June 1984 £1.20

STUDIO SOUND

AND BROADCAST ENGINEERING

A LINK HOUSE PUBLICATION

LIVE SOUND POWER AMPLIFIERS

MASTERING TECHNOLOGY

When we designed the new Series 20 stereo tape machine, we harnessed the power of the microprocessor to produce the latest generation of ¼" and ½" studio mastering recorders.

The micro takes the hard labour out of setting up for any session. That's because every pre-set can be stored in the machine's own non-volatile memory, for three different tape speeds, three eq standards, and five tape types. And that can amount to some 588 variable audio parameters. Recall is a single button operation, while updates can be carried out in minutes.

Safe and accurate tape handling is guaranteed by the micro, as all three DC servo motors use motion sensors for pinpoint accuracy. So constant tape tension is maintained under all conditions.

But the Series 20 isn't just highly intelligent – it has been designed as a truly practical machine, accommodating full size 14" reels, horizontally or vertically mounting, available as a table top machine or with its own roll-around base, to suit every studio.

Once again, we've taken high technology and applied practical common sense. Which is, after all, the design philosophy on which we have built our reputation. And the success of Soundcraft products thoroughout the world.

Soundcraft
APPROPRIATE TECHNOLOGY

LONDON · *5-8 Great Sutton Street London EC1 0BX England. Tel. (01) 253 6988 Telex 21198.*
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STUDIO SOUND
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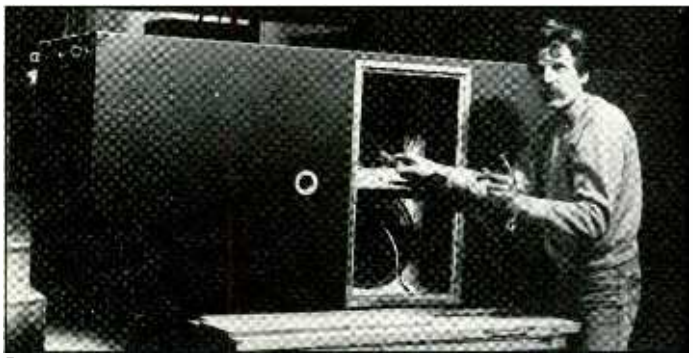
SPECIAL FEATURES



FEATURES

REGULARS

REVIEWS

Cover: Yamaha's PC5002M power amp (see review page 78). Photography by Roger Phillips

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A LINK HOUSE PUBLICATION

June 1984
Volume 26
Number 6
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Advice, instruction, back-up support. These are the key words in HHB's digital service philosophy.

We feel that with technology this advanced and innovative, these factors are more important than ever before.

We keep a full range of Sony digital audio products, from the low-cost PCMF1 processor to the DAE1100 editor and PCM1610 processor needed to make your CD compatible masters, and of course the CDP101 Compact Disc player.

Additionally, we can supply the video recorders you need, in both U-matic and Betamax formats, and advise you on which machines suit your needs best.

Our comprehensive rental service now includes all these products, delivered and installed, and with full instruction on their operation from trained, experienced personnel.

We can also offer a fully-equipped in-house editing and transfer facility.

So whether you need to buy or rent, or just find out what all the excitement is about, surely it makes sound sense to contact us – HHB the Number One Name in digital service.

DIGITAL?

HHB!

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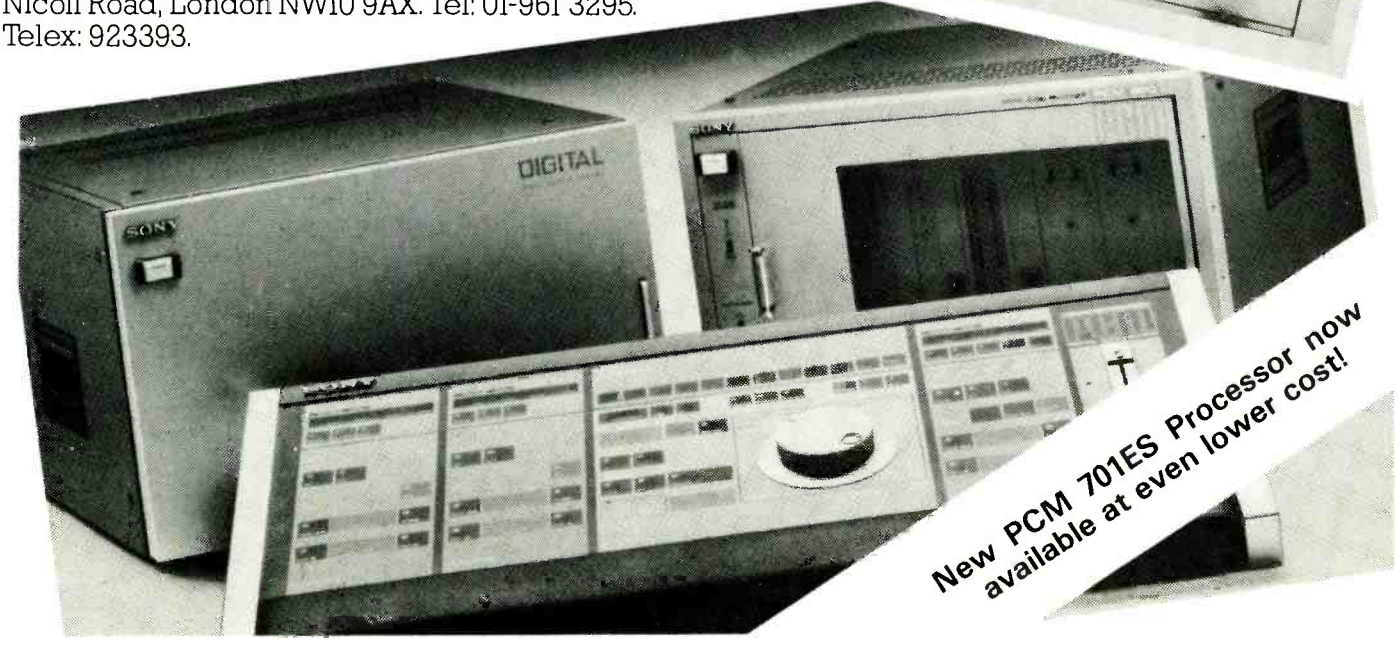

EDITORIAL

EDITORIAL

This month's comments, observations and opinions from Richard Elen

Digital audio enters a new phase

Since taking part in the APRS/*Music Week* Digital Audio seminar last year, I have attended another two such events, the SPARS Digital Audio conference at the University of Miami (at which I was very kindly asked to speak) and the IERE Colloquium on the Compact Disc, which was organised and introduced by our own Hugh Ford. And although there were dissenting voices at both events, it was quite obvious that there has been a distinct change in attitudes: very few people now doubt that digital audio as it is today 'works', or that the Compact Disc won't 'take off'—quite simply, it does, and it has. The questions now being asked are 'How do we get the best out of it?' and 'What is the second phase of Compact Disc marketing?' I present some suggestions to both questions.

First, it is quite obvious to me that a primary requirement in the studio usage of modern digital audio systems (and those to come) is that of *care*. Some of the CDs I have heard indicate that, quite simply, normal studio practices have been forgotten —for example in the setting of the azimuth on analogue recorders used to transfer a master to *1610* for CD mastering. Weird derivations of the original master have been used to produce CDs, often suffering from noise or other nasty mistakes. Digital equipment has been incorrectly lined-up (just like any other piece of audio gear, they *do* drift!) and sometimes they are incorrectly used, resulting in such things as digital masters with pre-emphasis and no pre-emphasis flag. Such mistakes no longer risk losing the public's confidence in the medium as a whole, but they could well result in some record companies getting a bad name for CDs just as some of them have been known for 'standard faults' on vinyl pressings.

Record companies must also learn that the only acceptable master for CD production is the original in many cases, and that there should be a very good reason for using something else, like an EQ'd copy. To back this up, it would be as well for CD mastering and digital audio post-production facilities to check back to make sure that the master they have is the right one, at least for the time being, until record companies know what they are dealing with.

In the studio, it must also be remembered that the preparation of a CD master tape is not the world's easiest thing, especially when it comes to PQ subcodes and filling in the cue sheet. Just as the majority of studio engineers would not expect to physically cut a master lacquer so, at least for the time being, they should pass the master on to a specialised facility for final preparation. In many cases, such a facility will be the cutting room you usually use. That way, all you need to do is supply accurate SMPTE timecode values for the start and end of each track on the tape, and leave the DAPP facility to decide whether you should have the index marker 5 or 15 frames before the actual start of the track, and the like. If that sounds like I'm putting the studio engineer down, not so: I personally wouldn't cut anything more important than a demo lacquer myself, and the CD I am currently recording will be prepared by one of the top DAPP centres in the country. I will be there, but I want it to be right, so I won't do it!

As to the marketing of CD, it seems to be going OK. Polygram, in the shape of Clive Swan, sees the market moving towards the 18+ age group from the 25+, and broadening out into pop from the current mix of classical/AOR. This is already happening. Neither do we need to worry about people not buying CD players because they already have regular turntables (a silly argument anyway: if that was true, they wouldn't have bought video recorders, cassette machines or FM tuners)...they are buying them all right! In addition, Polygram announced at CES that they are adopting the SPARS Digital Audio Recording Code (DARC) proposals, initially on CD only (although the principle can, and *should*, be applied to *all* discs that utilise digital techniques). It was interesting to note here, however, that an article from the *Hollywood Reporter* quotes Polygram US as saying that *they* thought of the SPARS coding—happily, the announcement by Polygram Europe gives credit where it's due.

The problems in the first phase of CD were not 'would people buy them' but 'where can they *get* them from' but now there are enough players to go round, and plenty of discs available...

Well, I should qualify that. It was with supreme annoyance that I recently discovered that there are loads more contemporary music CDs available in the USA than in Europe, and this is in spite of the fact that many of them come from here! Warners are the main culprits: all their CDs are pressed in Hanover, but for some reason they are reluctant to drop more than a handful of titles in the UK on their way to the States. Why?

Then there is the weird story of the 'audiophile CD'. During my visit to the Coop in Boston, I noticed an odd thing. Al Stewart's *Year of the Cat* was one of the first RCA CDs released in the UK (RCD 11749). Here it was in the store on import (RCA don't have Al Stewart in the USA if I remember correctly) at their sale price of $15.64 (usually $18.99 or so). Next to it was the Mobile Fidelity CD of the same album, labelled 'Original Master Recording' and pressed by Sanyo in Japan, retailing for $24.95. Could someone please tell me who had the better masters? It was recorded at Abbey Road, but mixed at Davlen Sound Studios, Universal City, so the masters may well have stayed in the States. But surely, RCA would have retrieved those masters (or at least transferred them to *1610* in the USA) and prepared the CD from the originals? So there should be *no difference whatsoever*. I could not bring myself to spend $24.95 on a CD I already own, but perhaps someone could tell me what this nonsense is all about? If there is a difference, it would be RCA UK's fault, methinks.

So not everything in the CD garden is lovely—at least, not as far as I'm concerned. Maybe I have weird tastes, but the man from Polygram said that the first market CD was aimed at was the 25+ male buyer interested in classical and AOR product...maybe I like the wrong sort of AOR?

STUDIO SOUND
AND BROADCAST ENGINEERING

STUDIO SOUND is published on the second Friday of the preceding month. The magazine is available on a rigidly controlled requested basis only to qualified personnel (see back page for terms) or for an annual cost of **£14.00** UK, **$40** US surface mail, **$75** US airmail, **£20.25** overseas surface mail or **£32.50** overseas airmail to non-qualifying readers or where more than two copies are required in a studio or small organisation. *All* subscription enquiries, including changes of address (which should be *in writing* and preferably including an old address label or at least the 7-digit label code) should be made to the **Subscription Department, Link House, Dingwall Avenue, Croydon CR9 2TA, Great Britain.**

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ABC MEMBER OF THE AUDIT BUREAU OF CIRCULATIONS

ITA is probably the only major pro-audio dealer in the U.K. that boasts a specialisation in tape recorders. Foremost of all tape recorders we can offer the professional is the Otari range.

We have been supplying Otari recording equipment to the major recording studios and broadcasting organisations throughout the world for over twelve years.

And, when you buy Otari from ITA, you'll enjoy a unique after-sales maintenance and service programme that is every bit as reliable as the equipment we supply.

Call into our new West London showroom and you'll find a wide range of equipment on working demonstrations, or we'll be happy to demonstrate the larger machines in the working environment of your own Studios.

For more information on any Otari products contact Mick Boggis at ITA, 1 Felgate Mews, Studland Street, London W6 9JT. Telephone: 01-748 9009 (Telex: 21879).

INDUSTRIAL TAPE APPLICATIONS
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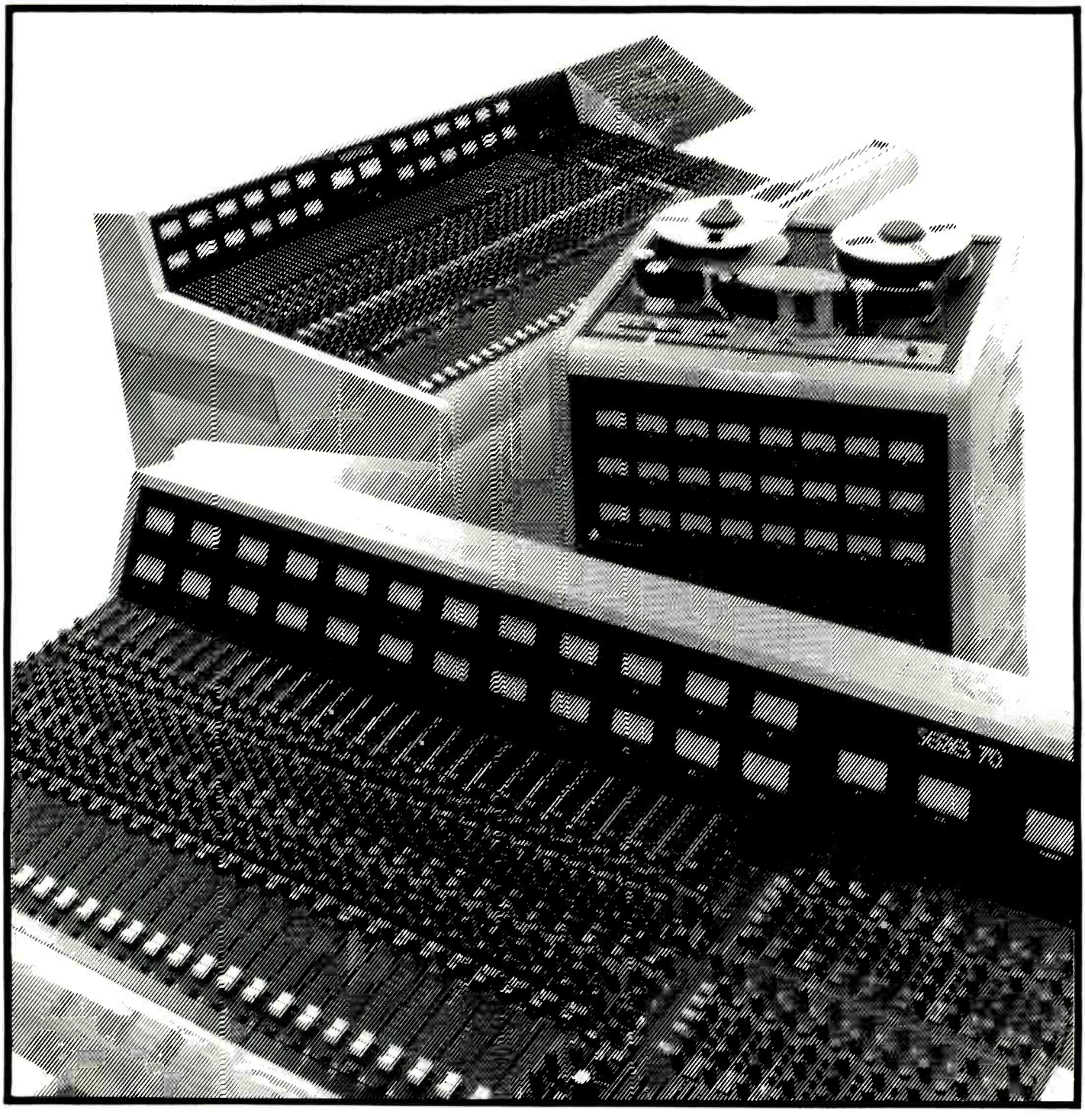
REMEMBER. ITA FOR OTARI.

..... tried, trusted, TRIDENT



For the committed professional there is one word that represents the highest standards in studio hardware – Trident.

The Series 70/Series 80B consoles and TSR machine are production engineered to the quality you associate with Trident. Off the shelf or customized you've never been able to buy a Trident for less.

Using the TSR multitrack machine as the foundation of the system, Trident packages cover advanced recording for the producer's studio up to full industry standard.

The range consists of TSR 16 and 24 track machines, supplied with remote controls and full auto locator at a price that foreign imports can't match.

The Series 80B is a 32 input, 24 group/monitor console, and the Series 70 is a 28 input, 16 group 24 monitor console. Both desks are fitted with a fully professional patchbay, 4 echo returns with EQ, and have the facility to use the monitor section as further inputs on remix.

Your limit isn't 32 inputs, Trident's engineers will design you an individual 56 input console at a price which will impress your bank manager.

So don't mince words – say Trident.

TRIDENT

Trident Audio Developments Ltd.

Shepperton Studio Centre Shepperton Middx. TW17 0QD, U.K.
Tel: Chertsey (09328) 60241. Telex: 88139282 (TRIMIX G)
Trident (U.S.A.) Inc. 652 Glenbrook Road, Stamford
Connecticut U.S.A. Tel: 203-357 8337

TRIDENT

No matter which musical direction you're taking, ITA can put together a package system just right for you.

Take a trip to our West London showroom and you'll find a complete range of recording equipment – from sophisticated 24 track Otari MTR 90's right down to Fostex Multitrack recorders small enough to hold in the palm of your hand.

In fact, our product range is one of the largest available anywhere. And when you buy from ITA, you'll enjoy our unique after-sales maintenance and service programme. So all you need worry about is the creativity.

If you'd like more information on our home recording deals contact Mick Boggis at ITA, 1 Felgate Mews, Studland St., London W6 9JT. Tel: 01-748 9009.

INDUSTRIAL TAPE APPLICATIONS
PROFESSIONAL PRODUCTS DIVISION
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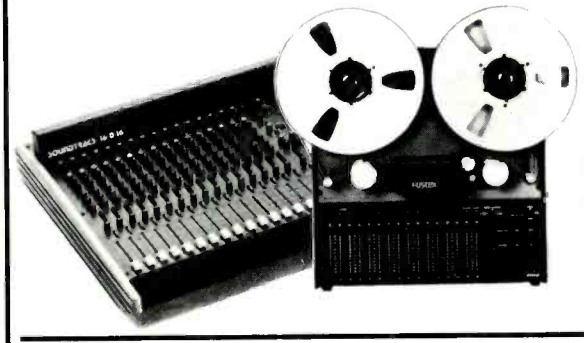
PACKAGE DEALS FOR PEOPLE GOING PLACES.



FOSTEX B-16 AND SOUNDTRACS 16-8-2 MIXER

The amazing ½" 16-track B-16 is unquestionably the best-engineered product yet from Fostex. As with other Fostex recorders, the application of Dolby C ensures that the narrow track format really can produce very high quality results.

We unreservedly recommend the Soundtracs 16-8-2 mixer to go with the B-16. This excelllent little British- made unit offers tremendous flexibility in operation, is solidly-built and has features not even found on mixers of the same format selling for 3 times as much.

Special Package Price: £4,450.

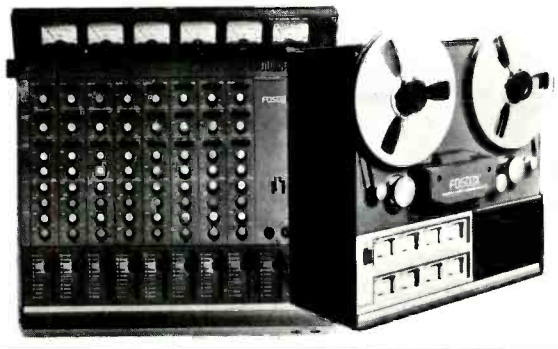
TASCAM 38 WITH ITAM NOISE REDUCTION AND P.E.P. 1200 MIXER

A nice mid-range system for the serious songwriter and smaller demo studios.

When the Tascam 38 was introduced last year it set new standards in cost-effectiveness. Combined with the Itam DB30/8 simultaneous noise reduction, excellent results can be obtained.

The PEP 1200 is a budget 10/4 mixer with a tremendous range of facilities for the price. Full 8-track monitoring and metering are fitted, there are 2 aux. sends and 4-band eq. on each channel.

Special price – £2,350 (also available without noise reduction: £2,100.)



FOSTEX A-8 WITH 350/3060 MIXER

Many home recordists prefer to stick to equipment from one manufacturer. Fostex cater for this by having a range that covers a lot more than just recorder and mixer; there are all kinds of outboard effects too. We're offering the most popular items in the Fostex range as a special offer.

The Fostex A-8 is still the world's smallest 8-track, but many users consider its performance at least the equal of some ½" systems. Combined with the 350 mixer/3060 meter bridge combination, as Fostex intended, a very compact, neat, yet powerful system is the result.

Special price – £1,425.

Whether you need one copy or two thousand you'll find Otari have everything you need.

Available exclusively from ITA, Otari are the world's brand leaders in high speed tape duplicators as well as manufacturing some of the best professional sound equipment.

The Otari range of duplicators has been expanded to include the new models featured.

The DP4050-OCF Reel-To-Cassette Duplicator and the DP2700 automatic Cassette Loader are still available.

Details of loop-bin duplicating systems and video tape loading equipment are also available on request.

ITA have supplied major recording studios and broadcasting organizations throughout the world with sound recording equipment for over twelve years.

And, at ITA, we realise that our involvement doesn't end with the installation of the product. In fact it's just the start.

Which is why we've devised an after-sales maintenance and service programme that's every bit as reliable as the equipment we supply.

If you'd like more information on the Otari range of professional recording equipment, then do not hesitate to contact Mick Boggis at ITA, 1 Felgate Mews, Studland St., London, W6 9JT. Tel: 01-748 9009 Telex: 21879.

INDUSTRIAL TAPE APPLICATIONS
PROFESSIONAL PRODUCTS DIVISION

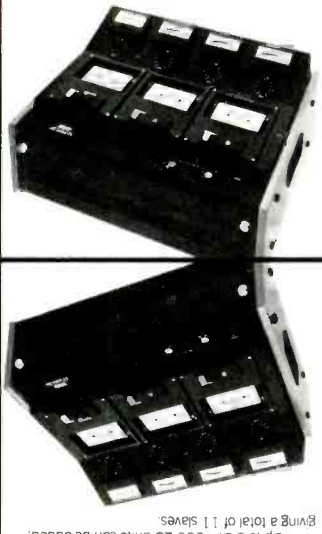
ITA

ITA FOR OTARI DUPLICATORS.

DP 4050 C2

The C2 is a cassette-master copier running at 8x speed, providing simultaneous copying of both sets of stereo programme material. Two slave positions produce 2 C60 cassettes in under 4 minutes.

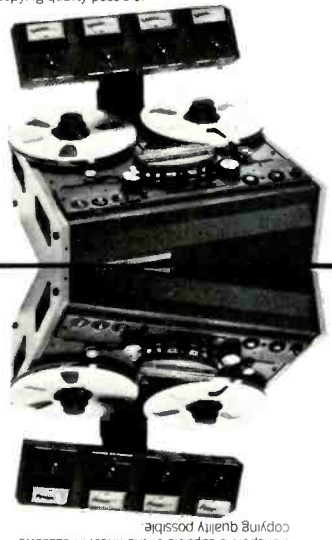
Up to 3 DP4050-Z3 units can be added, giving a total of 11 slaves.



DP 4050 OM

A brand new product, the OM is a high-quality, dual-capstan reel-to-reel transport running at 8x speed (30 or 60 ips). It can drive up to 6 Z3 slave units and can bias chrome tape.

A duplication system based on this master transport is capable of the finest in-cassette copying quality possible.



DP 4050 C1

Another brand-new product, this is a high quality low-cost 8x speed copier with one slave position only.

However, it can be expanded with Z3 units up to a total of 3, or 6 if the OM reel-master transport is interfaced as a buffer. The slave position can also record from the OM master.

ITA FOR OTARI DUPLICATORS.

THE MORE-AFFORDABLE 948.

From the makers of the world's finest broadcast turntables comes the EMT 948, a direct drive unit that embodies the proven circuitry and reliability of the EMT 950 in a compact format.

Featuring almost instant start (0.02 secs), stop and reverse cue; motor-driven tone-arm lift and integral amplifiers, the EMT 948 has a new shock-absorbing system and pick-up illumination.

Available for use with a standard 47k-ohm cartridge, the EMT 948 is an integrated system ready to drop straight into a desk-top. The EMT 948 brings excellence within greater affordability.

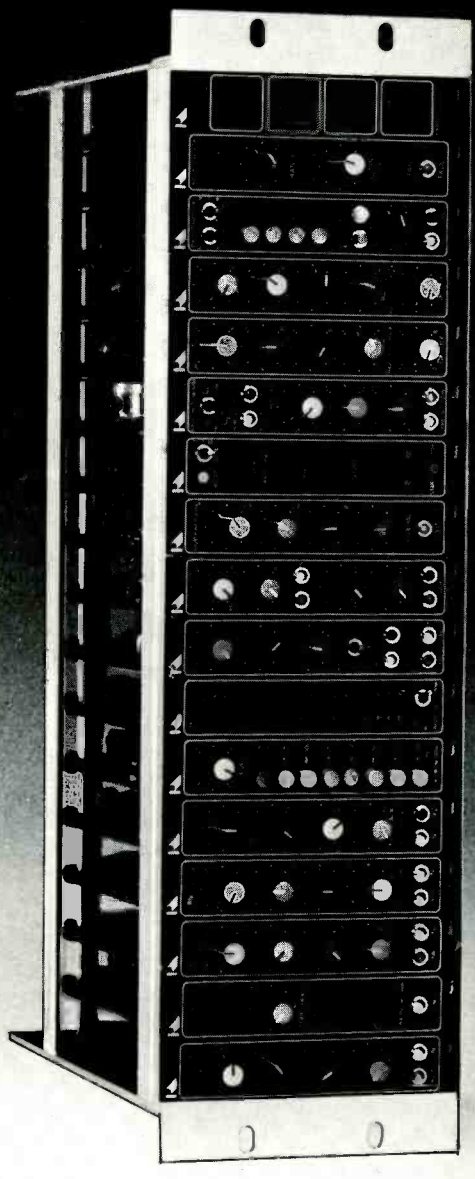
For further information contact F.W.O. Bauch Limited.

EMT FRANZ GmbH
Postfach 1520. D-7630 Lahr. Tel 07825-1011. Telex. 754319. Franz D

F.W.O. Bauch Limited
49 Theobald Street, Boreham Wood, Hertfordshire WD6 4RZ
Telephone 01-953 0091 Telex 27502

Rebis RA200 Series

The Nº1 Gate



The Nº1 System

Get the full facts on the most creative modular system in the world.

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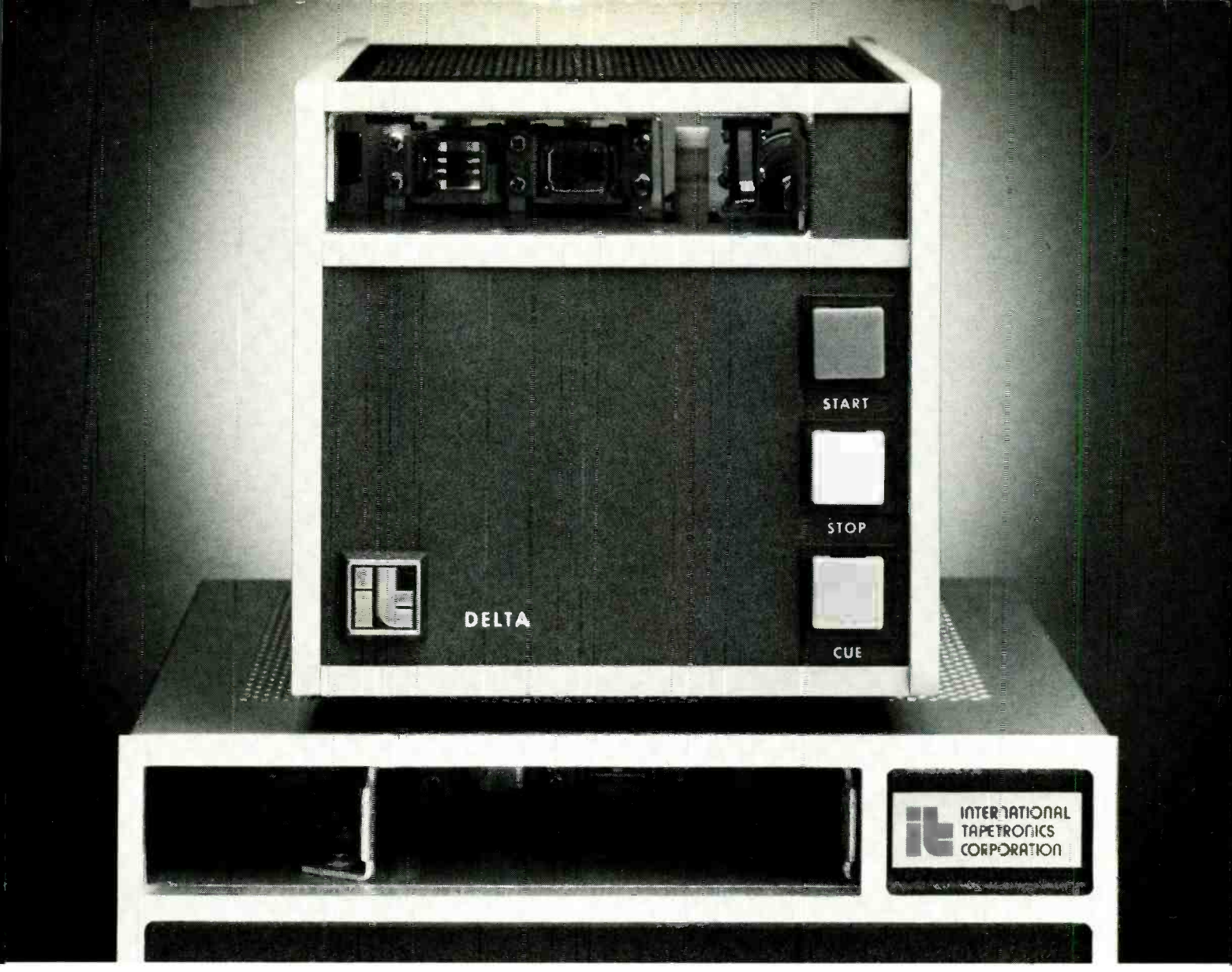

WHY CHANGE A WINNER?

Now, a new generation of cartridge machines is available from ITC: the Delta Series. It represents a major advance in practical technology for the studio, and it took time to develop. Because significant breakthroughs don't happen overnight, especially when they have to supersede such a well-proven and dependable workhorse as the Premium Series.

So the Delta Series had to be something special. And it is. The culmination of extensive and intensive research and development over the past few years, the Delta Series is an electronically and mechanically superior range of machines – more compact, with improved performance, incorporating a host of new operating features, and realistically priced!

Of modular construction, Delta Series units are easy and convenient to align and service. Sound quality is optimum, with minimal flutter and smooth frequency. New features include: a microprocessor-controlled digital cue tone detector; a positive cartridge guide system; high-speed cue as standard; high-accuracy crystal-referenced servo capstan motor drive with a ceramic shaft; new low noise amplifier design; space saving fit three compact Delta Series into a 19" rack.

The Delta Series has been rigorously tried-and-tested in the field with outstanding results; for more information, just write or 'phone.

ITC. Sound quality.

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NEUMANN CONDENSER MICROPHONES

It is essential that microphones used for digital recording be capable of covering a dynamic range of at least 96 dB, since this is the range between the quantizing noise of a 16-bit system and its clipping level. Neumann condenser microphones have always provided 110 dB – some as high as 129 dB (r.e. IEC 179) – but this is only one of their many advantages. There is no doubt that your digital recordings will continue to have their best chance at success if they are made using Neumann microphones. We'll be glad to send you our catalog 12C.

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turnkey mix May 1984

Otari launch 16 on one inch at AES

There was speculation before last months show in Paris. A low cost 24 track was top of the list. The surprise was, a very top of the market, sixteen on one.

Features of this new machine include a microprocessor controlled transport, superb audio electronics, foolproof function interlock and simple SMPTE interface.

More specifically, there are features that reflect engineering from much larger machines. a three speed transport, with bi-directional wind, external speed conrtol and spot erase.

Audio circuitry comes with active balanced line input/output, phase compensation and high speed master bias adjust.

The recorder is intended for demanding post production - in terms of both performance and affordability.

Not yet available, but we have provisional specifications for your reference. Price is expected to be around £10000

Industry updates to Otari from Turnkey

The past year has seen a great number of professionals move on from European or American equipment to the remarkable MTR 90 from Otari.

In many cases, where the move to digital is too early, established names in the studio industry such as **Wessex** and the **Barge** have chosen the advanced features and proven reliability of the MTR90. **Trident** bought their second Otari from Turnkey soon after the first, once they compared it's superior facilities and quality to their existing machines.

Livingston Studios are about to do the same thing.

Even in the equipment rental field, both **Multitrack Hire** and **Brittania Row** have chosen Otari from Turnkey. Putting a 24 track on the road is probably the toughest trial a precision machine can go through. The Otaris perform consistently.

It has also been a year when the truly independants, the top producers and artists, have invested in the new Otaris. **Genetic, Paddy Kingsland, Madness, Ian Stanley** and **Ian Anderson** to name but a few.

But perhaps the most rapid developments have been in the audio/video sweetening fields. Facilities like **Complete Video** and **Silk Sound** have chosen Otari from Turnkey. Satisfying the need for precision audio circuitry and tape handling, that keeps pace with the VTR's.

Throughout the recording industry the Otari MTR90 is being recognised as the obvious choice of mastering multitrack.

We offer a complete service of supply and backup on all the latest Otari stereo and multitrack products.

Call Garry Robson to find out more about upgrading to a new Otari from Turnkey.

CALL TURNKEY FOR FOR FULL INFORMATION AND PRICES ON ALL PROFESSIONAL AUDIO PRODUCTS. COMPLETE 44 PAGE CATALOGUE IS AVAILABLE ON REQUEST WE CAN HELP YOU TO FIND AND ARRANGE FINANCE. INSTANT CREDIT OF UP TO £1000 IS AVAILABLE TO PERSONAL CALLERS ONLY IF YOU HAVE A VALID CREDIT CARD.

Why Turnkey is first for all Soundcraft Systems and Packages

Widest experience We began selling Soundcraft about the time they moved on from PA to major recording consoles. In that time we have supplied and installed every model of console for applications and locations as wide ranging as a castle in Scotland, through major music studios and to PA in the middle east.

Complete design service We can build studios right from the ground up. Turnkey Two specialises in international standard acoustics for both studio and control rooms. And our wiring team has long experience of every type of installation. We can see every manner of project through to final commissioning.

Best prices Our systems or package price reflects how we buy more Soundcraft than any other dealer in the world. When you buy a complete studio, your savings can be even greater.

Broadest selection As well as stocking the major processor and accessory lines in Britain, we also offer several exclusive imported products. Our aim is satisfy every studio need.

Factory trained personnel It is in our interest as well as that of our valued customers to ensure fast backup service should any problems that may arise. Our technical department's response is both prompt and effective.

All effort to get you started As a credit licence holder, we can help to find and arrange finance for your purchase. If you are upgrading we may be able to move your old equipment on for you.

In every way we are the experts at supplying, installing and fully backing up Soundcraft.

Call Andrew Stirling or Garry Robson about our range of studio supply services. Nobody knows Soundcraft better.

Fastest Tascams now on sale

The TEAC Fifty series transport is exceptionally rugged and designed to shuttle tape at high speed. All three motors are linked to the microprocessor control SMPTE interface. It is built to keep pace with the most stringent demands of locking to video for sweetening.

Audio performance is most certainly Tascam's best yet, with direct coupled electronics, differential front end amplifiers and eight separate power supplies so as to attain peak performance from the circuitry. XLR style connectors are used throughout.

For a limited period, we are offering a massive **17% discount** on the official list price of these machines.

This is a unique opportunity to buy this new breed of half inch eight track, built for the most demanding uses.

Call Garry Robson or Jon Ridel for more details.

Friendly Comparison

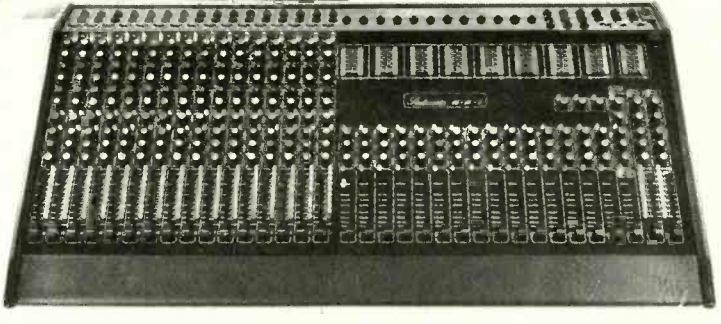
An active DI box costs more than a passive one - yet there are professional applications for both.

B.S.S.'s offering is the state of the art in signal matching. There's a very high impedance, low noise ampifier at the front end. There are no loading or bandwidth restrictions on the original signal. Output is balanced, on a standard XLR . Battery or phantom powering is possible. Switches select input level, ground lift, phase (for stereo use), and low pass. B.S.S. is the choice when the highest signal integrity must be maintained at every level.

E.M.O.'s direct box is the very first accessory that Turnkey sold. It's extremely rugged and built in to an indestructible diecast box. (We have never had one back for service). Input and linking are on jacks, output on XLR with earth lift switching. Whilst it accepts all levels, we mainly recommend it for use in matching line or speaker signals directly to balanced microphone inputs.

Turnkey offers a wide range of audio signal matching products, including transformers, boosters and attenuators. Call us for any advice on the level.

Phantom mod for BSS is now available ex-stock.



Introducing the RSD 16-16-2. A brand new mate for the Fostex B16

It is remarkable how many mixer manufacturers have responded to the introduction of the Fostex B16. Each, in his own way has acknowledged how this tape machine provides sixteen tracks at a fraction of previous costs.

Our packages so far have included consoles from Allen & Heath, Soundtracs, SECK and Soundcraft.

