to read too much into such criticisms as there are. One manufacturer has complained, somewhat bitterly and not without reason, about reviewers 'nit-picking'; perhaps it is a back-handed complement when there are only nits to pick. The *LST* clearly has strong competitors at under half the price, but given the high cost of the rest of a modern studio, this is hardly relevant. It is most certainly a speaker to live and work with.

Footnote

My comment that the two *AR-LST* units supplied for review sounded virtually identical is not at first sight borne out by Hugh Ford's response curves (which I did not see until some while after writing my comments). This difference in response as measured could be a reflection of how far apart the serial numbers of the two speakers were. However, one should bear in mind that with a speaker such as this, using a multiplicity of drive units, a very small change in angle or distance is likely to produce quite large changes in response as measured, because of interference patterns as well as the normal angular response variations of units. This perhaps underlines the dangers of placing too much emphasis on the measured frequency response of a loudspeaker in comparing reviews, and the difficulties of correlating measured response with subjective assessment.

AGONY COLUMN

Throughout the morning rehearsal, Sir Thomas Beecham knew there was something wrong with the orchestra although the fault was not obvious. It took many bars before he located the cause in the string section; the lady cellist was clearly experiencing an off day. No matter how she tried, she could not control the strident noises coming from her instrument to the requirements of music or conductor. Having obtained no response to appeals for diminuendo, Sir Thomas felt the matter required a more direct approach. Without fuss, he dismounted from the conductor's rostrum, walked across to the string section and whispered in the offending cellist's ear: 'Madam, between your legs you have the most beautiful instrument in the world. The object is to play it, not scratch it.'

AMBISONICS—PART ONE

sonic two channel encoding also uses a great circle but takes account of the freedom to tilt and otherwise modify it slightly to improve stereo and mono compatibility, and to implement other refinements; details will be published in due course. This work is very consonant with conclusions reached by the BBC.[7]

3. Compatibility between surround and stereo playback has often been discussed without explicit realisation that original sound (including reverberation) may come from any direction, will necessarily be encoded in some manner, and therefore must be located (more or less well) in some direction in stereo playback. Stereo compatibility therefore involves making these directions as acceptable as possible, while recognising that for example originally rear positions cannot be correct in stereo playback; ie it is essentially a mapping operation. Once this is realised, the basic choice is seen to be largely prescribed by the need to avoid contradictions[6] and this choice is followed in Ambisonics. It appears not satisfactory to map the comparatively small stereo front-sector on to itself, letting the devil take the hindmost and sometimes encode it as front-sector.
4. Effects. Although the unique ability correctly to treat natural sound is an important feature of Ambisonics, it also provides facilities for all the usual artificial 'effects', and some not available (or which cannot even be defined) in some other systems (see Part Two).

Preserving options in the recording studio

Much of the present uncertainty concerning methods and standards for surround reproduction may be ascribed to systems having been promulgated at a stage which now appears to have been premature in relation to the formulation of adequate aims, and to the development of adequate theoretical tools for implementing these aims. The consequence is not only lack of agreed standards between systems, but also a tendency to patch up deficiencies so that there is variation of encoding standards even within what is nominally one system. So-called 'logic', ie signal-controlled gain, may be seen as a response to such deficiencies, and it is not difficult to show that this stratagem is at most of only limited value.

Technological reality is however now coming to the fore, and it is not surprising that systems proposed with the benefit of later knowledge seem to have been preferred by independent critics, notably the Nippon Columbia BMX system among current two-channel commercial proposals [7,8,9]; perhaps it will not be thought too disingenuous to mention that the NRDC Ambisonic system (with which BMX is essentially compatible) has come still later. Research by various groups around the world has in fact converged on surprisingly concordant conclusions about how surround reproduction should be implemented, and there is now less doubt that the present confusion will be resolved along these lines than about exactly when it may happen.

So long as uncertainty remains, it is prudent for any studio to record in a form that is likely to remain useable no matter which viable standards are eventually adopted by the industry. Part Two consequently lays stress on preserving options in this way.

References

1. Gerzon, M. A. 'Surround-sound psycho-acoustics', Wireless World, December 1974, p 483.
2. 'Regular Matrixed Disk Records'. Japan Phonograph Record Association, Engineering Committee Standard, dated Tokyo, March 25, 1972.
3. Gerzon, M. A. 'A Geometric model of 2-channel 4-speaker matrix stereo systems' (in press).
4. 'Standards for Quadraphonic disc records'. United States RIAA, Bulletin No E7, 12 September 1973.
5. Scheiber, P. AES Journal Vol 19, p 835 (1971).
6. Fellgett, P. B. 'Directional Information in Reproduced Sound' Wireless World Vol 78, p413 (1972).
7. Ratliff, P. A. 'Properties of hearing related to Quadraphonic Reproduction' BBC Research Department Report 1974/38.
Crompton, T.W. J. (based on work by) 'Subjective performance of various quadraphonic matrix systems. BBC Research Department Report 1974/29.
8. Shorter, G. 'Matrix Decoding'. Hi-Fi News & Record Review Vol 20, No 3, March 1975.
9. Holmes, P. 'Elektor Vol 1' Dec 1974 p 33.

Between us, DIN Hi-Fi sound doesn't cost the earth.

These new Philips N6310 stereo headphones must be the bargain of the century – because they give just as good performance as other headphones of the same type (meeting DIN Hi-Fi 45|500), have several extra advantages, look better and actually cost less.

They have an impedance – 2 x 600 ohms – so you can use them with studio equipment. And you can choose them ready-fitted with the type of plug you need – 360° DIN, or 6.3 mm Jack, or Loudspeaker DIN plugs.

Built on the 'open air' principle to give superior bass response, they give smooth coverage from 20–20,000 Hz.

Weight is only 160 gm, sensitivity 92 dB at 1 mW, maximum power input 2 x 20 mW, and nominal power output 2 x 1 mW.

With a 360° DIN plug, suggested selling price is only £12.44 including VAT; with other plugs, slightly more.

See your Philips Dealer and post this coupon for full details to:-
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Please send me the full facts on N6310 Headphones.

Name ____________________

Address ____________________

PHILIPS

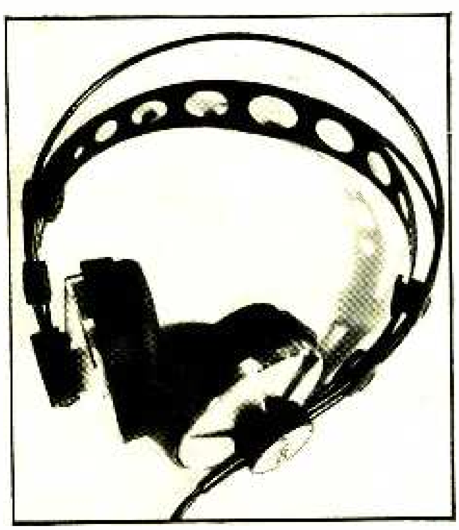
Simply years ahead.

PHILIPS

Studio requirements for headphones are very different from those of the domestic listening environment. Usually, electrical and mechanical construction is more important than sound quality. Most applications are for foldback where electrically lightweight cans are prone to damage when the inevitable fader is left up while listening to the last take in the control room. This assumes escape from mechanical damage. However, requirement does exist for headphones exhibiting sound quality as a primary feature, such as in ob and mobile monitoring. This survey includes models serving both categories. The demands of the recording studio explain the absence of some headphone models in the medium cost bracket which optimise neither feature.

Survey: headphones

AKG K140



ADASTRA
Adastra Electronics Ltd, Unit N22, Cricklewood Trading Estate, Claremont Road, London NW2 1TU.
Phone: 01-452 6288/9.

H5
Impedance: 8Ω.
Construction: close.
Max power input: 0.5W.
Features: mono.
Weight: 360g.
Price: £5.

G5555
Impedance: 8Ω.
Frequency response: 20 Hz to 20 kHz.
Spl: 110 dB at 1 mW.
Construction: close.
Max power input: 0.5W.
Features: coiled lead.
Weight: 390g.
Price: £15.75.

G8000
Impedance: 8Ω.
Frequency response: 20 Hz to 22 kHz.
Spl: 130 dB.
Construction: close.
Max power input: 0.5W.
Features: coiled lead.
Weight: 350g.
Price: £10.85.

G8030
Impedance: electrostatic.
Frequency response: 20 Hz to 20 kHz.
Spl: 95 dB.
Max power input: 10W.
Features: self energising power unit.
Weight: 420g (headset only).
Price: £46.80 complete.

AKG
Akustische und Kino-Gerate GmbH, Brunhildengasse 1, A-1150 Wien, Austria.
Phone: (0 22 2) 92 16 47.
UK agents: AKG Equipment Ltd, Eardley House, 182/4 Campden Hill Road, Kensington, London W8 7AS.
Phone: 01-229 3695/6.

K100
Impedance: 600Ω.
Frequency response: 20 Hz to 20 kHz.
Spl: 112 dB at 0 dBm input level.
Construction: close.
Max spl: 125 dB at 20 mW.
Features: high noise exclusion.
Weight: 360g.
Price: £9.90.

K140
Impedance: 600Ω.
Frequency response: 20 Hz to 20 kHz.
Spl: 112 dB at 50 mW.
Construction: open.
Max spl: 119 dB at 250 mW at less than 1% thd.
Features: light weight.
Weight: 175g.
Price: £16.