Now RSD enters the field with a new mixer, built especially for the Fostex Recorder.

In the first place, it is unique amongst the budget range by providing sixteen output groups. These feature switchable line/tape bargraph monitoring, and sends to a final mixdown pair.

Inputs are balanced with dual sweep equalisers, and a total of four auxiliary busses. An add-on block of inputs is available, and up to 32 inputs are possible with no complication.

Specs are of course excellent being in line with what current technology has to offer.

We are offering exclusive packages with the B16, at a special promotional price to launch this new product in the marketplace.

Call Jon Ridel or Garry Robson for full details.

TURNKEY CAN OFFER [illegible]E-UP FACILITIES FOR ALL PROFESSIONAL AUDIO PRODUCTS WHETHER PURCHASED FROM OURSELVES OR NOT WE CAN HELP YOU TO FIND [illegible]E. INSTANT CREDIT OF UP TO £1000 IS AVAILABLE TO PERSONAL CALLERS ONLY IF YOU HAVE A VALID CREDIT CARD.

Turnkey Two update leads to another

Windmill Lane Studios in Dublin cover the whole range of activities from basic music recording through to film and video overdub. In such a highly competitive market place , it is essential to maintain the highest international standards.

Not long ago, Andy Munro of Turnkey Two was called in to upgrade the monitoring system from the original JBL installation.

A custom built, three way system was specified, using Gauss dual 400mm bass drivers, a 75mm, low distortion mid-dome and 15mm soft domed tweeters. Phase compensated electronics and active equalisation were used to ensure maximum phase integrity.

We now hear, that Windmill's sound success continues and that this month, they take delivery of an SSL 4000E series console.

Proving yet again how one successful upgrade always seems to lead to another.

Short Term Digital Recording

It is probably the most desirable effect in the studio today. The ability to capture a live sound, from a fraction to several seconds long, and store it in a digital memory. Then perform editing, manipulating or looping and hold ready for use. Using a remote switch or sync pulse, the sound is triggered into the mix.

That's just one of the features on the AMS, DMX Delay system. There are two channels of delay, with independant control of feedback on each channel, VCO, depth and speed. Pitch change facility can also be added. And all of course maintaining a full 18kHz bandwidth, low distortion and very silent operation.

The reason why DMX is so powerful and versatile is because it is microprocessor controlled and modular. This delay system can be expanded and its facilities tailored to any particular applications.

Turnkey are South of England distributors for AMS, and of course we also supply the RMX 16 digital reverberation system. It maintains the lead as a British designed and built system that challenges other world class products with its accurate and authentic sound.

Call us for more information or to arrange for a demonstration.

Budget pop to high end vocals, our latest top ten microphone review

From the hundreds to choose, there's just a handful that remain firm favourites amongst sound recording engineers.

These then are the top ten best sellers (in no particular order) from our wide range.

AKG C451 For well over a decade, this has been the studio condensor system to buy first. Interchangeable capsules for omni, cardioid, peaking and shotgun plus a wide range of mounting accessories.

Sennheiser MD421 It has been christened the black rogue. It breaks all the rules with a plastic case, shotgun tests, internal stand clamp and built in tone control - yet it remains a firm favourite for both vocal and instrument applications.

Shure SM57 A classic, popular vocal microphoine that's rarely seen in its unbattered state. Cardioid patern, or unidirectional as the Americans would have it.

Fostex 505 A very popular new microphone from the personal multitrack people. Unidirectional and with built in mesh windshield. Surprising value in quality dynamics.

AKG D80 It's that shape again, yet a proven winner from AKG. Originally intended as a vocal microphone for rock'n roll, it has found its way into many budget set ups as a good all rounder.

AKG D190 General purpose, rugged microphone featuring a sintered bronze windshield.

Neuman U87 The microphone that all others are compared to. Despite its high price tag, every studio knows the importance of owning the quality that this microphone offers.

AKG D222 An updated version of the original D202, two way dynamic. As with a crossover in loudspeakers, this arrangement ensures the highest quality possible in dynamic microphones. The transducers are acoustically suspended, there's a hum compensation coil and equalisation.

AKG D12E Normally seen with its distinctive shape stuck inside a kick drum, this is another of AKG's updated classics. The integral 'bass compartment' boosts low frequencies around 100Hz. A large diameter diaphragm accepts high levels of bass sound without distortion.

Shure SM58 Probably the most familiar shape in microphones. It's legendary performance has been refined over the years to the point where it is just as acceptable in the studio as it is on the road.

Full specifications on all the microphones are available on request.

In addition to extensive stocks of these models, we also keep other popular microphones in our warehouse. Any microphone from these manucacturers is available to special order.

We offer a comprehensive range of stands and mounting accesories. Also cables and in-line transformers.

360 presents the best acoustic instrument sounds in the world

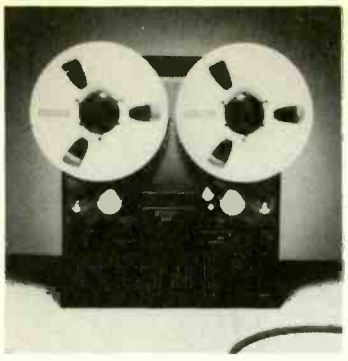
Introducing a keyboard that doesnt synthesise its sounds - it duplicates real ones. Strings with the rich sound that only the best acoustic instruments have. In fact, a whole catalogue of studio recorded sounds, stored on digital memory chips. As real as the master tapes they're cut from.

The 360 Digital Keyboard is eight voice polyphonic, and holds up to thirty two instruments. You can even play two instruments at once - two under each key or divided by a player selected split point. There's also vibrato and pitch bend wheels, filtering and expression pedal.

The sound of the 360 Digital keyboard is unlike any other because full length notes are used - some as long as eight seconds. There is no looping, no audible transposition, no synthesized envelopes. Top West Coast musicians were called for the sessions, and the sound engineered under tightly controlled conditions.

You can choose sounds for the keyboard at the time of purchase - as many or as few as you want; it's always expandable and you can add at any time.

Call Dave Whittaker to find out more about the 360 digital keyboard. Arrange for a demonstration and judge the sound for yourself.



Pioneer's Progress, beyond the studio

Apart from the major studio operations, there's a new way that music for film and advertising is being put together.

Ken Freeman is a composer, arranger, artist and producer. He is responsible for commercial soundtracks such as the prize winning BMW Graveyard and more recently for Flymo and the Hewlett Packard 'Touch' computer.

Four years ago, Ken was first in Britain to buy a Synclavier.

In the time since, he has applied his creativity to the potential of this computer based music system. Working essentially with Synclavier, Linn Drum and occasional keyboards, he has the flexibility to play with and manipulate the highest quality real and synthesised sounds. A few keystrokes can change an arrangement, an important tool in the art of matching the subtlety of sound to picture.

There's the ability to create new effects, and accurately lock sound to picture. In his own words, the resulting musical sound is "between orchestration and Radiophonic".

Ken has the freedom to experiment on a major scale with new sounds and effects. And to "make mistakes without paying for them".

Till now, the basic sounds were multitracked on an eight track. Recently, Ken upgraded to a Fostex B16 from Turnkey, providing even greater flexibility and quality.

The music production system he has built works to produce soundtracks for the demanding visual media. As cable channels open up, there will be an ever growing market for efficiently produced music. "This is the way of the future".

Room for Success. Turnkey Two update Park Gate Studios

Whilst some studio projects seem to drag on for ever, there's the occasional one that demands extremely fast, organised, reaction.

When Park Gates studio, near Battle decide to go SSL, it was natural to bring the control room up to international standareds at the same time.

Having won the contract Turnkey Two produced plans to refurbish the control room within the space of two weeks. To create extra space, the control room wall had to be moved, and the original tape storeroom, was converted to a machine room.

Our experienced building team then completed the project in a remarkable three week feat of endurance.

STOP PRESS Turnkey Two has just signed the contract to refurbish Townhouse Three - the old Ramport studios, in Battersea.

Call Andy Munro at Turnkey Two to discuss control room and studio design.

Do you have a copy of our Fact File yet?

Based on our wide experience of private and commercial studio projects, we have prepared a unique file of information.

It contains facts, figures and comment, covering all aspects of establishing a successful 16/24 track operation.

In short, it is essential reading for anyone considering a major multitrack venture.

For your free copy, apply directly to Garry Robson.

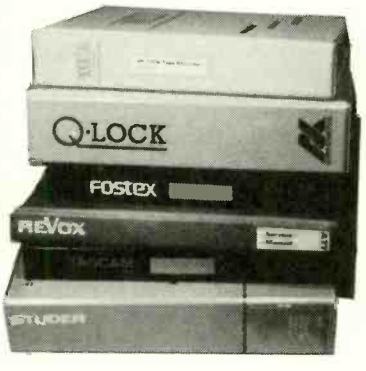
Turnkey Service, backup for all recording equipment

Our workshop experience with leading brands of mixers and recorders has grown from the humblest of four tracks to the most advanced microprocessor controlled twenty four tracks.

We hold extensive documentation on all the leading makes

We are pleased to perform a routine line-up on portable equipment or arrange to call out an engineer for any major work.

And of course, our studio installation team is also ready to undertake projects of any size.



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Prices shown are exclusive of VAT and delivery charges. Please call us for a firm and final price. Prices on any pro-audio product or a copy of our 44 page catalogue are available on your request

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The Quiet Powerhouse

We're talking about noise, not volume.

True, the main purpose of any high-power amplifier is to pump out high-power sound, and in this respect the Yamaha PC2002M is up there with the best of them. But any amount of volume won't help if the sound reproduction is poor, prone to hum and noise, or just plain distorted.

And that's where the design of the Yamaha PC Series scores. For a start, we've used two large-area, side mounted heat sinks, diffusing excess heat throughout the whole structure, doing away with noisy and potentially unreliable motor-driven cooling fans. And the excellent thermal dispersion is backed up by newly designed protection circuitry which senses the unlikely onset of thermal stress, as well as protecting against DC offset and excessive peak power levels.

Moreover, the PC circuitry is designed for barely measureable distortion – less than 0.05% THD at its conservatively rated full output of 240W + 240W into 8 ohms. A flick of a rear-panel switch transforms the PC2002M into a 700W Mono amplifier ideal for parallel full-range systems and the like.

Add to all this a smooth, accurate frequency response (10Hz-50kHz), a slew rate of 60 Volts/microsecond even at maximum output, and the result is an amplifier that can power anything from broadcast and recording studio systems to Disco or Rock PA, with hum, noise or distortion definitely a thing of the past.

Sophisticated for the studio, reliable for the road, the PC2002M delivers totally faithful reproduction at the lowest or highest volume level. So if you could use 240W per channel of clean, quiet, stereo amplification you could certainly use a Yamaha PC power amplifier.

Because quality matters just as much as power.

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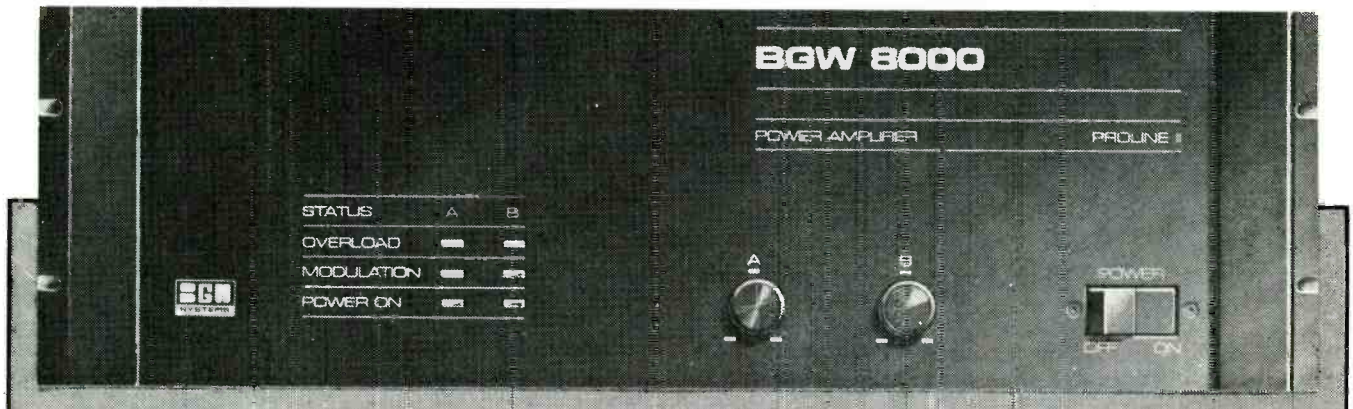
the new BGW 8000 Professional Power Amplifier.



- First BGW amplifier to employ ultracase™ output transistors.
- Fail safe electronic speaker protection.
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Power Output:	400 watts into 4 ohms at 1kHz, 600 watts into 2 ohms at 1kHz
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Intermodulation Distortion:	Less than .05% at rated output into 8 ohms
Hum & Noise:	110dB below rated output into 8 ohms A weighted
Slew Rate:	20 volts per microsecond
Slew Factor:	≥ 5.5
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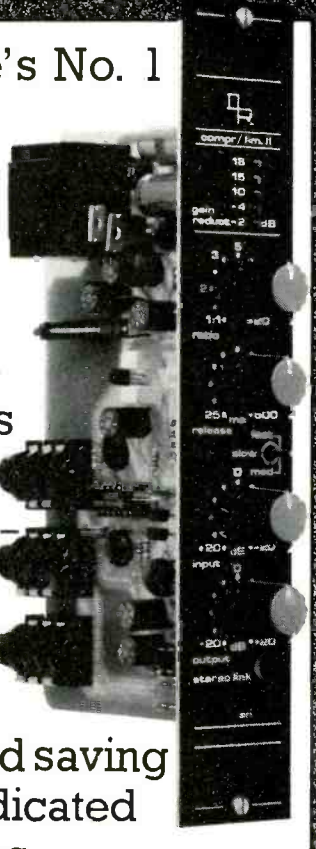

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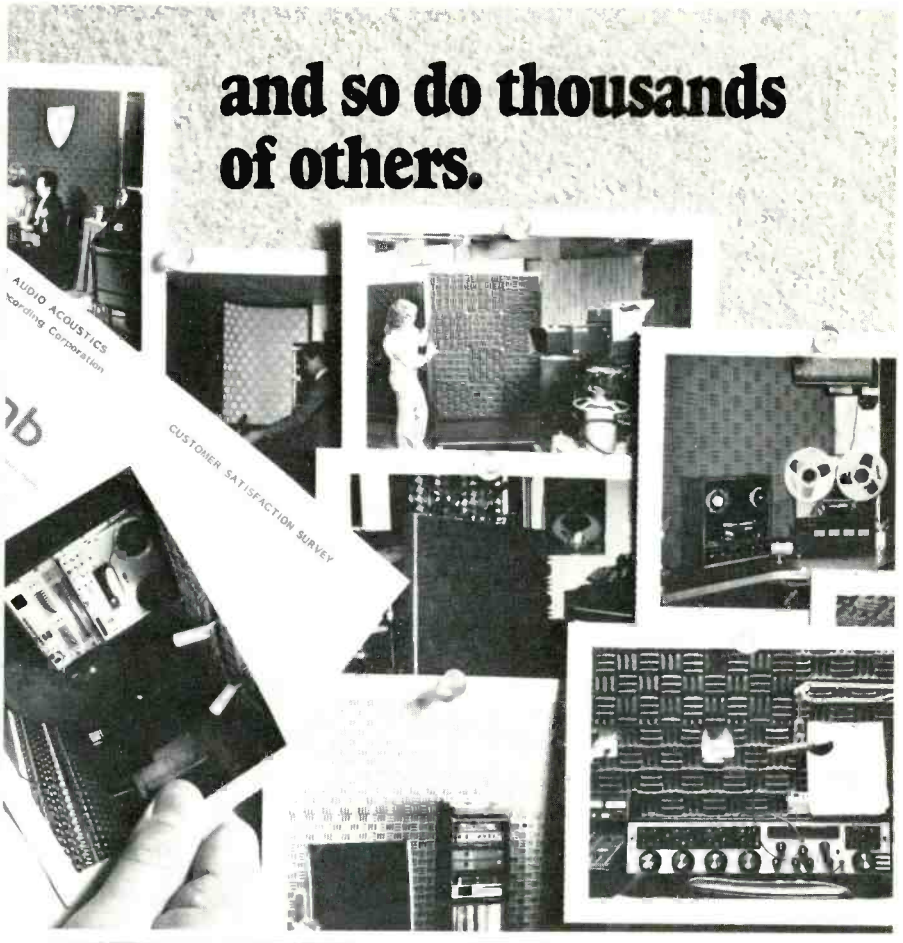

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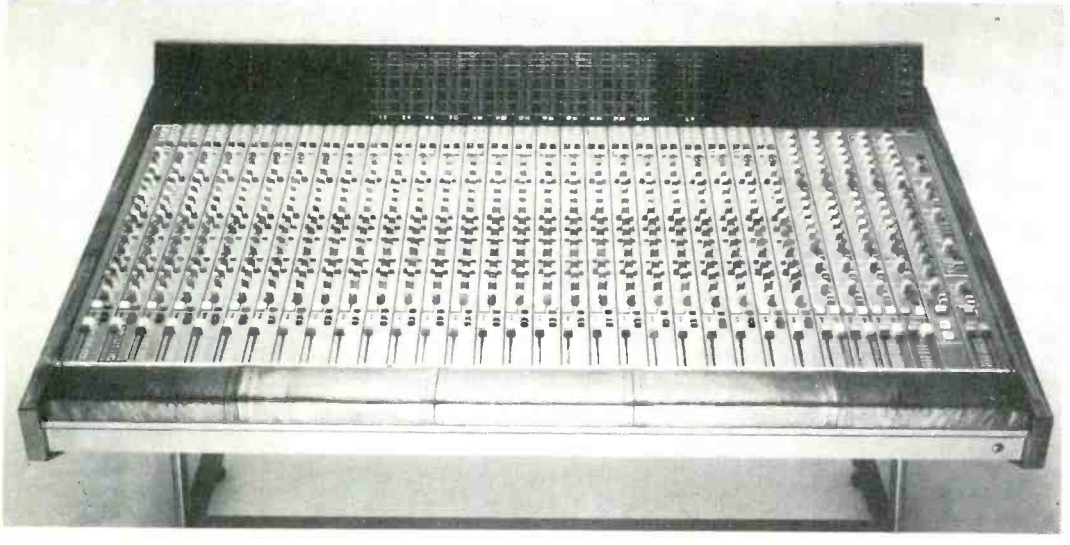

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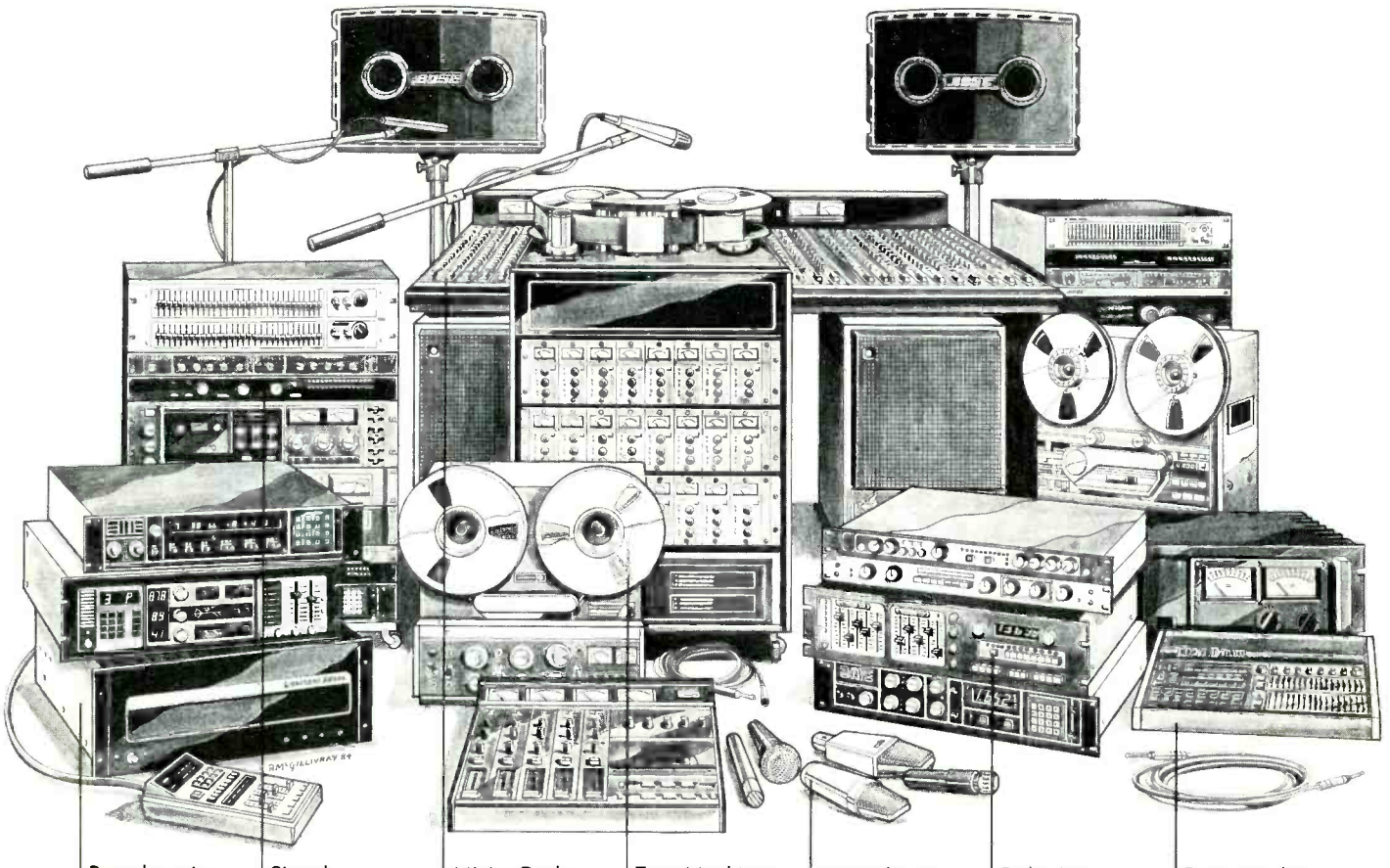

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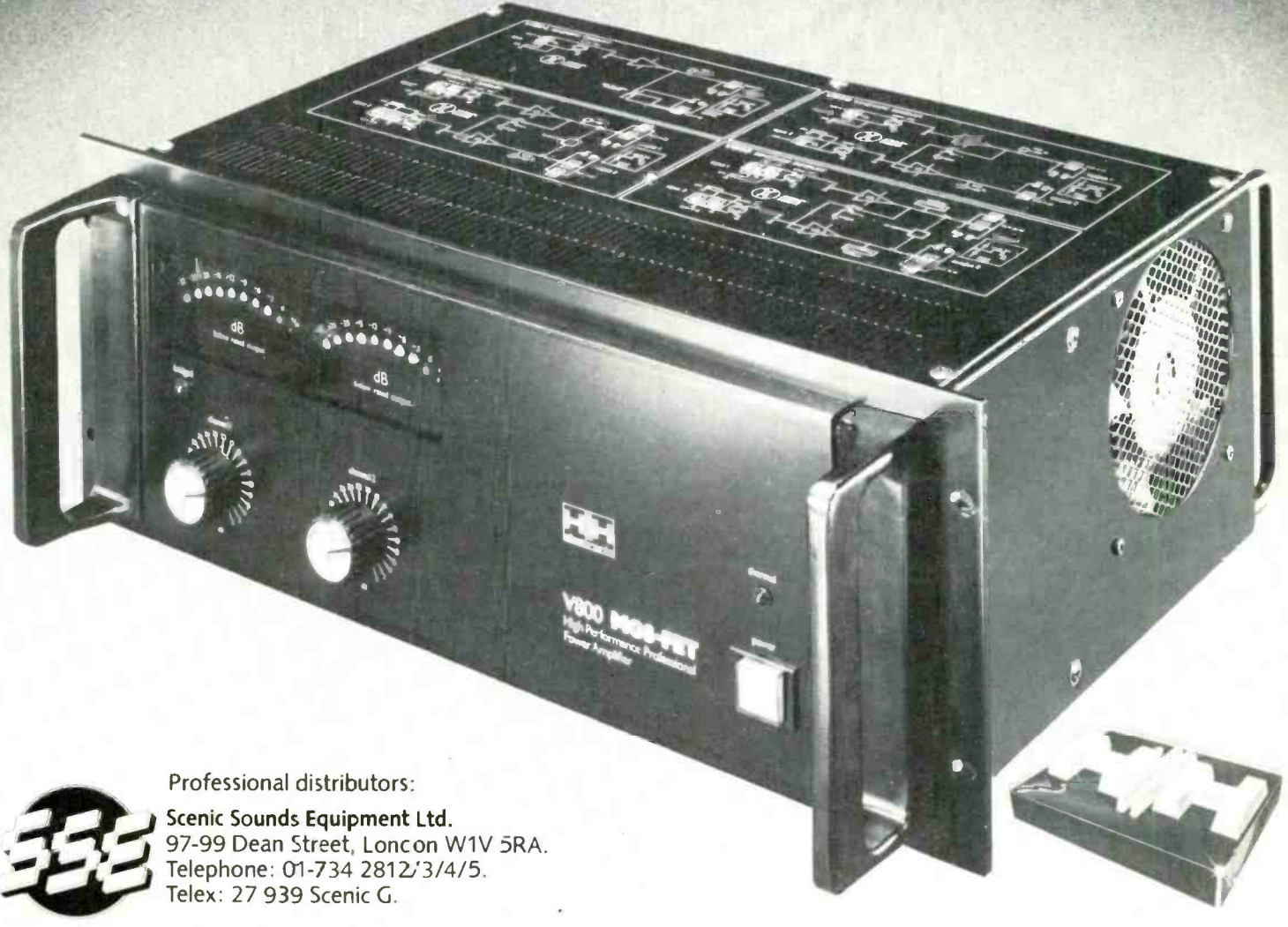

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Calrec 'M' Series mini mixers

Calrec have announced a new series of mini mixers in a rack mount format which are available with between 8 and 16 channels. Designated the *'M' Series*, each channel in the units has switchable mic/line inputs with 5 dB per step attenuator giving ranges of −70 dB to −10 dB on mic and −20 dB to +20 dB on line. All channels have 3-band equalisers with three switchable mid frequencies. In addition, there are 12 dB/oct HF and LF filters each of which has three selectable roll-off frequencies.

The output arrangements allow a stereo A/B output and an independent mono output which is switchable pre or post the main A/B faders and has separate mixing facilities of those signals to allow a completely independent mono output to be achieved in level and mix. Three high level inputs have been included and these may be used as tape returns or routed to the main mix as extra inputs. It is possible to configure these inputs as pannable mono or ganged stereo.

Talkback facilities and condenser mic are included allowing routing to main output and aux sends, in addition to four external circuits. Non-locking PFL buttons are fitted as are a post fade listen locking facility. Metering is PPMs or VUs as specified. Compressor limiter modules are available to fit the frames.

Inputs are *XLR*-type while outputs are *XLR* and multiway connectors. There are a number of factory wired options such as insert points or separate outputs from channels. The units may be mains or battery powered and there is provision for phantom powering.

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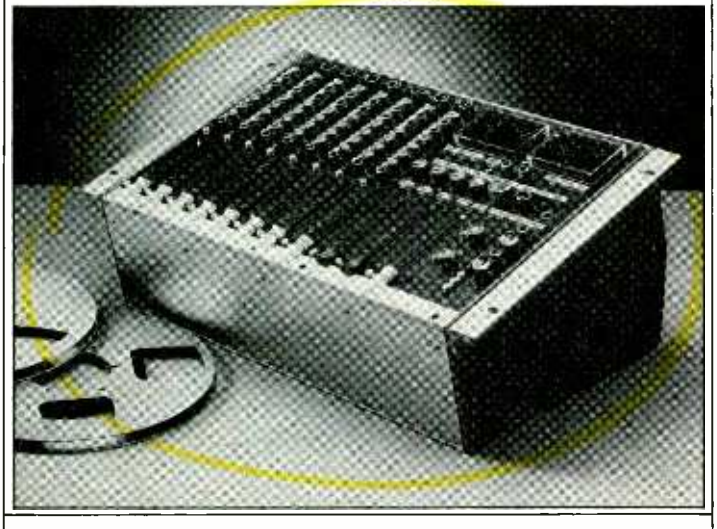


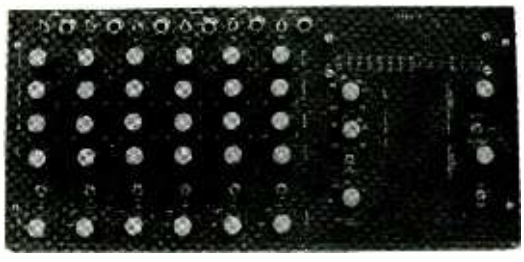
Audio & Design digital PRO 701

New from Audio & Design is a 'professionalised' version of the Sony *701* 16-bit digital processor, the *PRO 701*. The modified unit has *XLR* connectors and is fully balanced, with operating levels up to +22 dBm. It also incorporates ADR's coincident time correction circuitry which gives the channels a coincident output. Input level controls are replaced with a 12-position input/output unity gain switch that sets the operating level in 2 dB steps from +22 dBm down to −2 dBm.

Additional features include switching for PAL/NTSC recording, CTC of course, record pre-emphasis and copy prohibit, as well as digital input/output facilities to interface with further ADR products or with optional interfaces for *1610* or EBU format.

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

USA: Audio & Design/Calrec Inc, PO Box 786, Bremerton, WA 98310. Tel: (206) 275-5009. Telex: 152426.



CRS stereo mixer

New from Central Recording Services, the *CRS 6-2* stereo mixer is designed for maximum performance from dynamic or capacitor microphones, where relatively few inputs are required and where 'complex' facilities such as aux/echo sends and 3-band EQ are not involved. *XLR* transformerless inputs are provided with maximum gain of 76 dB and equivalent input noise of −128 dBm. Switchable phantom power is available, as is bass/treble EQ. Also on-board are LED-type PPM output meters, a variable LF filter and a 1 kHz line-up oscillator.

Central Recording Services, 17 Roy Close, Narborough, Leicester LE9 5DN. Tel: 0533 866883.

Futterman OTL valve amps

Although successfully developed and patented by Julius Futterman in the 1950s, output transformerless (OTL) valve (tube) amplifiers have only recently become a commercial reality. This is partly due to the patent itself, which prevented other companies from pursuing the concept, and partly because solid-state circuits rapidly gained such a stronghold. Confident of the sonic benefits to be had from OTL valve technology, however, New York Audio Laboratories have continued refining the designs and now offer a range of models to suit various applications.

It has long been recognised that output transformers are the primary limiting factor in valve designs, but their use has conventionally been a necessary evil. Typical audio valves (eg *EL34, KT88*) operate at high voltage and high impedance, whereas loudspeakers require comparatively low voltages and present low impedance loads. Conventionally, the way around this is to employ a transformer to carry out the necessary impedance matching—to let the valve 'see' its optimum load and to provide the speaker with a good, low impedance drive.

High performance transformers are notoriously difficult to manufacture, however, because of the inductive properties inherent in their design. A kind of electrical inertia is produced which inhibits the performance, particularly at high frequencies. The larger the transformer the larger its inductive effect, so that good amplifiers above around 40 W are generally rather thin on the ground. Typical problems are: impedance matching which varies with frequency; amplitude distortion, particularly at LF; phase shifting with accompanying distortion; poor transient response; and limited power bandwidth.

Various companies have, of course, refined the performance of output transformers, notably by adding special 'feedback' windings, but even the state-of-the-art designs suffer demonstrable performance failings. The only valves suitable for low impedance loads were intended for video applications, but Futterman adapted these for audio and refined his circuits over a period of some 25 years as new valves were released.

The input stage of the Futterman amplifier comprises a voltage amplifier directly coupled to a phase splitter which is itself AC coupled to the output stage. The latter consists of a number (four to six depending on the model) of output valves operating in push-pull and behaving as a large current source. The load is connected via an output capacitor.

There is still much faith pinned on the musical attributes of top-class valve designs with some studio circles and New York Audio Laboratories have produced an informative leaflet elaborating on the qualities of the Futterman designs.

New York Audio Laboratories Inc, 33 North Riverside Avenue, Croton on Hudson, NY 10520, USA. Tel: (914) 271-5146.

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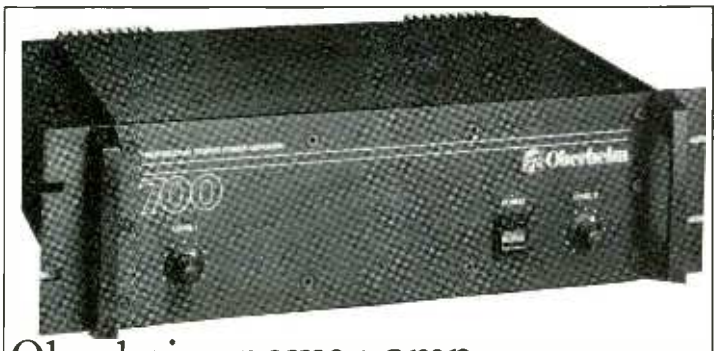


Oberheim power amp

Oberheim Electronics have produced a new stereo power amplifier, the *Model 700*, for their professional range. Rated at 200 W RMS/channel into 8 Ω (350 W/4 Ω) for 0.1% THD across 20 Hz to 20 kHz, the amplifier can provide peaks of 250 W (440 W). Designed primarily for live keyboard and sound reinforcement applications, hum and noise are specified at 104 dB below the rated output.

The amplifier's power bandwidth extends from 10 Hz to 40 kHz and ruggedness tests have included driving the full output of one channel into the input of the other! Almost any source and any load can be used without risking the amplifier itself. Since the amplifier uses no current limiter it can also drive highly reactive loads without distress. Front-mounted level controls are fitted.

Oberheim Electronics Inc, 2250 South Barrington Avenue, Los Angeles, CA 90064, USA. Tel: (213) 473-6574.

UK: Atlantex Music Ltd, 1 Wallace Way, Hitchin, Herts SG4 0SE. Tel: 0462 31511. Telex: 826967.

Sunn amplification

New from Sunn is a dual-channel power amplifier, the *SPL 6800*. Features include electronic balanced inputs (or transformer coupling via an octal plug), switch selectable stereo or bridged mono operation, independent temperature control on each channel, DC crowbar output protection, detented level controls, and 5-way binding posts for the outputs duplicated by jack sockets. Power output is 275 W/channel into 8 Ω (600 W into 2 Ω) per channel or 800 W into 8 Ω (1200 W into 4Ω) bridged. THD is quoted at <0.05% at 400 W into 4 Ω, input impedance 15 kΩ and sensitivity 1 V.

The *6800* uses a 'digitally controlled' sensing system to monitor errors due to clipping, shortened outputs, etc, automatically reducing the signal until the fault is cleared. This condition is shown on a front panel indicator. No less than 32, 250 W power output devices are employed and the safe operating area of each is constantly checked. The use of so many devices apparently increases reliability, presumably because each is under-run. The bridging option is switched and octal accessory connectors allow the use of ancillaries such as transformers (as above), passive/active crossovers, subsonic filters, etc.

Sunn Musical Equipment Co, Amburn Industrial Park, Tualtin, OR 97062, USA. Tel: (503) 638-6551.

Netherlands: Paws Sound Service, Weteringstraat 46, 1017 SP Amsterdam. Tel: (020) 239501.

BGW power

Model *2125* is the first in a new range of equipment from BGW Systems. A single-channel power amplifier, it is housed in a 2 U, all steel chassis which is convection and conduction cooled. Featuring all-discrete circuitry, it uses BGW's latest low noise differential configuration at its front end with a rugged four-transistor output stage. Provision is made for a plug-in input transformer. The unit offers 110 W continuous into 8 Ω across the audio band and a maximum THD figure of 0.1% is quoted with IMD less than 0.05% at any power level below the rated output.

BGW Systems, 13130 South Yukon Avenue, Hawthorne, CA 90250, USA. Tel: (213) 973-8090.

UK: Court Acoustics (Sales) Ltd, 10-16 Mercer Street, London WC2. Tel: 01-240 3648.

Rauch X900/ FET power amp

Having defined a requirement for a multipurpose power amp, Rauch have produced the *X900*, a 400 W + 400 W (into 4 Ω) design combining power MOSFET technology with maximum operational flexibility and rugged mechanical integrity.

Transformerless balanced inputs and multiple protection circuitry are notable features, as are the three, switched operational modes which allow: conventional stereo; linked (eg for ECO'd systems); and bridged mono. Inputs are *XLR* and the outputs via *XLR* or standard binding posts. Peak LED (1 dB below clip) indicators and 31-step indented gain controls are provided.

Rauch Precision Engineering, Monitor Systems Technology, Brook Farm, Fowlmere, Royston, Herts SG8 7SA. Tel: 076382 442.

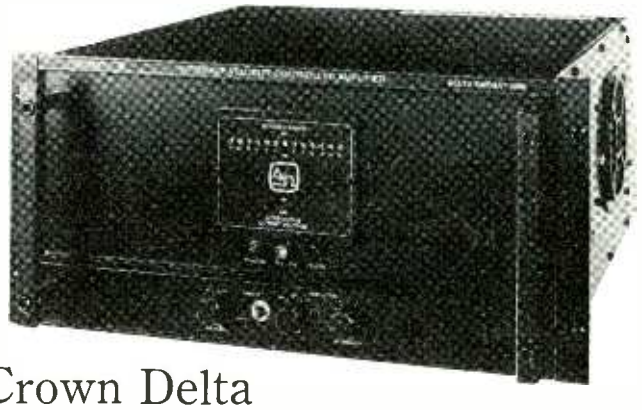
Studer monitor

The Studer *2706* is a 3-way studio monitor designed for rooms of between 70 and 180 m^3. The voice coil of the large bass driver is wound directly on to a light metal former to provide good heat dissipation and the hub geometry is arranged so as to maintain a constant magnetic field over its whole excursion range; this ensures high linearity up to the clipping point. Mid and treble are high power dome units with carefully defined dispersion patterns. Connectors are 4-way screw-banana types. Compact, it uses a braced hardwood enclosure covered with grey nextel.

Studer International AG, Althardstrasse 150, CH-8105 Regensdorf, Switzerland. Tel: 01 840.29.60. Telex: 584850.

UK: FWO Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts WD6 4RZ. Tel: 01-953 0091. Telex: 27502.

USA: Studer Revox America Inc, 1425 Elm Hill Pike, Nashville, TN 37210. Tel: (615) 254-5651.



Crown Delta Omega 2000— active control

New from Crown, the *Delta Omega 2000* power amplifier incorporates circuitry which enables it to monitor and correct for the behaviour of the speaker, its crossover and the cables involved. Unlike other such designs which rely on extra cable runs for the monitoring function, the *2000* incorporates 'a velocity-control system at the amp/speaker interface in which the speaker velocity informs the amp, while the amp controls the velocity'.

The correction circuit compares the waveform current of the voice coil output with the amp's input, adding in the required compensation to correct any non-linearities introduced by the load. It is said to be sensitive to both the reactive and resistive components of the speaker function.

Rated at 600 W into 8 Ω, the *Delta Omega 2000* has LEDs for 'instantaneous dynamic range' indication, and to show signal present, standby, power-on and 70.7 V (RMS) level. Input is to a 3-post screw terminal panel and the output to high current screw connectors. DC and LF (<10 Hz) protection and input delay (4 s) are optional and switched.

Crown International Inc, 1718 West Mishawaka Road, Elkhart, IN 46514, USA. Tel: (219) 294-5571.

UK: HHB Hire & Sales, Unit F, New Crescent Works, Nicoll Road, London NW10. Tel: 01-961 3295. Telex: 923393.□

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HHB Hire and Sales, Unit F, New Crescent Works, Nicoll Road, London NW10 9AX. Tel: 01-961 3295. Telex: 923393.

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Conference report

Richard Elen took part in the SPARS conference on digital audio which was held during March 9th to 11th at the University of Miami

The recent SPARS conference on digital audio had many of the same aims as the *Music Week*/APRS seminar held in London last year (*Studio Sound,* February 1984). Starting off the event with an evening session on the first day, Ken Pohlman (Director of the University of Miami Music Engineering Technology Programme) gave a rapid rundown of digital techniques, including Delta Modulation as well as PCM.

Friday's session began with a panel discussion: 'If it's so good, why is it so bad?' with Michael Tapes (Sound Workshop); Roger Nichols (Soundworks); Bruce Botnick (Digital Magnetics) and John Eargle (JBL and JME Associates). Michael Tapes proposed that today's digital audio was far from being the 'perfect' sound claimed by some marketing people and hi-fi magazines. There were differences in players and in recordings and often he had heard CDs which were, to him, unlistenable whereas the vinyl album was fine.

Bruce Botnick and Roger Nichols pointed out that very often, particularly with early CD releases, it was uncertain exactly what the CD source was. Often it was a copy master of uncertain generation EQ'd for analogue cutting.

John Eargle examined the added distortion caused by tape saturation and disc replay in the analogue domain and noted that these could often produce effects that sounded good. He also suggested that the 'classical' comments made by some (eg Professor Fellgett of Reading University, previously quoted by Michael Tapes in his introduction) about the discontinuity of the digital recording medium; the indefinite development possibilities of analogue; and the built-in limitations of the quality of any defined digital systems, were all inaccurate: with lowpass filtering (which all current recording systems incorporate, analogue or digital), a digital system *is* a continuous medium (the quantisation steps exist only in the digital storage domain, which we never experience), and that analogue had practical limits even if there were not theoretical ones.

Both Tapes and Eargle agreed that we all consider different aspects of the music recording as being important: we might notice the things we like or dislike about a digital recording, but it is important to look at which aspects we regard as important, as these will determine how we react to the overall effect of the system.

Speakers from the floor commented on whether or not the CD would be supplanted too soon, perhaps by laser-read cards, and that a repeat of the quad debacle might occur; and on the realiability of CD as a medium. Michael Tapes returned the minds of the audience to the fact that we were discussing digital audio in general, not just CD, but Nichols pointed out that the CD was relevant as it was the 'lowest common denominator' of digital audio. If there were no CDs, he would be less interested in the use of digital multitrack. Nichols finds that he had to do less work with digital audio in the studios—he needs to do less correction with digital to recover losses in the recording process. He also finds the digital machines easier to use, especially the fact that punchouts do not need a space . . . the machine crossfades between new and original material on drop-in or drop-out. Additionally, he finds a great advantage in being able to make *identical* safety copies and not being afraid of degrading the overall sound if they have to be used in an album.

Digital equipment must have the very best circuitry in all areas

John Eargle suggested that not all digital recorders have the best analogue circuitry—often the entire system is designed by a 'digital department' who may not have the best knowledge of analogue as well as digital. Digital equipment must have the very best circuitry in all areas.

The second session discussed the preparation of master tapes for CD manufacture, with Bob Ludwig (Masterdisk); Roger Nichols (Soundworks) and Bill Foster (Tape One). Of vital importance is the alignment of the equipment. Heads must be clean; normal studio practices must be followed to higher standards than usual. Many poor CDs are the result of poor masters or master preparation. In addition, care must be taken with timecode: it must be contiguous and not be drop-frame; it must not have any major crossovers (eg 99:59:59:. . . to 00:00:00:00) as these cause clicks. At least 1.5 min of digital silence with timecode must be laid at the front of the tape; you must also leave at least 30 s of digital silence at the end. If you mix to a different machine, you can add timecode for your own use, but remember that it may not be valid on the *1610,* whose code must be locked to the sample rate.

The timecode is laid on audio track 2 of the U-Matic tape. On track 1 is the PQ subcode. . . this is laid 1 min into the tape. The PQ subcode contains frame-accurate timecode values for such points as first valid timecode on tape; start of music, end of track; last valid timecode; etc. There may well be a cue offset for different CD manufacturers (Polygram recommend 5 frames lead-in to each title except the first on the disc, which should have 2 s lead-in). The panel recommended that *exact* cue timecode is put on the mastering sheet: the manufacturer can then add his own favourite fiddle-factor. Other codes, like title, UPC, names of tracks, etc, are included in the subcodes. On the mastering sheet are placed details of 'disturbing effects' (analogue dropouts, clicks, etc) to enable the manufacturer to check whether a sound is an error or actually known to be there.

All these items of data and times must be frame-accurate as the tape will be rejected by the factory otherwise. The codes placed on the disc are generated from this data, including index flag points which enable you to access different sections of a movement within a title.

The final seminar of the Friday, 'Digital for Dollars' concentrated on the economic aspects of digital audio for the recording studio. The panel consisted of Hamilton Brosius (Audiotechniques), Chris Stone (Record Plant), Joe Tarsia (Sigma Sound) and Murray Allen (Universal Studios, Chicago).

Chris Stone led off with his experiences of the 3M digital equipment in the early days (The Digital Business, *Studio Sound,* February 1984). Five years and one week after leasing that 3M system, he took delivery of a Sony *3324,* which is owned by his rental company. Rental is the solution to declining studio rates as clients will pay to rent new gear where they may not feel justified in paying increased studio rates.

Chris Stone has already found that his film clients (eg on *Star Trek 3* and *Digital Dream)* notice the difference of digital; there is a market there to be exploited: indeed, film people may skip the analogue multitrack stage and go straight to multitrack digital.

Modern equipment is a substantial investment, Stone notes, and leasing may be one of the few ways to handle the requirement. Studio owners will have to learn about leasing deals. The next question is how to get the money in: a Sony *3324* may cost $4,000 to $5,000 per month—where will that come from? The studio owner requires good financial sense. Stone has shown that digital makes sense under the right conditions.

Murray Allen decided, 3½ years ago in the recession, to increase his market share by leasing 3M digital equipment. He shopped around for money and found excellent possibilities for leasing. But how long would the machine last? When would it become obsolete? This needed to be considered. The digital move cost no more than 1.5% of the studio's total expenditure over five years, so an experiment was a viable possibility. Then they used an advertising campaign to plug the 'forgetfulness' of analogue tape as against digital. Studio rates for digital were raised—an extra $50/hr. They hit the ad agencies the same way, and did simultaneous mixes. Clients suggested useful applications for the 32-track, using the extra tracks over the normal 24 for extra vocals over the same music beds and rapidly built up the business. On tape, 10 commercials sessions can come out of a single reel of tape. These are rolled off to empty reels, and each client pays the studio minimum for tape—$200—plus they pay for the reel!

In addition, higher-level technicians are employed to look after the digital gear, and they have many other aptitudes—for example, they have built several useful items of equipment. It all adds up to a healthy profit ▷

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although there is only a small profit on the actual leasing.

Joe Tarsia did not feel that digital was viable in the early days. He still does not feel that owning the gear is viable, although he will rent a machine from time to time. Tarsia feels that Sigma Sound *will* enter the digital age in the future, but he has yet to work out exactly when would be best. He notes that only one of this year's Grammy award winners (The Police) was digital—and it was only digitally mixed. So for Sigma, it will be digital...but not yet.

Most studios are likely to want to purchase a 2-track digital recorder by 1985...and most major manufacturers will be announcing them. Mack Emerman notes that Criteria studios now have two Mitsubishi *X-80* 2-tracks; they have left 30 in/s ½ in machines idle and unused...the ½ in machines were definitely a bad investment. Now they are looking at digital multitrack, and they feel that this offers a noticeable quality improvement. But the question of money is there too. Will multitrack digital pay for itself as the stereo machines have?

John Eargle urged students at the seminar to learn about digital audio and understand it. New technologies have always been damned. But we have to have an eye on innovation, and an eye on the future.

The first session of the final day of the conference covered standardisation of digital audio, and Ken Pohlman introduced Curtis Chan (Sony), Tore Nordahl (DEC/Mitsubishi), Lance Korthals (dbx), Almon Clegg (Matsushita) and Richard Molstad (3M).

Pohlman led off by drawing attention to a 1978 *AES Journal* article, illustrating the diversity of systems at the time. Notable was the variety of sampling rates in use, as well as the large number of linear and non-linear encoding schemes. Today there are perhaps fewer systems, but there is still no such thing as inter-system compatibility, despite the agreement on sampling frequencies.

To begin, Curtis Chan discussed the DASH format. The DASH standard offers a wide range of speeds and track formats suitable for a variety of studio applications. LSI technology is being shared between the DASH manufacturers. In addition, the different versions within the DASH standard utilise many of the same circuit blocks. The DASH format includes several levels of error correction and concealment.

Lance Korthals presented factors offered by the dbx CPDM system as used in the *700* series digital audio processors. His primary point was that CD offers 90 dB while studio gear offered the same: surely it was better to have higher quality gear in the studio? CPDM has 110 dB dynamic range, which is roughly equivalent to 19 or so bits of PCM. The dbx system thus 'emulates' a PCM system that is beyond present standards. In addition it is cheap. Korthals believes that the market should decide on the standard to be adopted.

Tore Nordahl indicated that Mitsubishi felt that the DASH format was not strong enough, and that 24-track might not be sufficient for many studios. He agreed that the domestic standard was set, and that the present professional standards were good enough for today's applications. Several leading US studios have adopted the Mitsubishi multitrack, and there are a number of 32-track *X-800* machines around. Telefunken had also adopted the format and would be manufacturing in Europe. The Mitsubishi system, says Nordahl, is stronger than DASH with regard to error-correction. A complete track of data can be lost without affecting the replay, due to the use of parity tracks. Mitsubishi have examined the DASH format and feel that for example, if the DASH control data track is lost, the replay may be muted. Mitsubishi does not depend on a single control track and may thus be more resilient. Mitsubishi can utilise double-density formats for future 64-track recorders.

3M is redesigning its digital machines, says Richard Molstad, due to the original system failing to meet FCC RFI characteristics. The *DMS* system can be improved (it is 1970's technology as opposed to DASH) but this would be difficult without changing the format. Considering multitrack applications only, many factors have to be matched for tape-to-tape compatibility. Mechanics, error-correction, coding density, tape speed, track width and position, sampling rate, codec method (eg PCM/CPDM), etc, all have to be compatible. DASH does not include a 32-track, which 3M research indicates there is a preference for in the marketplace.

Although the 48 kHz sample rate standard is acceptable, the 44.1 kHz CD standard may be a problem—but we are stuck with it. Sixteen-bit converter quality will determine the major sound parameters of PCM systems. CPDM sounds good, but it is not possible to perform DSP within the CPDM domain. There are trade offs between bit storage density and hardware complexity and reliability; a number of code structures exist which each have their own strong and weak points.

Agreeing to standardise all these points is very difficult. DASH is sophisticated and thus expensive. But it will probably remain expensive and then become obsolete.

Almon Clegg dealt with the philosophy of standardisation. There are mandatory standards and informal, voluntary standards...digital audio is one of the latter. Economics is an important consideration, and may require compromise. De facto standardisation offers benefits in the area of sharing technology and thus R&D costs. Digital audio for the studio is not a large market, yet a great deal of highly expensive technology is involved. Voluntary standards help to make this development worth while. Also, reliability, interchangeability and maintenance methods are improved.

Disadvantages include the fact that some types of innovation are discouraged. Some levels of compromise are involved. Some parts of the market may not be served. The system may not remain state-of-the-art. Finally, the large manufacturer has an advantage over the small.

There is now a worldwide digital cassette standardisation committee, which is expected to decide after the end of 1984. Some units may be available in 1985. Would it be useful or not if the format was DASH-compatible?

Curtis Chan noted the differences between the DASH and *X-800* format claims regarding error correction. No specs have been published for the Mitsubishi and he challenges the Mitsubishi claim that it has superior error-correction to DASH, for a number of reasons.

Tore Nordahl claimed that analogue compatibility did not exist, for example between 24-track machines. There are sound differences and preferences. This will also be the case between say, a Sony and a Studer 24-track digital. Is there really an advantage in standardisation?

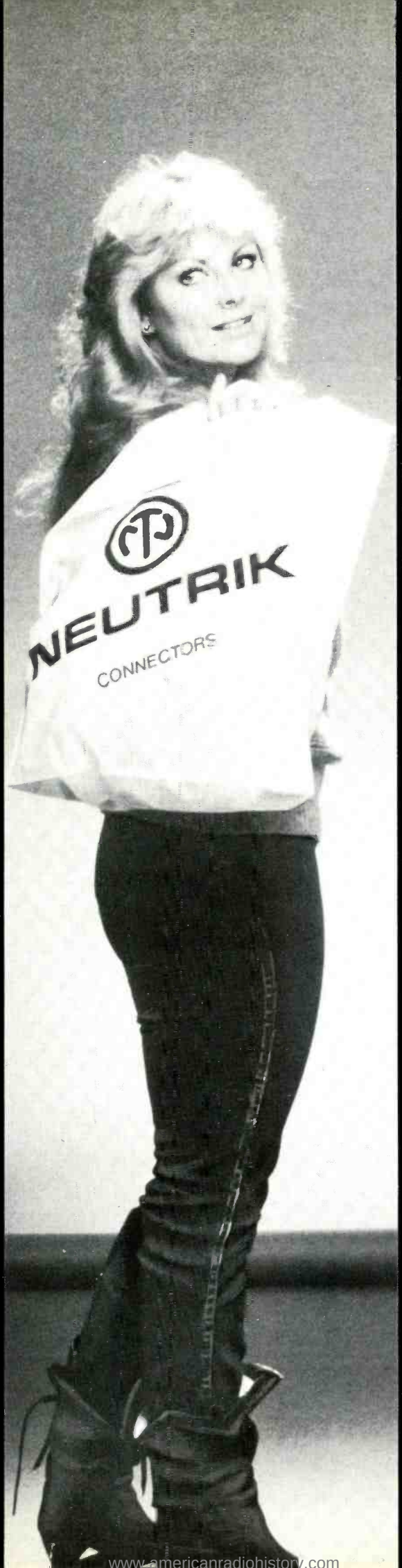
Richard Molstad pointed out that there was not the volume in the pro-audio market to allow prices to be realistic. Would it not be more sensible to use other storage techniques, eg magneto-optical disks, which will also be in use by the far greater-volume computer market, in a few years' time perhaps? Curtis Chan responded that expansion from the pro-audio field into the domestic audio field made the market large enough. Almon Clegg suggested that the domestic audio field might 'drive' the pro-audio market... and there was an average 7-year cycle in replacement of domestic products. Digital audio started about seven years ago, and might just be reaching the peak of a cycle.

Lance Korthals pointed out that despite the apparent lack of need for extra headroom between record, mix, and master in PCM, in the real world there was a great deal of level changing and engineers also allow for headroom. This would eat up dBs so that in practice, having the same dynamic range in the studio and in the domestic (CD) format, ie 16-bit PCM, was not enough. The dbx system gave you 20 dB to use for correction of level and for headroom.

The final session involved hi-fi writer Len Feldman, Chris Stone, and myself on topics including the possibilities and pitfalls involved in transferring analogue tapes to digital for CD; aspects of the public's view of the Compact Disc and its present and future market position; other possible entertainment formats of the present and future, including *Beta Hi-Fi* FM sound recording for home video and the *Audiofile* laser-read optical card format from Soundstream; and the issue of product labelling. On the latter topic, Chris Stone noted that Polygram had adopted the SPARS labelling code, although they were claiming it was their idea—despite which the move by Polygram was expected to be significant in terms of record company acceptance internationally. Stone also showed a copy of the cover artwork of a new album from the KPM music library which will be the first released album to use the SPARS coding format. Being recorded analogue multitrack, mixed to stereo digital and cut for vinyl release, the coding was 'ADA'.

The Conference ended with a general discussion in which Michael Tapes took an active part, ranging over diverse topics including how CD and vinyl discs compared today and what future developments held in terms of quality.□

AES '84



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Developments, addresses, people

btx & Harrison Systems agreement

Harrison Systems and the btx Corporation have announced the signing of an agreement between the companies covering the development of btx automation products for incorporation into the Harrison family of audio consoles. Under the agreement, Harrison will offer an in-console version of the btx *Softouch* in their consoles under the Harrison name. The *Softouch* will be specifically tailored for the requirements of the consoles providing assistance with timecode applications and synchronisation and control of multiple ATRs, VTRs and film transports enabling automation of the post production process. Harrison will be offering the unit with consoles for customers in multitrack music recording, radio and TV production and film post-production.

HH Electronics & HH Acoustics

As from March 21st, 1984 the assets and trade marks of Harrison Industrial Developments Ltd and HH Acoustics Ltd have been acquired by the Carlsboro Group of companies. HH Electronic and HH Acoustics will continue to be operated completely separately from the other companies within the group and the policies will be to further develop and improve HH products. HH will continue to be based at the same address in Bar Hill, Cambridge, UK, with most of the original staff to maintain continuity of sales and production.

Address changes

- Pilkington Fibre-optic Technologies has moved to new premises, two miles from their former location. The new premises are two and a half times the size and have further room for expansion. Pilkington Fibre-optic Technologies Ltd, Kinmel Park, Bodelwyddan, Rhyl, Clwyd LL18 5TY, UK. Tel: 0745 584500. Telex: 61148.
- Springtide Sounds, have moved from North London to new premises at Mezzanine Suite, 1 Central Buildings, Westminster, London SE1. Tel: 01-222 8841.
- The Digital Entertainment Corporation (DEC), the US affiliate of Mitsubishi Electric Corporation, who are responsible for Mitsubishi digital audio systems in the US, has opened its New York City sales office. Digital Entertainment Corporation, Suite 1530, 555 W 57 Street, New York, NY 10019. Tel: (212) 581-6100.
- Soundcraft Magnetics Ltd, the professional tape division of Soundcraft Electronics has moved to new premises in North London. This will give three times the manufacturing and development space. In the meantime sales and marketing will remain at the Great Sutton Street, EC1 premises.
- Stage Accompany moved to larger premises as from January 1, 1984. The new addresses are: Stage Accompany, Anodeweg 4, 1627 LJ Hoorn, The Netherlands. Tel: (0)2290-12542. Telex: 37989 STAGE NL.
Stage Accompany, Vennweg 5, 446 Nordhorn, West Germany. Tel: (0)5921-16196.

People

- George Sheehan has been appointed national sales manager/ dealer sales for Sony US professional audio products. Mr Sheehan has been with the Sony Corporation for 16 years and was most recently north east regional zone manager for Sony Communications.
- HHB have announced that Richard Kershaw has joined the company and his area of operation will be digital installations, digital editing sessions and general digital enquiries.
- Sifam Ltd have appointed the Hon Michael H C Perry to the position of managing director. For the previous year he held the position of deputy managing director.

Forthcoming events

- May 11 to 14
AES 2nd International Conference, Anaheim, USA
- June 13 to 15
APRS Exhibition, London, UK
- September 21 to 25
International Broadcasting Convention, Brighton, UK
- September 25 to 27
AES Convention, Melbourne, Australia
- October 8 to 10
AES 77th Convention, New York, USA
- November 29
Sound Broadcast Equipment Show, Birmingham, UK

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WIRED FOR SOUND

Cliff Richards' sound engineers discuss their system and their philosophy with Ralph Denyer

Twin Sounds & Productions was set up by Cliff Richard around two years ago. Up until that time he had always hired sound systems, but then decided to buy the system he had been using and put his key soundpersons, Colin Norfield and John 'JJ' James, in charge of its care and development. The system would also be hired out when Cliff wasn't using it himself.

Since then Twin Sounds have been drawing considerable favourable comment—from the not always magnanimous concert sound system industry amongst others—for achieving good, consistent results. They've only been fully operational for a year or so and during that time have demonstrated their abilities with Cliff, The Everly Brothers, U2, Elvis Costello and others. In April they commenced a two month tour with Bucks Fizz and July will see the culmination of their efforts when they extend Cliff's system for four nights of concerts with the boss at Wembley Arena.

Colin and JJ's association with Cliff started way back at the tail end of the '60s. Colin decided to give up trying to make a living playing bass with a group called Crew whom he describes as strictly 'small time'. They had used Orange equipment and when Colin saw a job going at the manufacturer's London shop, he applied and got it. This was back in the days when a good PA system consisted of a 100 W amplifier and a pair of 4 × 12 in column speakers. An outstanding system might have an extra two columns and an extra 100 W slave amp. Colin would go out on the road looking after PA equipment on hire and eventually got a shot at mixing, something he'd always had a fascination for.

Colin: "I felt I had a feel for mixing and I always wanted to have a crack at it, which I got in about 1974."

At the same time, Cliff and the Shadows were hiring sound systems from Orange. Colin started going out as part of Cliff's sound crew and eventually became Cliff's exclusive out front man. When Orange started to back out of the hiring business, Colin took Cliff to Brian Hatt's Complex Sounds company and remained with him.

JJ had played guitar in a semi-pro band and had also worked for the Post Office in telecommunications research. When he saw a job going at Orange for a repair man, he saw it as an opportunity to do work which combined his two main interests, music and things electric.

JJ eventually became technical manager of the Orange factory and stayed with them until their demise in the late '70s. But he was still involved with the technical side and development of Cliff's system. When Orange finally folded in '79, he went out on the road for Complex Sounds and essentially, as well as working with many other acts, he and Colin have worked as a team looking after Cliff's sound since that time wherever he appears in the world. They use Cliff's own system in Europe and hire in countries where air freight costs make its use impractical.

Complex Sounds basically developed two systems, one for Cliff working with his own band and the other for the Shadows who by then worked mainly as a separate entity, occasionally joining forces with Cliff for special concerts. It was in 1982 that Cliff decided to go the whole hog and have his own sound system that would be hired out to other acts when he wasn't using it. He bought about half of the sound system he'd been hiring from Brian Hatt's Complex Sounds and put Colin and JJ on the permanent payroll of the new company, Twin Sounds & Productions Limited. Then Colin and JJ went to work expanding and developing it further. This left Hatt with the system he'd developed and built up primarily for and around the Shadows.

Colin and JJ spent around three months planning, designing, adding and interfacing the system and TSP have now been fully operational for just over a year.

Investment

Though the set up ensures that Cliff has a quality sound system and a good team to operate and look after it, other considerations were involved in his (and his management's) decision to buy his own.

JJ: "The company has to stand on its own feet and make money. It's not a benevolent organisation. We can't just waste money."

He regards the discipline of running a financially viable concern as being beneficial as it "keeps us under control". Hard working as Cliff is, he doesn't do enough work solely in Europe to make the company viable unless the system is hired out when he's not using it. But Colin and JJ feel that other non-financial factors are of equal importance.

JJ: "I think that a lot of it was that they wanted to give Colin and I a bit of security. They didn't want to lose us. We're getting older and we're both married with kids."

Colin continued "They've got a philosophy of: where something works, keep it. Don't keep fooling around.

"It's like one big happy family when we go on tour. Even when we're not on tour, we'll have a social evening with Cliff. Go out somewhere and have a curry and a get together if we haven't seen each other for six months."

JJ: "I think that feeling helps the results that are produced. Because everyone's got respect for everyone else. That's an approach we use with other people apart from Cliff. We always try to identify with and, get on with the musicians. It's not like *them* and *us*."

They know only too well how a lack of communication can result in a state-of-war type of atmosphere when people focus all their attention on their individual contributions, forgetting the overall show.

JJ: "We try to really communicate with the musicians and work together with them to get a good gig. That's basically what it's all about. We produce the results between us."

In essence, Cliff uses a dual system. The questionable validity of sound system power

ratings withstanding, the band's stereo system can deliver something in the region of 10 kW, while Cliff's stereo vocal system can deliver something of the order of 5 kW.

JJ: "When Cliff started the company, that was the main investment, building this separate vocal system from scratch."

Colin: "It's for the headroom really. What normally happens on a gig is you get a good sound for the band. Everything sounds really nice and then you have to bring all the instruments back down in level to get the vocal over the top. With Cliff's system, there is a separate 5 k just for vocal."

Though the band is excluded from the vocal system, Cliff's vocal does go through the band's system to a certain extent.

JJ: "So if you look at it as a 4-way system, the vocals are in all four bands of the band's system and the top three bands are duplicated on the vocal system.

"I think that partly contributes to the cleanness as well, because a transducer is going to perform better if it's just got a vocal to handle, it's going to cope with it more efficiently and better than it would the total programme. That's it really. I think that contributes to why it is notably a good clean vocal sound."

Though they feel the system 'triumphed again' on the Everly Brothers reunion concert at the Albert Hall, Colin and JJ are anxious to ensure that the rig isn't thought of as only being suitable for acts consisting just of vocals and a backing band. They also feel that is an outmoded concept as far as Cliff is concerned, anyway. When they did the London Apollo with the boss last year, they managed to pick up some work on subsequent concerts there. One, which really put the equipment through its paces, was CND's 'The Big One', a charity concert with many bands on the bill including Elvis Costello and U2.

JJ: "It wasn't the kind of gig we would have tried for because—to be quite honest—I wouldn't have been sure that we could handle it. We thought, 'Oh dear, we're going to struggle a bit with this' but the split system coped with it very well. U2 brought their own out front man and I think he was quite impressed. So don't write it off as, 'Oh, this is just a middle-of-the-road type of system'."

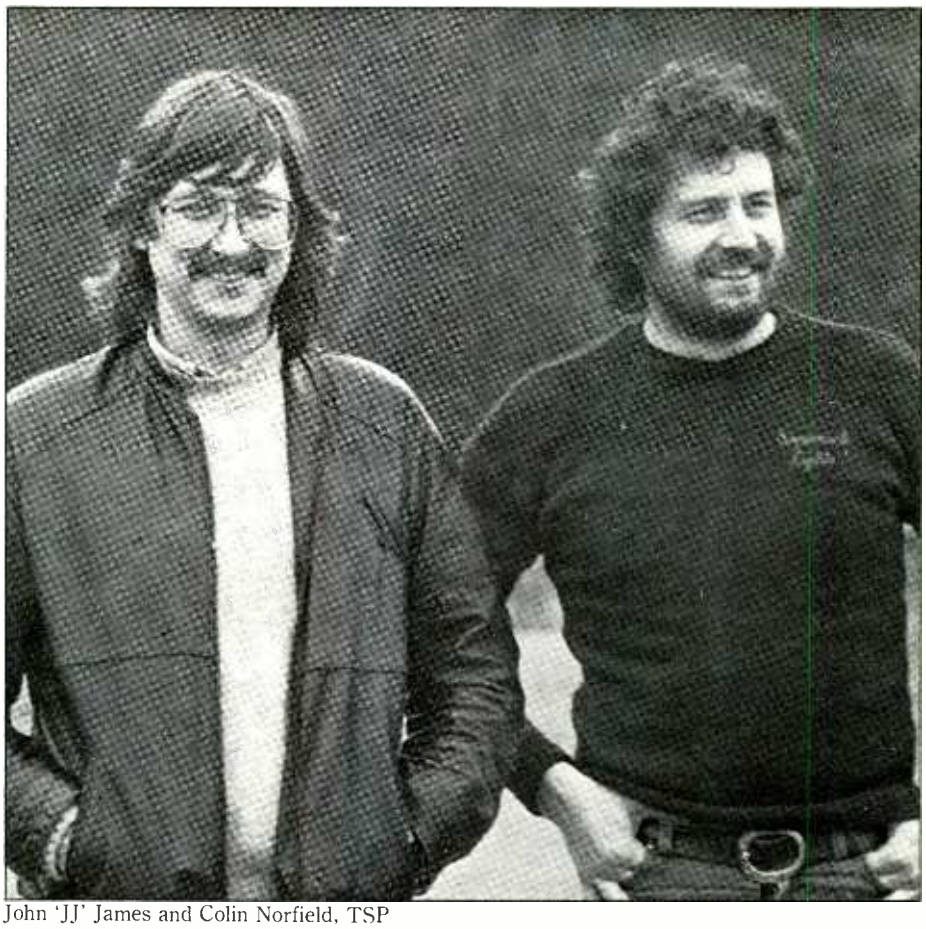
The system

Cliff's vocal mix goes from the Soundcraft *Series 800 B* mixing console through its own Roland 2 × 15 graphic equaliser to a 3-way crossover built by JJ. There are then four Hill Audio *DX 501* amplifiers powering six ASS Tony Rossell-designed combination cabinets on each side of the stage. Each cabinet houses two 10 in Electro-Voice speakers, one above the other. Directly above them is a JBL *2425* horn with a JBL *2370* flare on each side of which is a Beymer *CT 20* tweeter operating on its own passive crossover at 8 kHz. Colin and JJ did a lot of development experimentation with the dual system around 1980-81.

Colin and JJ find the ASS cabinets, which were designed by Rossell to their own specification, to be practical in that they are compact and can be handled easily by two people. There are no bass bins on the vocal system, which starts to roll off from 200 Hz at 12 dB/octave.

JJ: "In theory, one would think that 200 cycles is a little bit high but in practice it seems to work."

Accepting that the speaker array stacking varies from venue to venue, they simply mix the speakers from both systems, using the basic principle of "pointing a bit of everything at everyone" and as JJ says, "using a bit of common sense". The fact that the vocal system cabinets cover all frequencies



Photograph: Ralph Denyer

John 'JJ' James and Colin Norfield, TSP

simplifies setting up.

The equipment is designed to be versatile when being hired out. For example, if a smaller system is required but trucking space is limited, crossover facilities are available to allow a bottom end system to be added to the vocal system. In the other direction, they supplement Cliff's complete system for the very big venues as they will be doing for his Wembley dates in July.

The band system mix goes from the console through a Lindsay *RPA 27* graphic equaliser to a 4-way crossover. Then for each side of the stage there are: Hill Audio amps powering eight RCA 1 × 15 in bass bins, six Electro-Voice 1 × 15 in low-mid-range units, four mid-range units housing four JBL *2482* horns, three on JBL *2350* flares and the other on a JBL *2355* flare, and four high-frequency units each housing two JBL *2402* horns.

JJ made some slight modifications to the earlier Hill amplifiers but only to make them more able to stand up to the knocks and bangs expected on the road.

"There are a couple of capacitor changes but nothing that affects the sound or principle. We find the new *DX* range much better and they don't need any modifications. The *DX*'s are nice amps that haven't given us any problems. Eventually we may change all the others over to the *DX* range."

The monitor system consists of a 26-input 10-output channel console, with Hill and Crown power amps driving a selection of Electro-Voice, JBL, Gauss and ATC speakers and horns. The mixing console was custom built by JJ specifically to cater for their needs which makes it easier and more convenient to use than to adapt a standard.

There are quite a lot of DI keyboards with Cliff, none of which go through amplifiers on stage. With Cliff's musicians—and with other bands when agreeable—JJ always encourages sending the sound of the keyboards on stage through the monitor system. He knows a lot of musicians won't go for this at any price but always tries gentle persuasion. He particularly likes keyboards' on-stage levels under his control because of the blanket effect they can have on the overall sound, covering a wide frequency range.

JJ: "It helps Colin to achieve a better sound out front. When we do sound for other people, I try to get as much under our control as possible but some people might resent that and might not want it. It's very easy for a battle to develop on stage. Someone wants something louder, then someone else needs something else louder.

"My approach to monitoring is: you don't get anything other than yourself through your monitor until you ask for it. You can try to give everyone their own mix but then things can escalate. In the end—although you might make the people on stage happier—you spoil the show, which is crazy."

JJ is not in any doubt whatsoever that gaining the trust of the musicians in order to maintain sensible overall control of the sound levels on stage is of paramount importance.

JJ: "But to be able to do that, you have to be able to get on with people at the right level. So, as I say, you can't get into the *them against us* thing because they won't respect you. They won't take any notice of what you ask them to do and it all gets out of hand. So it takes a bit of psychology as to how you approach the musos. Not that I haven't made mistakes. But the only way to get it right is to get that: 'We're all working together for the show out front'. It all comes back to the whole thing about being a team. And I think that's what Cliff has really grasped. The team aspect is important, right through with everyone."

Colin and JJ don't try to take credit for introducing innovative features. Half the time they don't seem to quite understand why anyone could have a great deal of interest in their *modus operandi* because they feel they are just doing the obvious, albeit with considerable care and attention. Also they are not averse to utilising someone else's idea and developing it to suit Cliff's show. In spite of

WIRED FOR SOUND

the available technology in sound reproduction, backing singers frequently achieve the nearest to an acceptable sound level to pitch to by means of a decidedly low technology finger in the ear. Alternatively JJ says you can ensure the happiness of backing singers by giving them exactly what they need through on stage monitors. All you need to do is work out a cue sheet about a mile long, devote all your attention to it, and let the rest of the show go to pot.

The seed of the idea for the solution to that problem was sown when Colin and JJ saw the backing singers at a Pink Floyd concert using headphones from the monitor desk. JJ got the soldering iron out and devised a system for Cliff's three singers whereby they have a small control box on a mic stand with a simple set of knobs so that each singer can set the four vocal levels they receive, how and when it suits them. Because the on-stage sound levels are controlled, Sony *Walkman*-type headphones have proved quite effective.

JJ: "I think everyone agrees that has helped them to sing better in the live situation. No matter how good a backing singer you are a live situation is difficult to handle, with the drum kit and bass roaring away. That's a little system we take wherever we go in the world now, in a brief case sized flight case.

Teamwork

Colin and JJ are definitely a team. JJ accepts that Colin is a better musician than he and is therefore usually better at musical decisions. Conversely, Colin recognises JJ's superior knowledge and judgement on the technical side of equipment performance.

In conversation, it becomes clear that rationale is the keystone of their approach. They are very aware of the trap of becoming too absorbed solely in their own aspect of a gig. Fundamentally, they recognise the fact that their contribution is only one element of the overall presentation. They don't believe that concentration on technical excellence should override a general awareness.

Yes, they do have an AMS digital delay, an Eventide *Harmonizer* and other similar devices but they don't fall into the trap of becoming so entranced with it all that they forget all about the people on the stage. JJ feels that experience, maturity and motivation are all factors in achieving good quality sound. He mentions attention to detail as also being important.

JJ: "I'm not decrying other people but perhaps because we're a bit older, we're stuck with this as a career now and we're not steaming about the country, out on tour making prats of ourselves. I'm not saying that we don't have a laugh, because we do. But perhaps we take the gig and the work side a little more seriously than some."

Colin cites a disciplined soundcheck as being one of the major factors in achieving a good concert sound: "You don't need an hour or an hour-and-a-half soundcheck. You need a band that is disciplined—Cliff's band is—just to slap through it. I know it's boring to do it every day but that's what it needs. It's no good going in there in the afternoon and just messing about or the show will be all over the place. Get in there, do it right, and when the show goes on, it's all there."

Mention of the acoustics altering the sound balance when the audience are in the hall drew a certain amount of scepticism from both Colin and JJ.

Colin: "I don't really believe in that too much."

JJ: "Great excuse if you mess up though, isn't it? A lot of the reflections die down a bit but the actual character of the sound doesn't alter too much."

Though a standard piece of equipment for most concert sound engineers, Colin doesn't carry a spectrum analyser.

Colin: "It's one of those things that everybody's got and some people sit there all night reading away. It's something else for them to look at and take their attention off what they really should be doing."

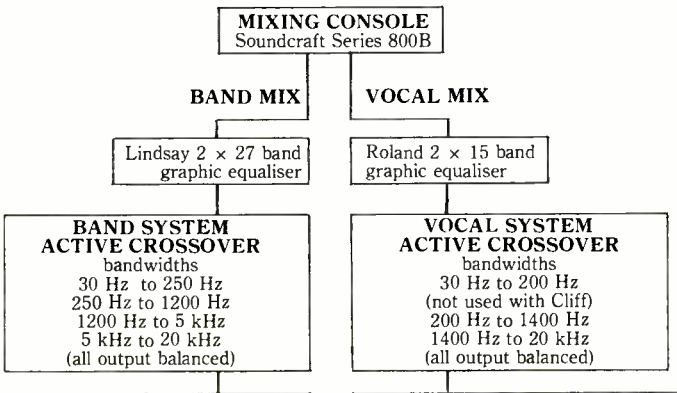
JJ: "It's great to use as a shortcut to achieve an initial move but not to set up and take as gospel. You've got to listen to the music and work on it."

Colin feels the same way about the amount of horns they use, in that just because something is common practice, doesn't mean you should accept it blindly, especially if your ears tell you not to: "Most people would probably think we're under-horned. We've got eight *2482*s (on the band system) and that's it, four a side. That's not a lot compared to many people. But there again we have been told by friends in other sound companies that we have a very smooth system. Seven or eight times out of 10, I can probably take our horn levels down on the crossover because for me, they're just too much. So why have any more?"

As far as on-stage miking is concerned, the mic selection is dominated by Electro-Voice and the chosen miking techniques are fairly standard. Cliff uses Nady radio mics for mobility. The drum kit overheads are worth a mention because they use Electro-Voice *DS 35*s which, Colin says, "goes against the book because they are tight vocal mics".

But they don't use them as overheads in the strict sense, for ambience, because they are really close on the cymbals and don't pick up any significant snare or toms, they say, cleaning the sound up more than anything else. □

SCHEMATIC DIAGRAM OF ONE SIDE OF TWIN SOUNDS & PRODUCTIONS' SPLIT CONCERT SOUND SYSTEM



BAND SYSTEM PER SIDE

Bass
Four Hill Audio 602 amplifiers driving eight RCA 1 × 15 in bins

Low-Mid
Three Hill Audio 602 amplifiers driving six Electro-Voice 1 × 15 in bins

Mid
Two Hill Audio 208 amplifiers driving four JBL 2482 horns, three on JBL 2350 horns and one on JBL 2355 in individual units.