K150
Impedance: 600Ω.
Frequency response: 25 Hz to 20 kHz.
Spl: 112 dB at 1 mW (0 dBm input).
Construction: open.
Max spl: 125 dB at 20 mW at less than 1% thd.
Weight: 240g.
Price: £14.

K160
Impedance: 600Ω.
Frequency response: 16 Hz to 20 kHz.
Spl: 112 dB at 1 mW (0 dBm input level).
Construction: close.
Max spl: 125 dB at 20 mW at less than 1% thd.
Weight: 330g.
Price: £22.

AUDIO-TECHNICA
Audio-Technica Corporation, 2206 Naruse, Machida, Tokyo 194, Japan.
Phone: 0427 22 7641
UK agents: Shriro (UK) Ltd, Shriro House, The Ridgeway, Iver, Bucks SL0 9JL.
Phone: 0753-65222/7.

AT703
Impedance: low.
Frequency response: 20 Hz to 20 kHz.
Construction: close.
Max power input: 200 mW.
Weight: 250g.

AT706 electret
Impedance: low at input to inverter.
Frequency response: 10 Hz to 25 kHz.
Max power input: 10W.
Features: separate inverter transformer.
Weight: 220g (headphone only).

AT707 electret
Impedance: low.
Frequency response: 20 Hz to 25 kHz.
Max power input: 0.8W.
Features: built-in inverter transformers.
Weight: 310g.

BEYER
Eugen Beyer, Elektrotechnische Fabrik, D71 Heilbron, Thereseinstrasse 8, West Germany.
Phone: (07131) 82348.
UK agents: Beyer Dynamic (GB) Ltd, 1 Clair Road, Haywards Heath, Sussex PH16 3DP.
Phone: 0444 51003.

DT100
Impedance: 400Ω (standard: others available).
Frequency response: 30 Hz to 20 kHz.
Spl: 110 dB at 1 mW.
Construction: close.
Max power input: 1W.
Features: available with various types of cord and termination.
Weight: 350g.

DT900
Impedance: 600Ω.
Frequency response: 30 Hz to 18 kHz.
Spl: 114 dB at 1 mW.
Construction: close.
Max power input: 200 mW.
Features: various terminations available.
Weight: 190g.

DT480
Impedance:
Frequency response: 20 Hz to 20 kHz.
Spl: 115 dB at 1 mW.
Construction: close.
Max power input: 1W.
Features: various terminations available.
Weight: 495g.

DT302
Impedance: 600Ω.
Frequency response: 20 Hz to 20 kHz.
Construction: open.
Rated power input: 7 mW.
Features: ultra light weight.

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Soft contact

(like columbus's egg, a simple answer to a difficult problem)

AKG headphones K 140 "cardan"
– the ones with the universal joints. Unlike eggs, heads are not all alike. So we have developed the automatic headband. It adjusts itself to any size of head, but keeps the contact pressure equally distributed. Pressure? Well, hardly any, that's why we say "soft contact".

AKG

Automatically adjusting headband. Soft contact. Large diaphragm. Frequency range: 20–20 000 Hz. Light metal alloy casing. Each earphone on universal joint. Suitable for all hi-fi equipment. Available in 104 countries all over the world and from your hi-fi-dealer.

Weight: 66g.

DT48
Impedance: 8.25 or 200Ω.
Frequency response: 16 Hz to 20 kHz.
Spl: 112 dB at 1 mW.
Construction: close.
Max power input: 0.2W.
Features: various terminations available.
Weight: 400g.

DT96
Impedance: 400Ω.
Frequency response: 30 Hz to 17 kHz.
Spl: 110 dB at 1 mW.
Construction: close.
Max power input: 0.1W.
Features: various cords and terminations available
Weight: 120g.

The company also manufacture modified headphone sets with built-in induction loop receivers to enable cordless operation. Other products include mic/headset combinations.

DYNATRON
Dynatron Radio Ltd, Ditton Walk, Cambridge CB5 8QD.

SP-3
Impedance: low.
Frequency response: 16 Hz to 22 kHz.
Construction: close.
Features: two-way driven with full x over.
Price: £21.99.

Dynatron SP3

EAGLE
Eagle International, Precision Centre, Heather Park Drive, Wembley HA0 1SU.
Phone: 01-903 0144.

H2008
Frequency response: 20 Hz to 20 kHz ±5 dB.
Construction: close.
Features: spun nylon diaphragm.
Weight: 350g.
Price: £12.

SE40
Impedance: 8Ω.
Frequency response: 25 Hz to 16 kHz.
Construction: close.
Price: £9.80.

SE60
Impedance: 8Ω.
Frequency response: 25 Hz to 18 kHz.
Construction: close.
Price: £10.80.

Eagle H2008

GOLDRING
Goldring Ltd, 10 Bayford Street, Hackney, London E8 3SE.
Phone: 01-985 1152.

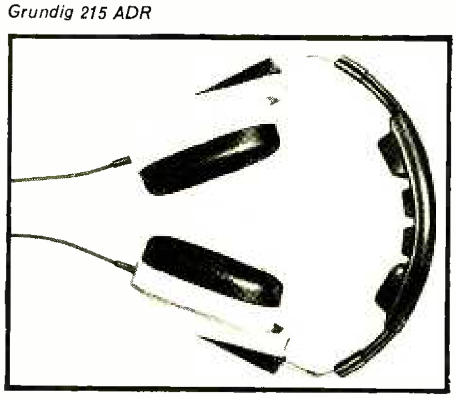
K-105
Impedance: 8Ω.
Frequency response: 18 Hz to 20 kHz.
Spl: 96dB at 1 mW.
Construction: close.
Max power input: 0.5W.
Price: £12.90.

K-110
Impedance: 200Ω.
Frequency response: 16 Hz to 22 kHz.
Spl: 91 dB at 1 mW.
Max power input: 0.1W.
Price: £18.

GRUNDIG
Grundig (Great Britain) Ltd, Newlands Park, London SE26 5NQ.
Phone: 01-659 2468.

215ADR
Impedance: 400Ω.
Frequency response: 20 Hz to 20 kHz.
Spl: 100 dB at 1% thd.
Construction: close.

Grundig 215 ADR



HITACHI
Hitachi Sales (UK) Ltd, New Century House, Coronation Road, Park Royal, London NW10 7QN.
Phone: 01-965 9861.

HD60
Frequency response: 20 Hz to 20 kHz.
Construction: close.
Max power input: 0.5W.
Weight: 420g.
Price: £14.90.

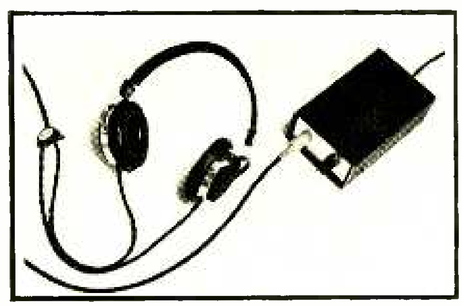
HOWLAND-WEST
Howland-West Ltd, 3/5 Eden Grove, London N7 8EQ.
Phone: 01-609 0293/6.

CIS 1100
Impedance: 150Ω.
Frequency response: 18 Hz to 22 kHz.
Max power input: 0.1W.
Features: very thin.
Weight: 130g.
Price: £18.

Micro MX1
Impedance: electrostatic.
Frequency response: 20 Hz to 25 kHz.
Spl: 115 dB at less than 1% thd.
Construction: close.
Features: self powered converter.
Weight: 240g.
Price: £42.

CIS300
Impedance: 8Ω.
Frequency response: 20 Hz to 20 kHz.
Construction: close.
Max power input: 0.5W.
Features: control box, stereo/mono/volume.
Weight: 400g.
Price: £11.50.

Howland West Hero HXI Electrostatic



KOSS
Koss Corporation, 4129 N'Port Washington Avenue, Milwaukee, Wisconsin 53212, USA.
UK agents: Tape-Music Distributors Ltd, 114 Ashley Road, St Albans, Herts AL1 5JR.
Phone: St Albans 64337

ESP9
Impedance: electrostatic operation.
Frequency response: 10 Hz to 19 kHz ±5 dB.
Construction: close.
Features: supplied with power unit.
Price: £86.50.

PRO-5LC
Impedance: high.
Frequency response: 10 Hz to 20 kHz.

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NAD RP18

NAD 20E

The RP18 and 20E headphones are two of the finest currently available.
The 20E is a state-of-the-art electrostatic headphone and the RP18 is a new design with a planar electromagnetic drive system; it can be plugged directly into normal headphone sockets. A full list of NAD stockists can be obtained by writing to us at the address below.

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THE EARS OF GOLDRING.

If you have good sound to listen to, you can match its quality with these handsome Lenco K105 Headphones. They are good to look at, good to listen through, comfortable to wear and not expensive. Providing high quality stereo reproduction, the headphones have a frequency response of 18/22,000 Hz and an impedance of 4/16 ohms. Supplied complete with 220 cms of curled cord with a standard jack plug.

Goldring

Goldring Ltd., 10 Bayford Street, Hackney, London E8 3SE.

SURVEY: HEADPHONES

Construction: close.
Features: individual volume controls.
Price: £34.50.

PRO 4AA
Impedance: medium.
Frequency response: 10 Hz to 20 kHz.
Construction: close.
Features: individual volume controls.
Price: £31.50.

KO747
Impedance: 600Ω.
Frequency response: 30 Hz to 20 kHz
Spl: 110 dB at 1% thd.
Construction: close.
Features: mono/stereo switch.
Price: £23.50.

KO727B
Impedance: medium.
Frequency response: 10 Hz to 18 kHz.
Construction: close.
Price: £18.00.

KRD 711 Red Devil
Impedance: 600Ω.
Frequency response: 10 Hz to 17 kHz.
Spl: 110 dB at 0.5% thd.
Construction: close.
Features: crunch proof.
Weight: 340g.
Price: £12.50.

HV 1A
Impedance: 600Ω.
Frequency response: 15 Hz to 20 kHz.
Spl: 109 dB at 0.5% thd.
Construction: open.
Features: 'high velocity' driver.
Weight: 260g.
Price: £26.50.

Koss ESP9

PHILIPS
Philips Electrical Ltd, Eindhoven, Netherlands.
UK distributor: Philips Electrical Ltd, City House, 420 London Road, Croydon.
Phone: 01-689 2166. Telex: 946169.

N6310
Impedance: 600Ω.
Frequency response: 20 Hz to 20 kHz.
Spl: 92 dB at 1 mW.
Construction: Open air principle.
Max power input: 20 mW.
Features: Available in 3 types of plugs.
Weight: 160g.
Price: £10.46.

PIONEER
Pioneer Electronic Corporation, 4-1, 1 Chome, Meguro, Meguro-Ku, Tokyo, Japan.
UK agents: Shriro (UK) Ltd, Shriro House, The Ridgeway, Iver, Bucks SL0 9JL.
Phone: 0753-65222/7

SE205
Impedance: 8Ω.
Frequency response: 20 Hz to 20 kHz.
Spl: 115 dB at 0.3V.
Construction: close.
Max power input: 0.5W.
Weight: 450g.

SE300
Impedance: piezo electric driver.
Frequency response: 20 Hz to 20 kHz.
Spl: 100 dB at 3V input.
Construction: close.
Max voltage input: 30V.
Features: static capacity 0.08 μF.
Weight: 280g.

SE305
Impedance: 8Ω.
Frequency response: 20 Hz to 20 kHz.
Spl: 108 dB at 0.3V input.
Construction: close.
Max power input: 0.5W.
Weight: 435g.

SE700
Impedance: piezo electric driver.
Frequency response: 20 Hz to 20 kHz.
Spl: 100 dB at 3V.
Construction: close.
Max voltage input: 30V.
Features: static capacity 0.1 μF.
Weight: 295g.

Pioneer SE 305

SENNHEISER
Sennheiser Electronic, 3002 Bissendorf/Hann, West Germany.
Phone: (05130) 8011.
UK agents: Hayden Laboratories Ltd, Hayden House, 17 Chesham Road, Amersham, Bucks HP6 5AG.
Phone: 02403-5511.

HD424
Impedance: 2000Ω.
Frequency response: 16 Hz to 20 kHz.
Spl: 102 dB at 1 mW.
Construction: open.
Max power input: 0.1W.
Weight: 190g.
Price: £27.

HD414
Impedance: 2000Ω.
Frequency response: 20 Hz to 20 kHz.
Spl: 102 dB at 1 mW.
Construction: open.
Max power input: 0.1W.
Weight: 135g.
Price: £18.80.

HD110
Impedance: 200Ω.
Frequency response: 20 Hz to 20 kHz.
Spl: 98 dB at 1 mW.
Construction: close.
Max power input: 0.1W.
Weight: 285g.
Price: £40.20.

SONY
Sony (UK) Ltd, Central Distribution Dept, 219 Bath Road, Slough, Berks.
Phone: Slough 34611.

ECR500 Electret
Impedance: 30Ω at input of inverter.
Frequency response: 20 Hz to 20 kHz.
Spl: 91 dB at 1V, 300 Hz.
Construction: 'hear through'.
Max spl: 114 dB.
Features: impedance converter supplied.
Weight: 350g (headset only).
Price: £57.50.

STAX
Stax Industries Ltd, 25-5 Zoshigaya, 1-Chome Toshima-Ku, Tokyo, Japan.
Phone: 03-981 7227.
UK agents: Wilmex Ltd, Import Division Compton House, New Malden, Surrey KT3 4DE.
Phone: 01-949 2545.

SR5 and SRX/3
Impedance: electrostatic.
Frequency response: 30 Hz to 25 kHz.
Spl: 110 dB maximum.
Construction: close.
Features: power units with varying spec. available.
Weight: 390g and 380g.
Price: £42 and £88. Power units priced about £30.

UHER
Uher Werke Munchen, 8 Munchen 71, Postfach 711020, West Germany.
UK agents: Uher (UK) Ltd, PO Box 30, Braintree, Essex CM7 7RG.
Phone: Braintree 23192.

W675
Frequency response: 20 Hz to 20 kHz.
Construction: open.
Features: DIN 5 pin plug.
Price: £24.90.

WHARFEDALE
Rank Radio International, PO Box 596, Power Road, Chiswick, London W4 5PW.
Phone: 01-994 6491.

ISO DYNAMIC
Impedance: 100Ω.
Frequency response: 16 Hz to 22 kHz.
Spl: 95 dB at 30 mW.
Construction: close.
Max voltage input: 23V rms.
Features: 120 dB spl at 0.1% thd.
Weight: 450g.

Koss introduces Phase 2™

An exciting new concept in stereophonic listening

Koss engineers have developed a new phase to stereophone listening. A concept so exciting and so different from other stereophones, we called it Phase 2.

In effect, Koss Phase 2 Stereophones do for the music lover what the zoom lens did for the photographer. By bringing the orchestra into vivid close-up or expanding the musical sphere surrounding you so that you feel encircled by a panorama of sound.

You have the option of personalising each stereo recording as if it had been tailor-made to your individual taste, being able to do things that until now only a recording engineer could do at the original session.

The secret is the rotating Panoramic Source Control located at the lower edge of each earcup. They range from zero to 10, and as you advance the level you feel drawn closer and closer toward the centre of a live performance.

Now flip the Ambience Expander switch on the right earcup to the E position. You'll hear a dramatic expansion of the centre channel on your recording that gives you incredibly enhanced depth and richness. Then rotate one control separately from the other; it's like sitting on the piano bench one minute and in the midst of the violin section the next.

To go back to conventional sound, set the Ambience Expander on N position and reduce the Panoramic Source Controls on both ears to zero. As an added convenience a Momentary Comparator switch on the left cup lets you compare the new sound capabilities with the conventional stereo mode.

Ask your Audio Dealer to let you hear Koss Phase 2 Stereophones. And write for our free full-colour catalogue.

KOSS
STEREOPHONES

Please send me full details of the Phase 2 and all other Koss stereophones and accessories.
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NAME

ADDRESS

The high levels of sound now generated by bands on stage and by monitor speakers in studio control rooms may constitute a long term risk to the hearing of musicians, audience and engineers.

Hearing damage

ADRIAN HOPE

IF YOU STAND with unprotected ears near a steam hammer, a rifle range or a sheet metal working machine, you will suffer a shift in the threshold of hearing. In other words, your ears will become accustomed to the noise and thus attenuate it, deafening you to quiet sounds. If exposure to the loud noise is only brief, then the threshold shift will only be temporary, and your hearing will return to normal within hours or at the very most days. However, if exposure continues, day in, day out, year after year, the temporary threshold shift will become permanent and you will start going deaf. This has long been accepted as an occupational hazard in some areas of industry. The phrase 'deaf as a weaver' sums up the inevitable result of a lifetime spent working in a jute mill.

We hear because sensitive hair cells in the ear sense air pressure changes and transmit impulses to the brain. Excessive sound creates excessive pressure on the cells and this causes the damage. When the damage is temporary, the shift of threshold is temporary, and when the damage is permanent the threshold shift is permanent. The process of permanent damage is slow but irreversible and because the process is slow, the effects often pass unnoticed for years. When the threshold of hearing has risen by about 25 dB, then there will be a slight impairment in the understanding of everyday speech. When it has risen by 30 dB, the sufferer will realise that something is going seriously wrong with his ears and consider the use of a hearing aid. A hearing aid will not repair the damage, but simply amplifies sounds to reach higher thresholds. Unfortunately, hearing loss is often more than a simple shift in threshold; the upper frequencies may be rolled off more drastically than the lower, and this will make speech unintelligible. Try this for yourself by playing a dialogue disc or tape and roll off the top frequencies—the dialogue becomes muffled and no amount of gain boosting can repair the problem.

Although it has long been known that industrial noise constitutes a risk to hearing, it was not until the 1970 Department of Health & Social Security Report, *Hearing and Noise in Industry*, by W. Burns and D. W. Robinson,[1] that a serious attempt was made to evaluate the problem statistically and quantitatively. The report was followed in 1972 by a Department of Employment *Code of Practice for Reducing the Exposure of Employed Persons to Noise*,[2] and these two documents are now standard references. Neither investigates the possibility that excessively loud music can be regarded as synonymous with industrial noise, but over recent years this suggestion has been put forward with increasing persuasion.