HF
One Hill Audio 208 amplifier driving eight JBL 2402 horns paired in four units.

VOCAL SYSTEM PER SIDE
Four Hill Audio DX 501 Series amplifiers
Six ASS combined frequency units each housing two 10 in Electro-Voice speakers, one JBL 2425 horn on JBL 2370 flare and one Beymer CT 20 tweeter with passive crossover at 8 kHz.

Monitor system consists of custom 26-in 10-out console with Crown and Hill amplifiers powering JBL, Electro-Voice, ATC and Gauss.

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One AMS digital delay
One Lexicon Prime Time
One Eventide H910 Harmonizer
One Roland 555 chorus echo
One Roland 27-band graphic equaliser
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One Crown D60 amp (for cans FOH)
One Alpage varispeed AL300 cassette machine

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FRANKFURT '84

KEYBOARDS AND COMPUTER MUSIC

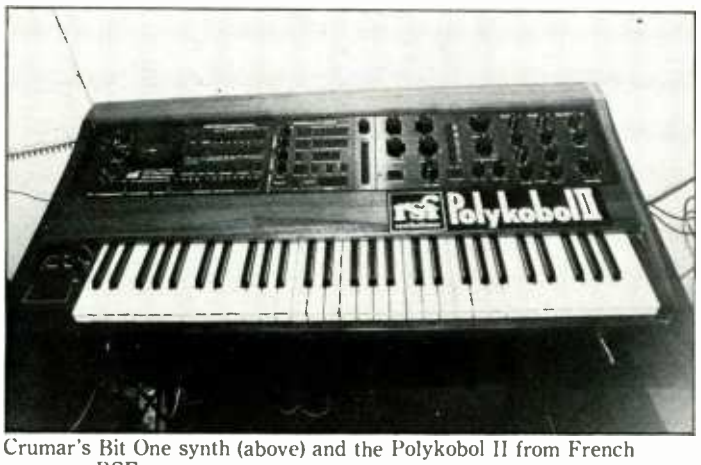
Mike Beecher continues his report on the electronic instruments which were featured very strongly at the Frankfurt Music Fair

Korg's *Poly 800* synthesiser is a logical step from the *Poly 61*, as it displays all voice setting parameters, not just those dialled up. It's an 8-voice MIDI instrument able to send and receive note (no velocity) and joystick data, program changes (not parameters), and sequencer control signals (this will be useful for MIDI drum machines). Sixty four sound programs can be stored on cassette and the sequencer makes up to 256 polyphonic events, with cassette dump as well. Korg's four usual function joystick is included and DCOs can be assigned for one DCO/8-voice or two DCO/4-voice operation. With stereo chorus, detune, harmonic pitch selection, 6-stage digital EGs and noise generator, this is a big improvement over the *Poly 61*.

Korg also showed a shoulder-strap keyboard instrument prototype, new tuners and the compact *Super Section PSS-50* for programming drum, bass and ensemble backings.

The French RSF company have sold a lot of 19 in rack synth modules to studios in the past and now have their long-awaited polysynth, the *Polykobol II*. It's a large scale 8-voice digital polyphonic synth with pressure and touch sensitive 5-octave keyboard, analogue-style controls and good visual indication through the use of 2-colour LED switch banks. A miniature cassette system is included on the panel for storing 768 sound programs in 16×48 groups and can also save a long 10,000 note polyphonic sequence (in 64 K) holding pitch, modulation, dynamics and program changes as well. For some reason, possibly due to the development time, there's no MIDI control as yet, although stereo outs, sequence clock, filter/VCA external control and microbus communication is provided. The system is based on three *6809* 8-bit processors. As a result, the strength of the *Polykobol II* lies in its sophisticated modulation control, with probably more assignations than you'll ever need that embrace key velocity, dual wheel controllers, arpeggiator, keysplit and a new waveform generation technique.

Possibly of interest is Crumar's new 6-voice programmable polysynth due to its MIDI compatibility. The *Bit One* synth, as it's called, gives Crumar's line a new look, with its multifunction controls that, although few in number, offer full access to the digital synth parameters, including two DCOs, two LFOs, VCF, VCA, plus 64 program memory, tape interface and MIDI.



Crumar's Bit One synth (above) and the Polykobol II from French company RSF

If you cater for organists in your studio, Wersi's new organ kit range can extend your MIDI instruments into the 2-manuals and pedals domain through their MIDI-equipped *Alpha*, *Delta* and *Condor* digital 'organs'. They have the potential of full sound programming through RS232 and individual upper/lower manuals and pedals note recording and playback through MIDI. They have also developed the first 'kit' MIDI keyboard controller with full dynamic control encoding over some 75 dB.

And it's worth noting that Yamaha also put MIDI on their *FX series* organs too, although no-one appears to have got round to using it.

Without properly testing the new products from a surprise entry to the music market—Akai—it's too early to determine their potential use at professional level. However, they have an interesting concept called the *Micro Studio System*, based on a 12-channel multitrack recorder/mixer. This uses a new ½ in cassette tape to capture 12 tracks more efficiently than the standard 1 in format.

A *MS16 Music Processor* adds an easy method of manual note/sound ouput for making a polyphonic 10,000-note composition (in *MicroComposer* style). It can also be linked to MIDI instruments to be a general programming tool like Roland's *MSQ-700*. Two rack-mounted units, the *Rhythm Oscillator Bank MR10*, contains 12 MIDI-controlled percussion sounds, and the *MS404*, a useful analogue to MIDI convertor add to the system. But Akai's 'new technology look' 8-voice MIDI polyphonic synth *AX80* attracted a lot of attention. Containing 32 presets with 64 sounds, full fluorescent display of parameters, dynamic touch keys, and new function 'Next Key' for instant modification of sounds, it makes a worthy entry into music synthesis for Akai. However, in the rather noisy environment of the exhibition, the *AX80* did not appear to offer any improvements in synthesis.

The CBS Rhodes *Polaris* synth's production schedules did not allow it to be ready for Frankfurt, but it will be worth keeping an eye out for, as it has MIDI, sequencing and soundmaking on the lines of the *Chroma*, with micro software extended to *Apple II(c)*, IBM *PC* and Commodore *64*.

You've probably guessed we've left the most innovative entry of Yamaha into their 'Year of the Computer Instruments' until last! Having been on sale in Japan for some time, it was good to see Yamaha's own computer, the *CX-5*, on show.

From the micro point of view, it's destined to be the first true *'MSX'* machine to enter the UK. In a nutshell, that means it follows a specification drawn up by several Japanese and American companies that will enable easy interchange of software. *MSX* is a mnemonic for *MicroSoft eXtended Basic* that offers great programming scope and, although there have been criticisms of the specification's standard graphics, sound chips and *Z80* 8-bit restrictions, there could be more ▷

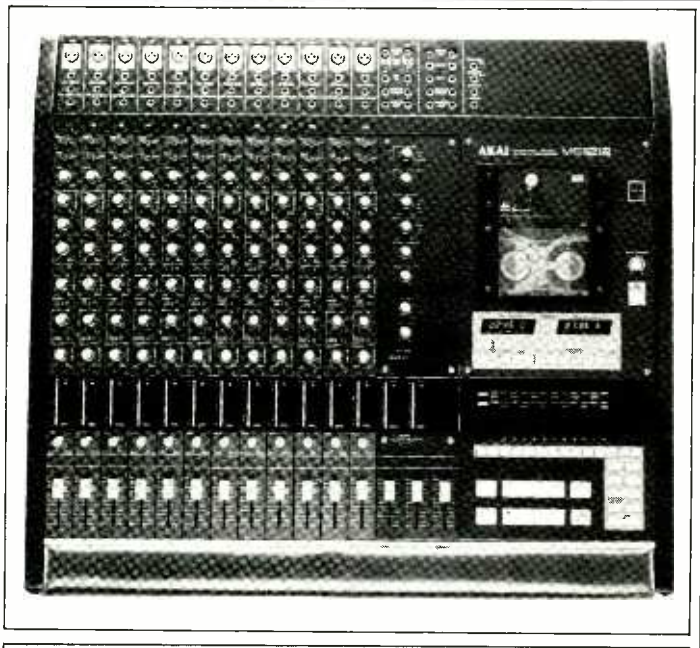
software for *MSX* micros than any other. Other *MSX* micros already in Japan are the Sony *Hit Bit HB-55* and the Sanyo *Wavy 10 MPC-10*, and Japanese music mass feature Basic programs to play music from them.

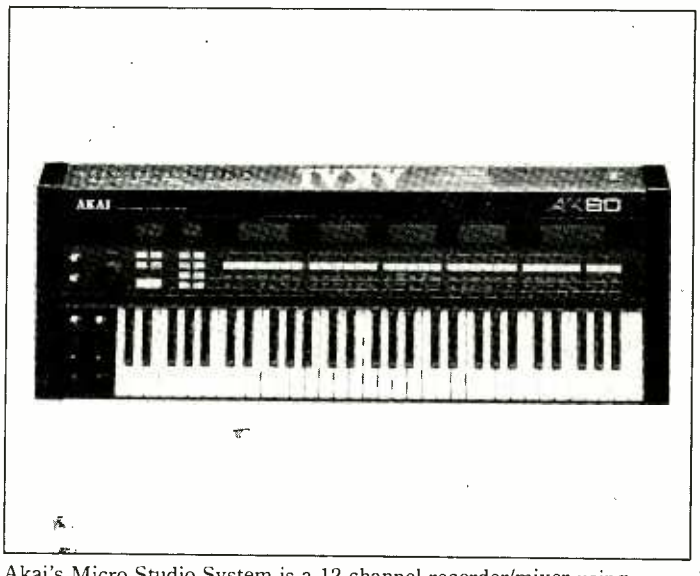
What is astounding, is that for the price of £550-600 in the UK, you'll be able to buy a Yamaha *CX-5* micro, complete with 8-note poly FM synth module *(SFG-01)* similar to a *DX-9*, and add-on 3½-octave F to C keyboard *(YK-01)* that both plug directly into the left side of the micro.

The single command 'Call music' transforms the *CX-5* into a professional synthesiser and Yamaha have developed their own LSI to more than meet the *MSX* sound chip standard. This *YN-2149* device gives 8-octave, 3-note voicing plus rhythm accompaniment and an optional magnetic strip reader will produce complete music from Yamaha's *Playcard* system for family musicmaking and utilising excellent screen graphics like a 'playing' keyboard. Although the on-board sequencer does not have external sync, it still puts the BBC and Commodore sound chips way out of its class.

But for serious musos, it's the FM module that's the serious proposition. If you don't care too much for the *YK-01*'s smaller keys, you simply plug in any MIDI controller instead. There are already several software programs available on cartridges for full screen editing of the FM module, the *DX-9* or the *DX-7*, as well as versatile manual/real time composing software (using music staves that can be printed out). Full use of traditional dynamics, repeat and expression marks make the software 'musician-friendly'. The *CX-5* has 32 K ROM for system control and 48 K RAM memory that includes 4 K for its own use, a big 16 K just for making complex graphics and animation (32 sprites in three sizes that can move behind each other to help considerably in on-screen music score display), leaving 28 K for your Basic language programs. Although that's nearer the BBC *B*'s 25 K than the Commodore's 38 K user memory, the *MSX* Basic greatly increases the ways in which you can use the available memory. Even the cursor 'pad' could be a joystick music performance controller! A disk drive operating system known as *MSX DOS* will eventually extend the current use of cassette and cartridge software programs.

Coming back to the music, eight tracks of music (and percussion) can be created with just one FM card with a different sound on each track through some clever multiplexing by Yamaha's large team of Japanese programmers. The *SFG-01* module does in fact use four operators and eight algorithms as on the *DX-9* and the basic set-up with the module inserted gives 48 FM preset voices, auto rhythm/bass/chords, record/playback of sequences, cassette save, keysplit (including poly/mono assign), LFO pitch and amplitude modulation, portamento and MIDI out.





Akai's Micro Studio System is a 12-channel recorder/mixer using ½ in cassette tape and (below) their AX80, an 8-voice MIDI polyphonic synth, attracted a lot of attention

Yamaha's *QX-1 Digital Music Programmer* is virtually a dedicated 'microcomposer' that could be the centre of a complete MIDI studio system. Its alphanumeric keyboard also has music symbols as extra functions and enables the creation of 'perfect' compositions in manual or real time (using a MIDI keyboard) up to a mammoth 80,000 notes (close to an LP's worth at 30 to 40 min without pressure) that is automatically stored with an 'intelligent' 5 in disk unit built in to the *QX-1*. It records in eight tracks of limitless polyphony and will store all the attributes of a MIDI instrument including the *DX-7*, organising your music into eight chains of 32 banks. Bounce-down between tracks, output channel assign, MIDI channel selection, full editing and transposition of individual parts is easily done from its integrated 20×40 LCD display. MIDI in, thru and eight out sockets, tape sync in/out, metronome out and footswitch are included.

If you're wondering how to make use of eight MIDI outputs, then the answer lies in the *T8PR* 19 in rack FM module system. The combination of this with the *QX-1* must be a dream come true for many musicians as the *T8PR* can hold eight FM voice cards that have the identical soundmaking qualities of a *DX-7*, with six operators and 32-voice memories, plus a master module that enables one *DX-7* to play another eight *DX*'s as well! Each module can be reprogrammed from a *DX-7* or *CX-5* and separate playing of each can be done through a MIDI keyboard, computer link or the *QX-1*. Each FM card has its own memory protect switch, output volume level, MIDI in/thru and mono line out, while the master card has in, thru and out to channels 1-8.

Making use of the *DX-7* sounds is the new *KX-5* shoulder-strung remote MIDI keyboard that is hoped to be an ideal low cost stage performance instrument. Of course, the price will be high, in the order of thousands.

I'd almost given up hope that Yamaha would bring out a drum machine, but with UK demo expert Dave Bristow showing that *DX*'s could make phenomenal percussion—even kettle drums, tubular bells, gongs and anything that's vaguely wooden or metallic, they've surprisingly taken the plunge not with FM but with two digital PCM 8-bit rhythm machines, the *RX11* and the *RX15*. Still, PCM has been well proven by Yamaha and Technics and it's hard to tell the difference between PCM and sampled sound these days.

The bigger machine is the *RX11* (at around £750) and has 16 percussive sounds (12 simultaneously), with variable accent level programmable into 100 rhythm patterns for use in 10 songs of 255 'bars' per song (around 2,000 events in all). A RAM cartridge saves complete sets of rhythm programs. Real time or manual input can be used to enter the required rhythm patterns, with selectable panning and 'swing' features, alphanumeric LCD and dual LED displays, plus tape in/out (sync in/out), MIDI, foot start/stop, 10 instrument outs, stereo out and phones.

The *RX15* (£600) has 13 sounds, 1500 events total, no LED display, independent outputs or cartridge slot, but it's otherwise the same.

The production of the final *DX-1* (from last year's 'prototype') is now complete, and it represents Yamaha's state-of-the-art FM system instrument. It's not just two *DX-7*s in one because it employs full studio/stage performance memory, 3-way output, comprehensive panel display and 6-octave weighted wooden keyboard that not only has velocity and pressure (after touch) sensitivity, but enables the latter to be different for every individual note.

We'll be highlighting a lot of these products in the coming months and would welcome user comment from studios too. There's no doubt a whole new dimension will be added by making use of MIDI in the next year, so we'll keep you informed of packages as they become available.□

Within the UK, for general information on MIDI you can contact Electromusic Research on 03744 67221.

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ELECTRO-ACOUSTIC REVERBERATION ENHANCEMENT SYSTEMS

Artificial enhancement of acoustics is not a new factor in auditoria or recording studio design although recently there has been a considerable reawakening of interest in such systems. Peter Barnett of Acoustic Management Systems is a consultant with a considerable interest in such systems and in this article gives a brief history with current applications and developments.

Considerable interest has been generated on the subject of variable acoustics probably due to the proliferation of multipurpose auditoria over the past 10 years, which if they are to be truly multi-purpose must by definition also be multi-acoustic.

The subject would fill a respectable size book and as such cannot be adequately served in a single short article, inevitably some aspects will get left out and most will be treated with indecent haste; and because of the emotive nature, and obvious commercial potential of the concept, some degree of criticism and disagreement is a foregone conclusion. Therefore to allay any possibility of being misunderstood, I would like to state that I do not consider reverberation as being the only significant parameter associated with auditoria acoustics or our listening experience. The density, magnitude and time of arrival of reflections is equally important, so too is the shape of the decay curve. Reverberation time is however readily measured and as such can be, albeit with a little difficulty, directly correlated to our subjective listening experience.

The systems discussed are primarily concerned with lengthening the reverberation time of multipurpose auditoria, but since they act upon the existing acoustic field and hopefully modify it, they must also affect and influence other associated parameters.

The crux of the matter is, when considering the subjective effect and objective measurements, is by how much does the said 'reverberation' enhancement system cause the acoustics to change and are such changes consistent with our expectation?

The deliberate act of attempting to increase the reverberation time of performing arts spaces is apparently not new. The Greeks and Romans are reported to have used earthenware pots ('eheria') of many different sizes and hence tonal properties to provide a degree of resonance in amphitheatres. The same type of approach has been observed from studies of Byzantine architecture where metal vases ('golaniki') were set into the walls and domes of temples. Stretched strings in the roof spaces of churches have also been reported.

I personally doubt the effectiveness of such systems since although these resonant systems are capable of storing energy and releasing it over an extended time period, the damping losses, impedance mismatch and energy conversion from wide to narrow frequency band content, imply a very low level of re-radiated sound such that the subjective effect of the apparently increased reverberation time would be insignificant. Also due to the action of compressing the frequency content of the input energy, a vase (Helmholz resonator) will at most frequencies absorb sound, and would therefore maybe reduce the reverberation time; although what the implications of this under free field conditions are, I am not sure.

The last 50 years have seen numerous attempts using electro-systems to increase reverberation time, I think it would be fair to say that most did not meet the expectation of either the recipient or even the designer, but that is not to say that all were outright failures; any limitations were probably as a result of inadequate technology. In any case such attempts are a tribute to and demonstration of a definite need, consultants and performers would clearly rather not suffer the inadequacies of the inevitable compromise that would result.

Taken at face value it may seem a simple matter using a microphone, reverberation means, amplifier and loudspeaker to produce the desired effect; in fact the converse is true if the added reverberation is to be subjectively acceptable, and most importantly without undue colouration. The acceptability of the quality of the reverberation is not a function of the excellence or intrinsic nature of the reverberation unit; a considerable number of first class machines are currently used in studios and the recording industry, but they have the advantage that there is no feedback problem to contend with. It is the interaction and transfer function between the microphone and loudspeakers that causes most of the problems.

TABLE 1

Type of presentation	Ideal reverberation time at 500 Hz
Cinema	1.0 s
Pop music	1.0 s
Speech	1.0-1.2 s
Drama	1.0-1.4 s
Comic opera	1.2-1.4 s
Baroque opera	1.2-1.4 s
Grand opera	1.4-1.6 s
Symphonic (Baroque period)	1.2-1.5 s
Symphonic (Classical period)	1.5-1.8 s
Symphonic (Romantic period)	1.8-2.5 s

Electro-acoustics versus architecture

On the assumption that the economic climate of the present and of the future prohibits the wholesale construction of multi-unit single purpose performing arts spaces; for example the South Bank complex in London comprising Royal Festival Hall, Queen Elizabeth Hall, Purcell Room and National Theatre; the trend will inevitably be towards the provincial multipurpose hall. Thus invoking the acoustical compromise outlined in the introduction, hence given that the above premise is accurate for the future, if the space is to be acceptable for both drama and symphonic presentations, then some form of variable reverberation will be required. To place the problem in perspective, **Table 1** gives the typical reverberation time required for a variety of different performances expected in a multipurpose auditorium. From this table we can infer that to satisfy all performances we need to be able to adjust the reverberation time by a factor of around x2.

It would be possible, and indeed

it is fairly commonplace, to design a hall to have a mid frequency reverberation time in the region of 1.5 s and to accept the inevitable loss of intelligibility of speech, and the undesirable loss of resonance and warmth expected for symphonic music.

Consider the following equation:

$$RT = \frac{KV}{A}$$

Where V = volume of the space; A = total absorption present; and K = constant. (This is a much simplified general equation. Calculation of reverberation time in a space is a complex matter. The geometry of the space should be taken into account.)

It can be seen that a doubling in reverberation time may be accomplished by either doubling the volume or halving the absorption, or indeed by a combination of both such that:

$$\frac{V'}{A'} = \frac{2V}{A}$$

To double V represents a formidable architectural task, and in any case an increase in V will produce a corresponding increase in surface area and hence absorption, together with an increase in the mean free path such that desirable early reflections will arrive later.

A more feasible method would be to change the mean absorption coefficient, ie change A. This could be accomplished by utilising rotatable ceiling or wall panels; each panel could have one surface acoustically hard and the other acoustically soft. The problem with this approach is that most of the absorption is fixed and inherent, that is the major fixtures, fittings and of course the audience. Thus in general terms the best attainable is probably a change of some 30%, invoking a corresponding change in the reverberation time.

The variable acoustics by variable architecture method may be summarised as follows:

- limited effect;
- expensive;
- slow to operate.

It would be totally inaccurate to suggest that an architectural solution was not feasible. A combination of variable volume and absorption would produce the required change, and with care the undesirable effects could be optimised, but it would still be expensive, slow to operate, and would impose further limitations and restrictions on the architect so that he was less free to exercise the licence of his art.

Electro-acoustics probably provides the best all round solution to the problem, and although not inexpensive, it is probably an order of magnitude less expensive than an architectural method.

Current systems

There are two separate philosophies available to the designers of reverberation enhancement systems; they may be loosely categorised and defined as in-line systems or non in-line systems.

The difference is self-explanatory: an in-line system contains the reverberation means between the microphone and the loudspeaker, and a non in-line system amplifies the reverberant field that exists between the loudspeaker and microphone. At the present time non in-line systems have gained favour—the demise of the in-line system was probably due to two factors, firstly the inadequacies of the reverberation means, and secondly, the real and always attendant problem of feedback. In fact rather unfairly the reverberation devices take the majority of the blame. Using current technology this can no longer be true, using digital techniques it is possible to purchase, at modest cost, reverberation units of exceptional quality. The problem of feedback is of course always present, although with a little privileged foresight I do not think it will be long before the feedback problem is resolved, and therefore systems based on the in-line principle, or a combination of the two may well reappear.

Returning to the present, there are currently two systems commercially available; *Assisted Resonance* (*AR*) for which Acoustical Investigation and Research Organisation Ltd (AIRO) is responsible and *Multi-channel Reverberation* system (*MCR*) which is manufactured and installed by Philips.

The two systems operate on the non in-line principle although in concept they are fundamentally different.

Assisted resonance

Assisted Resonance was developed by Professor P H Parkin. 1965 saw the start of a four-year research and development programme to install a system in the Royal Festival Hall to correct the shortfall in low frequency reverberation.

An *Assisted Resonance* system consists of a large number of microphone-amplifier-loudspeaker channels with each channel being, as far as practically possible, frequency independent of the others. AIRO suggests that this frequency independence is achieved by the use of high Q acoustic filters, together with the selectivity afforded by the careful siting of these units (see **Fig 1**). The system employed in the Royal Festival Hall uses 168 of these channels and achieves a reverberation magnification as shown in **Fig 2.** Parkin also recorded an increase in sound pressure level with the system on and this amounted to some 1.9 dB in the 125 Hz octave band.

The number of channels used is based on work carried out by Schroeder and Kuttruff who demonstrated using a statistical method that the transmission response between any two points in a space had peaks which may be expected to occur, on average, at a frequency interval n(f) given by:

$n(f) = 3.91/RT$

For the Royal Festival Hall this implied a frequency spacing of around 3 Hz and hence to cover the frequency range 58 Hz to 700 Hz required some 200 channels.

In 1969 AIRO was granted a licence to exploit the *Assisted Resonance* concept and between 1969 and 1983 some 10 systems have been installed.

The latest systems bear little resemblance (except in principle) to the Royal Festival system. AIRO reduced the number of channels used and increased the frequency range over which the system was to operate. A recent typical system employs 90 channels and covers the frequency range 63 to 1300 Hz. The channel spacing is not allocated on the basis of constant frequency, rather the spacing is typically 4% at low frequencies and 2% at the highest, it is based on the premise that the ear's discrimination is related more closely to a logarithmic ▷

FIG.1
SCHEMATIC OF ASSISTED RESONANCE CHANNEL

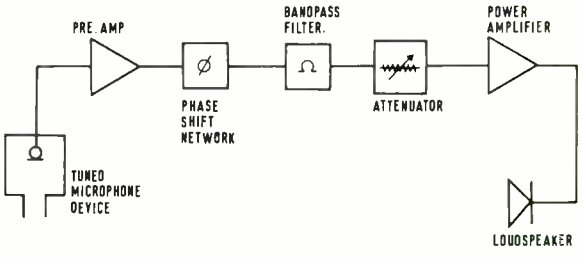


FIG. 2
ASSISTED RESONANCE-ROYAL FESTIVAL HALL LONDON U.K.

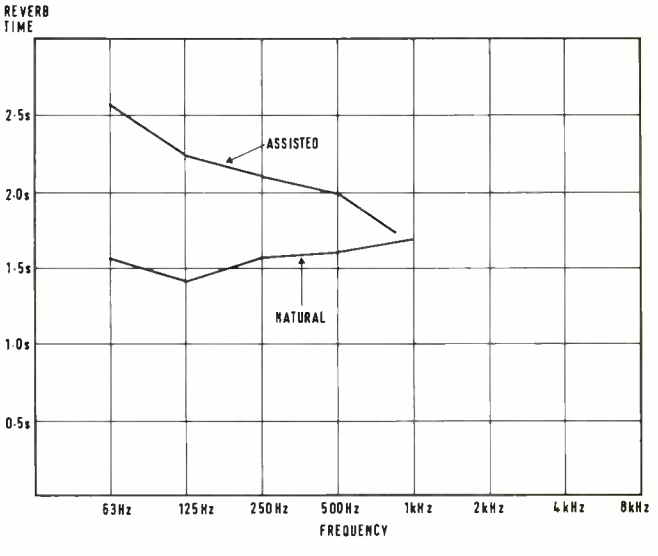
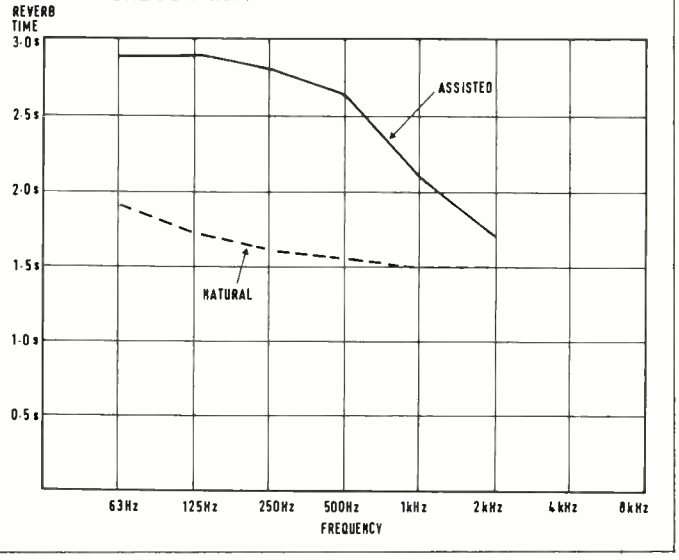


FIG.3
ASSISTED RESONANCE-HULT CENTRE-EUGENE-OREGON U.S.A.



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rather than arithmetic frequency interval.

Obviously the technology employed has altered, AIRO now uses 50 W MOSFET power amplifiers instead of the 5 W valve (tube) amplifiers of the original RFH system, and instead of fixed attenuators they use a microcomputer to change the gain. The latest system installed was in Eugene, Oregon (1981). **Fig 3** shows the performance of this system.

Multi-channel reverberation system

This system is based on work carried out by Professor N V Franssen published in 1968. This system as its name suggests and in common with *Assisted Resonance*, consists of a large number of channels (between 50 and 100), the exact number being dependent on the space and the reverberation magnification required. The channels however are, unlike *Associated Resonance*, not frequency selective, and are therefore not frequency independent.

A typical *MCR* channel is shown in **Fig 4.** Equalisation is applied to correct for the random-directive sensitivity of the microphone, loudspeaker and the transfer function between them. The principle behind this system is simple and compact, basically since in the diffuse field the sound energy density and the reverberation time are directly related, then if the diffuse sound is amplified the reverberation time will suffer a corresponding increase.

The Philips *MCR* system also differs from *Assisted Resonance* in another respect; the placement of the *Assisted Resonance* microphones is critical, an acoustic experiment is carried out (the hall needs to be substantially complete) to find pressure peaks at preset specified frequencies and amplitude. With *MCR* however the positions of the microphones and loudspeakers can be determined on the drawing board, and as I understand it each element must be in the reverberant field with respect to any other element. This is perhaps both one of the strengths and weaknesses of the *MCR* system. It is obviously attractive to be able to define precisely the positions of transducers, but for very small spaces it could prove impossible to find sufficient positions that satisfy both the reverberant field criteria and the magnification required.

Again, in common with *Assisted Resonance*, the *MCR* systems reverberation magnification is dependent directly upon the system again. Both systems operate at between −5 dB and −10 dB below feedback, and as such there is only a small margin of error, the *MCR* system has a continuous checking system that inspects the electronic gain to detect the onset of problems. It does not of course check the total loop gain since this would involve continous acoustic measurements. The *MCR* system is also fitted with two detection and measuring microphones which are placed between the sound source and the system microphones. These microphones provide advance warning of levels outside the systems capability (110 dB re 2×10^{-5} Nm^{-2}) such that overload and distortion will not result.

To date, five *MCR* systems have been installed, the most recent is in Limehouse Studio 1, London, where it is intended to provide an acoustic climate suitable for orchestral presentations in an otherwise acoustically dead space. The Limehouse *MCR* system uses 79 channels (20 W/channel) and covers the frequency range 63 Hz to 8 kHz. The maximum reverberation achieved is shown in **Fig 5.** Seven steps of reverberation are available between the natural and the operational maximum; there are two further steps of 0.5 dB each, but these can introduce some colouration on percussive sound.

FIG. 4
SCHEMATIC MULTI-CHANNEL REVERBERATION SYSTEM (SINGLE CHANNEL)

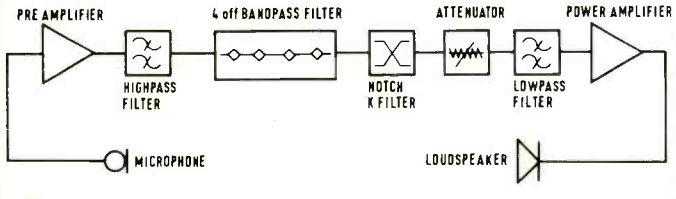
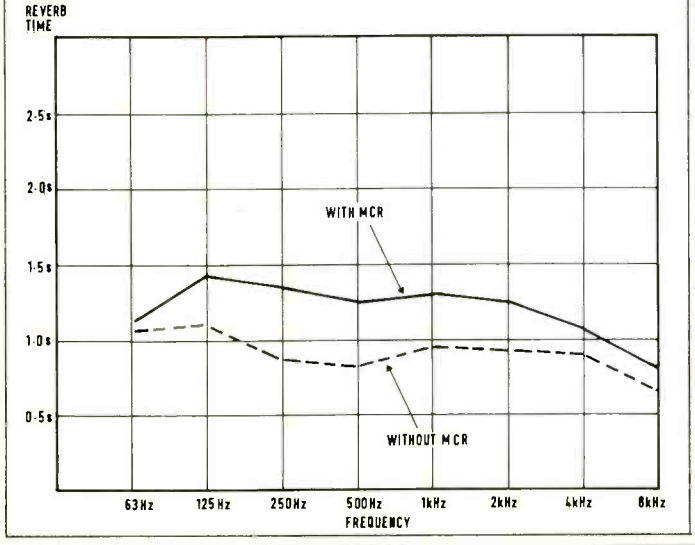


FIG.5
MULTI-CHANNEL REVERBERATION SYSTEM LIMEHOUSE STUDIO 1, LONDON U.K.



Visits

I was fortunate to be able to visit two installations, Limehouse (*MCR*) and the Royal Festival Hall (*AR*). I did not intend to draw any comparisons between the two systems or installations but I feel that to do each system justice some attention to the relative merits and differences are necessary.

Firstly the mechanics of the installation: the standard of Philips work was excellent, the control panels, with the exception of a slightly ambiguous remote panel, were well laid out in a logical fashion, the wiring and circuit construction was of the highest standard. The *Assisted Resonance* system by contrast was not in the same league, but to be fair to AIRO they inherited much of the system, and that for which they were responsible necessarily had to be integrated into that which was existing. It would be less misleading if for example the Limehouse studio installation was compared with the Eugene installation which was AIRO's latest system.

With regards to effect, there is a definite inconsistency, on paper (compare **Fig 2** with **Fig 5**) *AR* should come out way on top, but in fact I would have rated the *MCR* system as slightly more effective. Having said that I should clarify and explain exactly what I mean.

Both demonstrations were carried out without the benefit of a live orchestra and therefore any suggestions I have regarding live performances must be a matter of conjecture. The AR system was demonstrated using pink noise as a source and with the *MCR* speech was used. Using the pink noise source there was absolutely no doubt as to the difference with the system on and off, and the decay times were inconsistent from a subjective and objective standpoint.

It was difficult to tell when the *MCR* system was on, until that is, you turned it off, which serves to demonstrate how natural the system sounded. The *MCR* is reported to produce an increase in sound pressure level when on of around 2 dB. I did not measure it but I would suggest that this increase was consistent with the subjective effect. I suspect that the *AR* system did not quite produce as much, but again no measurements were taken.

Finally in completing the comparison within reason an *Assisted Resonance* system can provide an increase in reverberation time frequency tailored to suit needs while the *MCR* system is, I suspect, slightly less flexible, also *Assisted Resonance* is reported to provide greater RT increases than the *MCR* systems. In terms of price, an *Assisted Resonance* system would cost between £80,000 and £100,000 and an *MCR* £150,000 to £180,000.

Theoretical considerations

Although a great deal has been written on these systems and subsequent installations, there has been little about the fundamental theory. Quite naturally there has been some resistance on the part of the manufacturers to publish too much information as this could serve as a blueprint for any other interested party. Generally however we can assume that the fundamental premise behind each of the systems is that they replace the energy lost to the acoustic absorption. This necessarily implies a system power output consistent with the losses.

This may be demonstrated as follows, the reverberant sound pressure level in a space may be approximately calculated from the following equation:

$SPL = PWL - 10 \log_{10} V + 10 \log_{10} RT + K$

where SPL = sound pressure level; PWL = sound power level of the source; V = volume of the ▷

ELECTRO-ACOUSTIC REVERBERATION ENHANCEMENT SYSTEMS

space; RT the reverberation time of the space; and K = a constant to tidy up the units.

If for the same source power, and same volume we require the RT to be doubled, then an additional term $+10 \log_{10} 2$ is required and hence the SPL would be +3 dB.

The reverberation enhancement system should be able to provide both a power level increase and reverberation increase if this criteria is to be fulfilled.

I would like to add that the above is, with regard to the power, a much simplified approach, and the exact connotations depend on the time of arrival of the additional energy together with the degree of linearity of the system.

The limit of power output is determined by feedback and the *MCR* system is supported by an elegant piece of theory. Franssen determined that if the microphone was placed outside the reverberation radius with respect to the loudspeaker then the average loop gain of a microphone-amplifier-loudspeaker chain should not exceed −12 dB. And further if the system is to be stable and free from colouration this gain should be reduced to −17 dB. From this he deduced (since $10\log_{10}50 = 17$):

$$A_{(n)}\,\text{max} = 1 + \frac{n}{50}$$

where $A_{(n)}$ = 3 or 4.8 dB which corresponds to a three-fold increase in reverberation. This is of course the maximum that can be achieved and in practice although the channels are able to maintain electrical separation, they are acoustically coupled and therefore interactive.

It is also possible to approach the problem from another standpoint, in that if a microphone-amplifier-loudspeaker channel is excited by a pulse of short duration (ie, shorter than the transit time between the loudspeaker and microphone), then this signal will recirculate and decay at a rate determined by the gain of the amplifier and the acoustic loss between the loudspeaker and microphone. If a channel loudspeaker and microphone are separated by a distance L, and the velocity of sound is C, then the time taken to complete one cycle is L/C, and therefore in one RT period RT × C/L cycles will be made, and since one RT period implies a decay time of 60 dB then at each cycle 60 × L/RT × C dB shall be lost, this approach unfortunately infers that channels operate close to feedback. If L = 10 m, RT = 2 s then the loss per cycle will be approximately 1 dB; in other words 1 dB below feedback.

Again this is a much simplified appraisal but it does serve to demonstrate a point.

Although I stated that both *AR* and *MCR* are non in-line systems, due to the equalisation in the systems they do have an in-line component. In the *MCR* system the effect is almost certainly negligible by virtue of the fact that it is broad band, the *AR* system however is quite different, and it is this difference that probably limits the maximum magnification prior to the onset of unacceptable colouration.

The frequency selection of an *Assisted Resonance* system is provided at low frequencies by Helmholtz resonators and at high frequencies by ¼- and ¾-wave tubes. To achieve the 4% spacing the resonator has a Q of 25.

A Helmholtz resonator in common with electrical and mechanical filters may be regarded as an oscillatory system and as such may be defined in terms of the usual second order, second degree differential equation:

$$\ddot{x} + 2k\dot{x} + n^2x = n^2f(t)$$

where $2k = gr/w$, $n^2 = gs/w$ and $r\dot{x}$ is the frictional resistance where s = stiffness of the system. If the system is forced to oscillate at some frequency other than its fundamental, substituting $f(t) = a\,\text{Sin}.wt$ the steady state solution may be shown to be:

$$x = \frac{an^2\,\text{Sin}\,(wt + \theta)}{((n^2 - w^2)^2 + 4k^2w^2)^{\frac{1}{2}}}$$

and hence the period of the forced reverberation is the same as that of the applied force, namely 2m/w. But as soon as the forcing frequency is removed the system, albeit not instantaneously, will decay at its fundamental frequency, ie the tuned frequency of the resonator or room mode.

The rate of energy release will be determined by the Q of the filter and its fundamental frequency given by the formula:

$$RT = \frac{7Q}{\pi f}$$

hence for a Q of 25 at 100 Hz the RT of the filter would be approximately 0.5 s. Compared with the RT of the system or the hall this could probably be ignored, however, the fundamental Q of the resonator will suffer a quasi multiplication due to the recirculatory nature of the system. This may be realised by consideration of the situation at the first and subsequent passes. After the first pass the system has a frequency response equal to the response of the resonator, this response is after the transit time from loudspeaker to microphone re-filtered and hence would emerge from the loudspeaker as if it had been filtered by a system with a higher Q. This process repeats itself at each successive pass.

The final Q ($Q_{(n)}$) after n passes, ignoring any damping, may be shown to be related to the initial Q(Q_o) by the following equation:

$$Q_{(n)} = \frac{Q_o}{(10^{3/10n} - 1)^{\frac{1}{2}}}$$

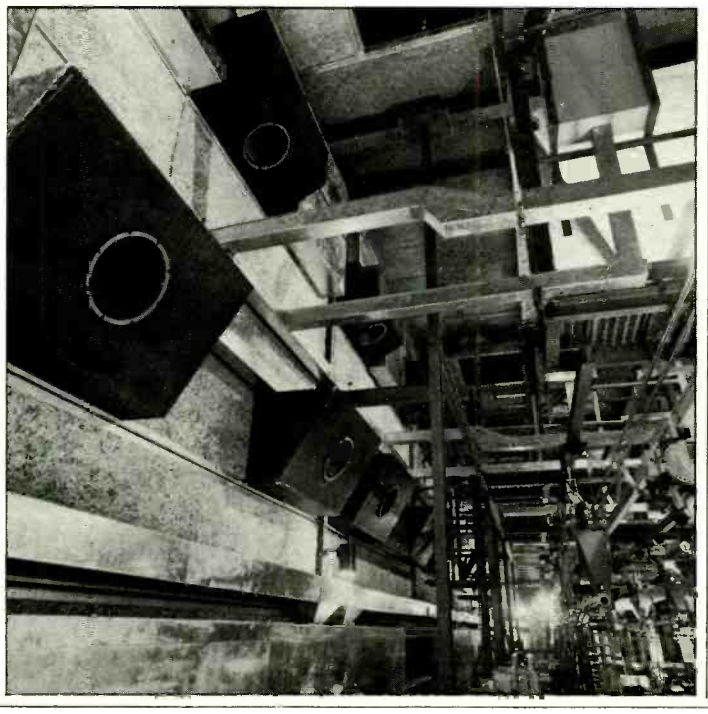
Now in a typical system we might expect the microphone and loudspeaker to be separated by a distance of some 6 to 10 metres and therefore during a 2 s decay approximately 70 passes would be made. Therefore starting with a Q of 25 the resultant $Q_{(70)}$ would be in the region of 250 which at 100 Hz would have an RT of approximately 5 s. This RT would in most cases be much longer than either hall or system, and therefore may be heard as colouration.

Although the foregoing was directed towards the filtration in an *Assisted Resonance* system, it could also apply to the *MCR* system since room modes can be considered in precisely the same way, the only difference is that the room mode may be considered as outside the system and hence *MCR* retains its non in-line status, and in addition the *MCR* system has many similar transducers distributed throughout the space which would serve to reduce this effect.

Quite clearly such resonant systems are not lossless and since they radiate their energy over a period of time the peak value is generally small compared with the excitation energy (see **Fig 6a**); in this case the filter ring would not be audible as it is well below the ▷

Assisted Resonance, Royal Festival Hall above ceiling

Part of MCR installation, Limehouse Studios



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ELECTRO-ACOUSTIC REVERBERATION ENHANCEMENT SYSTEMS

background level. If we however increase the excitation level, ie, the orchestra plays louder, then the stored energy in the filter also increases and in the case of **Fig 6b** the filter ring would be heard as colouration.

That colouration is a problem there can be little doubt (if only in the sense that it reduces the maximum magnification attainable); that filter ring is the prime cause cannot be stated as fact. However the means and the mechanism are present and therefore the hypothesis does seem reasonable. To assess the degree of the effect does require that the loss incurred as a result of the transition from the forced to the fundamental mode is quantified. This is no mean task!

The possibility of non-linearity is not only confined to the tail end of the decay process, the initial part of the decay may also exhibit a similar characteristic. By how much and for how long depends upon a number of factors.

Firstly power output **Fig 7** shows the effect of inadequate power output of the system, the decay process will follow the natural until the energy output of the system dominates and hence the decay process will be that of the system. It is partly for this reason that both *MCR* and *AR* systems quote in addition to the RT magnification, a sound pressure level increase.

In contrast with the colouration and filter ring which would manifest itself following a loud abrupt stop chord, the early decay time (EDT) is important during continuous passages of music. Unfortunately because of the linear output nature of these systems, the addition of two decay systems (natural and system) may produce an initial drop, this can be demonstrated as follows.

The decay of energy in a space may be described by the following equation:

$I_{(t)} = I_o \exp(-kT)$

where $I_{(t)}$ is the intensity at any time f, I_o is the initial intensity and K is a constant determined by the mean free path, the velocity of sound and the mean absorption coefficient.

Now when t = RT, then by definition:

$I_{(t)} = 10^{-6} I_o$

hence $I_{(t)} = I_o \exp(-13.8t/RT)$

If two decay processes are involved denoted by $I_{(t)}$ and $I'_{(t)}$ and they are additive we get:

$I'_{(t)} + I_{(t)} = I'_o \exp(-13.8t/RT') + I_o \exp(-13.8t/RT)$

Assuming that the system output is equal to the orchestral output then:

$I_{(o)}' = I_{(o)}$

Rewriting we get $I_{(t)'} + I_{(t)} = I_{(o)}(\exp(-13.8t/RT') = \exp/-13.8t/RT)$ when t (time) = o ie at the start of the decay process $I_{(t)'} + I_{(t)} = 2I_o$. or $I_o + 3$ dB

If the natural RT is much less than the RT′ of system, then the influence of the natural system will rapidly reduce; therefore there will be a sharp initial drop until the system decay processes take over.

In other words depending on the rate of initial drop and the time period that elapses prior to the domination of the system decay the effect on the EDT may not be consistent with the later magnification of the reverberation time. This is a gross over-simplification of the situation; in practice the difference between the source/sytem arrival times at both the system microphone and the audience area will determine the resultant of the summation.

Conclusions

It may seem to the readers that have endured and stayed the course that any such conclusions reached are a foregone formality, in that I am sceptical of the worth of such systems. Nothing could be further from the truth for although I have been quick to point out the inadequacies of these systems, they represent the state of the art and are infinitely preferable to nothing at all.

I do not like compromise solutions. Those multipurpose halls that are endowed with a single acoustic climate are in the words of an old and sadly missed friend of mine, 'neither fish foul nor good red herring'. Those halls which are fitted with some form of reverberation enhancement device are often critical of the performance and effect of these systems and this is not surprising since they are in a privileged position. Some of the criticism is poorly founded often prompted by a comparison of the cost of these systems with that of the regular sound equipment. A better cost comparison would be between the reverberation system and the cost of perpetrating a similar effect architecturally.

Further these systems have been cited as insurance policies taken out by the acoustical consultant in case he gets his sums wrong and in addition it is preferable to effect a solution using natural means.

A natural solution would almost certainly mean a single solution (a compromise) or at the very least variable acoustics over a very limited range, and with regards to an insurance policy; for what—against providing a multipurpose space with a single purpose acoustic climate?

Both Philips and AIRO have contributed a great deal to our understanding of this subject and to the improvements and flexibility of the acoustics in multipurpose space and I am sure that such systems will continue to gain favour and be used for some time or at least until someone comes up with something better.

What I have tried to do is provide an insight into the subject, together with suggestions that may explain some of the problems and inadequacies. Obviously some readers will not agree with some of my opinions and conclusions, some may even plain disagree. Whichever is the case the subject could use some criticism, preferably constructive.□

Acknowledgements: Finally, I would like to take this opportunity of thanking Tony Jones, Rob Hill and Bill Stevens of AIRO; John Mordaunt and Stephen De Koning of Philips; and Ron Payne of Limehouse Studio for their co-operation and assistance.

FIG.6
EFFECT OF FILTER RING

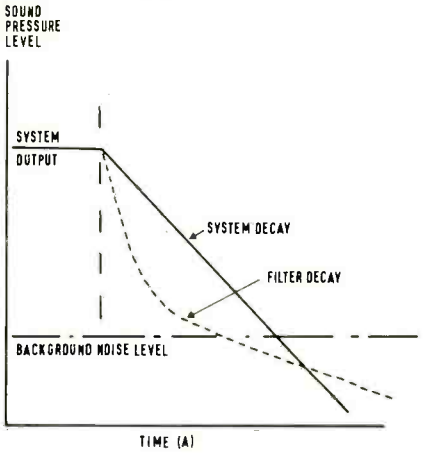
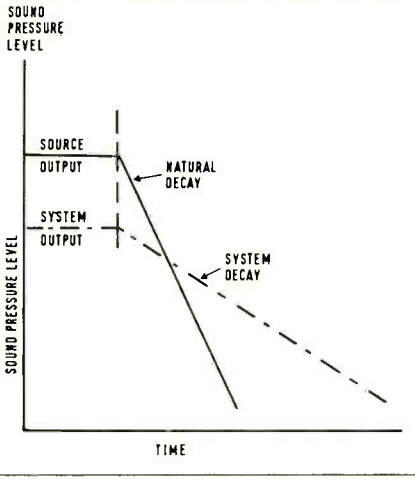


FIG.7
EFFECT OF SYSTEM LOW POWER OUTPUT



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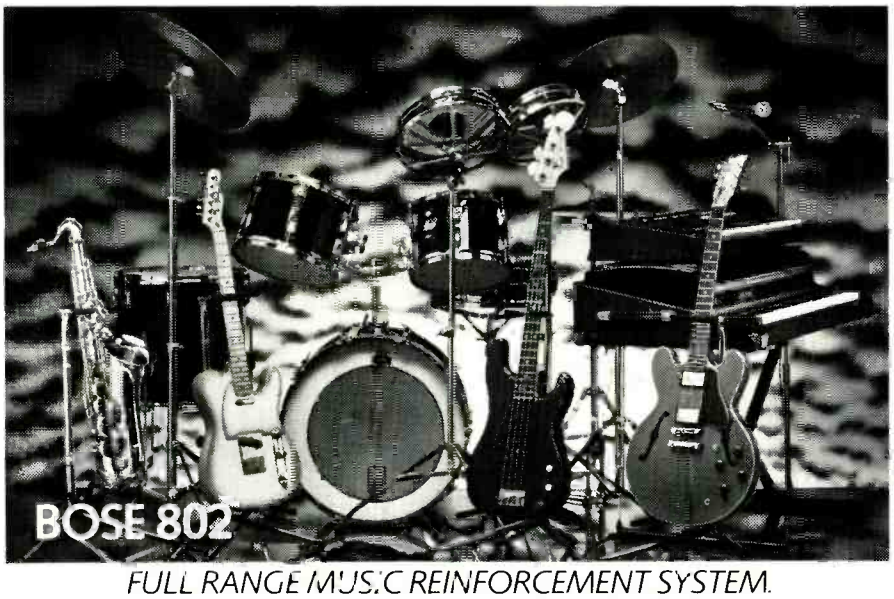

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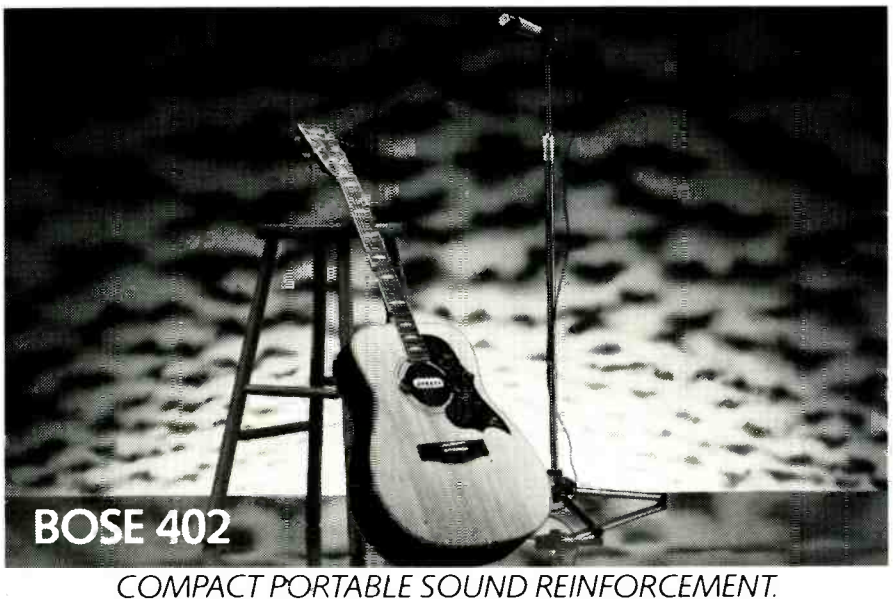

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BIG BAND SOUND

Recordings of big bands made within the 'big band era' have a distinctive sound. Ex-broadcast engineer John Longden tells a few secrets.

As one who was working in BBC studios and on OBs in those big band days, I have been making the point for many years that the effort to revive their sound has always failed to be convincing for the very reason Barry Fox mentioned in his Business column (February 1984).

Until the late '40s we balanced large orchestra shows on only three or four microphones. They were usually 'A' or 'B' ribbon mikes, sometimes with a *4017c* moving-coil omni. The 'A' ribbon was the famous *AXB*—later known as an *AXBT* when it was fitted with a Ticonal magnet which gave it an additional 8 dB output—and the 'B' ribbon was similar but was mounted in a large round case.

The technique was to move the artists around rather than the microphones. A typical set up would be a rhythm section ribbon placed in the vicinity of piano, bass, drums and guitar. Full use would be made of the fact that the ribbon had a figure-of-eight polar diagram, and although the rhythm mic was standing in a position to favour the piano, the guitarist would not hesitate to move closer to it for a solo spot and then return to his original seat, usually just in front of the string bass.

The drums bashed away just behind or to one side of the piano. Strings, woodwind, saxes and trumpets would all be balanced internally, although we would frequently sling a ribbon above the orchestra using another ribbon in a front floor-stand to be shared by a group of saxes, soloists, vocalist(s) and the announcer.

If one of the sax players was doubling on say, clarinet, he would step forward to this microphone. It was also usual to regard this closer microphone as available when brass instruments were playing a few bars with mutes, and the musicians were well-schooled in making obvious hand signals before picking up their mutes or commencing a solo passage. In general it worked well.

Experienced broadcasting musicians gained an expertise in turning away from the mic or moving to the dead side of the ribbon before playing forte, and moving in for the pianissimos. I think that they were much more aware of how to manipulate their sound balance for themselves, though the programme engineer, as he was then called, always had the final say.

Since the general aim was to broadcast the sound *as it was being heard in the studio* rather than an equalised, corrected and modified version of itself, everyone concerned had a common goal. You didn't really find it very difficult to agree whether the final effort was good or bad. It needed only a direct comparison between the original sound in the studio and what was heard in the monitor cubicle, although as it was all live and nothing was on tape the only way the balance could be judged at all was during rehearsals.

Various members of the orchestra, then the conductor, would come and listen while the same number was played over and over for each of them. Since this meant that one or another instrument was missing while it was his turn to judge the balance there were some hiccups!

An interesting sidelight on a musician's ability to assess a balance emerged. Because the musicians were almost always working in an internally balanced situation they became accustomed to hearing their own band in quite an individual way, according to whichever instruments normally worked closely with them and we soon learned that the most reliable opinion came from the conductor who, from his position in front, was used to a more balanced sound though still too close to know what the audience was really getting.

Unfortunately those big bands were LOUD and through years of standing so near, most conductors were noticeably deaf. I remember Ted Heath whose open brass was blasting away at him from a distance of only a few feet wore a hearing aid! Disco-type levels were not unknown 40 years ago.

It was just as well that musicians were willing to move around to change the balance and regulate levels during the performance as there were no limiters in the desks, and the line volume meter (forerunner of the PPM) was very crude.

Also the potentiometers—faders to you—worked clumsily in 2 dB steps: a very coarse adjustment. An additional hazard awaited the unwary engineer in that low-level mixers were the order of the day, this meant that as you faded up any one of your three or four channels the others would go down. The potentiometer was a stud type, rotating over a sensible 180°. **Fig 1** taken from an early BBC training manual shows what it looked like. Ergonomically I think it was superb.

If you were unlucky enough to get a short-circuit on a mic cable as you faded ▷

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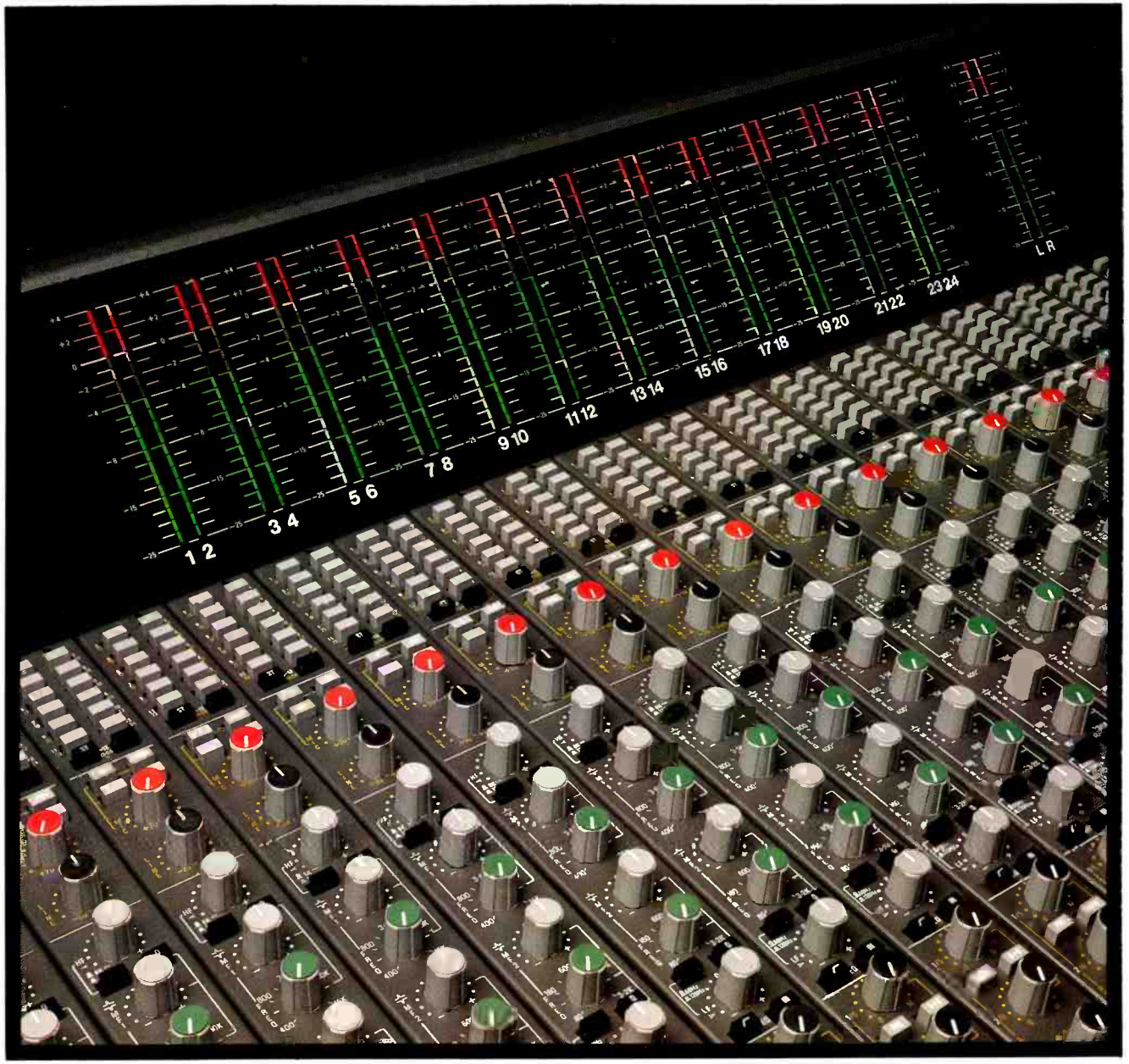

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BIG BAND SOUND

up that particular channel you lost the lot! As a result, engineers tended to be cautious of knob-twiddling and this showed in their balance techniques.

A short-circuited microphone was not at all a rarity as the microphones were not fitted with *XLR* terminations, but with three large terminals. You had to bare the ends of the cables and connect up to the terminals every time, so the odd whisker of wire from terminal post to metal case was not unknown.

A quirk of the *4017c* moving-coil microphone design also caused frequent one leg earth faults. A quarter wave acoustic pipe inside it could come adrift and touch the terminals inside the casing.

All this may seem to be getting away from the original points raised by Barry regarding the Big Bands' balances, but I think it explains the totally different approach of the earlier engineers. They had to nurse their equipment and would rather do something to change their studio acoustics than attempt an electrical change and this in my opinion had one very great advantage: it meant that everyone in the studio was aware of any alterations and the mic positions were nowhere near as close as they are today so the ratio of direct to indirect sound from an instrument was much less. More of the studio's acoustic was present and as a result I think we made more use of such things as acoustic screens and what was known as Cabot's quilting, a kind of Kapok mattress that you could hang on the walls. We also fully exploited the dead side of the ribbon mics to increase separation. One would even move members of the audience to get good audience effects, seldom allowing anyone in the first few rows of seats near the front of stage microphone.

(It is interesting to note here that in the early stages of the Second World War when a separate audience effects mic was rigged it was watched over by a member of the Home Guard armed with a .303 rifle. He would also be present under the microphone which was suspended in an otherwise empty auditorium during cinema organ broadcasts.)

We had to be wary of out of phase microphones. Apart from the dangers of putting the wires on the terminals the wrong way round (Red wire always on the Right) a ribbon microphone works in reverse phase if you turn it through 180°. With only two or three mics in use the effect of fading up an anti-phase mic was a disastrous cancellation effect—a literal fade-out.

Finally, a word of warning to would-be historians. Don't believe everything you see in archive photographs. Many of the pictures purporting to be 'so-and-so during their recent broadcast' were in fact separately posed, and bands of the day preferred to be pictured in the positions they would normally adopt at a public performance which unfortunately means that the exact microphones which were used and their positions are not necessarily known.

Also there were little 'tricks of the trade' resorted to by programme engineers which they were not always keen to publicise, since they were much frowned upon by the engineering hierarchy who were generally theoretical purists. Unauthorised modifications or additions to mixers and microphones were strongly forbidden but rife, and many of these became jealously guarded personal secrets, so that at one stage an elite breed of PEs began to emerge as bandleaders would ask for individuals for their programmes. I remember quite a flurry of internal memos flying about to forbid the practice of attaching an empty cigarette packet to the back of a ribbon mic with rubber bands to achieve a primitive 'presence' effect. It was said to work even better with a segment of broken 78 gramophone record (they were brittle and broke very easily!).

One device which I personally used quite frequently has appeared in very few photographs so far as I know. This was an attempt to get a cardioid characteristic and since we had no cardioid microphones (the Western Electric *4033* arrived later) we hung a ribbon and moving coil one above the other and paralleled their outputs (see **Fig 2**).

This combination of figure-of-eight and omnidirectional meant that in one direction they were in phase (front) and in the other were cancelling (back). Instant cardioid! At a recent exhibition I was amused to read a caption under a picture of the ITMA* team using this combination of microphones, which suggested that it was a lack of confidence in the mics which led to a 'main and stand-by' rig being used. It wasn't—it was a 'cardioid' in use to combat the PA system. I know—because I rigged it!

All such devices would be whisked away very quickly indeed if there was a photographer in sight, and too many requests for one's services from artists could lead to embarrassing confessions and disciplinary procedures!□

*BBC Radio comedy programme from the '40s.

FIG.1
EARLY STUD-TYPE POTENTIOMETER

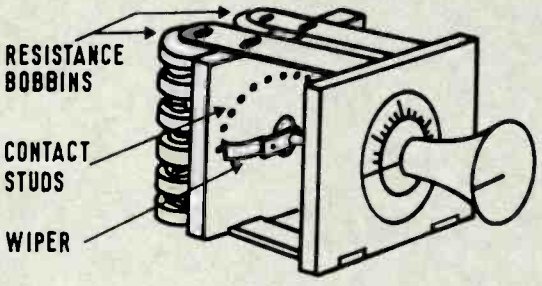
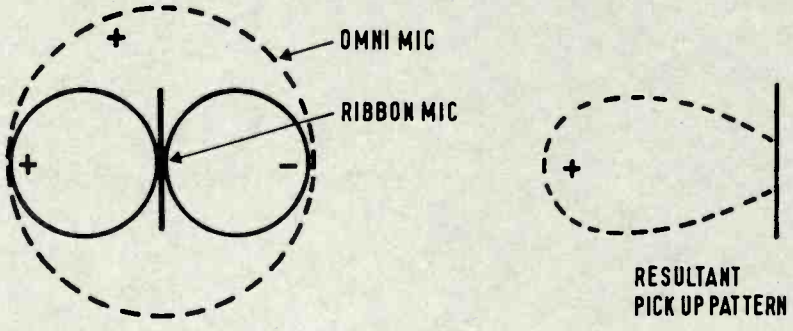


FIG.2
A CARDIOID RESPONSE COULD BE SIMULATED USING AN OMNI/RIBBON COMBINATION



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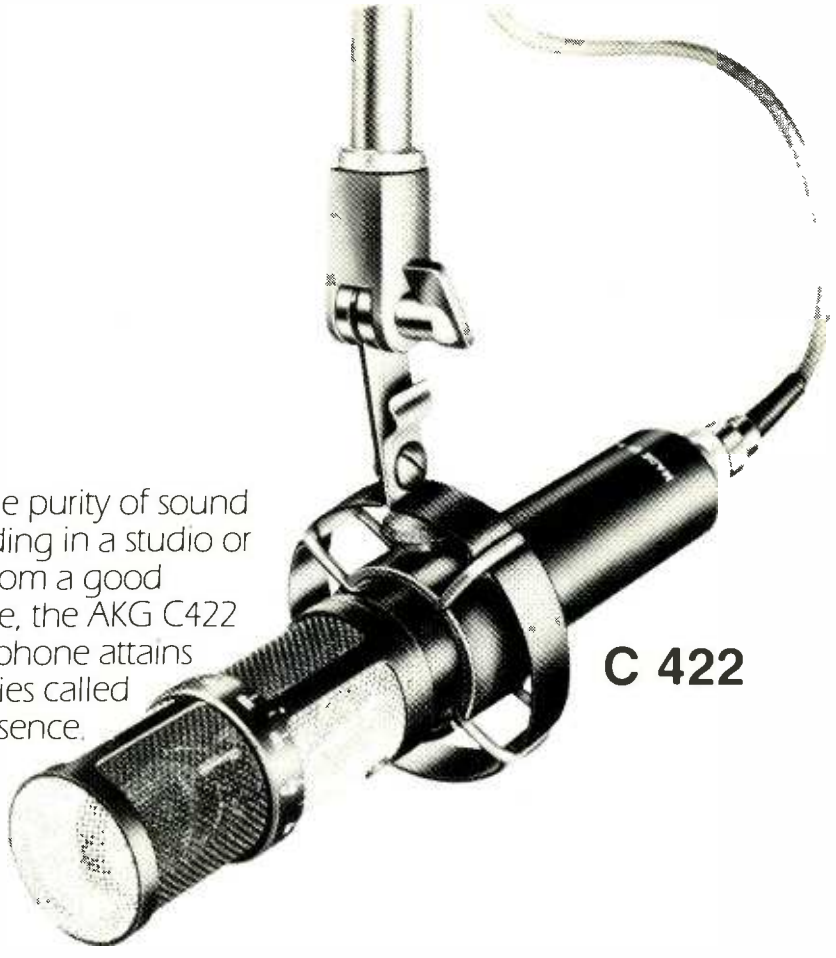

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BUSINESS BUSINESS

Barry Fox investigates the facts behind the industry news

Doh, Ray, MU

They say all the best novels and film scripts start life as a short item in a local newspaper. Who will write the story behind motions (ix) and (x) from a recent Musicians' Union branch meeting? I quote:

"We request the Executive Committee to make redundant from the Union's service, the officer responsible for the organisational catastrophe of the 'out of tune piano', at the 1983 Biennial Conference. This brought a great deal of embarrassment to a delegate (the bandleader and the person who had to perform on the instrument) and several esteemed London musicians... the Branch views with deep concern the embarrassment caused (with regard to the 'out of tune piano'). This in effect caused a lowering of performance standards. This Branch asks for a categorical assurance from the Executive Committee that this will never recur."

If it does recur, I do hope they sell tickets and advertise it well in advance.

Tape tangles

BASF in Germany has just been celebrating 50 years of magnetic tape. It was in 1934 that the German company delivered the first batch of 50,000 m of tape to AEG Telefunken. Two years later Sir Thomas Beecham was touring Germany with the London Philharmonic Orchestra. One scheduled concert was in the BASF hall at Ludwigshafen. Company engineers taped the concert and Sir Thomas skipped the reception afterwards so that he could listen to the playback. Last month the LPO performed exactly the same programme at the Barbican. One member of the orchestra had been at the 1936 recording. Vernon Handley was supposed to conduct but at the last minute he was ill and replaced by Brian Wright. Egg on face of any reviewer who wrote it up in advance. Egg also on any magazine which prints BASF's picture of the 1936 concert, complete with BASF caption, which incorrectly says it is the London Symphony Orchestra.

To be strictly accurate, it wasn't BASF that staged the 1936 concert, it was I.G. Farben, the chemical cartel that fuelled the German war machine.

Recently I did a broadcast about BASF's early work on tape. Routinely, the radio station made a cassette recording of what went out. But the recording is incomplete, because the tape tangled. Yes, you've guessed it, it was a BASF cassette. I have the tangled tape to prove it.

Broadening horizons

You can always tell when the going is getting tough in an industry. The companies trying to sell their wares start thinking about PR, by which I mean Press Relations or Public Relations. I've been writing this column for quite a few years now and still get almost all my news through the grapevine, at exhibitions and as spin-off from other areas where the firms are better geared to telling the press what is happening. The studio industry just hasn't been switched on to PR.

For the benefit of any firm wondering why its new ideas aren't getting noticed, here is a bit of advice that may help.

A great deal of what you read in any specialist magazine (whatever the field) is written by freelance contributors. Although the magazine may well have specialists on the staff (as does *Studio Sound*) they can't write everything. Just look at the contents page, read the staff listing and you'll know who is working from the outside and who is on the inside. When a clumsy PR firm sends a press release, with expensively produced glossy photos, to the magazine it gets read by the office staff. If it grabs them it gets used. If it doesn't it usually ends up in the bin on the floor. Only if it has obvious relevance to a freelance contributor will it be forwarded out of the office. Think about it: how can the magazine staff possibly know what may just happen to touch on a story which an outside contributor is working on? That's why most press releases, and product launch invitations, only occasionally end up with contributors. Obviously things get even more confusing if more than one contributor might be interested. The simple answer, adopted by PR people who really know their trade, is to make initial contact by letter, or press info, sent c/o the magazine. Sounds obvious doesn't it? Well you would be surprised how many PR people don't work that way.

There is in fact a simple reason why they don't. To work that way you have to know who is writing what in which field. And that means either having an interest in the subject or doing the hard grind of reading not just the specialist magazines but more general publications that carry articles on the subject. In the studio field that means reading not just *Studio Sound*, but the music press, the hi-fi press and the broadcast press as well. So if you are a hardware firm wondering why you aren't getting heard, try the simple experiment of asking your PR person which freelance writers they regularly talk to. The result may surprise and disappoint you, but explain a lot.

Stop that tune

A nice snippet from IBS, the sound engineers' newsletter. A new and inexperienced man was put on the job of recording the music for the Queen's Christmas message. The plan was to end the broadcast with a recording of a military band playing the National Anthem in the grounds of Buckingham Palace. The raw engineer kept messing up the stereo balance and trying again. Just as the band was striking up for the 11th time an equerry arrived with a note from 'Her upstairs' which read: 'Would you please stop playing that tune. I am trying to hold a conversation with someone and every time you start playing they stand up.'

Franchise fever

Last year Capital Radio won its franchise to go on being London's pop commercial radio station. Local Radio Workshops' £10.50 polemic on the station didn't stop it. Although obviously biased and predictably dismissed by Capital as 'laughably inaccurate', it makes some important points in a meticulous dissection of the station's 10 year history. It also makes a very useful antidote to Capital's glossy and self-satisfied PR image.

Capital won its original franchise with promises of a news section responsible for current affairs, and a drama department for radio theatre. The newsroom was axed in 1974, to save money. The drama department also disappeared at around the same time as the newsroom. Only when the franchise came up for renewal in 1983, did Capital start producing drama again. Also in the run up to the franchise, Capital dreamed up a 'music festival'. This was an umbrella title for the kind of concerts that are happening in London throughout the summer months anyway. The grand opening, spread over three days at Camden Lock was a shambles. No-one, least of all the pretty ladies manning the Capital Cruiser publicity truck, seemed to know what was happening and when.

By coincidence, Camden Lock is home of TV-AM, the breakfast TV station which found that the only way to survive was to adopt a very trivial programme format that bears little or no resemblance to the format promised when it won the franchise.

The big question now is what will happen if Britain is cobwebbed with cable and saturated with satellite broadcasts that do not live up to the promises made to secure the contracts. If the broadcast watchdogs have no teeth, who will watch over the watchdogs?□

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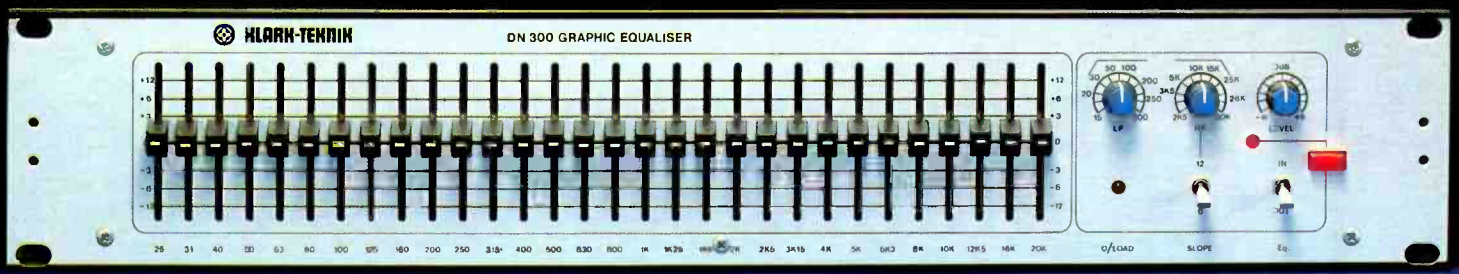

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A-1 BEHIND THE SCENES

Large, American sound system company, A-1, designs, constructs, hires and operates every type of installation. Tony Ryder visited their main facility in Hollywood.

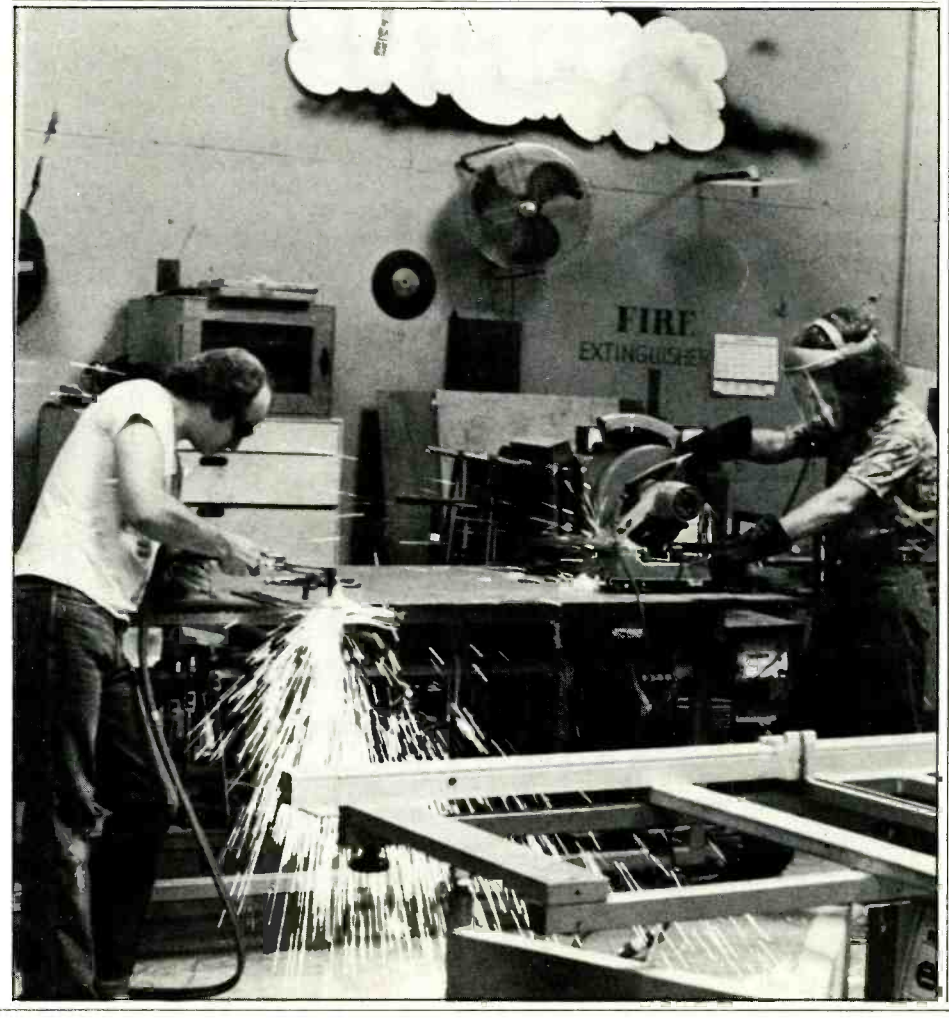
A sound-reinforcement system should be invisible to anyone who attends a concert or live show. In the best of situations, no one, except for the sound crew, needs to be aware of the sound system. As the link between the performance and the audience, the speakers, microphones, amplifiers and other equipment are simply a means to accurately reproduce what's originating on the stage. Yet as soon as one little thing goes wrong—a hum, a buzz, a dead mic, or a single distorting speaker—everyone becomes aware of the monstrous flying trusses, the dozens of dangling cabinets and miles of cable lying on the floors of stage and arena. (Ironically, of the thousands of components and connections that compose a contemporary audio system, the only one that's remembered is the one that causes a problem. And if it lasts long enough, the reputation of the entire company suffers as a result.)