The first positive action was taken by the Leeds local authority, who invoked powers made available to them by the Leeds Corporation Act of 1906, to impose a statutory limit of 96 dB(A) on musical performances in the area. But although this action was born of the best motives, it has been strongly criticised on several counts. Probably the most pertinent criticism is that the limit adopted is in practice over-protective. Although, at the time of writing, the Leeds limit still stands at 96 dB(A), it is unlikely to remain so for much longer.

The Control of Pollution Act, 1974[3], however, gives wide powers to local authorities throughout the United Kingdom to impose noise level limits. Unfortunately it gives no guidance over the actual limits which should be imposed. Thus it is possible that other local authorities will soon take action similar to Leeds which will be criticised as over-protective. There are signs, already, that the GLC has plans to impose sound level limits on public music performances and, although the levels which the GLC is considering are higher than those adopted by Leeds, it is likely that they would still outlaw the louder concerts and clubs.

The single most informed critic of Leeds has been Sandy Brown Associates, who produced a report to the Association of Ballrooms on *Hearing, Health and Music*[4]. Much of the Leeds action was based on work carried out[5, 6] and conclusions drawn by R. W. Fearn, Principal Lecturer at the Department of Architectural Studies at Leeds Polytechnic, and the Brown report disagrees with both Fearn's conclusions and the Leeds measures. But Sandy Brown has, for years, publicly expressed fears that excessively loud amplified music constitutes a hearing risk, and one of his associates, Alex Burd, has published his views on the problem as an AES paper[7]. It is this background that makes the report by Brown on the Leeds measures so important; most of the other vociferous attacks on Leeds have been launched by parties who have absolutely no understanding of the complex acoustic and medical issues involved and, who often have vested financial interests in loud music. Also Sandy Brown made clear to the Ballroom Association that if he took the commission the Association would have to foot the bill, whatever the conclusions. In the event the Association, in Brown's words, 'was lucky'; report found Leeds over-protective.

It is possible that some STUDIO SOUND readers have already suffered in one way or another from the Leeds decision. Certainly, pop groups now shun the area, and the only live music is orchestral, classical, folk or anaemically amplified, soft pop. This must inevitably have affected local promoters and if the leeway given by the Control of Pollution Act is taken up by other local authorities, then the same situation may soon exist in other parts of the United Kingdom. But most important to people in the business is the fact that there is danger. There are now few informed observers now who will put hand on heart and argue that the Burns and Robinson warnings over noise and hearing loss do not also apply to excessively loud music. Unfortunately, few people can agree on just how music can be equated with industrial noise, and thus what the real risks are. But as studio engineers are more likely to be running those risks (whatever they are) than any other sector of the community, they would be well advised at least to consider the facts that have been established and the various interpretations that have been placed on them.

Although many people will be familiar with the dB scales of sound measurement, a crisp reminder of the definitions may not come amiss because they are essential to an understanding of the topic.

Sound is conventionally measured in units of pressure or intensity at the ear. The basic unit of sound pressure is the newton/square metre (N/m^2), and the basic unit of intensity is the watt/square metre (W/m^2). Both measurements are most conveniently expressed on a dB scale, and the following formulae are used:—

Intensity level in dB $= 10 \log_{10}(i/i_0)$, where i is the intensity of sound in W/m^2 and i_0 is the reference intensity level (0 dB) of $10^{-12} W/m^2$. Sound pressure level in dB $= 20 \log_{10}(p/p_0)$, where p is the sound pressure in N/m^2 and p_0 is the reference level (0 dB) $0.00002 N/m^2$.

The two reference levels given above are generally regarded as standard and were deliberately chosen to bring the intensity and sound pressure dB scales substantially into line. However, because sound power energy or intensity (analogous with electrical power) is proportional to sound pressure (analogous with electrical voltage or current) squared, a doubling of sound power, intensity or energy is written as a 3 dB increase and a doubling of sound pressure is written as a 6 dB increase. Virtually all dB values likely to be found in these pages, and bandied around in the context of noise-induced hearing loss, are sound pressure level meaurements, and most sound meters are in fact sound pressure meters. However, such meters normally have weighted response curves. The 'C' curve or scale represents nearly flat frequency response and the 'A' and 'B' scales involve various degrees of low frequency suppression. These scales are intended to compensate for the non-linear response of the human ear to different frequencies at different levels. Most of the meters which engineers are likely to encounter in studio or allied work will read on the 'A' scale, and although this is not regarded as ideal for noise risk measurement purposes, it has been almost universally adopted as a reasonable working compromise.

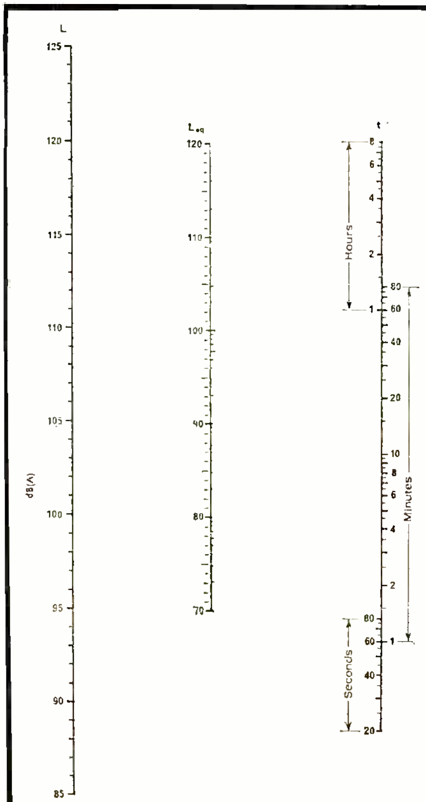
The normal threshold of hearing of the human ear is such that a sound of 0 dB(A) is only just audible. Normal conversation, television or radio listening levels are around 60 dB(A), a loud factory or workshop has an average level of around 90 dB(A), most discotheques or pop groups produce sound levels of over 100 dB(A), a jet plane at a couple of hundred yards notches up around 120 dB(A), and at 135 dB(A) the human ear is likely to suffer instantaneous permanent damage. At 150 dB(A), the whole body is at risk. But it is not uncommon for studio control room levels to be at around 120 dB(A) when pop music is being monitored, and levels of 128 dB(A) are not unkown.

Working with industrial noise, Burns and Robinson concluded that only sound levels of under 80 or 85 dB(A) can be regarded as totally safe. In the more realistic middle ground in between this and the 'instantaneously dangerous' 135 dB(A) level, Burns and Robinson suggested that the human ear must be regarded as being at long term risk if it is exposed for eight hours a day to continuous sound levels of over 90 dB(A). So, if this level and duration is to be encountered, then ear protection, eg ear muffs, is needed. Still working with the notional concept of continuous sound (which is often the practical case in industry where machines create noise all day at virtually constant levels) Burns and Robinson laid down the guide line for safe exposure to higher levels. Each halving of the duration of the eight hour day permits an increase of 3 dB. Thus, if exposure to continuous high level noise is for four hours rather than eight, the noise level can be safely increased to 93 dB(A). If exposure is for only two hours, it can be 96 dB(A), and so on upwards—until the upper absolute limit of 135 dB(A) is reached.

Levels of noise which indicate a serious hazard to hearing

Exposure duration hours per day	Maximum sound level dB(A)
8	90
4	93
2	96
1	99
½	102
¼	105

Fearn, in Leeds, carried out meticulous and extensive tests on the hearing of young pop club and concert attenders, comparing them with control subjects who did not attend. He concluded that the loss of hearing which the subjects exhibited indicated that Burns and Robinson's guide lines for industrial noise were equally applicable to pop music noise. It was this that brought Leeds to impose the 96 dB(A) maximum level limit. Brown argues that music, even the most monotonous pop music with the smallest dynamic range, cannot reasonably be equated with continuous levels of industrial noise. This raises probably the most important single point to emerge from the whole mass of confusion and half-truths which have been bandied around over recent years. The Burns and Robinson Report and Code of Practice clearly indicate that sound should not be regarded as continuous unless it is reasonably steady and never fluctuates by more than 8 dB(A). But, very little if any pop music, falls within this category.



NOMOGRAM FOR CALCULATION OF EQUIVALENT CONTINUOUS SOUND LEVEL

Burns and Robinson and the Code of Practice offer an answer to the problem of evaluating the risks of non-steady noise. This is based on the use of L_{eq} or 'equivalent continuous sound' levels. This gives a value for exactly what the name implies—the sound level that will produce sound energy and effects directly comparable to a continuous sound of the same numerical value. A conventional sound level meter (reading in dB (A) will indicate a true value for L_{eq} only when the sound level being sensed is continuous and steady. If the sound is discontinuous and erratic in level, then L_{eq} can be defined mathematically by the following equation:

$$Leq = 10 \log \tfrac{1}{8} \int_0^T \frac{[PA(t)]^2\,dt}{Po^2}$$

where:

Leq = equivalent continuous sound level, normalised to an eight hour exposure
T = total working period in hours
PA = instantaneous A-weighted sound pressure in N/m^2
Po = reference rms sound pressure as specified in BS 661:1969 clause 2006, viz 2×10^{-5} N/m^2
t = time

It should be borne in mind that because Burns and Robinson were working on industrial noise, all their deductions and predictions centre round an eight hour day or 40-hour week. This has become the standard currency of noise risk. Thus when equivalent levels are given they are normalized to an eight hour day and require further adjustment if they are to be applied to shorter periods of time, such as pop concerts, or longer periods of time, such as all-night mix-down sessions. As an example, an L_{eq} level of 90 dB(A) normalised for an eight hour day would not be exceeded by a two hour concert or session with an L_{eq} of 96 dB(A). Also, because we are talking in terms of L_{eq} rather than peak readings, that two hour-session could contain sound levels of well over 96 dB(A) provided that they were between levels of below 96 dB(A). For instance, one minute at 105 dB(A) would require 32 minutes at less than 90 dB(A) to maintain the 96 dB(A) L_{eq} level.

The Department of Employment *Code of Practice* contains a useful, nomogram for calculating equivalent continuous sound levels from discontinuous levels. Simply take a ruler and draw a straight line between the measured sound level in dB(A) on the L scale to the time of exposure on the t scale. The point at which the line crosses the centre scale gives the L_{eq}. Thus exposure of 90 dB(A) for eight hours gives an L_{eq} of 90 dB(A); but an exposure of 102 dB(A) for two hours fifteen minutes per day gives an L_{eq} of 96 dB(A).

It is also worth bearing in mind that noise dose meters are now coming onto the market which will give a direct reading of L_{eq}. Thus the time may come when studio engineers will wear L_{eq} dose meters just as workers with radioactive materials consistently wear radiation dose meters.

Sandy Brown's report points out the fact that even the most monotonous sounding pop music has an L_{eq} level which is substantially lower than the maximum level that the music reaches. In one discotheque visited by Brown's researchers, the L_{eq} measured with a dose meter was 92.5 dBA. and the maximum level

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$$H = 27{\cdot}5 \left[1 + \tanh \left(\frac{L_2 + 10 \log_{10} (T/T_0) + U_p - \lambda i}{15} \right) \right] - U_p$$

which the meter read during the evening was 102 dBA. The L_{eq} calculated by statistical analysis was 91.4 dBA. In another discotheque the L_{eq} as measured by the dose meter was 96.3 dBA, the maximum level recorded was 104 dBA and the L_{eq} calculated statistically was 95 dBA. Thus, in the first discotheque there was a discrepancy of 9.5 dBA between maximum and L_{eq} levels, and in the second discotheque there was a discrepancy of 7.7 dBA.

Leeds refuses to work with L_{eq} (or has so far refused), on the grounds that there can be no knowing what the disco or concert attenders have been doing where they have worked during the day. But in this Leeds is accused of being over-protective. Critics maintain that the majority of disco and concert attenders, who work in quiet surroundings during the day, should be allowed to enjoy loud music at night if they wish, and should not be penalised because a few attenders will have been in noisy surroundings during the day.

Most of the argument in this article has so far been academic. Because excessively loud amplified music is a relatively new phenomenon and hearing damage is slow to appear there are few people who are sufficiently deaf to cause immediate concern. And it can always be argued that those who are showing signs of deafness would have done so anyway. This is perhaps, the biggest problem facing the individual. Is he to believe the prediction of hearing loss made by Burns and Robinson and echoed by R. W. Fearn in Leeds, or is he to regard them as unproven and not worth considering? If the arguments linking noise and music are ever conclusively proven, there will be by then large numbers of pop fans and engineers who are already suffering from possibly substantial and irreversible hearing loss. In any case, if the attitude of the public towards the warnings repeatedly offered them over the risks of smoking are a reliable guide, then even when there is concrete proof that loud music causes hearing loss, many people will still bury their heads in the monitors and ignore it.

Burns and Robinson produced a formula which gives the noise-induced hearing loss H which can be expected in a given percentage *P* of a normal population which is daily subjected to a noise level LA_2 over a period of time T. This formula is written as: (see above)

where λi is a constant depending on sound frequency, T_0 is a reference duration and U_p is a constant depending on the selected percentage *P*. LA_2 is a sound level reading that is not exactly the same as the noise level L which can be read directly off a sound level meter, but Burns and Robinson give conversion tables for this and other parameters in the equation.

As only the most mathematically active minds will feel inclined to work out their own predictions from this formula, I will plagiarise the published work of R. W. Fearn and Sandy Brown to give the following examples of what type of risk can be predicted from Burns and Robinson's work.

The following table shows what can be expected after five years of eight hours a day exposure at various equivalent levels. Thus the table shows how ten per cent of the population is far more risk prone than fifty per cent of the population, and how hearing loss hits hardest at 4 kHz (so-called 4k dip). But any dip at 1 kHz is important because that frequency is in the middle of the main speech band.

Equivalent noise level dBA	Predicted hearing loss dB At 1 kHz 10% level	At 1 kHz 50% level	At 4 kHz 10% level	At 4 kHz 50% level
91	6	0.6	15	2
95	10	1	20	5
97	11	1	22	7
100	12	2	27	8
107	18	3	38	17

Put in words of one syllable, if ten sound engineers expose themselves eight hours a day for five years to equivalent noise levels of 107 dB(A), then one of them is likely to suffer a hearing loss of 18 dB at 1 kHz and a staggering 38 dB at 4 kHz. The 107 dB(A) level is high but not unknown by studio standards.

I find this quite horrific and can only hope, for the sake of many studio engineers, that there is a flaw in the chain of calculations using the Burns and Robinson formula and my interpretations. But I doubt it. Likewise I hope, but doubt, that there is a flaw in my interpretation of the calculations put forward by Sandy Brown, also on the strength of the Burns and Robinson formula. These suggest that if ten sound engineers work for four hours a day for two years at an equivalent level of only 100 dB(A), then one of those ten can expect a hearing loss of 8.7 dB at 500 Hz, of 9.3 dB at 1 kHz, of 11.4 dB at 2 kHz, and 17 dB at 4 kHz. In this connection, mark well that the American Academy of Ophthalmology and Otolaryngology regards a hearing loss of 25 dB as the beginning of impairment of understanding spoken English.

Before anyone shouts 'scaremonger!' too loudly, let him first try telling a joke softly to someone who has worked half his life in a sheet metal factory or a jute mill. Let him then remember that monitoring music at high levels is a comparatively new occupation, and that the progress of noise induced hearing loss, although sure, is slow.

This can be his downfall, but the knowledge of it can also be his salvation. Anyone who feels he is at risk has time on his side. If he is prepared to have his hearing checked out every year or so, he will have a clear picture of any loss that is accumulating. Once he knows he is suffering a loss, he can take steps to curtail it, for instance by cutting down on pop music monitoring or cutting back on levels from speakers (or headphones because it is, of course, only too easy to produce dangerously high levels on phones). Once an engineer realises that he has a problem, he could well consider the possibility of wearing a sound dose meter to warn him when he is at risk of aggravating this hazard. On the other hand, of course, he could simply cross his fingers and, like drunken drivers, heavy smokers and over-ambitious amateur rock climbers, reckon that 'nothing like that will ever happen to me.'

References and further reading

1. Hearing & Noise in Industry. Burns, W. & Robinson, D. W. HMSO. £1.75.
2. Code of Practice for Reducing the Exposure of Employed Persons to Noise. HMSO 1972. 52½p.
3. Control of Pollution Act 1974, Chapter 40. HMSO. £1.22.
4. Hearing, Health & Music—Report to the Association of Ballrooms. Sandy Brown Associates, 12 Conway Street, London W1P 5HP.
5. Leeds Department of Architecture. Reports Nos. AS71/5 and AS72/7: Pop Music and Hearing Damage. Fearn, R. W.
6. Physics Bulletin, October 1974. Letter, p.422. Fearn, R. W.
7. Hearing Damage from Music—UK experience. Burd, A. J. Audio Eng. Soc. September 1974.
8. World Medicine. August 11, 1970, pp.21-25.

● *Recent events thicken the plot and raise many more questions than they answer. The Greater London Council has published a draft Code of Practice that places industrial limits on entertainment. Although the Code is not yet formally in force there are signs that it is already making its presence felt, for instance when conditions are attached to licences given by the GLC to concert promoters.*

The GLC limit is the L_{eq} recommended by the British Government and the ISO as a guideline for industry—a daily eight hour dose of 90 dBA continuous sound, or the energy equivalent in discontinuous and varying sound spread over the duration of the concert. Tests I have run in the London area show that this limit effectively kills all loud music stone dead. One pop group clocked up the full safe GLC dose for the day in around quarter of an hour—and they weren't particularly loud at that. A disco with a moderate sound system hit the full daily dose in not much over one hour, even though there was segué sound in the club for hour and a half hours a night. Most interesting of all was the reading from a virtually acoustic jazz piano trio—86% of a full daily dose in two hours playing time. By this token every musician who has played a lifetime in a jazz big band (such as Basie, Ellington, Heath, Kenton, Rich, Goodman) should be well and truly deaf by now. But as far as I know they aren't, so is the ear more tolerant to 'nice' noise than 'nasty'? No-one seems to know or care, but I am currently looking into this possibility and would welcome any comments that any readers may have for inclusion (without attribution, if requested, of course) in a further article shortly.