Now of course, people in the music business—musicians, managers, promoters, engineers, producers, etc—must devote some attention to sound quality in a live environment. Their livelihoods, either directly or indirectly, depend on good reviews and favourable responses from the crowds that attend the shows. For that reason, audio professionals are exposed regularly to explanations and critiques about typical sound systems and their practical applications for this tour or that one. But seldom does anyone get a look behind the scenes at the extensive support facilities, staff, and inventories of equipment and parts required to keep those systems operating, and dependable reputations intact. To shine a bit of light on the internal workings of a reinforcement company, A-1 Audio gave us a tour of their 20,000 ft² main facility in Hollywood, California.

A-1 Audio is a one-stop, vertically integrated service company that handles the design, construction, set-up and, if necessary, operation of full-scale, flown systems for international, contemporary-music tours (Barry Manilow, Doobie Brothers, Frank Sinatra, etc); sophisticated fixed installations such as those demanded by Las Vegas/Atlantic City-style show rooms (Caesar's Palace and the Aladdin Hotel in Las Vegas, Resorts International in Atlantic City, Britannia Beach Hotel in the Bahamas, Hotel de Mexico in Mexico City, etc); and complex audio/visual interfacing required to put on a successful corporate/industrial presentation (IBM, Yamaha, Cadillac, Mattel, etc).

Currently with four offices throughout the United States (Hollywood, Atlantic City, Las Vegas and the Lake Tahoe/Reno area), A-1 is proof that a company can survive and even flourish during a slow period like the last few years of record-industry cutbacks, and generally poor attendance at major rock concerts. "In addition to providing an accurate and dependable sound system, the secret is that we've vertically integrated a lot of little services under one roof, so our clients don't have to search all over town for everything they need," says Al Siniscal, president and founder of A-1 Audio. "Acts usually don't have very much time to prepare for a tour. By taking care of all the potential problems that can hassle a tour into frustration, we make their job a lot easier."

Supporting this approach is a two-pronged philosophy that Siniscal adopted, while



Dave Gibbons and Steve Meeus in A-1's fabrication shop—pre-tour construction of metallic equipment stand

in the US Air Force, as a project engineer for the Minute Man Missile Program. Even though the world of military policies may seem the antithesis of the typical recording-industry consciousness, the watch words of 'no excuses' and 'zero defects' apply equally well to both environments. "In the Air Force, the missile had to go when it was launched, or we were in major trouble," he says. "There were no second chances. A concert or stage show is the same way; it has to go on, or somebody loses a lot of money and gets a lot of bad publicity."

After Al Siniscal left the Air Force in the late '60s, his love for music (he plays several instruments) led him to the sound-reinforcement business. But what he discovered there surprised him. "People were using hi-fi equipment on stage. Or other components that were totally unsuited for the way in which they were being utilised. I was used to all the technology that was available in the military, and couldn't believe people weren't taking advantage of it."

So during 1970 Siniscal started A1-Audio in Las Vegas, Nevada by renting equipment to the major hotels and casinos, and doing house mixes for the acts that came through town. By applying the experience and knowledge of current technology gained in the Air Force, he managed to build A-1 into the multifaceted sound company it is today.

When you first approach A-1 Audio from the street, you get the impression that the brick building with oversized garage doors is just another Hollywood scenery shop located two blocks from the infamous Sunset Boulevard. But upon closer inspection, you notice the surveillance cameras, the security bars on the windows, and the huge 'A-1 Audio' logo arcing over the main window in the centre.

Once in the lobby, you're greeted by rows and rows of pictures—the majority of which are publicity photos donated and autographed by A-1's show-business clients. The rest are snapshot displays of crew members and various types of the company's audio installations in many locations around the world. The remaining wall holds racks of product literature, which A-1 sells or rents to touring clients, movie companies, TV stations/networks, and production houses. The two adjoining offices belong to Scott Danner, the traffic and office manager, and business/purchasing administrator Lyndon Walker. Besides handling all the paper work, and general business responsibilities, they maintain a current reference library of product information in four giant file cabinets for the convenience of the design and road engineers.

Behind an electronically locked door to the left of the lobby, lies the 'inner sanctum' filled with literally tons of equipment and the hustle and bustle of a small city. Directly inside the security door is Al Siniscal's office, decorated with more photos of A-1's accomplishments. An enclosed staircase behind his desk leads to a plush second floor lounge reserved for visiting acts, their management and guests. Through the picture window at the south end of the lounge, the artist can view a 100×100 ft area below, which is separated on the west side from the rest of the complex by a padded 6 ft high iron fence on small wheels. Gaffer's tape on the ground floor marks off the dimensions of several commonly used stages found in showrooms around the US.

Acts lease a 60×60 ft portion of the building for full audio rehearsals with flown speakers and all their instruments. As an aid in learning new material, or for perfecting segments of a show, multitrack tape machines are available so performances can be recorded live. While the 25 ft high arched ceiling doesn't provide quite enough height to accommodate a typical concert lighting set-up, A-1 has access to the TVC soundstage complex for full flow arena rehearsals within six blocks of the main offices.

Large pieces of unused equipment, such as speaker cabinets, consoles, etc, are stored in the remaining footage of this central area, as well as in the rehearsal area when that space is unassigned. The large room at the building's southeast corner, which may be secured by sliding metal doors, holds road cases full of smaller tour gear, such as outboard effects, microphones, test equipment, and so on.

All the cases for each tour are assigned a colour (for example: the red system, the green system, the blue system, etc) and marked with the appropriately shaded gaffer's tape for easy identification. The artist and the audio engineers for the act select specific components for their particular needs. Once the system is assembled, no other clients or company personal have access to any part of that system (except for maintenance and repair work) regardless of whether the act is working or not. The colour-coded road cases ensure that one group's equipment doesn't get mixed up with a neighbouring system, while sitting in storage, and every tour that goes out has everything they're supposed to have.

The rest of the Hollywood facility is divided into several distinct areas, and each has a specific responsibility within the totality of the business. Yet all function as a singe entity to keep the flow of groups and projects moving along at their optimum pace.

Off to the right of the rehearsal area (the west interior wall) and criss-crossing back and forth are stairways that lead to the various second floor offices. Like the artist's lounge, each office has picture windows overlooking the central rehearsal/storage space. At ground level are located the technical shop, the engineering lab, new product sales and piece rental storage.

Although several manufacturers produce sound-system components commercially, most reinforcement companies usually design their own cabinets utilising speaker and amplification specs that best fulfil their interpretation of how a system should sound and operate in a given environment. To develop such designs and advance the current state of technology as it applies to sound reinforcement, companies like A-1 Audio underwrite their own research and development. Bobby Ross, A-1's chief engineer and director of operations, works closely with Greg Oshiro, the electrical engineer in charge of technical services, and his staff to continually develop and improve their existing systems, while also evaluating new products submitted to them by outside vendors.

"Besides customising reinforcement systems to a variety of parameters and applications," explains Bobby Ross, "we get a lot of calls to supervise equipment interfacing, integration and modification, and to develop specialised electronic schemes like click-track, and wireless systems. In fact, we do entire stage layouts, which involve the optimum positioning of monitor speakers and stage equipment, the plotting of signal routing, and the assembly of sub-snaking and attendant wiring. When hanging systems are appropriate, A-1 engineers do the preliminaries, and then refer the drawings to an associated structural-engineering firm for approval. All this takes man-hours and money, but it's necessary if we're to continue offering our clients the best and most dependable system available.

The technical services group, under the direction of Greg Oshiro, has two primary objectives: 1) to reduce to zero the number of equipment failures on the road; 2) to advance the 'state-of-the-art' of A-1 Audio's equipment via appropriate and effective modifications, which make set-up easier, quicker and consistent from show to show. The tech shop thoroughly inspects, repairs, modifies (when necessary) and certifies every piece of gear that goes out the front door via a comprehensive evaluation system developed by Oshiro.

For example, every power-amplifier rack is disassembled, visually inspected, subjected to a battery of tests for continuity, frequency response, distortion, noise and mechanical shock. When the unit passes inspection, it's initialled, tagged in five places (each of the two amps, the wiring harness, crossover and the rack itself) and put into stock.

If equipment modifications are necessary to meet the exact specifications established by the systems engineers or artists, these are completed in-house as well. All work is thoroughly documented and copies are distributed as reference material to the crew in the field to answer any questions that may arise.

Operating a tech stop of this calibre means committing substantial investments to inventory and training. The most common equipment is supported by a full stock of parts, purchased in bulk directly from the manufacturers. Only top-quality, MIL-SPEC components can be used (ie all gold contacts, heavy-duty Lexan AMP connectors with custom covers, etc). Additional pieces, such as 50-pair snakes, wiring harnesses, patch bays, etc, are assembled by the tech department, too. Fortunately, standardisation of many parts, such as connectors, covers, cable, etc, has reduced stock costs substantially.

Says Greg Oshiro: "All solderers must be trained because wiring is an art. There are thousands of connections on a tour, and just one intermittent short that's difficult to track down can disrupt the whole system. We have to make sure that every tech does everything perfectly."

Although A-1 hires highly qualified personnel, improvements in technology and techniques are occurring all the time. To keep up with the progressing level of standards, A-1 takes advantage of the manufacturers' training courses, such as the JBL speaker reconing school and the CM Loadstar chain-hoist workshops. Al Siniscal and chief engineer Bobby Ross attend all the seminars. Department heads and road crew members participate in those training programmes that pertain to their fields of expertise. In the case of the loudspeakers, everyone on staff ▷

A1

associated with touring equipment is encouraged to learn as much as possible. "Something like the JBL reconing school gives them a good appreciation for the delicacies and limits of a loudspeaker," explains Al Siniscal. "After three days of reconing two of practically every speaker that JBL makes, they have much more respect for all the gear. And much more confidence if they're faced with any kind of defective equipment."

To augment this continuing education programme, A-1 also encourages the department heads and qualified personnel to lead periodic in-house training sessions on topics such as power distribution, equipment interfacing, grounding and shielding, the use of test equipment, general audio electronics, and specific equipment operation.

To further round out the overall education of each crew and tech person, road-crew members must spend some time in the tech shop doing repairs, and repair technicians must earn some road experience. "These guys get the feel for what it's like on the 'other side'," says Al Siniscal. "The tech crew comes to realise first hand that one bad solder connection can cause a lot of people a lot of grief when it happens in the middle of a show. And the road crew learns a greater appreciation and respect for the delicacies and value of the equipment they handle everyday. Having that 'other' perspective helps everybody do a better job."

To manufacture the Finland Birch cabinets they design and the trusses necessary to hang their flown systems, A-1 needed access to a fabrication shop. Under the direction of Lou Mannick, a registered certified welder in structural steel, the in-house department can build or repair practically anything made of wood, steel, aluminium, fibreglass and plastic. The shop is outfitted with special saws, welding gear, a dust-collection system, built-in compressor with many hoses throughout the shop and the rest building to supply power for their pneumatic tools, a finishing bay for spray painting and coating, and a library of wooden templates for all the cabinet designs they've ever made for themselves or their clients. Like the tech department, the fabrication shop has its own inventory on hand, which comprises stocks of the raw building materials, and bins of various latches, wheels, hinges, bolts, resins, finishes (paints, varnishes, plastics, carpeting), screws, etc. Again, standardisation of parts has reduced the total investment required, and thus reduced operating expenses considerably.

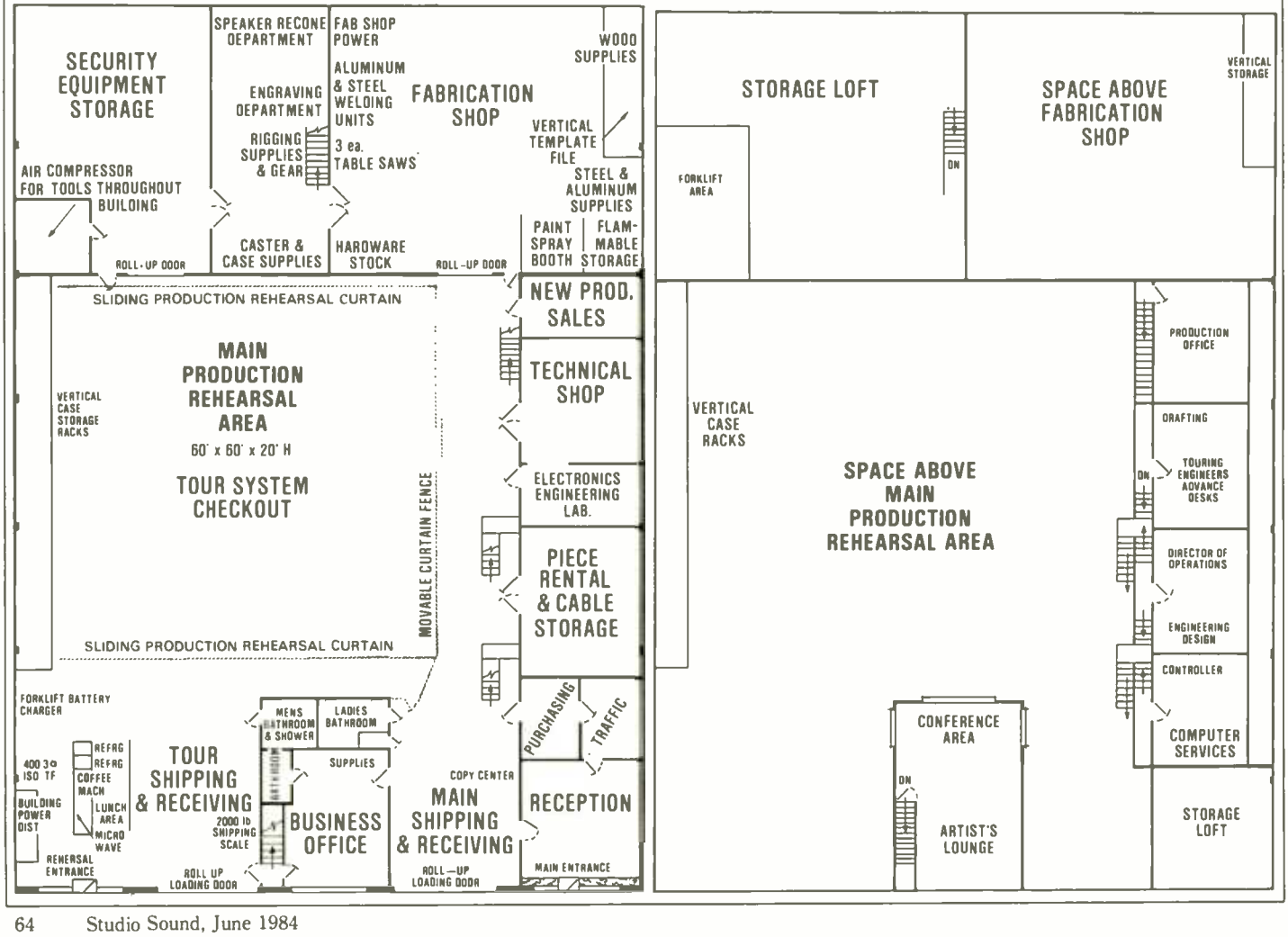
With such facilities available, A-1 Audio found that their clients could benefit directly, too. "Most road tours never seem to have enough time for pre-tour planning and preparation. So almost out of necessity, A-1 decided long ago to utilise the fabrication and maintenance shop to their advantage. The crew, Dave Bibbons and Steve Meeus, can provide all the little services that would drive a manager nuts if he had to search all over town for them. Over the years, we've been asked to adapt or duplicate TV stage props for live performance use, custom-build cases and stands for all sorts of electronic gear, refurbish road cases, construct odd structural reinforcement systems, repair drum risers, and load-test flying systems."

Adjacent to the fabrication shop are two more essential service areas. The engraving department prepares brass equipment labels (engraved panels) that are used to permanently mark all cabinets, boxes, cases, connectors. The engraving won't wear off like the printing on normal tags or labels, thus the chances of components being misplaced or incorrectly connected are reduced.

The second area is the speaker-reconing department, run by Sam Verdugo, who has been trained and authorised by JBL and Cetec Gauss to implement repairs to those companies' products. (Verdugo is an audio engineer and A-1's Spanish translator. Spanish is necessary for Mexican and South American projects, such as the Frank Sinatra one-night outdoor concert in Rio de Janeiro's 175,000-seat Maracana Stadium—the world's largest soccer stadium.)

The process of speaker reconing required the sealing off of the immediate area, and the installation of a ventilation system that maintains 'clean-room' status so that no dust particles contaminate the loudspeakers, while they are being repaired. And of course, this department keeps its own inventory of parts and supplies as well.

To maintain some kind of control over such a diverse business, A-1 Audio commissioned Robert Wellborn, an ex-sound engineer turned computer consultant/programmer, to supervise the installation of a computer system that would tie together all of the company's various aspects. After studying six



MIXING MASTERS?

Console Automation used to be considered a luxury. With the introduction of the MasterMix system, automation becomes not only accessible, it becomes so economical, simple, efficient and accurate as to be essential.

MasterMix can automate your existing console. Interfaces are available for most automation-ready consoles, and the MasterMix VCA fader package permits a complete update of virtually any console.

MasterMix records the Mix data on floppy disc. The traditional disadvantages of contemporary tape based systems, which introduced cumulative errors on repeated passes and were subject to dropouts, noise and distortion interference are eliminated.

Only one track of standard SMPTE/EBU timecode is required for synchronisation and a code generator is included as part of the main computer unit. Automation of level and mute decisions are stored independently and accurately to a single time code frame.

MasterMix is simple to use, and the increase in speed and quality of production will ensure that the system rapidly justifies its installation.

MasterMix is the new standard for automation systems.

MASTER MIX – the obvious choice

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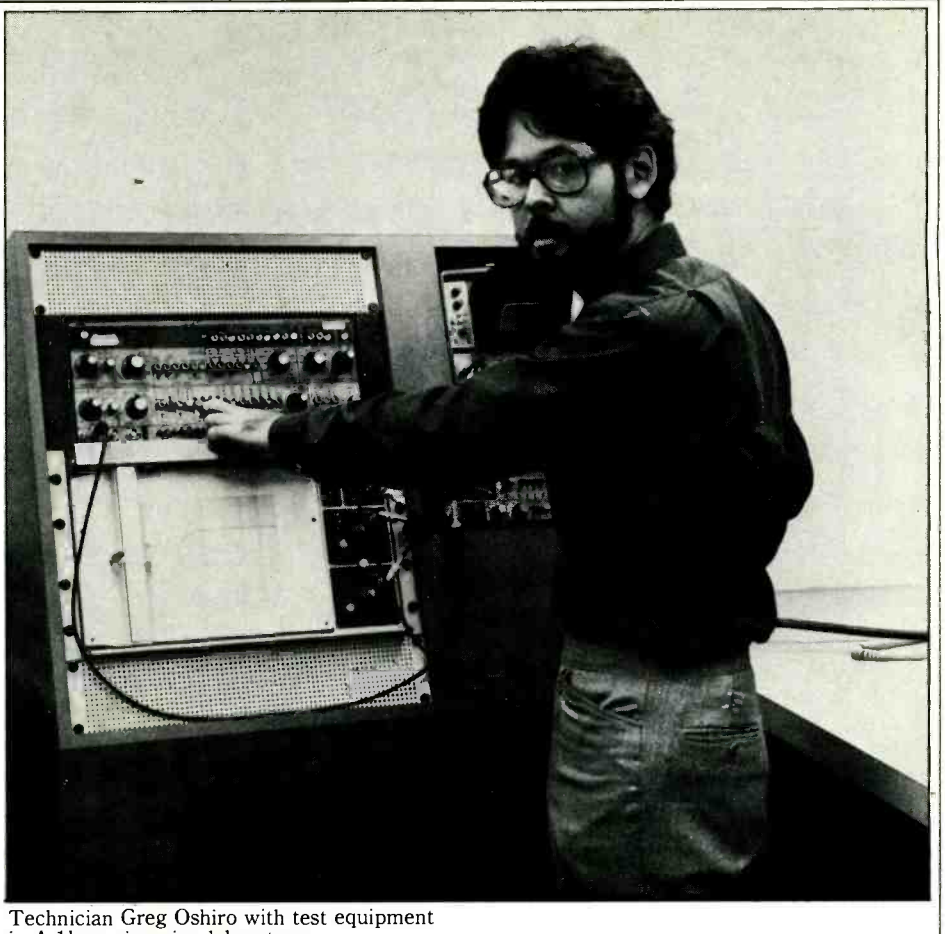
or seven of the best-selling database management and accounting products, Wellborn reached the conclusion that none of the commercially available programs were adequate for A-1's specialised needs. Instead, he spent two years (1981-1983) writing the necessary application software. The 25-module integrated system that he finished installing in December of 1983 controls every facet of the business—inventory, accounting, tour information and assignments, the capability to do all sorts of cross-referencing for statistical analysis of equipment performance and research about the needs and preferences of their clients, instantaneous data communication with the three other branch offices and tour personnel on the road, and much, much more.

Although the cost of research, development, installation and conversion to the new system has been substantial in terms of time and money, the return in terms of efficiency and accuracy has revolutionised and streamlined the way A-1 does business. "Probably one of the most important aspects is that our computer system (a Molecular Computer Systems CPU with Televideo terminals) allows us to maintain much tighter financial controls over our cash flow and inventory," says controller Sunny Marshall, "so we have more available capital to constantly upgrade our pro-audio equipment. And invoices and monthly statements can be accurate to the penny."



Technician Greg Oshiro with test equipment in A-1's engineering laboratory

Prior to adding a piece of equipment to the rental stock, all the relevant information, such as serial number, model number, weight, dollar value, etc, is entered into the computer. When the equipment is rented, the information is automatically transferred to the particular client's records. A push of a key prints out a complete equipment manifest listing totals for dollar value, volume (equipment dimensions), weight and whatever else may be requested to meet insurance, shipping, and international-customs requirements. The client knows exactly what equipment he has assigned to him, how much insurance to buy, how many trucks to hire for the tour, and how much shipping will cost him if he has to fly the equipment somewhere. Several copies can be produced within a few minutes for distribution to whoever needs one—the chief audio engineer, the tour manager, customs officials, the insurance company, etc.

"Before we installed the computer system, A-1 Audio, like most sound-reinforcement companies, was operating in the dark ages," says Bob Marshall, director of Computer Services. "The guys on the floor who packed the equipment for a tour would maybe throw in a few extra pieces, write up fairly sketchy manifests, and no one really knew how much was where. Now with a push of a button, we have a complete read-out of all the gear assigned to a tour, where it is on a particular day, and any information that we might need to run our daily business. For most office work, we just enter the first-show date and the system tells us the act's name, their location on a given day, what hotel the crew is staying in, and so on. We can pull out all the information with a few keystrokes."

A-1 Audio is presently in the process of bar-coding their entire inventory—"anything with a serial number," says Marshall. A couple of guys with handheld computers can do an inventory of tour equipment in a fraction of the time that it used to take, and with greatly improved accuracy. The stored information is then downloaded to the main system, where it is accessible by any of the other modules in the system, such as accounting (for billing the client for rented equipment) or preparing international carnet sheets.

A typical international carnet sheet prepared by A-1 Audio's computer system includes: item number, description, case number, serial number, weight in pounds, country of origin, values of each piece in US dollars, size (height × width × depth), volume in cubic feet and totals for the applicable categories.

A-1's representatives on the road and in each branch office also have access to the main system through modems and various telecommunications networks like the Source, Compuserve, and the newly organised International Management Corporation.

Tour receipts, itinerary changes and personal messages are sent via phone lines using Kaypro portables, Apple computers and Radio Shack *Model 100*s. The usual telephone tag or inadequacies of the mail service are eliminated and efficiency is increased on this level, too.

Augmenting the effort of the regular full-time staff are several auxiliary services: trucking to move equipment; structural engineers for certifying A-1's massive support systems; set designers; consultants for special modifications and constructions; production managers; etc.

Travelling engineers are provided a private office equipped with Watts lines, so they can conduct their business, consult with other engineers who have played particular rooms or tour circuits, prepare for up-coming tours, make advance calls, and whatever else may be needed.

Road crews have their own dining area with refrigeration and microwave cooking facilities. A shipping scale, a fork lift, massive power supply sources, and small transportation vehicles can also be added to the list of essentials that an audio company must underwrite to keep their business running smoothly. All of these components are integral parts of a giant puzzle that keep the resultant sound-reinforcement system accurate and dependable.

Like the rest of life in general, the simpler some process or product seems to be, the greater the effort that has been invested to ensure the continuation of that effortless appearance or operation. Specifically, a sound system that appears invisible to the audience and the artist, in reality, requires massive amounts of man-hours and diligence before the system leaves the warehouse. But not surprisingly, that's probably why the industry is called *professional* sound reinforcement.□

Al Siniscal Biography

Al Siniscal holds two degrees from Washington University in St. Louis, Missouri—a bachelor's degree in Chemical Engineering with a minor in Electrical Engineering (1963), and an MBA (1965). He also has completed basic postgraduate EE courses from UCLA and USC, which qualify him for certification as a Registered Professional Electrical Engineer (Reg 7705) in the state of California. Supplementary workshops include Syn-Aud-Con, JBL Reconing School, and CM Loadstar Hoist Maintenance School. In addition to playing several musical instruments, Mr Siniscal brings to A-1 Audio 15 years of experience as a working audio engineer in the professional music business.

-TURNER-

STEREO POWER AMPLIFIERS

The B302 Series is recommended for driving full-range studio and stage monitor loudspeakers rated at 50—100 watts 8 ohms, 150—200 watts 4 ohms; and for driving the "top end" components of a p.a. system (with suitable electronic crossover) i.e. mid range speakers, compression drivers, and tweeters with typical rating of 100 watts — 8 ohms, 60 watts — 16 ohms.

The B502 Series is recommended for driving high-powered studio and stage monitor loudspeakers and the "bottom end" components of a p.a. system (with suitable electronic crossover) i.e. high powered bass and mid range drivers where ratings are typically 100 — 200 watts 8 ohms, 300 — 400 watts 4 ohms.

SPECIFICATION →

SPECIFICATION	B302	B502
Power Output (Single Channel)	60w – 16, 100w – 8, 150w 4 ohms	105w – 16, 190w – 8, 340w 4 ohms
Power Output (Both Channels)	60w – 16, 95w – 8, 140w 4 ohms	100w – 16, 180w – 8, 300w 4 ohms
Power Response	±0.1dB 20Hz – 20KHz 80w 8 ohms	±0.1dB 20Hz – 20KHz 150w 8 ohms
Frequency Response	±0.1dB 20Hz – 20KHz 1w. 8 ohms	±0.1dB 20Hz – 20KHz 1w. 8 ohms
Distortion THD	<0.01% 20Hz, 75w 8 ohms <0.01% 1 KHz, 75w 8 ohms <0.05% 10KHz, 75w 8 ohms < 0.1% 20KHz. 75w 8 ohms	<0.01% 20Hz, 150w 8 ohms <0.01% 1KHz, 150w 8 ohms <0.05% 10KHz, 150w 8 ohms <0.1% 20KHz, 150w 8 ohms
Distortion IM	<0.05% 10mw – 100w 8 ohms	<0.05% 10mw – 190w 8 ohms
Hum & Noise	>110dB below 100w 8 ohms	>110dB below 190w 8 ohms
Crosstalk	>90dB at 1KHz 100w 8 ohms	>90dB at 1KHz 190w 8 ohms
Input Impedance	10K ohms, level control max. 50K ohms, level control min.	10K ohms, level control max. 50K ohms, level control min.
Output Impedance	<0.016 ohms, 20Hz – 400Hz	<0.008 ohms, 20Hz – 400Hz
Damping factor	1000 – 16,500 – 8,250 – 4 ohms 20Hz – 400Hz	2000 – 16, 1000 – 8,500 – 4 ohms 20Hz – 400Hz
Load Impedance	3 ohms to infinity	3 ohms to infinity
Rise time	3.5μs	3.5μs
Slew rate	10v/μs	10v/μs
Phase shift	–12° at 20Hz, –6° at 20KHz	–12° at 20Hz, –6° at 20KHz
Input sensitivity	1.42v for 100w 8 ohms	1.97v for 190w 8 ohms
D.C. offset	<10mv	<10mv
Channel Gain	26dB ±0.2dB	26dB ±0.2dB
Protection-Amplifier	The amplifier is protected against input overload, short and open circuit by comprehensive auto-resetting high speed electronic circuitry. All stages are inherently current limited to prevent chain destruction. Auto-resetting thermal cut-outs protect against insufficient ventilation. Hi-temp indicator on the front panel displays this condition.	
Protection — Power Supply	The power supply is protected, in the rare event of channel failure, by HT and main fuses; thus reducing fire hazard and maintaining second channel operation.	
Power Supply Energy Storage	25 Joules	45 Joules
Power Requirements	220/240v AC 50/60Hz 500w max. input	220/240v AC 50/60Hz 1Kw max. input
Net Weight	8.4Kgs	12.3Kgs
Shipping Weight	9.7Kgs	13.7Kgs
Net Dimensions	48.3 x 13.5 x 22.8cms (19'' x 5¼'' x 9'')	48.3 x 17.8 x 21cms (19'' x 7'' x 8¼'')
Shipping Dimensions	55 x 24 x 28cms	55 x 28 x 28cms

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A REMOTE HAND

The Delta-G system is a useful combination of a number of ideas. The possibilities presented by freeing the live sound engineer from being tied to an out-front mixing position are enormous. No longer will he have to rely on secondhand information relayed from different parts of the venue to change the levels of different parts of the system. The engineer will be able to move around the audience and optimise the sound at all positions within the limitations of the sound system and the application of Delta-G within that system. The ability to recall complete level settings from a memory, alter musical balance and equalise without sacrificing a dozen prime audience seats is very attractive. Vic W Dobbs of Spectrum Audio Ltd describes the Delta-G system, and in conjunction with Stephen Wheeler, chief sound engineer of Earls Court, London, covers the experience so far with the first practical installation.

Delta-G is a multi-channel, wireless remote controlled, software driven attenuator system for use in sound and public address installations. It is intended to enable the sound engineer to set up and balance the sound system quickly and efficiently from the point of interest rather than a fixed position, without assistance and without long trailing leads.

Comprising four parts: transmitter, receiver, master control unit and attenuator module, the system interfaces with the sound system at the input to the power amplifiers as shown in the diagrams.

The pocket sized transmitter operates on the VHF telemetry band, providing an output of approximately 1 mW which gives it a range of around 300 metres in open space. Commands are entered on a numeric calculator-style key pad which also includes specific function keys (+, −, ON, OFF, CLEAR and ENTER). In this way it is possible to access channels on an individual level, in groups, or as a total system.

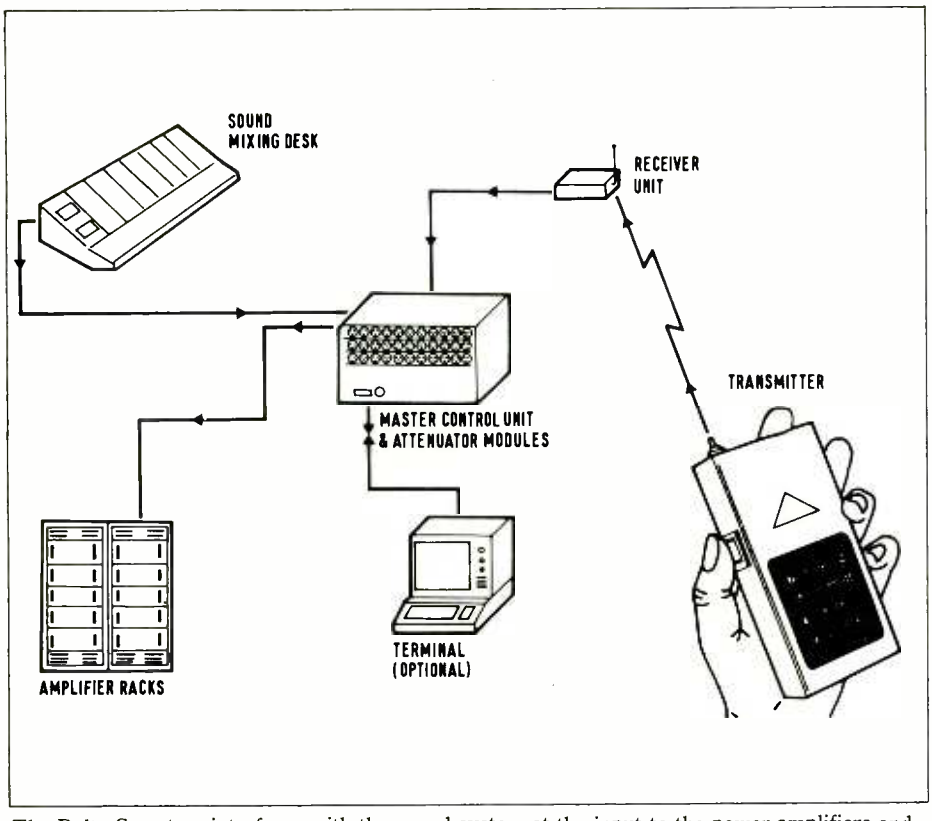
The receiver is normally sited in the auditorium or arena and is connected to the master control unit, from which it derives its power via a 3-core cable.

The master control unit encodes and processes the signals from the receiver, accesses the required attenuator(s) and then makes such changes as instructed. Limited user controls are also provided here; Standby, which sets the system to maximum attenuation; Default, which sets the attenuators to a fixed known reference value; Reset, which returns the system status from either Standby or Default condition to a previous setting. Being based on a *Z80* microprocessor the control unit carries the software in EPROM. All operational software and data upon turn on is down loaded into battery backed up RAM, this ensures that operational data and settings are retained even when the mains power is disconnected.

Delta-G transmitter.

Each attenuator module consists of eight audio channels. The control of the individual channels is effected by means of a daisy chain bus carried on a ribbon cable connected between the master control unit and each attenuator module.

The digitally addressed attenuator integrated circuits provide attenuation which is monotonic in the range 0-60 dB in 0.375 steps, although the software is configured such that one quantum step is in fact



The Delta-G system interfaces with the sound system at the input to the power amplifiers and leaves the sound engineer free to control sound levels from within the audience.

3 × .375 dB (approx 1 dB). Software can be adjusted such that one step equals N × 0.375 dB depending on requirements.

Including a terminal in the system allows the operator to adjust some of the parameters, eg group allocation and gain quantum steps, together with the ability to be able to 'save' channel and system settings for recall when required.

Earls Court

At the time of writing there is only one such system in operation, although by the time the article is pubished there will be more. The one operational system is installed in the main arena of Earls Court where it has been integrated into their extensive public address system. The Earls Court sound system was installed in 1976 and consists of approximately 75 loudspeakers distributed throughout the arena area driven by 42 power amplifiers. The system also includes two Midas mixing desks and a Lexicon digital delay unit, together with the usual graphic equalisers and compressor limiters. Although used mainly for seated arena events, the system also augments the original 100 V line distribution system which was installed circa 1935.

Acoustically Earls Court is uncompromising, the reverberation time is around 5 s and with a volume of approximately 1.5×10^6 ft^3 the critical distance (at 500 Hz) for an omnidirectional source is in the region of 20 ft; this would increase to some 50 ft taking into account the assumed directivity (8.0) of the distributed column loudspeakers.

However, since the system comprises many sources, the critical distance will further reduce if the (N-1 sources are considered to add to the reverberant field only and not contribute to the direct component. This means that the output balance of the system is critical if an acceptable level of articulation is to be maintained. Add to this two further complications: firstly that the output requirements for each zone differs not only from event to event, but from day to day; and secondly that the power amplifers are situated in a room on the top floor. The result is that the sound engineer has, a not necessarily serious, but definitely irksome problem.

During the spring of 1983, a 48-channel *Delta-G* system was installed; 42 channels were dedicated to the main system which left five spare to be used as required.

The first event after installation was the Royal Tournament. This is a notoriously difficult event since not only is there a wide range of 'ambient' sound levels generated by the individual events within a single show, but the PA set-up relies heavily on the absorption afforded by the audience. Unfortunately attendance varies unpredictably so last minute changes to the output of the system are required. In previous years, the sound engineer has had to make numerous frenzied dashes to the amplifier room to make these adjustments, and not surprisingly the balance of the system was rarely optimised. During the 1983 show with the aid of the *Delta G* system the sound engineer was able to make such adjustments that were necessary from the seated areas, and if the number of complaints is taken as representative of the sound quality and intelligibility, then 1983 was a considerable improvement over previous years.

That is not to say that there were no complaints, with some 293,000 people in attendance over a 19-day period, some adverse comments must ensue. However, the sound engineer was able to respond in a very short time, and in the presence of the complainant, adjust the level either up or down as necessary. As a public relations exercise it was impressive. At the end of each day the Earls Court sound engineer was able to compare the day's sound balance with the previous stored setting and interpolate to a best guess for tomorrow. No records were kept but it was generally felt that the level of complaints reduced as the week progressed.

Later in the year at the Garage Equip and Auto Equip trade show, last minute arrangements were made to allow Linda Chalker MP, Minister for Transport, to open the show. The area to be covered was not precisely defined and hence the output levels of the system could not be set, furthermore the engineer had no idea how loudly or how softly the speaker would speak, as there was no rehearsal.

A very effective solution was found, the engineer used two Beyer *S185* UK radio mics which were patched through two spare channels on the *Delta-G* system, he was then able to stand with the audience and turn the system on, making the required adjustments to the relevant zones, the only complaint was that he was unable to EQ the system at the same time.

Future

Looking to the future, Spectrum have discovered a novel way of providing sound effects from the system. The output of the receiver section provides the master control unit with commands and data in audio form, to which it responds and acts accordingly. Using a 2-track tape recorder with one track providing the music or effect, the other track can be used to record the data sent to the master control unit. In this way, it would be possible to manually arrange for a sound to travel around the arena, and then using the data track on the recorder, input that signal into the *Delta-G* system such that a specific effect could be played on demand.

Not perhaps the most sophisticated method of producing an effect, but certainly simple, reliable and very effective.

With regards to additional facilities, an EQ module would prove extremely useful, and in fact Spectrum have indicated that one will be available shortly. The ability to easily change group assignments and quantum steps would also prove very useful, and this facility will be added to later units.

Finally, it is worth mentioning one of *Delta-G's* most useful attributes; both the terminal keyboard and the remote wireless transmitter can be disabled, and only reactivated by a private code: very frustrating for inveterate knob twiddlers! □

LETTERS
LETTERS

Letters should be marked 'For Publication' and sent to the Editor at the Croydon address on page 3

Thank you...