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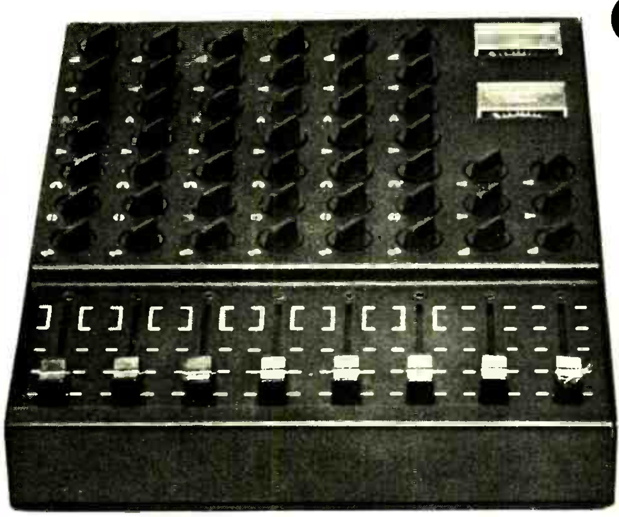

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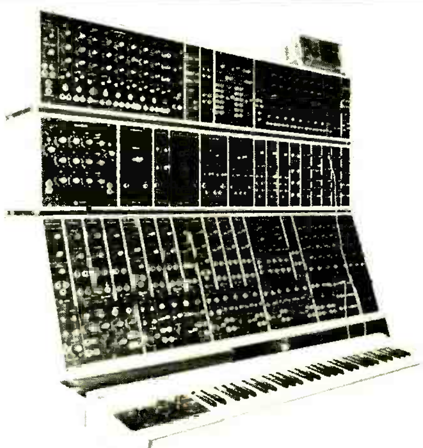

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AMBER MODEL 4550 AUDIO SPECTRUM DISPLAY

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MANUFACTURER'S SPECIFICATION

Frequency range: 20 Hz to 20 kHz.
Quantity of bands displayed: 10 octave-width bands.
Centre frequencies: 31.25, 62.5, 125, 250, 500 Hz, 1, 2, 4, 8, 16 kHz.
Centre frequency accuracy: ±5% internally adjustable.
Filter slope (asymptote): 12 dB per octave.
Display range: 10 or 20 dB selectable.
Accuracy of dB steps: ±0.25 dB non-cumulative.
Input Sensitivity range: 0 vu may be calibrated to indicate any absolute input level between −12 dBm and +12 dBm. Normally supplied with 0 vu = +4 dBm calibration.
Front panel attenuator range: 20 dB in 2 dB steps.
Attenuator step accuracy: ±0.25 dB non-cumulative.
Display Amplitude accuracy: ±0.25 dB for a steady sinewave at filter centre frequency (internally adjustable).
Quantity of audio inputs: 4, individually selectable.
Input impedance: greater than 18 kΩ.
Quantity of memories: 2, independent.
Maximum storage time: virtually indefinite with continuous ac power.
Display response time: display indicates within 1 dB of actual value; within 2ms above 1 kHz or 4 cycles or less 1 kHz and below.
Display decay time: to fall 20 dB takes approximately 2.3s.
Power requirements: 120/240V ac ±10% 48 to 62 Hz, 25 va.
Size: (excluding handle and feet) 133 x 210 x 279 mm.
Weight: 3.6 kg.
Price: UK: £880, US: $1800, Canada: $1600.
Manufacturer: Amber Electro Design Ltd., 613-100 Francois, Montreal, Canada.
UK agent: Scenic Sounds Equipment, 27/31 Bryanston Street, London W1.
Phone: 01-935 0141

WHILST NORMAL PROGRAMME level meters give an indication of the overall programme level, it is of course desirable to have some knowledge of the spectral energy distribution, because all current methods of audio recording reach a saturation point which varies according to the frequency of the incoming signal. In the cases of tape recording and fm broadcasting, pre-emphasis is used to increase the available signal to noise ratio, and such pre-emphasis directly affects the saturation point of the system. Similarly, in disc recording, there is the standard RIAA curve and the mechnical consideration of the system to be taken into account.

An even more serious situation arises in tape duplicating where a high speed master tape with good high frequency saturation performance is sometimes copied without 'treatment' onto a compact cassette format which has relatively poor high frequency saturation characteristics —the result being a terribly 'mushy' cassette being copied from a clean master tape.

Hitherto, the way out of these problems has been by purely subjective assessment of the programme material; the only suitable instrumentation has been a very expensive real time analyser costing several thousand pounds. While the Amber audio spectrum display is, in effect, a real time analyser, it has been specifically made for the recording industry and does not require the extreme accuracy of previously available instruments. It does, however, have perfectly adequate accuracy for the purposes for which it is intended and also includes some novel features which are not found in other real time devices.

To start with, the display consists of a 10 x 10 matrix of light emitting diodes, each vertical row of which indicates level in either 1 dB or 2 dB steps within one of ten octave bands. These are arranged to correspond to the horizontal axis of the display. The centre frequencies of the ten filters are arranged from 31.25 Hz to 16 kHz, thus covering the audio spectrum of normal interest. Unlike the expensive precision analysers, the filter shape does not aim to have the normal rectangular response as is essential for other applications. Another important difference is the fact that the Amber device uses a peak rectifier with a fairly long time constant hold circuit as opposed to the genuine rms rectifiers which are essential for spectral density determination.

So much for the display, and now to the really novel features. Being a digitally operated display the technique offers the possibility of operation in real time and from a digital store. The Amber instrument takes advantage of both modes. In real time, two operating states are possible. In the first, the band filters act upon the input signal producing spectral amplitude content on the display. In the second, all the display bands are run in parallel giving a single channel ppm indication.

A rotary four position switch selects the display data from either of two separate memories or from the two 'live' modes without affecting the accumulation of data by the memories. These are controlled by three push button switches for each identical memory. The first of these erases the contents of the chosen memory, such that the memory is ready to accept new data. Two modes of data entry are available: the first is a 'sample' mode in which the memory accumulates data when the 'sample' push button is depressed; the second is the 'enter' mode which is controlled by a locking 'enter' push button. While this button is depressed, the selected memory accumulates data and stores the maximum levels in each octave band. It follows that it is possible to accumulate the spectrum from two different sources (say master tape and 'treated' copy master) and to directly compare the spectra at the turn of a switch. Furthermore, the display may be operated in any mode while data is being accumulated.

Many other modes of use will come to mind when it is realised that the unit has four separate

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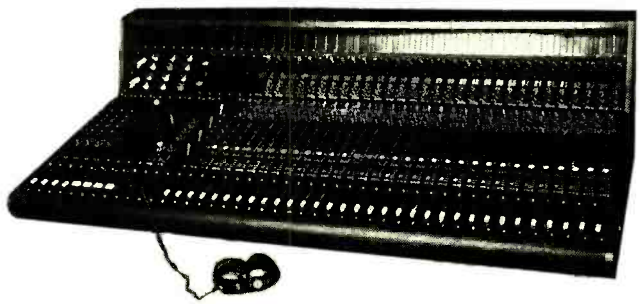


inputs which are isolated from each other. Either individual inputs or the arithmetic sum of any combination of input signals may be fed to the display in accordance with the setting of the four input selector push buttons. The final front panel facility is an input attenuator which covers a ±10 dB range in 2 dB steps, the zero point being determined by the setting of a rear panel calibration control.

To the rear of the instrument are the four electronically balanced inputs in the form of three pin *XLR* sockets, and IEC standard mains input, mains voltage selector and mains fuse, all of which are clearly identified. In addition, there are two calibration controls for adjusting the basic input sensitivity and for setting the dB per step of the display. Concluding, the auxiliary input for remote actuation of the 'sample' mode of either store and the auxiliary output. The latter is intended for using an oscilloscope to display the spectrum of the incoming signals and provides a timebase trigger and a 'Y' input. The resulting display is in the form of a vertical 'bar chart' with the rise and fall times of the instrument.

Construction

The external and internal appearance of the instrument are both neat and tidy with all operational facilities being clearly identified. However, while the individual components are not identified by component references, the layout and all details (both mechanical and electrical) are given in the first class instruction manual which is provided with each instrument.

A hinged carrying handle is provided, and this is also intended to act as a tilting device when the instrument is used on the bench; however, when used for the latter purpose the mounting point of the handle is too far to the rear, with the result that it is very easy to topple the unit on the bench.

Virtually all the electronic components are mounted on fibreglass printed boards, the bottom of the case being occupied by a mother board to which are mounted three sockets for the subsidiary boards, one of which forms the display. The mother board may be readily removed, as all the front panel controls and rear panel functions are wired to the mother board via plugs and sockets. However, I do have one relatively serious complaint about the construction, and this relates to electrical safety. As has been found with other American products, the mains voltage selector is in the form of a truncated slide switch which has too small a clearance between its solder tags and the metal case fixed to the instrument chassis.

Calibration

As supplied, and with the step attenuator set to zero, the 0 vu indication of the display corresponded to +4 dBm with the display in the 2 dB per step mode. However, the rear panel calibration control had a range of 24.7 dB with this initial setting near the centre of the range. One thing that was found to be rather confusing was that, when changing from the 1 dB to the 2 dB per step mode, the minimum display indication remained at a constant input level, as opposed to the 0 vu point remaining at a constant input level.

Probably the user will wish to set the overall sensitivity, but will not wish to adjust the individual centre frequencies and gains of the ten filters, all of which are adjustable by internal preset controls. This parameter, therefore, was investigated in some detail. In practice the centre frequencies were found to be within 3% of nominal in the worst case, and the level accuracy of the filters within 0.3 dB overall error, with the exception of the 16 kHz filter which was down 0.5 dB relative to the 1 kHz filter. Bearing in mind that these checks were made using the 'just on' points of the display leds having 1 dB increments, there is certainly no cause for complaint with this accuracy.

Again using the 1 dB per step mode, the accuracy of the display increments was found to be within ±0.2 dB between any two indications, and this excellent accuracy also held for the 2 dB per step mode!

The final matter affecting the overall level accuracy of the instrument is the operation of the ±10 dB step attenuator. This gave a creditable worst case error of 0.3 dB between steps or 0.33 dB absolute error overall.

Display response

It was found that the rectifier characteristic was to true peak, which is probably the best for the intended application of the instrument. However, this characteristic does mean that the instrument is not suitable for frequency response alignment using random noise sources and, in this respect, both the sales leaflet and the instruction book are misleading.

The effective rise time of the display is very fast, such that an indication within 1 dB of the final value is reached in 500 μs with a 16 kHz sinewave input, reducing to 1 ms at 2 kHz and about 8 ms at 250 Hz. The display then holds the final value with an effective measured fall time of 1.4s to −20 dB. While the fall time leads to the display being easily read, it may be felt that the effective rise time is too fast such that the instrument may display peaks which cannot lead to audible distortion—however, the proof of the pudding is in the eating.

Inputs and outputs

Whilst I have already mentioned the input sensitivity using the balanced input, it should perhaps be mentioned that the active input circuit is such that the sensitivity is identical in the unbalanced mode, but that the input impedance is lower. The impedance of the balanced input was found to be 17.8 kΩ when the input was not actuated, rising to 107 kΩ with the input active. In the unbalanced state the impedance was, as might be expected, half these values.

Checking the unit for possible interaction between inputs showed that interaction was at least 70 dB down at any audio frequency with the inputs loaded from a 600 ohm source, the interaction reducing with frequency to −96 dB at 1 kHz at a rate of about 6 dB per octave.

56 ▶

AMBER 4550

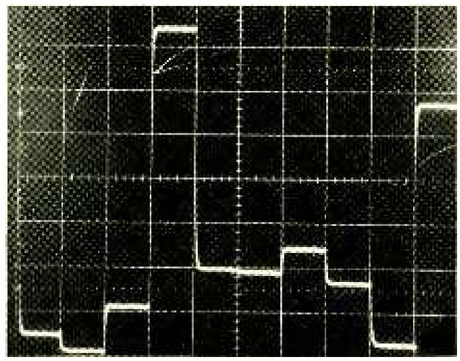
The oscilloscope output was generally satisfactory giving a linear output with approximately +5 volts corresponding to full scale output as per the 2 dB per step mode. The oscilloscope output was not affected by any analyser adjustments other than the input attenuator. One snag which was noted was that the oscilloscope output contained rather a lot of mains hum. It is thought that this is due to the high output impedance and the proximity of the output leads to mains wiring within the unit. The type of bar chart display created is shown in **fig. 1.**

Summary

The Amber *4550* Audio Spectrum Analyser is undoubtedly a very valuable tool for analysing the spectrum of recorded levels when duplicating tape or disc cutting. Furthermore, it may well prove to be a useful tool for evaluating signals before a recording process. It may also be used for measuring sinewave frequency response if the analyser's centre frequencies are appropriate, but, as explained, it does not have the rectangular filter response of the very expensive real time octave analysers. The foregoing applies to the peak rectifier characteristic. This means that it is not suitable for noise analysis or for evaluating frequency response using random noise, and in this respect the supplied literature is misleading. From a point of view of construction, the standard of workmanship and design is good, but the mains voltage selector switch requires modification for the British market. I have also mentioned one or two other matters which could be subject to improvement.

Overall, this is a very valuable tool, and is to be thoroughly recommended for applications where it is required to consider the possibility of signal compression by recording media and frequency sensitive devices.

FIG. 1



ELSTREE STUDIOS

number they played back academy. 'He had no hesitation, he said "I want Dolby",' Lumkin recalls. Not only did he want Dolby as a mono, on optical, he decided he would want a Dolby encoded stereo as well, which we did for him.' A three track magnetic recorded version of the film was shown in Beverley Hills at a Paramount Pictures Sales presentation towards the end of 1973, the first ever.

The way the Dolby system is used will vary. For the dialogue the synch track is taken from a Nagra 6.25 mm machine and Dolby encoded before it is transferred to a roll of fully coated 35 mm magnetic film. After this it is usually post-synched at a separate recording session, when the recording made on the set is replaced by a better recording made in the quiet of a post-synching studio. This recording is then encoded as it is transferred to 35 mm fully coated film and becomes the master dialogue roll. The music is mastered on a 16 track machine, often at a commercial recording studio, and each track encoded and decoded on record and replay as it is mixed on to a three track master. It will be decoded from the multitrack machine, mixed with the other tracks and the result will then be encoded as it goes on to the 35 mm film. The triple track will be of left, centre and right signals. In the case of music for a mono film, three track music is supplied and mixed down through the dubbing desk. The effects which are made specially for the film, post synched as the dialogue has been, will be Dolby encoded as they are transferred to the 35 mm film. Other effects available from a library, 'wild' effects, are generally not yet available in Dolby encoded form but effects libraries are building up their stock of encoded material. There may be twenty or more effects film rolls for a sequence.

Collecting and assembling effects is part of the dubbing editor's job. The dubbing editor on *Orient Express* was Jonothan Bates, and Bill Rowe spoke highly of him: 'He's the top dubbing editor. He doesn't just lay tracks, he studies the film.' Bill Rowe said that Bates had not used a single loop in *Orient Express*—most of the effects sounds were shot on the spot. He had even managed to use train noises (nobody knows where he dug them up from) which were recorded from the genuine Orient Express when it had been running.

All these rolls, of music dialogue and effects, may total 50 rolls of film. All of these cannot be mixed at once so premixes may have to be done to combine all the effects, or as many of them as possible, then mixing them with the music and dialogue. Bill Rowe: 'I try to avoid doing a premix. You only do them as an operational necessity. We can do 36 tracks at once.'

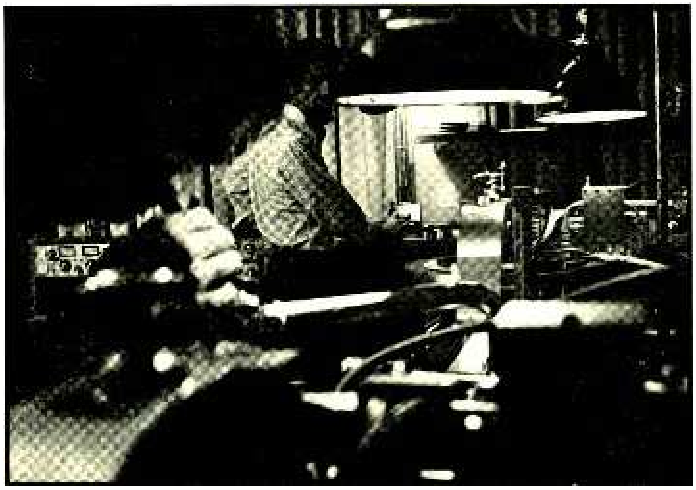
All the premixes—dialogue tracks, effects and music—are decoded through the rerecording desk, mixed, encoded again and placed on a 35 mm magnetic film in three tracks: dialogue, music and effects. This is the master roll. It is used finally to record the optical track. Simultaneously, a single encoded track is made for transfer to the optical sound recorder, using the anticipatory noise reduction system.

Does using Dolby make things more or less easy for the sound men. Mike Bradsell, editor on *Stardust:* 'In the editing process there are things we no longer have to make allowances for. If you're planning heavy music with dialogue you lose intelligibility if you're not careful. If you know you're going to get greater range and keep it flat you can take more liberties; I don't think people realise how much intelligibility is lost in the areas that get rolled off in academy. The music benefits a lot from Dolby. The equipment doesn't add any complications.'

Tony Lumkin again: 'Others don't know what problems they've got along the road, because we've grown up with it. They think they can go straight in but that isn't what it's all about. It needs expertise on that dubbing desk to make it work, to know what you can get away with and what you can't get away with.' A lot of them didn't have that expertise, he maintains. 'They could come unstuck.'

Be that as it may the system is in use and working well. I've seen two movies for which the soundtrack has been Dolby encoded and the difference is marked. In *Steppenwolf,* for example, there is a long sequence during a meal which is silent, really silent, except for the music of knives and forks. Yesterday they would have disguised the breakfast noise with brooding cellos. Today they leave it alone. And you can hear every word. *Stardust* was such a good film I didn't notice the sound.

Mastering Lab



BUSINESS FOR ANY good and well-known cutting studio is usually so brisk that working insanely and then lying in the sun when not must seem a pretty good proposition. And in the case of the Mastering Lab, add to that their almost-establishment position in LA circles, having been in their present form for more or less ten years, then commercial superstardom surely results.

It does. In late May, the top four in the Billboard album charts had been cut in the modestly-fronted emporium near Hollywood and Gower. A rough internal guess put the average for the year at around 20% the total American charts—one past sunny day they chalked up 26 of the 100, 'but we're trying not to work that hard now, Jesus no'.

At the centre of the Mastering Lab operation is Doug Sax, with Mike Reese also cutting during my visit and Sandi Johnson completing the apparent personnel: despite the ubiquitous nature of the product, theirs is a single cutting studio and the intention is to keep it that way.