Attn: Studio Sound
Many congratulations on a superb analysis of the British studio situation, editorial Feb issue. It is excellent reading and I hope it is well digested and acted on by all the studio people concerned.
Regards John Burgess, Air Studios, London.
(Taken from Telex message.)

...and goodnight

Dear Sir, Re your editorial November 1983 you may call yourself professional—I'd add cloth-eared big mouth to that.
Nevertheless, regards.
Yours faithfully, Mr Faccioni, Corrado Faccioni, Via Morigi, 2, 29100 Piacenza, Italy.

Soundfield stereo reply

Dear Sir, I've just read Gerald Reynolds' letter on my Soundfield/*stereo article and am delighted that he considered it worth commenting on. I agree more than I disagree and would consider most of our differences to be matters of taste, temperament, and fine tuning.*
I too spend a lot of time listening to Ambisonic reproduction, directly from B-format, and find it more satisfying in every way. In a sense I too can't stand stereo, just as I can't stand mono. On the rare occasions when I hear periphonic, I can't even stand Ambisonic. And sometimes, after a good concert in a good hall, I can't stand recordings of any description.
But as a recording engineer I try to identify with the great majority of music-lovers for whom stereo is the best system they'll ever own. According to my taste, stereo not only allows but demands a closer perspective than Ambisonics for the same apparent clarity. This, I'm convinced, is the most important conflict between the two systems.
Clarity is determined by perspective as well as 'presence' and is therefore an aspect of form. It includes being able to hear what (and where) the musicians are playing, but without exaggeration. In a recording, which you listen to again and again, everything *should be detectable if you want to look for it (sometimes you do). All the classical composers and performers I work with demand clarity. They write and play well and they like the result to be heard, even in large ensembles. Performance standards have improved enormously in recent years; it is no longer necessary to bury imprecision in soft-focus recordings. In the long history of music, only a fraction of the 19th century has exalted the deliberately amorphous. Even the French impressionists were rigorously exact. Blend and separation are aspects of the musical experience, not irreconcilable alternatives.*
It's certainly true that, to achieve a good Ambisonic balance, one must monitor Ambisonically. This is also true of stereo: should the great mass of stereo listeners be fobbed off with a random by-product? The BBC quite rightly declares a responsibility even to its mono listeners (a responsibility which the Soundfield *would admirably honour). One shouldn't be motivated merely by one's passion for sophisticated equipment, however superior. For instance, a perfect periphonic recording of a Gabrieli canzoni, with a 3-dimensional configuration of ensembles, might be confusing when squashed flat into an Ambisonic monitoring system. The lofty dismissal of stereo (and, by implication, its benighted listeners) can be a dangerously elitist attitude. One needn't descend to the 'granny's tranny" level to give the average stereo listener a fighting chance.*
Ultimately I look forward to the demise of the recording engineer's dictatorial powers. On that happy hypothetical day when domestic B-format recordings become available, our little debate will be a quaint fragment of history.
Yours faithfully, John Whiting, October Sound, 24 Old Gloucester Street, London WC1.

Industrial psychology

*Dear Sir, For G P Wayne (*Studio Sound, *January, 1984) to maintain so vehemently that the industrial psychologist has nothing to offer which might possibly be helpful to the sound engineer is really for him to say that* he *can think of nothing, and that is rather like the motorist who will not call out the AA because* he *can think of nothing the patrolman might do to make his car go again.*
He tries to make his point by means of a non-sequitur 'Neither can training be subject to this formalisation for people learn at dissimilar speeds and in different orders, given the opportunity.' (But why should a formal training scheme be unable to cope with different speeds or orders?); by false inference 'These problems point towards "on-site" instruction where the practice of the craft is made relevant by actual product, not hypothetical ones.' (But what makes him think that industrial psychologists do not believe in experience of actual work as an appropriate element of training?—their own training includes it.); and by false dichotomy '...where should our priorities lie; towards efficiency, and consistency between batches like our conveyor-belt schooling of children, or to promote the individual exercising of creativity, choice and responsibility?' (But why should creativity, choice and responsibility always be inefficient?).
This last confusion seems to lie behind all of Wayne's objections. There is no logical reason for his supposing that because an activity involves creativity or artistry, no formal procedures can improve its performance. Far from limiting creativity, proficiency increases time for experimentation, adaptation and exploring alternatives. Similarly, even if the psychologist could help only with manual skills, this could enable the sound engineer to achieve his own artistic goals (which the psychologist, of course, could never imagine!) with greater assurance.
The industrial psychologist is trained to study human behaviour at work and that behaviour is always complex because if it were not then a machine would do it. The sound engineer's job is certainly complex but this does not mean that every aspect of it is forever impenetrable. It seems likely that psychologists have something to offer: will they be given the chance?
Yours faithfully, Martin Crawshaw and Gerard Hodgkinson, Ergonomics Research Group, Department of Psychology, University of Hull, Yorkshire.

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LIVE SOUND EVOLUTION

Over the past 30 years live sound systems have changed according to musical fashion. Stephen Court considers the UK angle.

To discuss the history of live sound systems is, for all intents and purposes, to discuss the history of popular music, since they really both started at the same time. A study of their evolution occasionally leads one to consider how the course of events of one, was directly related to the progress of the other. If any doubt exists as to just how popular music started, or rather at which point in time you draw the line, then it is easiest to look at the history of music sound reinforcement and consider that the start of it really represents the beginning of rock music as we know it.

Obviously, sound reinforcement systems have been used for many years, but the development of live performance systems really began with popular music when rock and roll was introduced. The starting point for that was the transition from semi-orchestral backing in the early '50s, to the three or four piece bands. It is difficult to say which actually started first, but skiffle rather than pure rock and roll was the first time that popular music could equally be played on a low budget amateur basis. That was a relevant point; since skiffle could be played by virtually anybody who had mastered three chords; the huge guitar and sound equipment boom in the mid '50s was a direct result of that.

A typical line up was two acoustic guitars, a home made string bass and washboard percussion. Such was the natural acoustic level of those instruments, that the two or three part vocals were easily amplified by the room gain of most reverberant venues.

The transition from skiffle to rock and roll, by British artists such as Lonnie Donegan whose band structure really came from the traditional jazz bands, carried over to artists such as Tommy Steele et al playing at the Two I's in London's Soho. Skiffle groups started to include electric guitars, and the natural progression to real drum kits rather than washboards, meant amateur groups instantly achieved 'rock group' status with a proliferation of cover versions of numbers by artists such as Buddy Holly, Gene Vincent, Jerry Lee Lewis and all their contemporaries who started the rock and roll boom in the late '50s.

On the hardware side, one conjures up some magic names like the Hofner *Committee*, the *Solid Seven* and a host of other electric guitars which could be purchased for a few pounds. The amplifiers of the day ranged from the Selmer 15 W to the ultimate in professional equipment, the proverbial Vox *AC30*, giving a thundrous 30 W when used with an EMI 13½ × 8 in speaker and the like.

The existence of drums and guitar amplifiers naturally brought the overall sound level on stage to the point where the vocalists also required amplification. They first used the guitarists' amplifier and speaker systems, before adding vocal columns to the bands list of equipment. Names like Charlie Watkins with his Watkins *Dominator*, and Tom Jennings with the Vox *AC30*, the Selmer *Truvoice* and the Fenton Weill/Jimmy Burns combo, were all in at the start of live performance systems from the mid '50s to the early '60s.

For obvious reasons, at this stage, there was still little difference between what we now know as back line equipment and PA equipment. The Beatles used banks and banks of *AC30*s at their Shea Stadium concert, and the first real rock concert using a 1,000 W WEM sound reinforcement system was the Windsor Rock and Jazz Festival in 1967 with artists like Ten Years After, Nice and the Moody Blues. Although that was nearly a decade after Duane Eddy and Bobby Darin appeared at the Lewisham Odeon, a London cinema in 1959, sound equipment had hardly changed during that time.

One year later, 1968 saw the first fully professional sound reinforcement system as we know it today—at the Woodstock Festival in New York State. Vast arrays of speakers were used, and they too came from the cinema orientated industry. Not surprising since cinemas were used to filling large auditoriums with valve amplifiers in the region of 15 to 50 W, monstrous as they were, that sort of power meant the speakers had to be efficient. A typical horn loaded mid-range system can achieve efficiencies of around 110 dB at 1 W 1 m, whereas a typical efficiency for a cone speaker system is in the region of 85 dB for the same input. Dispersion apart, in real terms, it means that a horn loaded system for creating say 110 dB at 100 ft is not unusual. The same SPL with conventional speakers would require an input power of around a ¼ million W—so horns reigned!

Still the major problem with live performance was one of balance rather than anything else, and little had been done to improve the overall sound quality. As the sound level went up, so did the distortion, simply because there was no better equipment to handle it, and mass produced speakers in plywood boxes did little if anything to improve matters. Right up to 1969 major artists like The Who still used a handful of vocal columns, and a pair of WEM *Audiomasters* on stage.

I was working for the BBC at that time, and the sound level was so high, the only way to reproduce it was to use the ambience mics in the orchestra pit. I remember commenting to Pete Townshend that the use of an off-stage mixer with a sound engineer could be a considerable improvement. I shall never forget the look of horror on his face at the thought of having somebody other than a musician 'do the sound'.

The first chance to actually try a professional audio system—ie a revamp of studio equipment combined with speakers originally intended for cinema work—came in the early '70s, when a chance meeting with a band from my old Advision days, called Head Hands and Feet. Naturally most people involved in those 'pioneering' days had their own version of this, since nobody actually 'invented' the idea, but this particular band comprising musicians like Chas Hodges and Albert Lee, were playing at the Marquee, and I managed to persuade them—they had the same reservations as Pete Townshend—to try an off-stage mix. We still used the ubiquitous *Audiomaster*, but with banks of bass cabinets, horns and 'bullets'—a 3-way system.

Shortly after this, another group of studio engineers from Manchester were doing the same thing with a band called Hot Legs. This time they actually used a studio mixer out in the auditorium. The technicians eventually called themselves Formula Sound, and the group renamed themselves 10cc.

The progression to larger and larger systems using essentially studio desks and amplifiers, with massive RCA and JBL horn enclosures from the cinema days, led to more and more expensive set ups, that became prohibitive to even major groups. As a direct result, hire companies came into the field, and the concert touring business underwent a huge boom in the early '70s.

International Entertainments was one of the biggest, and led by Dave Hartstone whose stock until then comprised a stack of Marshall speakers and a few Hammond organs. At the peak of his company's activities, IES were doing around 14 concerts a week—an incredible amount of equipment when you consider bands like ELP went on tour with a staggering 36 tons of sound equipment.

Other entrepreneurs soon realised that PA was big business, and set up their own hire outfits. Ricky Farr started what is now known as TFA Electrosound, with a 3.2 kW rig comprising JBL *4560* bins and horns. Joe Brown who up until then had been hiring out guitar speakers with Jimmy Marshall's son, formed what is now known as Tasco, and Claire Brothers in America followed suit.

Essentially, all these companies used roughly the same equipment and the only limitations were the abominable acoustics of most concert halls combined with the short time they had to set up. Occasionally deviations from the standard 3- and 4-way systems appeared on the market, such as the Grateful Dead system which attempted to combine the individuality of back line equipment, with the advantages of large stacked systems. The result was literally hundreds and hundreds of small cone speakers and HF drivers in dispersive arrays stacked over the musicians. The system worked reasonably well, but as one can imagine when stacking what is virtually tons of hi-fi speakers, the dispersion was an engineer's nightmare.

To say a battle existed at that point is something of an understatement. The people controlling these systems came from totally different backgrounds, mainly from the major recording studios and the guitar amplification field. Their views were as different as their experience was—and that situation still exists to some extent today. The majority of equipment still emanates from those companies who made their name in recording equipment, and the crew from the 'back line' industry.

The result was usually total overkill, with huge sound systems that could often be reduced by 50% or more. The fact that such high levels of sound only served to agitate even more, the reverberant acoustics of concert halls, combined with the fact that as the speakers were driven harder, their voice coils heated up, with the result that their impedance rose proportionally, and the total power actually went down.

Any attempt to reduce the amount of equipment on stage, was usually met with such

scepticism from the artists, that on some occasions bass bins were placed on the stage without being connected, just to make them visually impressive. The overkill combined with the proliferation of second hand hire equipment led many bands to building their own sound systems and the reduction in large concert touring systems.

Overkill is still a problem in many cases as the entertainment at a recent dinner for this industry at a well known London hotel demonstrated. A major touring system company, had kindly loaned the sound system which had really been intended for a major rock concert in a large stadium. Since that was the experience of the technicians operating it, the small ballroom was literally stacked with equipment.

On the drum kit went nine mics which were totally unnecessary for that size of room. As a result, in order to overcome the sound level, the vocalists were turned up until they were excruciatingly distorted, and since the band could no longer hear the back line, they were provided with banks of monitors from another huge mixing console which only managed to increase the racket by adding even more distortion combined with feedback.

In such conditions, a drum kit can easily produce sound levels over 110 dB, so the 2 × 12 in and 2 × 15 in speakers in the back line would have had no difficulty in matching that, and the only reinforcement equipment necessary would have been a simple vocal microphone mixer with a couple of stand speakers to balance the band.

I recall being asked to sort out the sound problems of a band performing in what was virtually the back room of a pub in North London. The 'engineer' had a 16-channel desk about 3 m from the musicians, and the lead guitarist's 6 × 12 in speaker cabinet was actually miked up with a dynamic mic dangling over the top of the cabinet. The result was the most horrifyingly distorted cacophony imaginable, and one sometimes wonders if these bands wouldn't be better off as they were in the early '60s with a good quality vocal system only.

Having said that, when you consider the work that goes into an outside broadcast or a mobile recording, the mammoth task of setting up a 20,000 W rig for one night, a major scaffolding job with around 15 miles of cables and over 2,000 connections, just for one performance, and on the same night to take the whole lot down, fly across country just to start all over again, it is a constant source of amazement to me that any sound at all comes out of the speakers.

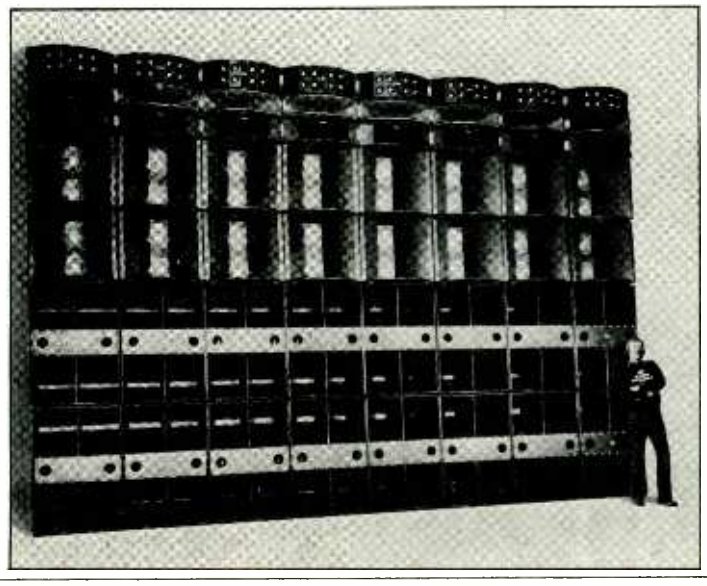
Attempts have been made to introduce 'in-house' systems to major rock venues, but these were invariably met with the 'devil you do know' syndrome and rejected for the equipment the band had hired anyway for the majority of their bookings.

This is an ironic point when you consider that a band will enter a recording studio, where they use the facilities in-house because the equipment and engineer are employed for their ability to create the sound required by the artists. There is no reason why that shouldn't apply in live performances, but experience tells us that nobody has yet managed to organise a custom built rock venue with any reasonable degree of success.

This is a strange situation when you consider the revenue generated by rock music compared with that of classical; where classical concert halls are still being built all over the world.

A 1,000 W WEM column system in use at the Windsor Rock and Jazz Festival in 1967

As used by Roxy Music and Pink Floyd during the '70s—a 20,000 W 4-way system



Even more ironic is the fact the classical venues such as the Barbican, have a reverberation time short enough for rock music, and most rock venues have a reverberation time only really suitable for orchestral music.

The point is that the shorter the envelope of a sound, the shorter the reverberation needs to be to reproduce it. In architect's terms, speech is the norm for short reverberation times, and yet a miked-up drum kit needs even shorter reverberation than speech if you want to reproduce the 'tight' drum sound of modern recordings. Of course echo can always be added electronically to drums, but a total contradiction of that is the increasing popularity of large reverberant rooms for drum recording in studios.

The universal acceptance of flying overhead systems does a lot to improve overall dispersion as well as reducing unwanted stimulation of bad room acoustics, and the benefits of increased power output by mutual coupling of overhead systems has considerably improved live performance systems over the last few years.

Another advancement following this, was somewhat surprising if you have followed the course of events over the last 20 years or so. With the change from full range cone drivers to 2- and 3-and 4-way horn systems, many designers attempted to make a full range speaker system in a single enclosure. Both in the USA and Europe, full range systems were launched on to the market, but were generally unaccepted by the live performance industry.

They worked well in principle, since they were in effect very powerful studio monitors—a logical approach. However, as soon as more than one unit was used, the dispersion became a problem simply because instead of an integrated stack of bass, low mid, mid-range and high frequency horns as with conventional systems, these full range systems had terrible problems with driver interfacing.

The full range cabinets rather died a death, and lay dormant for around 10 years. Following the popularity of flying overhead arrays, and record promoters' requests to 'tidy up' the vast stage stacks, many live performance engineers tried covering up the vast arrays with black cloth. A strange thing happened. Clients, audiences and bands alike commented on the apparent improvement of the sound quality.

We have noticed in studios, when setting up monitors, that with the grille cloths removed for alignment, comments were passed that 'the bass mid-range and treble weren't integrating'. Having returned from the lunch break or whatever during which time the grilles were replaced, this time comments were received that a great improvement had taken place.

The reasons for this are not altogether clear, but there does seem to be a psychoacoustic advantage of a single visual point source, rather than a vast array of drivers. Subsequently most major manufacturers of sound reinforcement speakers went back to full range cabinets, or at least two half-range cabinets to avoid dispersion problems, but still in the visual form of large studio monitors.

The change from sectorial and radial horns combined with acoustic lenses, to constant directivity horns, has done a lot to improve the overall dispersion of these systems, and represent the third generation of sound reinforcement speaker systems.

One likes to think that we have a long way to go in this field, but in reality little can be done until the acoustics of rock venues have been sorted out. There is little doubt that audience feedback does a lot to improve the musicians' performances, what a shame that cannot be combined with the sound quality of the recording studio.

The introduction of the Compact Disc means the public can now purchase a copy of the original studio master tape in a high street shop, and providing he upgrades his speakers, he can achieve the dynamic range of a live performance in his living room. The next step is to combine that quality with the stimulating experience of a live performance.□

POWER AMPLIFIERS

David Blair gives a short review of this ever-changing field

Of all the updating equipment features that have so far been prepared, power amplifiers is possibly the most difficult. This is simply due to sheer numbers—something in excess of 100 new models from such a diverse range of manufacturers that it is very difficult to keep track of individual models from every manufacturer. I therefore apologise in advance to manufacturers who are not mentioned as we restrict ourselves to a necessarily short form overview.

Aside from the large number of new power amplifiers introduced in the last year, there are a number of other interesting points. These new models are originating from manufacturers often well away from the accepted recording equipment centres of the world (Adyton from Norway and Perreaux from New Zealand); from manufacturers not normally associated with power amplifiers (Oberheim, Soundcraft, etc) and a wide range of specific application types.

There has been an increasing degree of specialisation in power amplifier design such that there are now dedicated power amplifier models for almost every possible requirement. Starting with the smaller end of the power amplifier market, both Sescom (*SH-1*) and Symetrix have introduced units specifically designated as headphone amplifiers being low power and compact units.

Careful design has allowed the production of single U rack mount amplifier designs of relatively high wattage that would not have been attempted a few years ago. One of the first units to be made in this size was from SAE but the *2B-LP* from Bryston actually has this point made in the literature, that it is only half the size of the original *2B* of which it is the operational equivalent.

Compact designs have no room for internal fan systems and therefore rely heavily on substantial effective heatsinks/fins. There is an increasing use of front mounted fins which makes great sense where units are to be rack mounted in such a way as to restrict convection cooling. In some units of a larger size these cooling fins are of such a size that they are turned into part of the cosmetic appearance of the power amplifier. A good example of this is the Studiocraft *F1* marketed through Bose UK.

It is perhaps this cooling aspect that is one of the few areas of differentiation between power units for live sound and studio use. There are very few units with fan cooling that are truly quiet enough for use within a monitoring environment. This is often aggravated by two speed fan systems where the change of speed can be very distracting. There are however some excellent amps for studio use with fans but such units will increasingly have to be silenced by distance or special racks to meet increasing monitoring requirement standards. In the live environment, the noise of fans is, within reason, less important and this has led to the development of a range of high power amplifiers with forced air cooling through internally mounted heat sinks. The change to fan systems that intake at the rear of the amplifier and exhaust at the front panel is fairly widespread now but I would like to see some figures to show the degree of difference between this and the reverse situation where the fans exhaust into the rear of the rack. If the rear of the rack has a suitable convection path for the exhausted hot air in the latter case I query the usefulness of rear intake where the input air temperature must be higher than the air in the front panel vicinity and therefore would not cool so effectively—or is this not the case? A completely different approach has been taken by live sound company Turbosound in a prototype power amplifier shown recently where the cooling system was based around horizontally rear mounted 'silvered fingers'.

While still on the subject of cooling, it is worth mentioning the *P-500* from The David Hafler Company which has MOSFET output devices and an automatic 3-speed fan system. In common with other Hafler products, this ▷

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POWER AMPLIFIERS

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There has been a large number of amplifiers originating from continental Europe, mainly Germany and France. These appear to be intended largely for live sound applications and are commonly available in a range of three or four output powers with maximum ratings of about 600 W/channel. As yet manufacturers such as Zeck, Bell, AMP, EMB, MAS, Power, 3xxx, Franck, PSS and Amix have been seen very little outside of their native lands but as the dollar fluctuates, this may change in the context of live sound.

Manufacturers moving into power amplifiers from other professional audio products usually are completing their overall product range. Good examples of this are Soundcraft with the *SA* range of Class AB amplifiers from 75 W/channel to 450 W/channel, and the D&R 2-channel 240 W unit recently introduced. Most unexpected was the *Model 700* from Oberheim, the US synthesiser manufacturer. Designed as a live sound unit, it can deliver 200 W/channel into 8 Ω.

Yamaha have a new range of units that may or may not replace the established *P* series. The *PC* series feature an improved specification and the top model *PC5002M* 500 W/channel is their biggest unit yet. It is two separate power amplifiers within the same chassis including individual mains leads. TOA have also introduced a new range of live sound units with the top model being the *P300* model rated at 300 W/channel.

Fender is a name associated with the musical instrument amplification side of live sound for many years and their recent move into sound reinforcement has led to the introduction of two power amplifiers, the *2224* and the *2244* designed solely for live use. The *2244* is rated at 440 W/channel.

Peavey have introduced two new power amps in the form of the *CS-1200* and the *DCA-600*. The *CS-1200* is a larger version of the established *CS-400/800* amps with a rating of 600 W/channel into 4 Ω. It is a two channel unit with very large front panel grill opening and LED metering. The *DCA-600* employs what Peavey describe as *Digital Energy Conversion* technology to optimise the transfer of electrical energy to the speaker under a variety of load configurations. It is rated at 300 W/channel, LED metering and display protection in a two U rack size.

Sunn have introduced the *SPL 6800* two channel power amplifier, a 275 W/channel unit with a digitally controlled sensing of amplifier error, output loading, and operating temperature. Again this is a dedicated live sound unit.

There have been a number of completely new manufacturers such as Rauch with the *X900* FET 250 W/channel; a range of MOSFET power amplifiers from Harrison Information Technology.

AB systems have added two new power amplifiers, the models *6220* and *9220* with outputs of 175 and 300 W/channel into 8 Ω loads with the usual AB Systems emphasis on ease of servicing. BGW have added broadcast versions of some of their smaller power amplifiers with improved RF protection and other features. They have also added the *Model 2125* as the first in a line of cost effective single channel units. It is rated at 110 W although can also operate with 25 and 70 V loads simultaneously.

FM Acoustics have introduced their largest power amplifier yet in the form of the *FM-1000*, a single channel unit following demands from customers for a unit of this size.

In the area of permanent installation systems, Millbank Electronics have added single channel 25, 50 and 100 W units to their *Talisman II* range as well as a low cost *E Series* 30 W model. Mustang Communications have introduced the *SS100S* which is a restyled version of the *SS100* offering a single channel output of 150 W in a 2U rack format with LED metering.

As was mentioned earlier, there have been some quite diverse power amplifiers introduced and the most extreme in terms of concept must be the Flutterman *OTL* output transformerless valve (tube) power amplifiers. These are mono units in a rack mount format with separate power supplies, also rack mount. The circuit design is the result of a fresh look at accepted valve technology and although this may sound a strangely cranky development, the brief listening experience that I have had of the *OTL* confirms that the unit has to be taken seriously and the interface between the amp and the speaker will tend to make speakers that previously may not have sounded to your taste sound quite different. Whether it is truer or not I can't say but certainly different.

Finally while on the topic of interaction between power amplifiers and speaker systems, one of the amplifiers that is gaining a lot of respect in some circles is the Crown *Delta Omega 2000*. On the purely power aspect it is capable of delivering a single channel of 600 W into 8 Ω. Included within the amplifier is the *Delta Omega* circuitry that evaluates the speaker cables, crossover network and speaker coils have on the radiated sound. The feedback from this monitoring allows the amplifier to compare the wave-form output of the voice coil with the amplifier input and correct non-linearities introduced by the load. There is also front panel control of the *Delta Omega* circuit and Crown say that it should be possible to adjust using one's ears only.□

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REVIEW

REVIEW

A high powered amplifier reviewed by Hugh Ford

YAMAHA PC5002M

The Yamaha *PC5002M* is a truly massive twin-channel amplifer which may be switched to twin-channel or bridged operation. Rated at 750 W/channel into 4 Ω or 500 W/channel into 8 Ω it can deliver 1.5 kW into 8 Ω in the bridged mode. This is an exceptionally heavy unit designed for rack mounting but equipped with good solid handles and feet. To the front all controls and indicators are recessed in addition to being protected by the handles at either side.

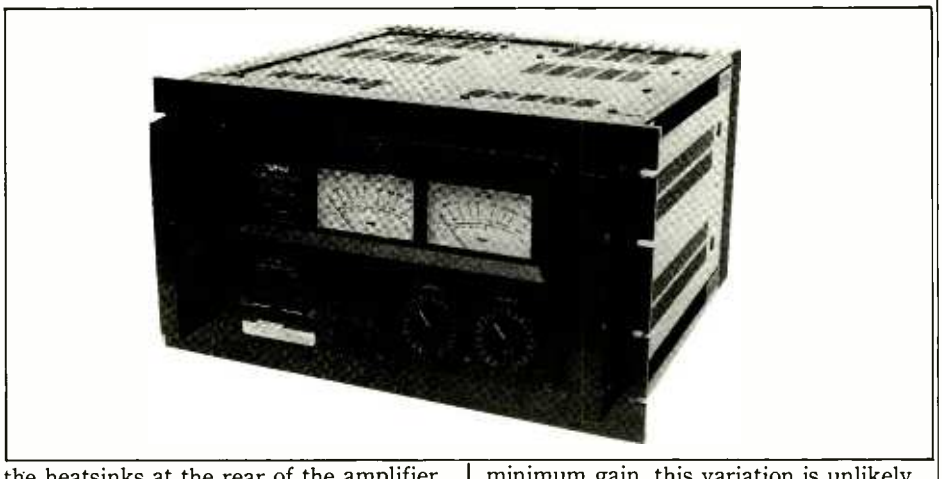
Two separate circuit breakers with power-on indicators control either channel with detented potentiometers controlling the gain in 1 dB steps down to −20 dB beyond which there is an off position. To the top of the panel twin illuminated meters with inbuilt clip LEDs are calibrated in decibels and power into 8 Ω for mono or bridged operation with the clear scaling having in excess of 50 dB range indicating from 10 mW to 1 kW in the mono mode. In addition to the meters, four warning LEDs are included behind a transparent panel. These indicate either thermal protection or electronic protection for each channel.

Between two finned heatsinks at the rear panel, the connectors and controls are well protected from mechanical damage. A peculiar feature is twin fixed power leads both of which are about 3 m long. Above the power leads a screw terminal strip underneath a transparent cover provides the loudspeaker connections which are clearly identified.

The audio inputs are electronically balanced at a screw terminal strip in addition to two *XLR* connectors for parallelling amplifiers. Three recessed screwdriver operated slide switches allow pin 1 of the *XLRs* to be grounded, insert subsonic filtering in both channels and switch the unit between twin-channel or bridged mode operation.

The construction is in the form of a thick alloy front panel which is attached to the rear heatsinks by four heavy alloy sections forming the corners of the amplifier. Joined to these are the light alloy sides and the steel top cover which has rather large ventilation holes. It is thus possible for debris to fall on to the printed circuit boards located horizontally below the top cover.

Separate power supplies for the two channels occupy the base of the amplifier with the audio output boards and their multiple output devices are secured to the heatsinks at the rear of the amplifier. Two driver boards locate horizontally below the top cover together with a single further board dealing with the input buffering of both channels.



Very good quality boards and components are used with everything being clearly identified and interconnections made via ribbon cables with pin connectors. The service manual includes full adjustment procedures, exploded diagrams of mechanical parts and a full circuit plus printed circuit board layouts.

Inputs and outputs

The input impedance varied from 49.3 kΩ at maximum gain to 65.4 kΩ at minimum gain, this variation is unlikely to be troublesome in view of the high impedance. Common mode rejection was excellent at low frequencies as shown in **Fig 1** for the two channels which differed by about 7 dB.

Input sensitivity for driving 500 W into 8 Ω was 1.766 V with the two channels matching to better than 0.05 dB at maximum gain. The 1 dB steps of the input attenuators were accurate resulting in a match between channels at any gain setting to better than 0.1 dB.

At the outputs the terminals were on the small side for large loudspeaker cables even in the form of bare wires and the fitting of eyelet tags was impossible.

Fig 2 shows the modulus of the output impedance in relation to frequency with the impedance being 15 mΩ up to 5 kHz offering a damping factor in excess of 500 related to 8 Ω.

Frequency response and noise

The overall frequency response from 2 Hz to 200 kHz at 1 W into 8 Ω is shown in **Fig 3** with the highpass filter in and out of circuit. At the high frequency end the −1 dB point is at 71.5 kHz falling to −3 dB at 106 kHz for both channels. Without the highpass filter the low frequency −1 dB point was around 0.1 Hz increasing to 10.5 Hz with the filter in circuit with the −3 dB point at 6.9 Hz.

Noise was measured for both channels at maximum gain with the input shorted, minimum gain and the worst case which occurred at −10 dB gain, the former two cases giving identical results (**Table 1**).

It is to be noted that the actual noise performance was excellent but that hum degraded the unweighted figures ▷

MANUFACTURER'S SPECIFICATION

Power output level: 0.003% THD, 20 Hz to 20 kHz stereo, 8 Ω 500 W + 500 W; 0.01% THD, 20 Hz to 20 kHz stereo, 4 Ω 750 W + 750 W; mono (BTL), 8 Ω 1500 W; mono (BTL), 16 Ω 1000 W.
Power bandwidth: 0.1% THD, 8 Ω, 250 W 10 Hz to 100 kHz.
Input sensitivity/impedance: 8 Ω, 500 W 1.73 V (+7 dB)/25 kΩ.
Frequency response: 10 Hz to 100 kHz, 8 Ω 1 W +0 dB, −3 dB.
Filter characteristics: subsonic 7 Hz, −12 dB/octave.
S/N ratio: IHF-A network, 8 Ω 122 dB.
Total harmonic distortion: 8 Ω, 250 W, 20 Hz to 20 kHz <0.003%.
Intermodulation distortion: 50 Hz + 7 kHz mixed, 8 Ω, 250 W <0.002%.
Damping factor: 8 Ω 1 kHz 500.
Power requirements: AC 120 V 60 Hz (U); AC 220/240 V 50/60 Hz (E).
Fuse: 15 A 250 V (U); 6.3 A 250 V (E).
Power consumption: 450W/channel (U); 350 W/channel (E).
Dimensions (w × h × d): 482 × 264 × 441 mm (19 × 10⅜ × 17⅜ in).
Weight: 61 kg (134½ lb).
Manufacturer: Nippon Gakki Company Ltd, Hamamatsu, Japan.
UK: Electromusic, 89/97 St John Street, London EC1M 4AB.
USA: Yamaha International Corp, PO Box 6600, Buena Park, CA 90620.

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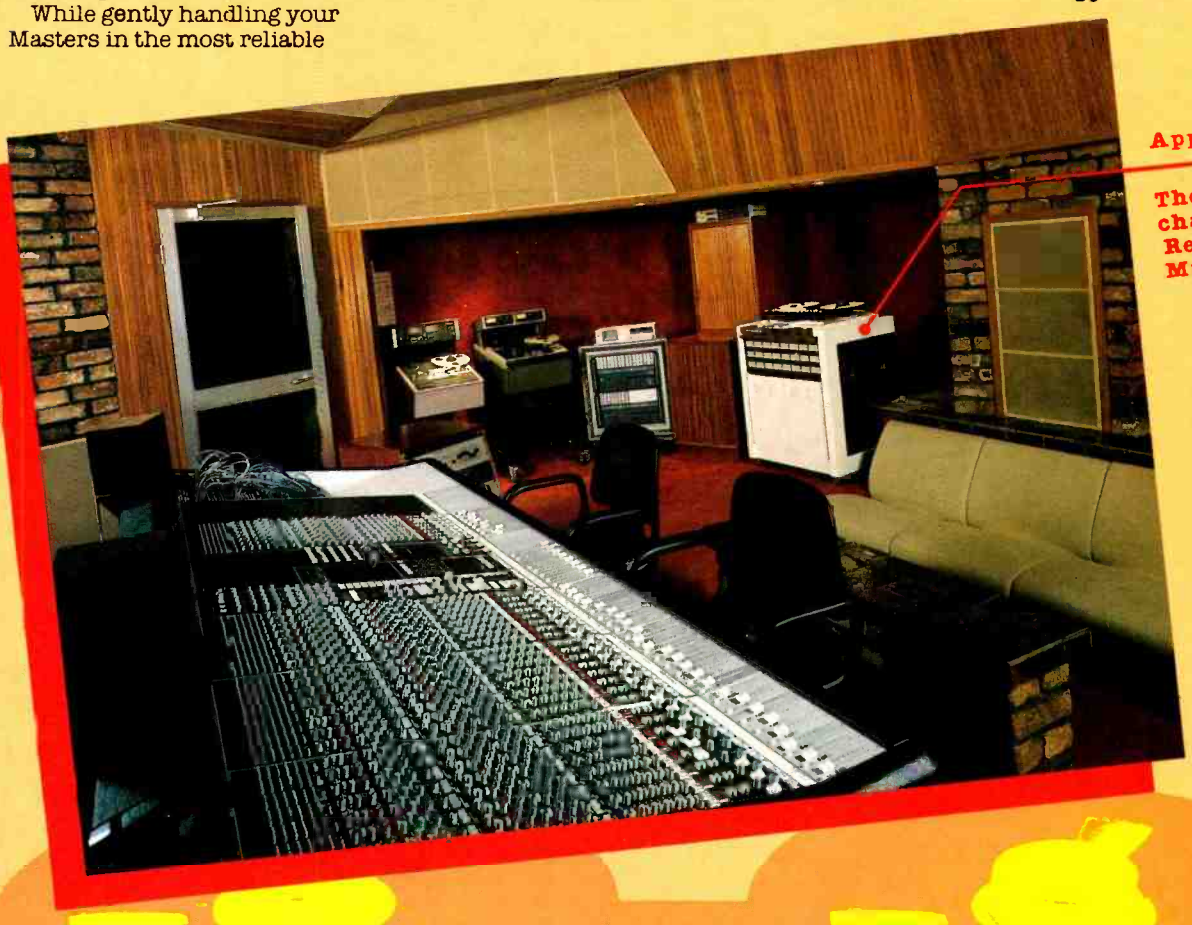


Application:

The MTR-90 Multi-channel Master Recorder for Music Production

severely at −10 dB gain setting. Fortunately the main hum component is at 50 Hz where it is subjectively less serious than at higher frequencies when the hum components were in excess of −100 dB.

Power output and distortion

Power output at the onset of clipping at 1 kHz was measured into 8 Ω, 4 Ω and 2 Ω, the latter being half the rated load which may be approached by some nominally 4 Ω loads. Whilst the amplifier had a rating plate indicating 220 V operation in the UK, it would be used on 240 V supplies so it was fed with 240 V stabilised within ±0.5%. At 220 V the power output at clipping would be proportionally lower as the output section rails are not stabilised within the amplifier.

Even my precision forced air cooled load box continuously rated at 1.2 kW could not cope with this amplifier, further 1% aluminium housed resistors being brought into operation.

Both continuous power output and burst power output for 10 ms bursts every 100 ms were measured and found to be identical for both channels with one or both channels driven as shown in **Table 2.**

Judging from the above this amplifier can deliver a very considerable power into any likely load. Considerable current is drawn from the mains making a low impedance supply advisable as each channel draws 9 A when delivering 940 W into 4 Ω, hence the twin mains leads.

Total harmonic distortion plus noise was measured at various levels below clipping into 8 Ω and 4 Ω for the two channels and found to be consistently excellent at all levels, **Table 3** being examples at the rated output and at 1 W output.

The impressive figures, which are at times close to the instrument residual and often largely noise rather than harmonics are outstanding. Furthermore the distortion products were harmonic rather than crossover products which were virtually non-existent.

Individual harmonics were below 0.01% from 20 Hz to 20 kHz at any level below clipping into 8 Ω or 4 Ω, but time did not permit more detailed measurements and the harmonics are probably at far lower levels.