While work may come and go, the gear is constant: for example, speakers one-offs with added crossover designed by brother Sherwood Sax (crossovers find their way to A&M, RCA, Sound Factory, and Sound Lab just down the road). According to Doug, Sherwood has just about the whole place attributed to him in terms of design credits. One relic still surviving and sounding smart is a 1948 Ampex, 'the 23rd off the production line,' which remains largely unmodified and includes the original relays. Replay electronics only are replaced . . . Sherwood's design. In particular, the 356 mm spool capacity is an obvious advantage with the upsurge of 76 cm/s recording.

Other technical areas remain practically as designed; when the studio was put together, the available commercial units were found wanting . . . subsequent introductions such as cutting amps 'give higher powers, but don't give me any reason for changing my mind'. The two old Scully lathes incorporate Neumann cutters but with homespun old valve amps continuing to give consistently good service. Elsewhere, tape machine playback, limiters and equalisers (all passive) are house designed . . . present results and clients list are testament to their ultimate persistence at least.

The most startling things to come out of the studio are hardly wildly commercial, although doubtless they aren't run as any audio charity. They are, though, in Doug Sax's words 'a labour of love', an expression which echoes round LA. Sheffield Labs is an associated company, run by Doug with partner Lincoln Mayorga, whose playing and arrangement complement engineering in the series of direct-cut discs which at the time of writing is a collection of three. Some are out of print: the limitation to two master lacquers (master and slave cutters) holds the total run to some 50 000 copies, and this with German Teldec's guarantee of 20 stampers for one mother, or 1000 to 1500 pressings each. A tape master is taken simultaneously at the session, 'but only for evaluating performance and mix, you understand'.

The fourth issue is rather more ambitious. As a result of the usual surfeit of telephoning in all directions and the corresponding amount of coordination, sessions were arranged with a total of 18 top LA session musicians, six classy backing singers, and Thelma Houston (released by Motown for the event). Direct lines were taken as usual from the studio next door, Producers Workshop, which is now equipped with a 32 input desk, custom-made with a pathological

avoidance of transformers and expanded over the previous 24 by Bud Wyatt.

In fact, more than 32 mics were set up during the session: despite the complexities of having to cut four or five tracks in real time to a standard demanded by the evolution of more leisurely mixing techniques, there was no way that the sound was to be compromised through lack of facilities. Apart from the musicians rearranging themselves between tracks in the time given by the disc itself, an amount of replugging had to be done, not to mention resetting as much eq as was necessary . . . many hands doubtless assisted engineer Bill Schnee in the lightning transformations required. The arrangements themselves pull no punches. And on some tracks both Gordon and Keltner are playing together, with stereo top kit, snare and bd mics on each plus two additional toms for the latter; that's real-time engineering.

What about separation in such a live situation? Sax: 'These stories about jumbles are just old wives' tales. On our records we get twice anybody else's separation since we don't have to trail through the console and tape machine twice . . . and you can quote that. Separation isn't of course automatically wanted—you need blend. But we don't baffle on these sessions and never have any troubles in fighting lack of separation. Each successive record has used less baffling until Thelma's when we used none at all.' Mayorga: 'And I started off by using the cans and conducting from those, but for more and more tracks I just took them off and listened. Apart from the drummers, I think everyone else did too.'

The music making leaps at you off the record — the electricity generated by needing to get 15 to 20 minutes of music not just right but good in one take is obvious in practice as well as theory. As Doug Sax points out, if it wasn't such an interesting session from the artists' points of view, there was no way that they could all have been collected in the studio at one time, with all the money in the world. The contrast with the usual rhythm plus subsequent overdub procedure is obvious: musically, the solid gold style is for the horns to simply tramp in at 2.30, play

SESSION LINE-UP

Trumpets
Chuck Findley
Paul Hubinon

Trombones
Dick Hyde
Lou McCreary

French horn
Dick Perissi

Sax/flute
Tom Scott
Jim Horn

Guitars
Dean Parks
Larry Carlton

Keyboards
Lincoln Mayorga
Michael Omartian
Mike Melvoin
Larry Knechtel

Bass
Reinie Press

Drums
Jim Keltner
Jim Gordon

Percussion
Gary Coleman
Victor Feldman

Vocalist
Thelma Houston

Background singers
Morgan Aames
Myrna Matthews
Marti McCall
Lisa Roberts
Jackie Ward
Jim Gilstrap

along with musicians that they might last have met last month, to music that they've just seen for the first time and don't give anything for. When rhythm and brass are playing at each other across a crowded room, there's feedback that used to be there in the good old days which we've got accustomed to missing now. Apparently the players spent the next few weeks complaining about the slow, boring sessions they were having to endure.

So: both music and technique coincided successfully, without undue compromise. To say that the session arrangement had to be tighter than usual is something of an understatement, and technically . . . the only limiters in circuit were on Thelma Houston and Reinie Press's bass. So the result is expected to be a limited issue of 50 000, held down by the mastering limitations, which must become a classic. But even when the music was finished and the players had gone home, worries had only just started.

'We had two lathes driven simultaneously, which means that those lacquers are rather precious. Then one of them didn't process, due to a faulty blank that had remained unseen despite our careful checking. Then a second side went down . . . I checked it out and it looked as if the record amp had gone down . . . $40 000 gone already and we start losing lacquers, that's no fun. I never felt quite that bad.

'I came in the next morning, having told Lincoln something was going wrong. Tried the lacquer again beside the tape avoiding the disc playback . . . the tape got blown off the tape machine. You know, that's the only time the playback's ever gone down, the first failure in eight years . . . you get so used to functioning one way, you get conditioned to think it's one thing. It was my birthday, too.'

The few pauses in this story-telling were interrupted because the liquor store came on to discuss the order. Yes, it was to be champagne, 11.00 am sharp, cold. Hey and I can get Mouton Rothschild cheaper from this other guy in Hollywood, what's with you?

Sheffield Labs' fifth project was under way, a direct-cut recording of Lincoln playing the complete Chopin preludes, Brahms Op 119 (three *Intermezzi* and a *Rhapsody*) and obscure Prokofiev piano arrangements of a waltz from *War and Peace* and a Contradance from *Lermontov;* he was abstaining from the party until later.

The expression, not mine, is 'state of the art, 30 years ago'. Well, perhaps a little better. It's generally called purist technique. One stereo mic leading directly from the Producers Workshop through unbalanced lines directly into the lathe. The only transformers in the signal chain are then those in the cutting amps, at which point perhaps you can start quibbling about the drive coils. Lincoln: 'Habit dictates that you go to tape, even if there's no editing to be done. Certainly, we're not expecting a flawless record, but at least it should be something of a piano sound. And it's good to do the music like this.'

Future projects include further piano from Lincoln, with other ideas in the melting pot. Glyn Johns threatens to take up his standing invitation to organise a session there. In the meantime, the labour of love seems to be getting harder, although malfunction of the photostat machine has occasionally hindered operations. Record Four should be out in July. Cost: $10 from Sheffield Labs, PO Box 5332, Santa Barbara, California 93108. UK distribution arrangements: watch this space.

Michael Thorne

Around the receptions

TO THE INN on the Park for the arrival of Mr Evel Knievel, singer, motorcyclist and sometime rocket pilot. Best freeload since they launched the Good Beer Guide some weeks back (same pr outfit incidentally. Full marks Brian Cartmell of Blackpool.) Scored a brace of lps, three posters and a T shirt—a bit on the small side but I've asked them to change it.

The record? Robert Craig Knievel, 35, from Butte, Montana should stick to what he knows best, breaking bones—more than 50 so far. Over to the man from the BBC: 'Is it true, Evel, that you have a death wish?' Mr Knievel: 'Bullshit. I enjoy life to the full and want to make the most of it.'

Fair enough squire, but please don't make any more records.

To the Manchester Square EMI hq for the launching of something a shade on the progressive side, an album of songs from the tv series *It Aint Half Hot Mum.* Impressive impromptu performance of *Whispering Grass* by Windsor Davies and the miniscule Don Estelle — after consuming large quantities of a beverage made from grain. I'm told the dynamic duo are now doing cabaret in Jersey. Go easy on the cheap booze, chaps.

To the Churchill Hotel to welcome Mr David Gates. Best gin and tonic of the week—a handsome measure of Gordons and not too much fizz. Nice one, A&M.

Mr Gates, the denim-clad pr man told me, was giving interviews upstairs and did I want to take a turn after the man from the *Daily Mail?* Sorry, David, time was running out and here comes that waiter again.

Freeloader

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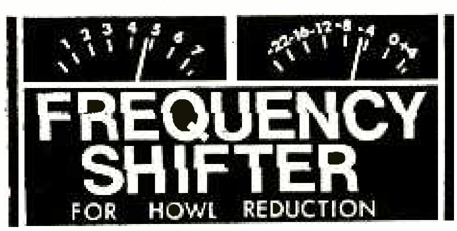

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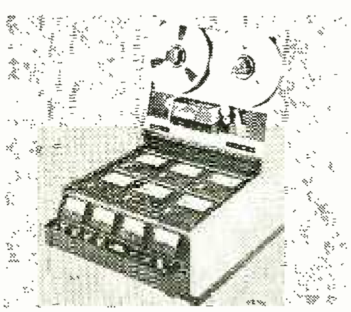

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Record it on a Revox A77

REVOX

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