Intermodulation distortion to the CCIF twin tone method using tones separated by 70 Hz was below the instrumentation residual at any frequency up to 200 kHz for both channels at any level below clipping—that is below 0.005%—a truly creditable performance. Similarly

Table 1 Noise referred to 500 W into 8 Ω

Measurement method	Min/Max gain Left	Min/Max gain Right	−10 dB gain Left	−10 dB gain Right
22 Hz to 22 kHz RMS	114.4 dB	116.0 dB	86.2 dB	83.4 dB
A-weighted RMS	119.8 dB	120.2 dB	105.4 dB	102.4 dB
CCIR-weighted RMS	114.1 dB	114.4 dB	100.0 dB	99.1 dB
CCIR-weighted quasi-peak	106.5 dB	106.5 dB	88.4 dB	84.7 dB
50 Hz hum	118.6 dB	120.5 dB	86.8 dB	84.0 dB

Table 2

Condition	Power output
Steady state 8 Ω	600 W
Burst power 8 Ω	660 W
Steady state 4 Ω	940 W
Burst power 4 Ω	1110 W
Steady state 2 Ω	1800 W

Table 3 Total harmonic distortion plus noise

Output		100 Hz	1 kHz	10 kHz	20 kHz
500 W into 8 Ω	Left	0.0032%	0.0025%	0.0032%	0.0047%
	Right	0.0032%	0.0025%	0.0040%	0.0065%
1 W into 8 Ω	Left	Noise	0.004%	0.0039%	0.004%
	Right	Noise	0.004%	0.0037%	0.004%
750 W into 4 Ω	Left	0.004%	0.0027%	0.0044%	0.0075%
	Right	0.0038%	0.0027%	0.0070%	0.012%
1 W into 4 Ω	Left	Noise	0.004%	0.0052%	0.0054%
	Right	Noise	0.004%	0.0049%	0.0051%

FIG.1
YAMAHA PC5002M
COMMON MODE REJECTION RATIO

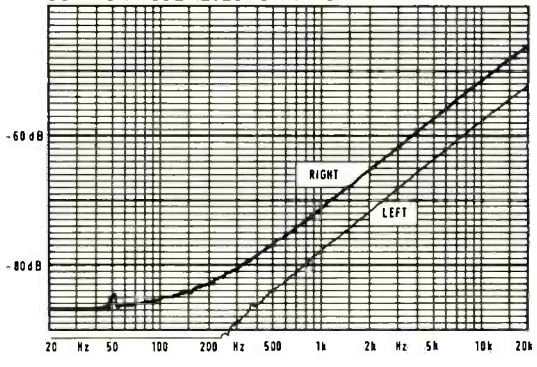


FIG.2
YAMAHA PC5002M
OUTPUT IMPEDANCE

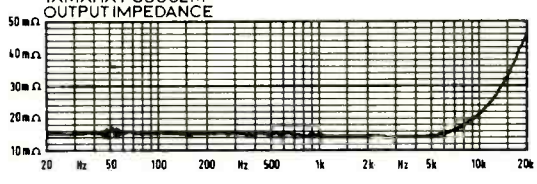
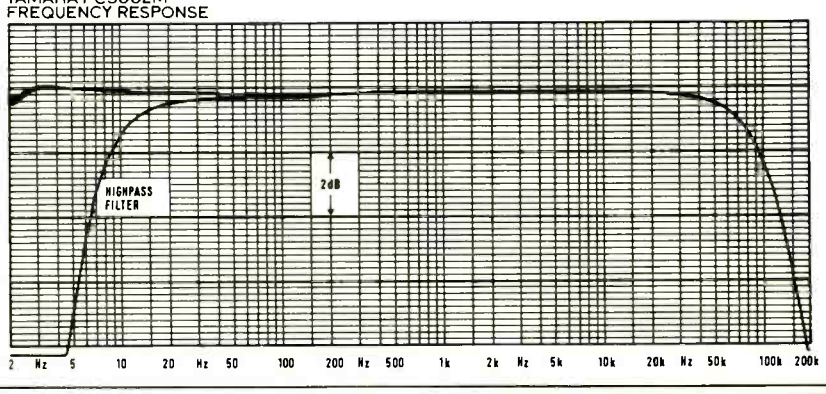


FIG.3
YAMAHA PC5002M
FREQUENCY RESPONSE



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The S30 Expander/Gate module sets a new standard in flexibility and quality. This module offers precise SLOPE control from 1:1 through the expander range (1:1.2 to 1:3) into the GATING range 1:4 (soft) to 1:20 (hard).

The RANGE control, whilst being manually set, will also vary automatically with the slope selected, according to the theoretical maximum for that RATIO. In the GATING modes a maximum of 60dB attenuation will be possible reducing to some 12dB on a slope of 1:1.2. The THRESHOLD can be varied from +12dBm down to —50dBm. In addition the SIDE-CHAIN can be pre-emphasised by up to 12dB in the HF or LF.

The ATTACK time has three switched positions giving 0.01mS(F); 5mS(M); and 40mS(S). The RELEASE time has a unique anti-log auto mode which speeds up as attenuation increases. The standard RELEASE ranges from 25mS to 4 seconds and incorporates hold facility which can be varied from out to 2 sec.

EXPANDER attenuation is indicated on a 60dB green bargraph with the first 10dB shown in single steps. The second ten segments working in 5dB steps.

S31 COMPRESSOR/LIMITER

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- ★ Side chain access
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- ★ Log/Lin release selectable

The S31 Compressor/Limiter is a dual function unity gain module which incorporates several new features.

A separate feed-back PEAK LIMITER can be moved by an indexed 20 position pot, over a range of 20dB from 0dBm to +20dBm. The Limiter has an auto attack and release function and operation is indicated by a single red led.

The feed forward compressor has linear RATIOS that can be continuously varied from 1:1 to 20:1. The THRESHOLD is an indexed 20 position pot and can be operated from +12dBm down to —50dBm (ideal for very soft slopes, 1.2:1 etc). RELEASE time can be switched to a LOG or LIN response. ATTACK time can be varied by a three position switch. (.03mS(F); 2.5mS(M); 25mS(S).

MAKE-UP gain is a 20 position indexed pot which will compensate for gain reduction from unity to 30dB of gain. The SYSTEM can be switched IN or OUT as well as the side-chain (SC) being routed to an extrenal equaliser. Gain reduction is indicated by a twenty segment orange led column with a range of indication from 0—60dB. Other features include a MASTER/SLAVE option which is switched on-board but with status indicated by front panel leds. This allows any one unit's MAKE-UP GAIN control to vary several units that are linked to it; thus simplifying stereo or four-channel operation. Control volt linkage for stereo operation is achieved by selecting STEREO link on the board.

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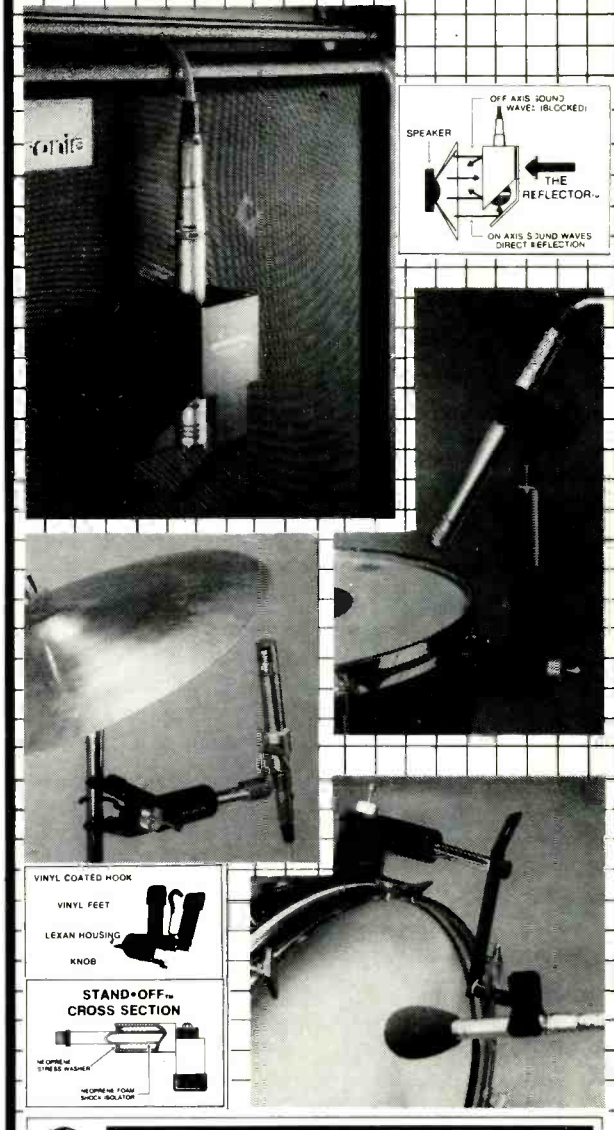

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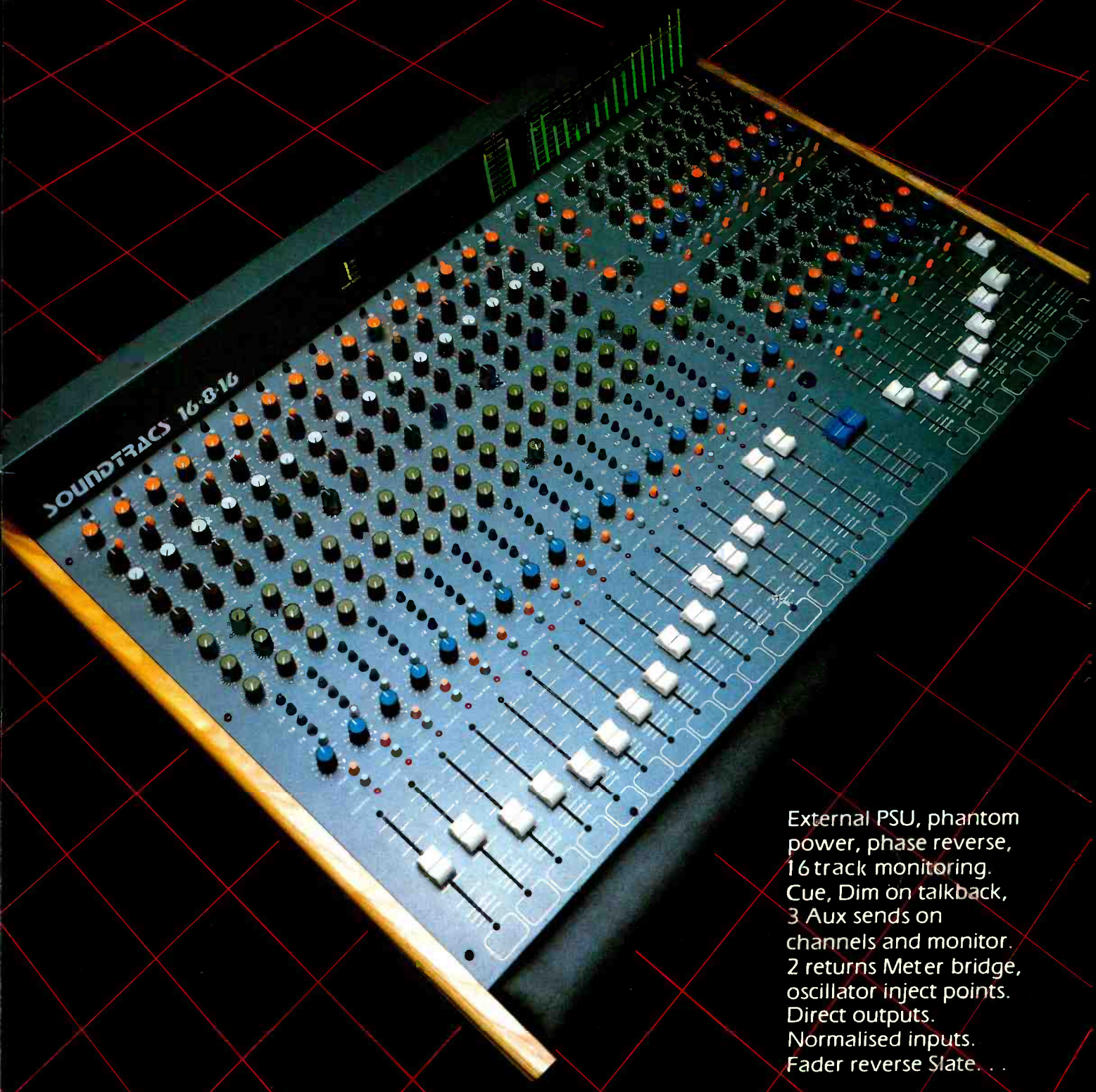

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intermodulation distortion to the SMPTE method using 50 Hz and 7 kHz tones mixed in a 4:1 amplitude was extremely good, being less than 0.004% at any level below the rated output into 8 Ω or 4 Ω.

Squarewaves at 1 kHz into 8 Ω in parallel with 2 μF overshoot as shown in **Fig 4** irrespective of level, the overshoot being on the large side. Rise and fall times were identical at 2 μs with the maximum slew rate being very fast at 55 V/μs.

Metering and indicators

The level meters provided an accurate indication of power into 8 Ω with the meters indicating waveform peak values. The rise time was reasonably fast at 10 ms with the fall time of 0.5 s giving good readability.

Within the meters the peak indicator LEDs were illuminated at the onset of clipping giving a useful indication on only 20 μs of clipping of a 10 kHz sinewave.

Asymmetrical overload if severe, operated the protection circuits as did full amplitude waveforms below 5 Hz. In operation the protection circuitry simply shut down the amplifier for a short time.

Other matters

Phase shift within the amplifier with or without the highpass filter is shown to be minimal in **Fig 5.** DC offset at the outputs never exceeded +3 mV, −1 mV with protection circuits operating if the DC in the output exceeded 5 V.

Crosstalk between the two channels was as shown in **Fig 6** being 110 dB at 125 Hz rising at 6 dB/octave.

Summary

The Yamaha *PC5002M* is an outstanding amplifier not only in terms of its drive capabilities, but also in terms of its really excellent performance. It is not often that amplifiers tax the best of distortion measuring instruments but this Yamaha certainly does.

In addition the standard of construction is very good with proper servicing information being available. Whilst no cooling fan is incorporated (they're always noisy) the amplifier ran reasonably cool under any conditions.

In short, if you want this sort of power in addition to a really excellent performance the Yamaha *PC5002M* fits the bill.□

FIG.5
YAMAHA PC5002M
PHASE SHIFT

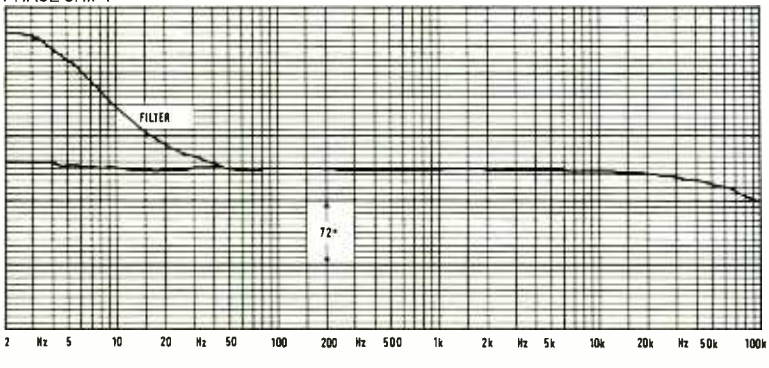


FIG.4

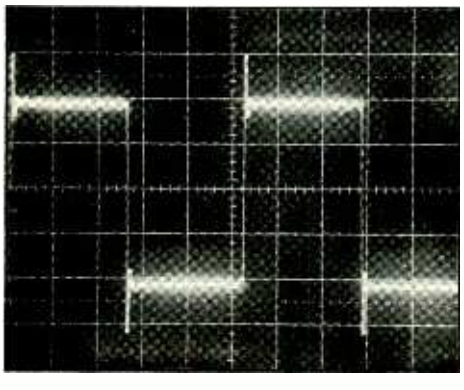
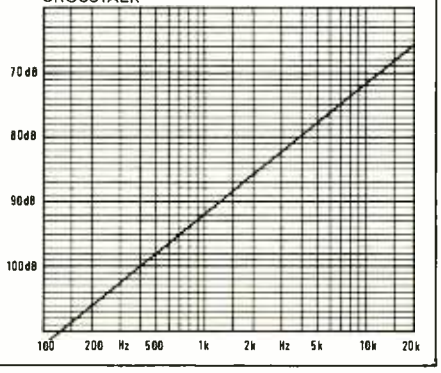


FIG.6
YAMAHA PC5002M
CROSSTALK



REVIEW

REVIEW

Hugh Ford looks at a TOA power amp

TOA P300D

The TOA Model *P300D* is a dual channel power amplifier which may be operated in the bridged mode. It is designed for rack mounting at 5 U in height and has two heavy duty handles.

Effectively the two channels are separate amplifiers each with its own power supply and on/off switch in the form of a magnetic circuit breaker at the front. LEDs above the circuit breakers indicate power on with three LEDs above the detented gain potentiometers indicating signal present, peak and protection in action.

To the rear of the unit the signal inputs take the form of unbalanced locking dual *XLR* connectors per channel for looping in parallel with dual ¼ in jack sockets. The power input lead is fixed and in the review sample did not have the correct UK colour coding.

Power outputs are at terminals/sockets on the standard ¾ in spacing with a removable link allowing the signal circuits to be isolated from the power line ground. Slide switches which may be mechanically locked allow the insertion of highpass filters in either channel with a third slide switch selecting stereo or bridged operation. An octal socket associated with each channel acts as an accessory connector.

Within the relatively lightweight steel case the two massive power transformers are mounted at the centre of the amplifier with the amplifier channels at either side of the case. The individual channels, which can be quite easily removed, are based on large alloy heatsinks, no ventilation fan is fitted and cooling is by convection through the sides and top of the amplifier.

Each channel consists of a large printed circuit board mounted on to the heatsinks plus a small board supporting the rear panel features. The boards are well made from good quality components but do not have identifications for servicing. Also the single 1¼ in fuses on each channel are not identified in value.

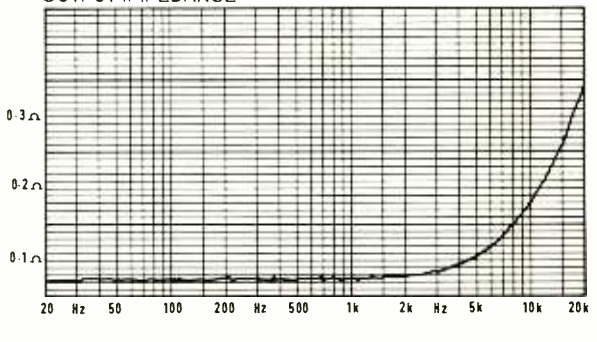
Generally the unit is well made and tidily wired with connectors, as opposed to soldered connections, which eases servicing.

Inputs and outputs

The unbalanced inputs had a sensitivity of 1.11 V for the rated output of 450 W into 8 Ω with the input impedance being 7.8 kΩ at maximum gain increasing to 9.9 kΩ at lower gain settings. At any ▷

MANUFACTURER'S SPECIFICATION
Power output: 300 W min sinewave continuous average power output per channel with both channels driving 8 Ω loads over 20 kHz bandwidth.
Frequency response: +0 dB, −0.5 dB, 20 Hz to 20 kHz.
Total harmonic distortion: less than 0.1% at 300 W, 8 Ω, 20 Hz to 20 kHz.
Intermodulation distortion: 0.03% using frequencies of 60 Hz and 7 kHz, mixed in a ratio of 4:1, at power output of 100 W into 8 Ω.
Input sensitivity: 1.23 V, 300 W into 8 Ω.
Input impedance: 10 kΩ (unbalanced).
Hum and noise: 109 dB below rated output (20 Hz to 20 kHz). 114 dB below rated output (IHF-A weighted).
Input connectors (per channel): male and female *XLR*s in parallel; pin 2 cold, pin 3 hot, and pin 1 shield; XLRs unbalanced and in parallel with two tip-sleeve (standard) phonejack.
Output connectors (per channel): standard ¾ in spacing, 5-way binding posts.
Indicators: green LEDs—signal presence; red LEDs—output clipping, circuit protection and thermal warning; green LED—power on.
Dimensions: (w×h×d) 19×8¾×18¾ in/483×222×475 mm.
Weight: 77 lb/35 kg.
Manufacturer: TOA Electric Co Ltd, Kobe, Japan.
UK: TOA Electric Co Ltd, PO Box 82, Castle Street, Ongar, Essex.
USA: TOA Electronics Inc, 1023 Grand Drive, San Francisco, CA 94080.

FIG.1
TOA P300D
OUTPUT IMPEDANCE



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REVIEW

FIG.2
TOA P300D
FREQUENCY RESPONSE 1W INTO 8Ω

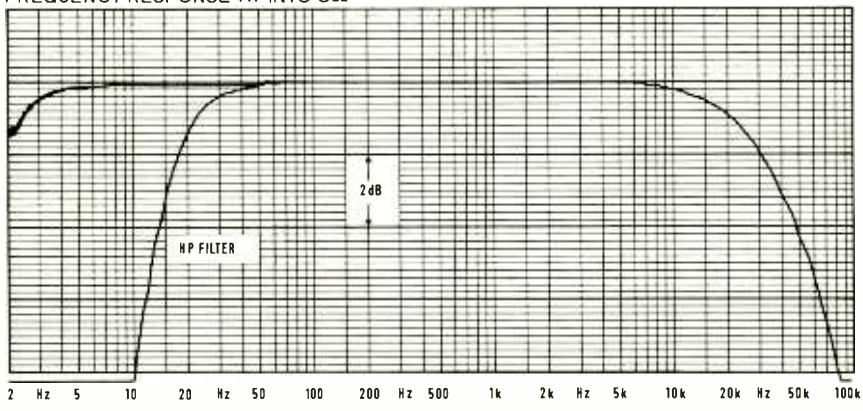

FIG.4
TOA P300D
HARMONIC DISTORTION 450W INTO 4Ω

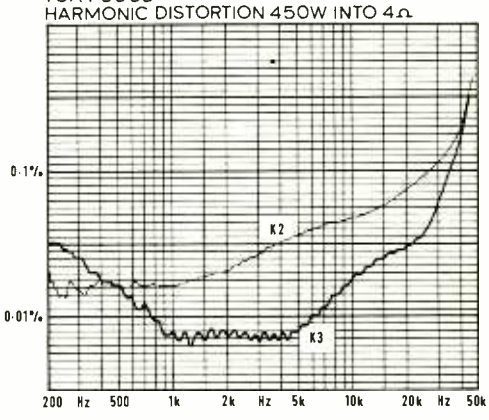

FIG.3
TOA P300D
HARMONIC DISTORTION 1W INTO 4Ω

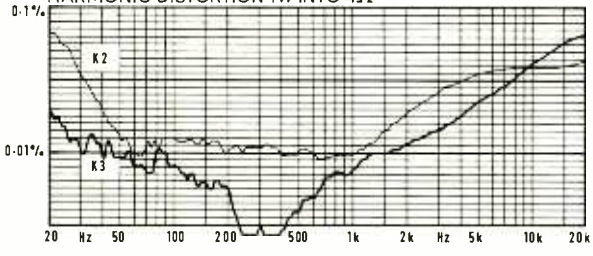

TABLE 1 Noise referred to 450 W into 4 Ω

Measurement method	Minimum gain Left	Minimum gain Right	Maximum gain I/P S/C Left	Maximum gain I/P S/C Right
22 Hz to 22 kHz RMS	98.9 dB	108.5 dB	84.9 dB	83.6 dB
A-weighted RMS	109.6 dB	112.6 dB	95.7 dB	94.5 dB
CCIR-weighted RMS	106.6 dB	106.6 dB	97.4 dB	96.0 dB
CCIR-weighted quasi-peak	102.4 dB	102.4 dB	90.3 dB	88.5 dB
CCIR-weighted arm	113.0 dB	113.5 dB	105.5 dB	104.1 dB
50 Hz hum	104.0 dB	108.5 dB	91.7 dB	90.5 dB
150 Hz hum	101.4 dB	127.0 dB	87.0 dB	85.3 dB

TABLE 2

Condition	Power output
Steady state 8 Ω	307 W
Steady state 4 Ω	520 W
Burst 8 Ω	400 W
Burst 4 Ω	720 W

TABLE 3 Total harmonic distortion plus noise

	100 Hz	1 kHz	10 kHz	20 kHz
450 W into 4 Ω	0.007%	0.011%	0.05%	0.11%
45 W into 4 Ω	0.009%	0.015%	0.054%	0.087%
220 W into 8 Ω	0.01%	0.0095%	0.03%	0.051%
22 W into 8 Ω	0.026%	0.011%	0.018%	0.033%

gain setting the balance between the two channels was within 0.1 dB with the detented potentiometers having nominal 2 dB steps which were reasonably accurate with the fully anti-clockwise position being 'off'.

DC offset at the outputs was always less than 1 mV with the damping factor being 160 referred to 8 Ω up to 2 kHz. The relation between output impedance and frequency is shown in **Fig 1**.

Frequency response and noise

Fig 2 shows the frequency response at 1 W into 8 Ω with and without the highpass filter in circuit. The highpass filter is sensibly a 12 dB/octave filter with its −3 dB point at 15 Hz and −1 dB at 20 Hz. Likewise the high frequency roll-off is well chosen being −1 dB at 20 kHz falling at 6 dB/octave to −3 dB at 38 kHz.

Noise in the outputs varied with the level control settings and also from channel to channel with power line hum and its harmonics being the main source of the variations as shown in **Table 1**.

Feeding the amplifier from a high impedance considerably reduced the power line hum components at maximum gain. Radiated noise from the power transformers was significant, but, probably not excessive depending upon the amplifier's location.

Power output and distortion

Using a stabilised 240 V AC supply and accurate instrumentation the power output at the onset of clipping was measured with steady state sinewaves and 10 ms bursts of 1 kHz sinewave. The results into 8 Ω and 4 Ω loads were indentical (see **Table 2**) for the two channels and there was no difference with single or both channels driven.

Total harmonic distortion plus noise was measured at spot frequencies at the rated power of 450 W into 4 Ω in addition to 220 W into 8 Ω and 10 dB lower with the results in **Table 3.**

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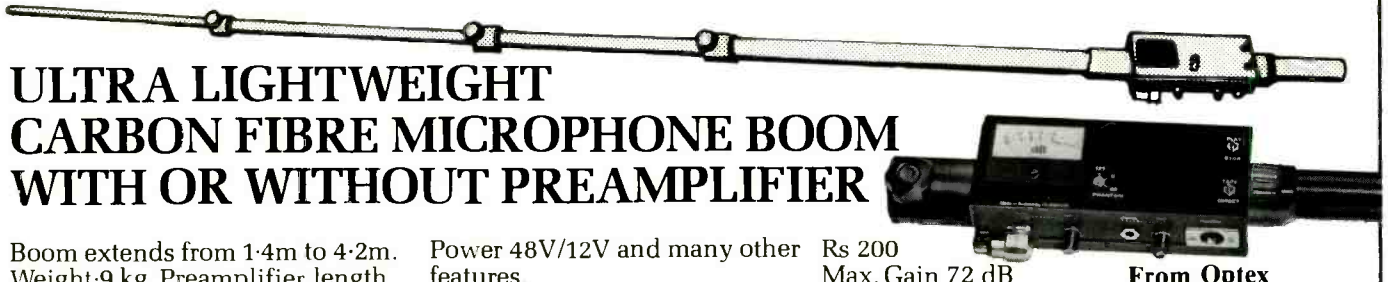

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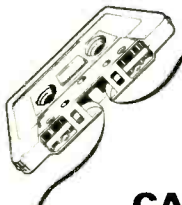

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The form of distortion was more harmonic than crossover products with both channels being similar except for the noise content as previously mentioned.

Fig 3 shows the individual second and third harmonics to be at a very low level at 1 W into 4 Ω with this pattern being followed at higher and lower powers. The situation at the rated output of 450 W into 4 Ω is shown in **Fig 4** (note different frequency scales).

Intermodulation distortion to the twin tone CCIF method using tones separated by 70 Hz was measured at the same peak equivalent levels and produced **Fig 5** and **Fig 6** showing a good performance but a significant increase in intermodulation distortion at high powers combined with ultrasonic frequencies.

Squarewave performance into 8 Ω in parallel with 2 μF was good as shown in **Fig 7** with the overshoot being independent of level below clipping.

The rise and fall times were both 10 μs for 10% to 90% amplitude with the maximum slew rate being 10 V/μs.

Other matters

Driving the amplifier into 10 dB of clipping with asymmetrical tonebursts showed that overload recovery was instantaneous without any transients or long term DC offset. It is however only wise to have the highpass filters inserted for loudspeaker protection in an audio system.

Crosstalk between the two channels was as shown in **Fig 8** which is more than adequate. **Fig 9** shows the phase shift with and without the highpass filter, no serious shift occurring within the audio band.

Power consumption was low when driving high frequencies at high levels as a result of which the amplifier remained relatively cool in operation.

The peak level indicators operated at clipping and were rather slow in operation requiring about 20 ms for a clear indication, they did however operate at true waveform peak with the signal indicator being illuminated at 200 mW output into 8 Ω.

Summary

As no information at all was supplied with the amplifier I may well have missed some of its virtues. Indeed I have no idea of the functions of the accessory connectors.

Generally the performance was good, but in some circumstances power line hum in the outputs may prove excessive.

This is a well made amplifier for rack-mounted use. I would however have reservations about its mechanical construction for mobile use. □

FIG.5
TOA P300D
IM DISTORTION 1W INTO 4Ω

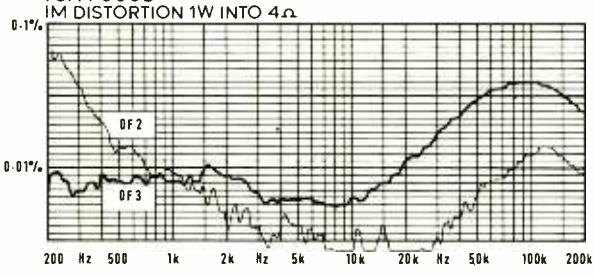


FIG.6
TOA P300D
IM DISTORTION 450W INTO 4Ω

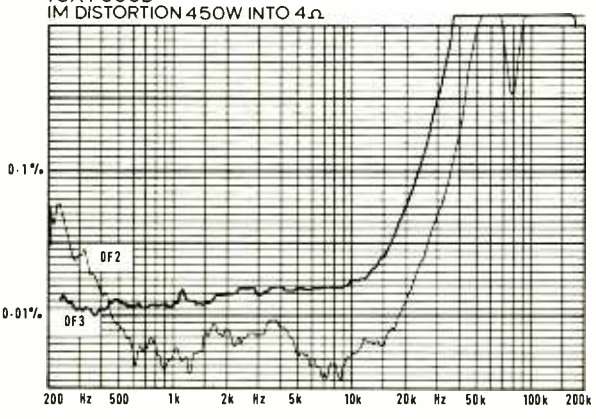
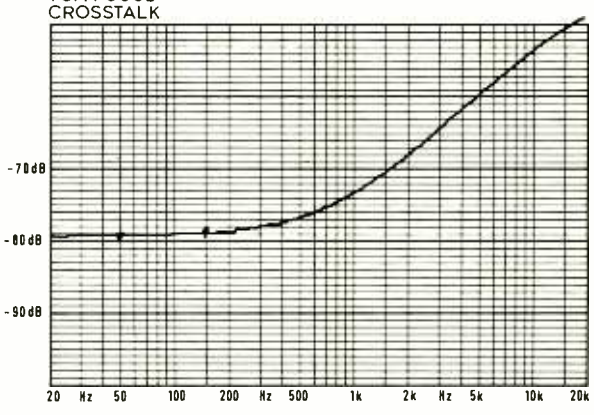


FIG.8
TOA P300D
CROSSTALK



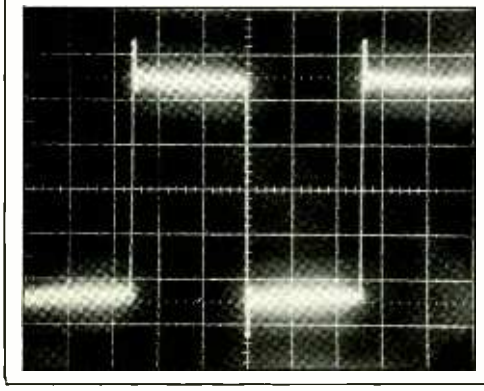
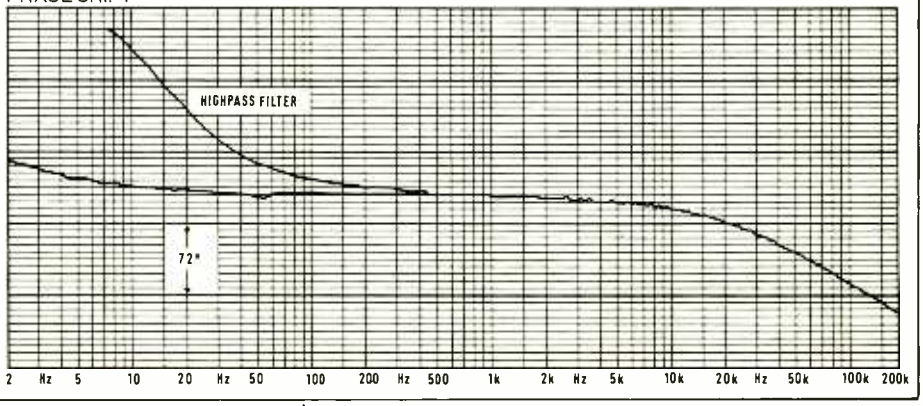


FIG.9
TOA P300D
PHASE SHIFT



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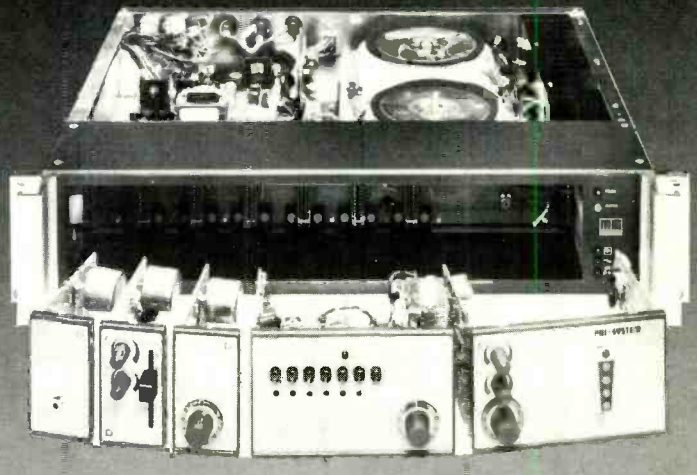

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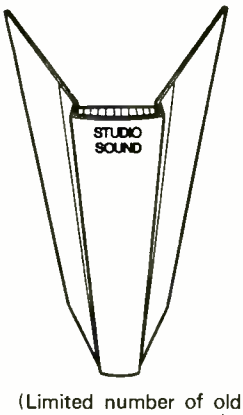

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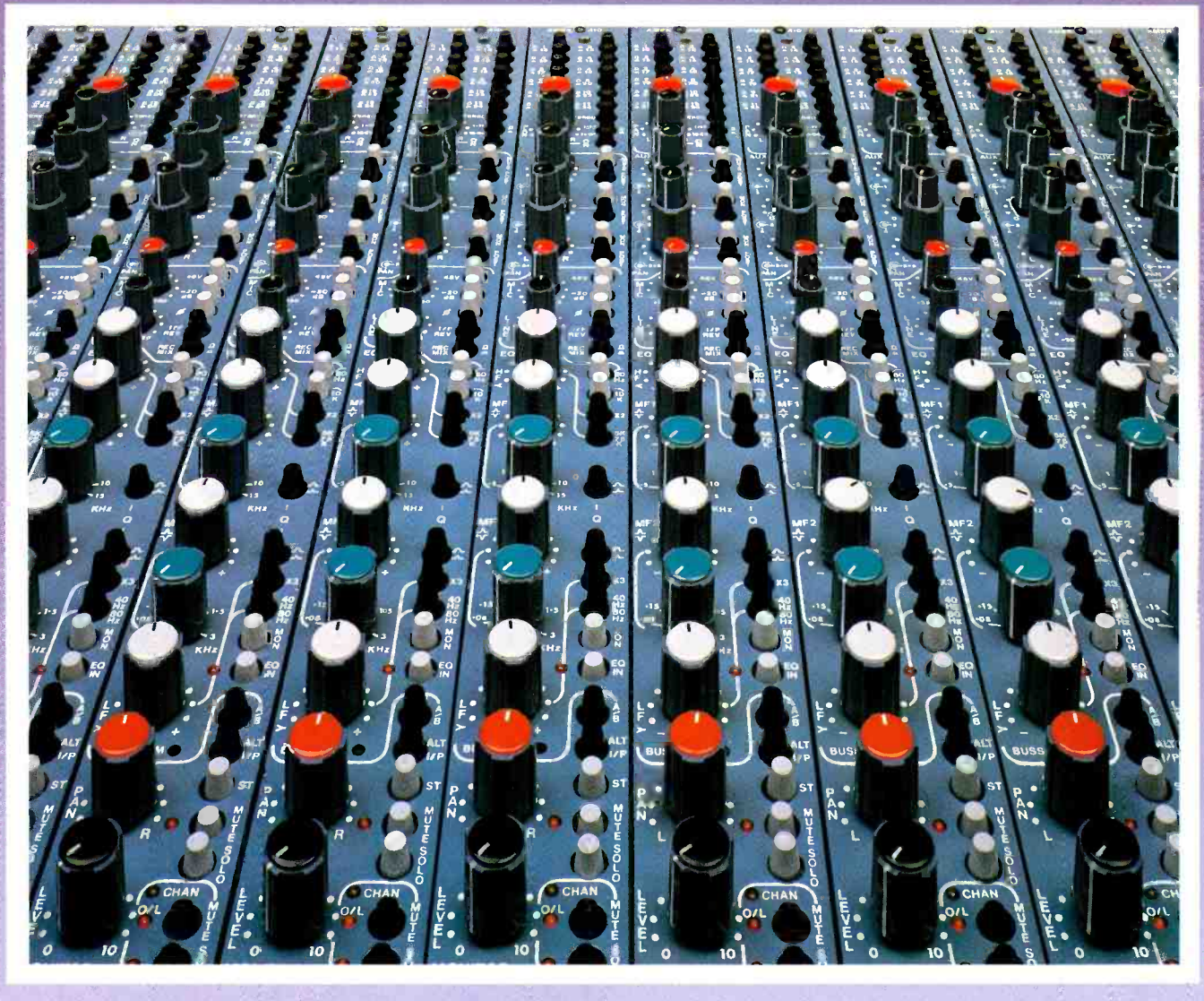

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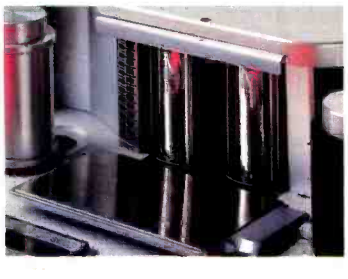

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